P.144 Ackerlund, WS; Ackerlund, Inc.;
steve.ackerlund@bresnan.net

Getting Unstuck: Application of Risk Communication Principles to Improve Project Schedules and Outcomes at Hazardous Waste Sites

Despite more than 35 years of accumulated experience in developing remediation solutions at Superfund sites since CERCLA was enacted, many projects continue to get mired down by the mass of technical analysis required and the seemingly unavoidable controversies and protracted negotiations that emerge from the technical complexity. This poster draws upon the presenter's doctoral studies in Risk Communication and Environmental Conflict Resolution and 25 years of environmental consulting experience to identify common sources of controversy at Superfund and RCRA sites. The case is made that embedded regulatory processes and conventional methods for solving purely technical problems unwittingly establishes a distributive form of negotiation which fosters a win-lose, combative attitude among the involved parties. In contrast, the general principles of integrative negotiation, also known as collaborative or win-win negotiation, is presented as a foundation for re-thinking the problem-solving process from both the social-communicative and technical perspectives. Three case studies involving CERCLA and RCRA sites are presented to represent wide-ranging ways in which general integrative negotiation principles have been successfully used to design and implement communication tactics that led to stakeholder agreement on remediation needs in a timely (and more enjoyable) manner.

W2-E.4 Agarwal, V*; Henshel, DS; Alexeev, A; Cains, MG; Indiana University; *varagarw@indiana.edu*

Integrating Defenders and Attackers into Cyber Security Risk Models

Current approaches to modeling cyber security risk assessment typically only include assets, the hardware and software of a cyber network, especially those based on the National Institute of Standards and Technology (NIST) Framework for Improving Critical Infrastructure Cybersecurity. Human factors are considered primarily in terms of how users use networks, which help defenders and IT managers prioritize assets; while the defenders and IT managers consider risk from their perspective of how to best protect their system. Risk management within the context of the NIST framework does not consider humans as actual risk factors, initiators and mitigators of risk, and therefore potential components of a predictive model of network security risk. Attributes of the human actors, attackers, defenders, and users, such as experience or knowledge, may significantly influence how human actors contribute to or mitigate cyber-risk, and thus are appropriate parameters to include in a predictive cyber security risk model. Extending our previous work which modeled the contribution of human factors to aggregate cybersecurity risk, we introduce human factor parameters to incorporate attacker and defender skills into our modeling framework. We use empirical distributions for the nodes in the Bayesian network, adapted from data observed and documented by studies of SQL injection attacks. Using empirical evidence gives a more versed view of how changes in the network affect the overall risk, in comparison to using theoretical assumptions. We discuss how including human factors contribute to increasing or mitigating risk in cyber networks, detailing the potential impacts and effects of human actors on risk posture, strategy, and response. We model and evaluate the risks for an SQL injection attack on a highly sensitive database server. We will discuss parametrization and validation of the model using empirical data obtained in the experiment on a virtual network test bed.

P.71 Aguiar Filho, A; Soares, ES*; Esquerre, KP; Barreto, TB; Pessoa, RW; Federal University of Bahia;
soares.eduardo.sampaio@gmail.com

Traffic-Accidents Prediction Using Advanceds Machine Learning Techniques

The present work aims at understanding a relation between vehicular accident types and some possíble causes at Brazilian highways. In order to carry out the analyzes, a database from the National Department of Transport Infrastructure (DNIT) for seven-year period (2005 to 2011) was utilized. The prediction model was built by using the space-time characteristics of the highway applied to the technique of gradient boosted Regression trees, GBRT, through the LightGBM package. The quality of the model was evaluated based on a test data set which represents 30% of the total data, through the confusion matrix, the non-information ratio, as well as the multi-class logarithmic loss. Model shows a good qualitative performance. The most influential variable in the accident type identification corresponds to the location of the stretch of the highway (km). Climatic conditions, the quality and characteristics of the stretches of the highway, among others, are suggested to be used in future studies as predictive variables as a way to improve model predictive performance. After this initial test, was proposed a better model using other powerful Machine Learning strategy.

T4-A.1 Aiken, DV*; Wharff, J; U.S. Department of Transportation;
deborah.aiken@dot.gov

Benefit Cost Analysis of Enabling Regulations: Insights from FAA's Small UAS Rule

Office of Management and Budget (OMB) guidance on Executive Order 13771, "Reducing Regulation and Controlling Regulatory Costs," refers to a broad category of de-regulatory options termed "enabling regulations." An enabling regulation is a regulatory action that expands production or consumption opportunities, and analysis of the benefits and costs of these rules present new challenges, especially to agencies historically concerned with regulating for risk reduction purposes. The primary, or first-order, benefit of an enabling regulation that relaxes existing standards to allow a new industry to unfold accrues to businesses, rather than consumers. Calculating business benefits requires a much different framework than agencies apply in estimating benefits for risk reduction. The problem is additionally complicated by the lack of data on an industry that has yet to emerge. At the same time, relaxing existing rules could introduce new risks to the consumers that an agency is accustomed to protecting. The Federal Aviation Administration (FAA) has begun the process of issuing regulations to integrate small unmanned air systems (UAS), or "drones" into the national air space. The FAA's Part 107 small UAS rule is an example of an enabling rule, which effectively reduces the cost of entry into the non-recreational, non-hobby (or ''commercial'') market for UAS services. This paper evaluates FAA's overall approach to the analysis of benefits and costs of the rule. We examine the unique difficulties encountered in the analysis of an enabling rule, particularly those that arise from a lack of historical data on an industry that has yet to emerge, and discuss implications for developing an overall framework for benefit cost analysis of enabling rules.

M4-A.2 Aiken, D; Good, DH*; Krutilla, K; Deborah Aiken, Department of Transportation, David Good, Indiana University, Kerry Krutilla, Indiana University; *krutilla@indiana.edu*
Uncertainty Analysis in RIAs for Transportation Safety and Air Pollution Regulations
This research assesses the uncertainty characterization in the RIAs of lifesaving rules issued by the DOT and EPA from 2011 through 2016. The goal is to identify standard practices; to assess the limitations and strengths of the evaluations; and to offer recommendations for improvement. Rules issued by the two agencies have different characteristics, and these differences influence the nature of the uncertainty evaluations. Both agencies have rules that mandate technology, but DOT rules also alter behavior or require certification. DOT rules target a focused subset of the population while EPA air pollution rules affect large populations. Noncompliance can be assumed in the baseline absent air regulation, whereas voluntary technology adoption is common in the market segments targeted by DOT rules. EPA rules rely on an air pollution modeling and empirical estimation of concentration response functions while DOT rules use a mix of data sources including crash databases, investigated crashes, and simulated crashes. Some DOT rules regulate infrequent safety risks (e.g., airline crashes) with only limited data available for evaluation. As a generalization, the major uncertainty in EPA rules lies in the concentration-response functions, rather than in the linkage between emissions control and the effects on concentrations, whereas more of the uncertainty in DOT evaluations occurs in the initial causal link between a safety intervention and crash avoidance/impact reduction. The link between emissions reductions and concentrations for EPA rules is based on peer-reviewed modeling platforms, whereas the heterogeneity of DOT rules necessitates a stand-alone evaluation of casual linkages between interventions and crash or accident reductions rule by rule. However, the different mechanisms for DOT rules are likely to be independent across rules, whereas EPA rules rely on the same mechanism for harm (PM2.5 health effects), giving the possibility of similar biases carrying over in the evaluations of all EPA rules.

P.184 Akai, K*; Makino, R; Takeshita, J; Kudo, T; Aoki, K; Shimane University; *akai@med.shimane-u.ac.jp*
Effect of Risk Probability Disclosure on System Reliability: An Economic Experiment
The purpose of this study is to experimentally examine the effect of disclosing the risk probability of each unit in a production system on human behavior and on the resulting reliability of the production system using human subjects in a laboratory. To achieve this goal, we used an economic experiment based on the theoretical model of Hausken (2002). To evaluate the effect of risk probability disclosure, we conducted one experiment in which the risk probability was disclosed to subjects and one in which the risk probability was not disclosed. We conducted first the non-disclosed-risk experiment and then the disclosed-risk experiment within subjects in both series and parallel systems. Our experimental results show that risk probability disclosure has two positive effects. First, subjects succeeded in improving the system reliability while cutting back on efforts to reduce the risk of their units when the risk probability was disclosed. In each system, the disclosed-risk condition achieves significantly higher system reliability on average than does the non-disclosed-risk condition, although the average level of effort is significantly lower under the disclosed-risk condition than under the non-disclosed-risk condition. Second, disclosing the risk probability simplified the subjects' decision-making process and reduced its cost because subjects made their decisions on the amount of effort to exert based only on the risk probability information without considering other factors, such as the number of accidents.

M3-C.1 Akl, S; Turner, MB; Rady, AS; Al Ashram, M; Kalimuthu, ; Lloyd, JM; Beauchamp, C; Al Hajer, K; Al Waheebi, A; Lillys, T*; Research Triangle Institute and Environment Agency- Abu Dhabi; *sakl@rti.org*
Analysis of Hazard Evaluation Data and the Development of a Risk-Based Inspections Schedule for the Environment Agency-Abu Dhabi
In March 2011, RTI, in partnership with the Environment Agency-Abu Dhabi (EAD), introduced the Risk Characterization and Hazard Evaluation System (RiCHES) and Data Collection Tool (DCT), a new and innovative approach to characterizing the risk posed by facilities in four risk dimensions: First Responder, Process Hazard, Ecological, and Public Health. Since 2011, 1500 hazard evaluations have been conducted at industrial and commercial facilities in Abu Dhabi. The DCT is used to collect data in the field at these facilities (hazard evaluations) using tablet computers and the data are subsequently uploaded to RiCHES where the responses to the questions in the DCT are mapped to risk scenarios in RiCHES and scored. The DCT is used on a daily basis to collect data using a simple interface using questions with answers that are characterized as high, medium, and low risk. The scores and data are stored in an Oracle database that is accessed through an EAD website. There are features on the website that allow users to identify the primary risk drivers at the facility and industrial sector level; these would be the scenarios that are driving the risk scores at individual facilities and within sectors. The end result includes risk scores that can be used to rank facilities based on risk. RiCHES currently functions as a decision-making tool that helps EAD to identify those facilities with high risk scores that should be inspected more frequently, those facilities with medium scores that should be inspected on a more regular frequency, and those facilities with low scores that should be inspected less frequently. This paper will describe the data analysis approach that has been used to analyze the hazard evaluation data collected so far and the approach that was used to develop a risk-based inspections schedule for industrial and commercial facilities in Abu Dhabi to replace the time-based inspection schedule that has been traditionally used.

T4-A.3 Alexeev, A; Jardine, E; Krutilla, K*; Kerry Krutilla, Indiana University, Alexander Alexeev, Indiana University, Eric Jardine, Virginia Tech; *krutilla@indiana.edu*
Cybersecurity Investment as A Differential Game
An adapted contest success function is used to model a competitive interaction in which one state actor devotes resources to breach the cyber network of the second. The probability of a successful attack/defense depends on this period's resources commitments, and the accumulated stock of knowledge in cybersecurity, which increases over time as a side effect of cumulative resource commitments. The contest success function includes technical efficiency and noise parameters. Payoffs are the utility losses for the defending state, which are approximated as economic losses, and utility gains for the attacking state, which proportional to losses of the defending state. The players move simultaneously in a multi-period, differential game, reflecting a cybersecurity environment in which state actors regularly attempt to penetrate cyber security networks over a long time horizon. The model is solved for an open loop Nash equilibrium in pure strategies, and a time-consistent subgame perfect equilibrium. The evolution of optimal resource commitments over time are evaluated as a function of the magnitude of the defender's expected losses and the model's other parameters. The policy implications are evaluated.

W2-E.3 Alexeev, A; Henshel, DS; Agarwal, V; Cains, MG*; Indiana University; *aalexeev@indiana.edu*

Cyber Attack Risk Evaluation using a Stochastic Epidemiological Framework

Security is a crucially important concern for sustainable operation of computer and communication networks given the plethora of attack vectors and the number of attacks per minute launched in virtually any network. Propagation of malware represents one of the main risk threats to network security. The process of malware spread and its dynamics can be modeled using adapted epidemiological models. Most models are deterministic in their nature, which produces an almost completely identified dissemination path. Deterministic models do not account for heterogeneity of the network components, such as in devices, software, and users. Behavioral and chance attributes of human agents (users) alone justify employment of a stochastic framework. Stochastic models allow for variability between simulations, permitting such useful features as stochastic resonance or stochastic extinction. Stochastic behavior becomes particularly important in small networks or when the number of initially compromised computers is small. This paper presents results of a study of malware spreading in heterogeneous networks using a stochastic epidemiological SIR-modeling framework that includes attacking and defending networks, and explicitly introduces their interaction. We describe malware propagation in a computer network with heterogeneous components using a system of ordinary differential equations to model deterministic dynamics of propagation. The deterministic trajectories are compared to those with stochastic input to either network as a unified whole or to specific input into a single component of one network. Simulations are conducted to model variation in multiple parameters or variables. The stochastic framework incorporates different characteristics of the attacking network, such as attack intensity and periodicity. The paper concludes with a discussion of the effect of stochastic behavior on risk of malware propagation in diverse computer networks.

P.48 Allen, BC*; Blessinger, TD; U.S. Environmental Protection Agency and Independent Consultant; *blessinger.todd@epa.gov*

Defining Priors for Bayesian Dichotomous Dose-Response Analysis

Bayesian approaches in dose-response modeling are becoming more common given the wide availability of Markov Chain Monte Carlo techniques and recent advances in Bayesian model averaging. An important consideration for implementation of Bayesian approaches is the specification of parameter priors. A Bayesian model averaging method recently released in EPA's Benchmark Dose Software (BMDS) defines model-specific parameter priors empirically based on 558 datasets obtained from EPA's IRIS database. This poster presents an alternative approach in which the priors applied to model-free quantities of interest (e.g., extra risk at a particular dose, background response, BMD50) are consistent across models that are fit to the data. Also investigated is the impact of the correlation among model parameters (which was not accounted for in the empirical investigation noted above). To address this issue, an alternative model parameterization is proposed for which the assumption of independence among parameter priors is reasonable.

W2-C.1 Almutairi, A.; Andrews, D*; Lambert, J.H.; University of Virginia, 151 Engineers Way, Charlottesville, VA 22904 ; *aa2ch@virginia.edu*

How Resilience Analytics Addresses Several Participants Disrupting Priorities for Infrastructure Systems

Participants in infrastructure development bring a variety of interests and backgrounds, characterized by complexity, interdependency, interconnectedness, and heterogeneous sources of uncertainty. For a decision framework that involves multiple individuals, the disruptive influences of participants must be taken into account. Recent developments in risk analysis and systems engineering have addressed the influence of scenarios to priorities for systems that involve multiple stakeholders, multiple objectives, and uncertainties in several fields of application. Particular recent work in this topic, however, has neglected to address the influence of the participants, which has been a topic of its own in other literature. This study addresses the need to extend resilience analytics and scenario-based preferences to account for the following requirements. First, it will quantify the influence of the level of participation of multiple participants in a scenario-informed assessment and management model. For a given set of future emergent conditions, a power and interest analysis will be performed to quantify the influence of the level of participation for each participant in the priority setting process. Second, it extends a resilience analytics approach to support planning that is influenced by BOTH scenarios of emergent conditions AND the several participants. This approach classifies future scenarios based on their disruptiveness to the priority setting while taking into account the influence of the participation levels of multiple participants on the priority setting. The methods are demonstrated at major container terminals at the United States that handle several million freight containers per year. The above innovation provides an understanding of what sources of uncertainty matter most and least to priority setting, with a critical new emphasis on accounting for the evolving interests of participants.

P.72 Amodeo, DC*; Francis, R; The George Washington University; *dcamodeo@gmail.com*

Optimal Re-allocation of Cargo Across Transportation Modes for the Recovery of Throughput During an Inland Waterway Disruption

A number of studies have looked at the relationship between attributes of port delays along inland waterways and the regional economic loss. These studies have typically integrated a loss model with either a simulation or stochastic program to generate a set of shipper responses to disruption. To our understanding, none of these studies have looked at the role of operational terminals in facilitating modal shifts when the disruption comes from barriers to vessel movement such as low water levels, lock closures, or vessel collisions. In this paper we propose a model to optimize cargo re-allocation mid-sail when carriers are faced with uncertain transit times due to disruption. The degree of feasible modal shift can be viewed as a contributing factor of network resilience. This ability to re-allocate a mode's commodity mix ensures continued service when one or more modes are disrupted. A critical input to this study is the capacity and capability of river terminals. After presenting the proposed model, we illustrate its use of a 500 mile commercially navigable segment of the Tennessee River.

W4-B.1 AOYAGI, M; National Institute for Environmental Studies; *aoyagi@nies.go.jp*

Public support for the climate change policies, from party support point of view

In this paper, we discuss about the people's support for climate change policies in Japan, risk perception, media exposure and public's political party support. The effects of political party support on climate change policy support has been reported in many countries, especially in the US, but hardly in Japan. We use our public opinion data with evaluation results of national political parties' policy proposals done by climate change NGOs in Japan during National Election in 2016. Our data is 2016 public opinion survey data carried out by authors from mid-June to early July, a few weeks before the Japanese National Diet Election. 3000 respondents were drawn from the Basic Residents Register. Effective responses were 1640(54.7%). Our results show that 94% of people chose options of "the weather is changing," and 63% chose "very much+very" anxious about the climate change or global warming. 88% chose "climate change is caused by "partly +mainly +completely" human activity. 72% felt personal responsibility for climate change prevention. 79% support Paris accord. For party support, as of the a few weeks before the election, only 24% of respondents chose "not yet decided", and 42% chose five in "democrat-conservative" zero to ten scale. This is not surprising, as Japanese political parties are not well differentiated, especially for the climate change policy. NGOs which are active in climate change policy making, such as WWF Japan and Kiko-Net listed up each party's policy agenda on that national election. According to their analysis, neither conservative nor democratic party were more likely to make aggressive climate change policy proposal. Some parties are more aggressive to the anti-nuclear policies but they were not necessarily tied with climate change policy. Thus, it would be safe to say that there is no differentiated policy proposal by each political party, this makes Japanese public's partisan dichotomy difficult on climate change policy support.

P.45 Arzuaga, X*; Yost, E; Hotchkiss, A; Beverly, B; Gibbons, C; U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, and National Institutes of Health, National Institute of Environmental Health Sciences, National Toxicology Program; *arzuaga.xabier@epa.gov*

Proposed key characteristics of male reproductive toxicants as a method for organizing and screening mechanistic evidence for non-cancer outcomes.

The adoption of systematic review practices for risk assessment includes integration of evidence obtained from experimental, epidemiological, and mechanistic studies. Although mechanistic evidence plays an important role in mode of action analysis, the process of sorting and analyzing mechanistic studies and outcomes is a challenging exercise due to the diversity of research models and methods, and the variety of known and proposed pathways for chemical-induced toxicity. The recently identified Ten Key Characteristics of Carcinogens provide a valuable tool for organizing chemical-specific data on potential mechanisms of carcinogenesis. However, such an approach has not yet been developed for non-cancer adverse outcomes. Our objective in this study was to identify a set of key characteristics that could be applied for screening mechanistic evidence for male reproductive effects. Identification of seven key characteristics of male reproductive toxicants was based on a survey of established mechanisms/pathways of toxicity. As a proof of principle, we applied this set of key characteristics to organize experimental and mechanistic studies that evaluate the effects of the PCB mixture Aroclor 1254 on the male reproductive system. A database was developed to capture the available information and experimental design details on Aroclor 1254 for each of the key characteristics of male reproductive toxicants. The proposed key characteristics provide a useful method that can facilitate the systematic and transparent organization of mechanistic evidence relevant to chemical-induced effects in the male reproductive system. Disclaimer: The views expressed are those of the authors and do not necessarily represent the views or policies of the US EPA.

P.62 Ashton, L; Berck, P; Cole, D; Hoffmann, S*; Todd, J; University of Wisconsin, Madison; University of California, USDA Animal Health Inspection Service, USDA Economic Research Service; *shoffmann@ers.usda.gov*

Can Scanner Food Purchase Data Help Us Identify Sources of Foodborne Illness?

Since the adoption of the Sanitary and Phytosanitary Agreement in 1995, food safety authorities around the world have been working to move from a hazard-based to a risk-based approach to food safety management. The international focus on risk-based food safety management has included a call to develop methods "to estimate the proportion of illnesses and death that is truly foodborne and the major food vehicles, processes, and food handling practices responsible for each hazard" (FAO/Codex. Principles and Guidelines for the Microbial Risk Management p. 7). The result has been an emerging area of food safety research, source attribution (Pires et al. 2009). Source attribution of foodborne illness is surprisingly difficult. As a growing body of research, has focused on developing new approaches to estimating quantitative relationships between food exposures and human disease, it has become clear that a wider range of methods are needed. This paper develops a new source attribution method using analysis of daily time series data to study of the relationship between enteric disease and food exposure. Our study uses daily data from Foodborne Diseases Active Surveillance Network (FoodNet) on illness from Campylobacter and Shiga toxin-producing Escherichia coli (STEC) O157 and daily food purchase data collected by Nielson. Both pathogens have been studied using other source attribution methods, providing a basis for examining the external validity of our approach. These data are regionally specific, allowing examination of geographic heterogeneity in the association between food exposures and disease. We explore the effects of temporal aggregation and lag structure as well as food category structure on statistical power. We find patterns of food association that are consistent with those found in prior case-control studies, but our results allow more specific regional and temporal patterns to these associations.

W1-C.4 Astill, GM; Economic Research Service, USDA; *gregory.astill@ers.usda.gov*

An Exposure Weighted Measure of Foodborne Illness Risk in Regulatory Analysis

The new rules under the 2011 Food Safety Modernization Act focus on prevention of foodborne illness by using a flexible approach informed by risk. The majority of previous research on sources of foodborne illness use the share of illnesses attributable to a certain commodity, but exposure to the commodity is also an important factor. Research that considers per capita consumption does so at an aggregate level combining fruit and vegetable categories. This article develops a foodborne illness risk ranking that accounts for consumption of the eight major animal product food categories as well as for 28 fruit and vegetable commodities. Heavily consumed commodities like milk, chicken, and beef are found to be less risky relative to other commodities when weighted by exposure, while lightly consumed commodities like fish & shellfish, chili peppers, and green beans are found to be more risky.

M4-E.1 Augspurger, T*; Basu, N; , ; 1 U.S. Fish and Wildlife Service, Raleigh, NC, USA; 2 McGill University, Ste-Anne-de-Bellevue, Quebec, Canada; *tom_augspurger@fws.gov*

One Health: Opportunities for SRA and SETAC Leadership and Cooperation to Improve the Health of People, Animals and the Environment

"One Health" is a concept to encourage and expand interdisciplinary collaborations in research, clinical practice, policy, and communication related to health of people, other animals, plants and the environment. The term is relatively new (since ~2003), and it is increasingly common to see One Health included by name in inter-institutional research partnerships, conferences, communications, and organizational frameworks – particularly those championed by the human health and veterinary medical communities. One Health as a term is seldom used within Society of Environmental Toxicology and Chemistry (SETAC) and Society for Risk Analysis (SRA) communications despite our histories of interdisciplinary environmental science (i.e., we do that work; we just call it by other names in our journals, newsletters, and presentations). The One Health concept (and related frameworks including Conservation Medicine and EcoHealth) presents opportunities for funding, communicating our science to new outlets, and new collaborations. We will discuss the origins, evolution, and utility of the One Health approach as an organizational framework and provide examples of ways in which SRA and SETAC expertise can benefit the One Health community, especially for chemically mediated health concerns shared among humans, domestic animals, and wildlife. We highlight examples from low- and middle-income countries where adverse outcome pathways and risk assessments, broadened by a One Health framework, could optimize the health of people, animals and the environment.

W2-H.1 Aven, T; University of Stavanger, Norway ; *terje.aven@uis.no*

Core Subjects and Principles of Risk Analysis

In a recent document from the Society for Risk Analysis a list of core subjects of risk analysis is presented (www.sra.org/resources). It captures five main categories of subjects: Fundamentals (science, knowledge, uncertainties, risk - other basic concepts); Risk assessment; Risk perception and communication; Risk management and governance, and Solving real risk problems and issues. In the talk I will discuss the background, rationale, purpose and importance of this document. I will also reflect on a related issue; what are the key fundamental principles ensuring prudent risk analysis? There is a strong need for authoritative guidance on how to best conduct risk analysis but is it really possible to formulate meaningful and useful principles on a generic level?

M3-C.4 Babendreier, J.E.*; Taylor, T; U.S. Environmental Protection Agency; Offices of Research and Development and Land and Emergency Management; *Taylor.timothy@Epa.gov*

Overview and Demonstration of USEPA's Risk-Informed Materials Management (RIMM) Tool System

The Risk-Informed Materials Management (RIMM) Tool System is a data gathering and analysis platform for conducting material disposal and beneficial use assessments. Users can evaluate risks to human and ecological receptors associated with exposures to organic and inorganic chemical releases from the land-based management of industrial by-products and other materials. Single-site or multi-site studies are conducted through deterministic or probabilistic simulation of one or more chemicals released from a material managed in one or more scenarios (farm field or land application unit, pond or surface impoundment, roadway subbase, landfill, material pile, or aerated tank). A typical application is comprised of up to four steps: 1) collect site-specific information for one or more sites in the contiguous US; 2) run sets of deterministic multimedia modeling scenarios across the site(s); 3) evaluate exposure and risk results; and, if desired, 4) calculate chemical- and material-specific screening concentrations for managing a material within each scenario studied. Spatially-explicit modeling is carried-out using the Human and Ecological Exposure and Risk in Multimedia Environmental Systems (HE2RMES) modeling system. To identify site locations and gather site-specific data needed for step 1, HE2RMES is complemented by the OpenTERRAworks 2D/3D Landscape Design tool, an open-source Geographic Information System (GIS) developed by USEPA. OpenTERRAworks acquires web-served data and provides the ability to, if desired, prospectively evaluate site-specific landscape modifications. Site-level data gaps are filled using regional and national datasets. Users can address uncertainty and sensitivity analysis, as well as leverage parallel computing tools provided for conducting larger studies. We present an overview and application of the broader system's abilities to support exposure and risk assessments across a wide range of spatial scales, spanning site-specific to national scope.

T2-G.3 Bailey, LB*; Bromfield, KE; Corin, C; Holmes, G; [New Zealand] Environmental Protection Authority; *lee.bailey@epa.govt.nz*

Helping make green New Zealand even greener: the challenges and rewards of a regulator sharing its risk assessment methodology

New Zealand's Environmental Protection Authority (NZ-EPA) is responsible for evaluating new chemical products entering, or manufactured in, New Zealand under the Hazardous Substances and New Organisms Act 1996. As part of this evaluation the NZ-EPA has conducted risk assessments in-house since its creation in 2011. Quantitative assessments are conducted on those hazardous substances that: contain a new active ingredient; are being used in a significantly different way; or where there are concerns regarding the impact substances are having on human health or the state of the environment. To increase transparency for industry bringing a new chemical into New Zealand the NZ-EPA is releasing guidelines for the first time. These explain how it incorporates qualitative and quantitative risk assessments with the 'unique benefit' and indigenous cultural assessment requirements in New Zealand. It is anticipated that the guidelines will also improve the trust and confidence that the NZ-EPA's customers, including the New Zealand public and environment, have in its approach and decisions. The process of collating this methodology document has already improved the NZ-EPA's internal risk analysis process by challenging its experienced staff to improve the justification for why models and parameters are selected. It highlighted several areas for further improvement in parameter selection and options for model choice improvements. These will need to be balanced against the timing and financial constraints of a small regulator and the associated regulatory, business and reputational risks. The NZ-EPA will use the release of its risk assessment methodology to encourage applicants to complete and submit their own comprehensive assessments, and will move towards evaluating these assessments rather than conducting them. This change will improve the practice of chemical risk analysis in New Zealand and meet the cultural and regulatory requirements for safer and greener substances.

P.26 Bailey, A*; Peterson, J; SLR International Corporation; *abailey@slrconsulting.com*

A Probabilistic Risk Model for Contaminated Site Management

Probabilistic risk assessment (PRA) uses distributions as an alternative to point estimates to calculate and present risk estimates, resulting in more complete and informed risk characterization. PRA also provides insight into the critical factors influencing risk estimates by formally evaluating the roles of variability and uncertainty. PRA is a useful tool to inform management decisions for contaminated sites where unacceptable point estimates of risk have adverse consequences, and to prioritize additional research to further inform risk estimates. The PRA presented herein evaluated cancer risks from arsenic-impacted soil under three types of residential exposure scenarios. A model was developed to incorporate changes in body weight, exposure duration, soil ingestion rate, and exposure time as receptors aged. Measured data from the population in the site vicinity, where available, were used to characterize exposure assumptions. The resulting risk distributions were used to focus remediation on areas likely to pose the greatest potential risk, thereby reducing remediation costs. This project represents the first PRA, to the authors' knowledge, accepted and used by a State regulatory agency to guide management decisions for a contaminated site. This presentation will focus primarily on the PRA methods and model, as well as application of results.

P.120 Bailey, LA*; Rhomberg, LR; Gradient; *lbailey@gradientcorp.com*

Incorporating ToxCast and ExpoCast Data into Naphthalene Risk Assessment

Inhalation of naphthalene causes nasal olfactory epithelial tumors in rats and benign lung adenomas in mice. The available human data have not identified an association between naphthalene exposure and increased respiratory cancer risk. Therefore, naphthalene carcinogenic risk assessment in humans depends entirely on experimental evidence from rodents. The United States Environmental Protection Agency (US EPA) Toxicity Forecaster (ToxCast) Database contains 882 in vitro assays for naphthalene, with more than 750 assays conducted in human cells. We obtained and reviewed all naphthalene ToxCast assay data and used that information for the following analyses: 1) Using a physiologically-based pharmacokinetic (PBPK) model for naphthalene (Campbell et al. 2014), we determined the naphthalene inhalation concentrations that correspond to relevant activity concentrations for all active naphthalene assays, and compared those concentrations to the naphthalene human equivalent concentration (HEC) derived in our recent naphthalene paper (Bailey et al., 2015); 2) We evaluated target endpoints for active assays in the context of proposed modes of action for naphthalene; and 3) We reviewed the assays within ToxCast to determine which might be expected to be positive based on proposed modes of action and carcinogenic endpoints for naphthalene. In addition, we evaluated naphthalene exposure information within the US EPA High-Throughput Exposure Forecaster (ExpoCast) Database in the context of our naphthalene HEC. Overall, although there are limitations and some uncertainties within the naphthalene ToxCast and ExpoCast data, the results from our analyses of these data are consistent with, and provide additional support for, the conclusions in our 2015 analysis.

T2-J.3 Baker, JE; ABA Standing Committee on Law and National Security; *jebaker1215@gmail.com*

Behavioral Considerations in Context: Crisis Decision Making by Senior Public Officials

Judge James Baker will offer commentary on the papers from the perspective of a legal scholar and White House advisor on national security decisions. Focus areas may include: formal and informal processes that presidents and cabinet members adopt for national security decisions; Congress's national security powers as they relate to executive branch decision-making processes; the suitability of national and transnational decision-making processes in specific bodies of transnational law (e.g., targeting decisions under the law of armed conflict); and opportunities to improve legal support provided to senior government officials.

P.102 Banan, Z*; Gernand, JM; Pennsylvania State University; *zoya@psu.edu*

Mapping the Emissions Exposure Risk due to Hydraulic Fracturing in Pennsylvania

In the past decade, the shale gas boom has led to increasing exploration and production of this strategic energy source with considerable potential economic and environmental benefits. However, there exist environmental health risks caused by emissions from shale gas development activities. Pollutant dispersion simulation results demonstrate that setback policy in Pennsylvania is not adequate to protect people from health effects due to exposure. We estimate the exposure level of a resident within the vicinity of the set of actual historical wells to evaluate the severity of this exposure experience. This study uses a Gaussian plume model to calculate the exposure values of fine particulate matter (PM2.5) over the Marcellus shale region of Pennsylvania, considering the density and timing of these activities. These results serve as input to create exposure maps that quantify the level of environmental health risk associated with these emissions. Results reveal the wellsite vicinities that did not comply with the EPA's exposure standards which implies a failure of public health protection policy at these locations. We combine these exposure results with disease risk and population density to create a series of risk maps that identify expected case numbers as a function of geographic area and time. Based on these risk maps, we evaluate policy alternatives for regulating the density of shale gas development activity in time and space to keep individual communities below the recommended exposure levels for pollutants emission in the future.

P.96 Bare, JL*; Abramson, MM; Barlow, CA; Scott, PK; Cardno ChemRisk, Arlington, VA; Cardno ChemRisk, Pittsburgh, PA; Cardno ChemRisk, Boulder, CO; Cardno ChemRisk, Pittsburgh, PA ; *jennifer.bare@cardno.com*

Use of air dispersion modeling to estimate historical community exposure from manufacturers of asbestos-containing products

Manufacturing of asbestos-containing products can result in the environmental release of asbestos into the surrounding community. Unlike exposures to asbestos during the manufacture or use of asbestos-containing products, community exposure has not been as well-characterized. However, asbestos emissions to a community cannot be generalized across all types of manufacturing facilities. In this analysis, a methodology using air dispersion modeling to estimate potential community exposure to asbestos from a hypothetical manufacturer of asbestos-containing friction products from 1965 to 1989 is presented. The USEPA preferred air dispersion model, AERMOD, was used to predict the annual airborne concentrations of asbestos up to 2000 meters from the facility. Continuous emission sources included 1) unloading of asbestos from a box truck, 2) uncontrolled fugitive building emissions prior to 1975, 3) controlled baghouse emissions after 1975, and 4) disposal of scrap asbestos. Prior to the introduction of a baghouse in 1975, asbestos emissions for the hypothetical facility were primarily attributed to the uncontrolled fugitive building emissions. Thereafter, there was a substantial decrease in overall asbestos emissions, with unloading emissions as the greatest contributor. As expected, predicted airborne concentrations of asbestos were greatest closest to the manufacturing facility and decreased by approximately four-fold after the installation of the baghouse in 1975. Uncertainties associated with the air dispersion modeling included the assumptions regarding historical asbestos usage and asbestos handling and processing at the hypothetical manufacturer. This methodology may be applied to similar exposure scenarios to reconstruct historical community exposure to asbestos with manufacturer-specific data and records.

T3-K.2 BARNETT, J*; FELLENOR, J; University of Bath; *julieatselhurst@gmail.com*

Public concern about risk: a critical (re) evaluation

The nature of public concern about risk, what occasions it, what it leads to and how to manage it has been an ongoing focus of academic, policy and practitioner attention for the last 50 years. The notion of the Social Amplification of Risk has provided a framework for considering these issues and in particular has focused scholarly attention on the way in which the object and magnitude of public concerns are often different from those of experts. Using the Social Amplification of Risk Framework, this paper critically evaluates the notion of public concern about risk. Through a review of the risk perception literature we identify the metrics that have been used to operationalise public responses to risk and consider the ways in which these metrics have been depicted and visualised. Against this backdrop we report the results of empirical work exploring the nature of public concern around the impact of tree pests and diseases by comparing survey results, interviews, social media analysis, emails to UK government and comments following media reports. On the basis of the literature and the empirical work we argue that in the first instance, concern may be best conceptualised as attentiveness. The range of data sources, both naturally occurring and those solicited as part of the research process, provide insight into the ways in which manifestations of 'concern' are a function of the methods used to capture, measure and depict it. Finally we outline the notion of a 'concern-public assemblage'; a notion designed to explicitly problematise existing ideas about publics and concern, and which captures the dynamic interrelations between people, policymakers, researchers and contextualised risk.

W4-F.4 Baroud, H; Vanderbilt University; *hiba.baroud@vanderbilt.edu*

Risk analysis methods in resilience modeling: an overview of homeland security applications

Resilience modeling has received an increased attention in the past few years due to its importance in homeland security applications, more specifically in protecting and enhancing critical infrastructure systems. As a result, there has been a wealth of qualitative, quantitative, conceptual, and applied frameworks developed to address national preparedness and resilience to potential disruptive events. As such applications involve uncertainty, risk analysis concepts significantly influence the development of resilience frameworks, models, and metrics. This paper constitutes an analysis of risk analysis techniques that are used in resilience modeling with a special focus on critical infrastructures preparedness applications. How is risk analysis used in resilience models? How is resilience defined and modeled in the context of risk? This work seeks to identify opportunities and challenges of leveraging foundational risk analysis and previously developed risk analysis methods to enhance resilience modeling efforts and ultimately strengthen national preparedness and resilience to disruptions.

P.17 Barr, C; Pinkston, K*; Seitz, R; Bailey, L; Guskov, A; McKenney, C; United States Nuclear Regulatory Commission (Author 1, 2 and 6); Savannah River National Laboratories (Author 3); Radioactive Waste Management Limited, UK (Author 4); International Atomic Energy Agency (Author 5); *cynthia.barr@nrc.gov*

International Activities Related to Development of Guidance on Human Intrusion in the Context of Disposal of Radioactive Waste

The International Atomic Energy Agency's Human Intrusion in the Context of Disposal of Radioactive Waste (HIDRA) project is developing guidance to assist countries with decision-making approaches within a safety case using the results of potential inadvertent human intrusion analyses considered in post-closure safety assessments for radioactive waste disposal facilities. HIDRA differentiates between inadvertent intrusion into geological disposal facilities where radioactive waste is by its very nature isolated from the biosphere, and near-surface disposal facilities, where the potential for inadvertent human intrusion into the disposal facility can be higher given the proximity to human activities in the biosphere. In the first phase of HIDRA, a draft report was completed providing background information on international safety standards and guidance for a general approach to address inadvertent human intrusion. The guidance addressed exposure scenario development, consideration of protective measures to reduce the potential for and/or consequences of human intrusion, and consideration of societal factors including risk communication. The objective of Phase 2 of the HIDRA project is to test implementation of the methodology developed in Phase 1. As part of this effort, examples of human intrusion analyses from various member countries are summarized and important findings and risk insights documented.

M4-D.1 Barrett, AM; GCR Institute and ABS Consulting; *tony@gcrinstitute.org*

Towards Integrated, Comprehensive Assessment of Global Catastrophic Risks to Inform Risk Reduction

We argue that there could be great value in comprehensive, integrated assessment of global catastrophic risks (GCRs) and risk-reduction options. We also argue for using value-of-information considerations to guide decisions on where to focus research efforts as part of a GCR research agenda; the value of information derives from its ability to help decision makers to achieve better decision outcomes. We discuss key challenges, and tractable steps, for assessing all types of GCRs and risk-reduction options. For example, a risk reduction cost effectiveness based approach to assessing value of information simplifies some problems in GCR comparison, by avoiding the need for use of a value of statistical life (VSL), which may be inappropriate given the scale of GCRs. Similar approaches could be useful in other areas where VSLs would not be appropriate. Finally, we illustrate the basic concepts using example calculations of risks from several types of GCRs, and associated risk reduction measures.

W1-E.1 Barrett, AM; ABS Consulting and GCR Institute; *abarrett@absconsulting.com*

HAZOP Based Emerging-Technology Scenario Hazard Screening

New technologies can increase the effective capabilities of terrorists and other adversaries to cause harm. Detailed risk analysis of all imaginable technology-use scenarios would be infeasible, but not all scenarios merit in-depth assessment. We adapt Hazard and Operability, or HAZOP analyses as a tractable means of prioritizing scenarios for more in-depth analysis. In the HAZOP based approach, the types of effects that emerging technologies might generate that would be of interest to adversaries are established, then relevant technologies are identified and assessed according to the degree of hazard they pose. We provide illustrative examples.

M4-I.2 Bartrand, TB*; Carotenuto, AC; ESPRI Institute; *tbartrand@esprinstitute.org*

Non-consumptive Drinking Water Use and Microbial Risk – Do We Need a Safe Breathing Water Act?

Safe Drinking Water Act (SDWA) regulations of drinking water microbial quality were developed primarily to manage risks associated with fecal pathogens and oral exposure. Because those regulations have been so effective, environmental pathogens and non-oral exposure routes (particularly inhalation) have emerged as critical drinking water hazards and exposures. This review identifies exposure pathways associated with non-consumptive uses of treated drinking water and pathogens relevant to those pathways. A wide list of relevant pathogens (bacteria, protozoa, amoebae, viruses, helminths, fungi) and their relevant exposure routes are presented and bellwether pathogens for use in developing risk managing strategies are identified. Assessing risks associated with non-consumptive uses is difficult for many of the reasons microbial risk assessment is difficult in general – sporadic occurrence of pathogens, poor association of relevant pathogens with indicator organisms or physicochemical indicators of water quality, and the long list of pathogens that could contribute risk. Pathogens relevant to non-consumptive use may originate in a building water supply and be transmitted through the building water system to a point of exposure, or grow in the building water system and be delivered during a non-consumptive use. In the first scenario, risk is assessed based on water quality of the building water supply and mitigated through treatment of the supply and monitoring. Assessing the risk in the second scenario requires knowledge of water quality of the building supply, the building plumbing system and the operation of the building water system. Mitigation can be via supplemental treatment, operational responses, or system redesign/retrofit. Competing risks arising from disinfection byproduct (DBP) exposure and scalding must be considered during development of risk mitigation strategies.

P.35 Bates, ME*; Fox-Lent, C; Corr, J; Cialone, M; Knorr, P; US Army Corps of Engineers; *matthew.e.bates@usace.army.mil*

Developing a decision framework for outer continental shelf sand resource management

This poster presents a multi-criteria decision analysis framework for managing sand resources (e.g., shoals) in the US outer continental shelf. Sand is mined from these areas for beach nourishment, combatting erosion and providing recreational value and storm protection. Offshore sand resources are finite and once depleted or made unusable by poor management practices are not typically renewed on human time scales. Working through a participatory process with practitioners in various government agencies and in industry, the authors developed a decision framework for evaluating areas for proximal use based on a balance of physical features, project needs, ease of extraction and transport, and long-term site sustainability.

T3-C.1 Baucum, M*; Nguyen, K; University of Southern California; *baucum@usc.edu*

Quantifying the Accuracy of Subjective Probability Estimates: A Meta-Analysis

Accurate subjective probability estimates play an important role in many risk assessment contexts. Although there is a respectable amount of scholarly works on probability assessments, there has not been a quantitative synthesis of research findings on this literature. The current meta-analysis attempts to close this research gap by systematically reviewing studies on probability assessments. In particular, this research addresses whether subjective probability estimates are better than random guesses, and it explores the effects of various methodological and substantive moderators on the accuracy of subjective probability estimates (including the effects of assessment context, response mode, expertise, and demographic variables). A comprehensive search for empirical studies on probability assessments between January 1st 1950 and January 1st 2017 in 133 different databases returned 466 records. Two independent coders screened all of the records and determined that 84 out of 466 records meet the study's inclusion criteria. The following effect sizes were coded independently: the Brier score, Murphy's calibration index, Murphy's discrimination index, and Yates' bias (confidence) index. A total number of 10 different moderators were also coded from the primary studies. Preliminary data analyses suggest that the accuracy of subjective probability judgments was better than the accuracy of judgments made by chance alone, and that judgments made by experts are significantly more accurate than judgments made by non-experts. Still, there is substantial heterogeneity in the effect sizes, suggesting the role of other moderators beyond expertise. We discuss the roles of these moderator variables and implications for the practice of probabilistic forecasting.

W3-E.2 Baum, SD; Global Catastrophic Risk Institute; *seth@gcrinstitute.org*

Quantifying Long-Term Severity

In the study of global catastrophic risk, it is often assumed that global catastrophes have outsized long-term effects relative to smaller catastrophes and therefore warrant outsized policy attention. In the extreme case, a catastrophe resulting in human extinction allegedly has much larger long-term severity than a catastrophe killing "only" 99% of the world population. This presentation questions this assumption via analysis of the long-term severity of catastrophes large and small. For small catastrophes, including deaths of a single individual, long-term severity can be analyzed via counterfactual demography and population ecology, asking what line of descendants would have existed had the catastrophe not occurred. Larger catastrophes raise questions about the stability of modern civilization; this includes scenarios in which the catastrophe starts small and then cascades into something larger. Over longer time scales, issues of technological transformation, genetic evolution, and the structure of the astronomical vicinity factor in. While there may still be reason to pay outsized attention to the risk of global catastrophes, all catastrophes can have long-term effects worth accounting for. The long-term severity of catastrophes raises several policy issues, including the question of how to account for large but ambiguous potential consequences and the question of whether there exist any thresholds of event severity below which potential consequences need not be considered.

T3-F.3 Beecher, JA; Michigan State University; *beecher@msu.edu*

Institutional Failure as a Risk Factor

Political and policy institutions play a vital role environmental and public health protection, but the Flint water crisis revealed their fallibility and precarity. Water and sanitation services are essential and water is the only utility product that is physically ingested. In their everyday lives, people should be able to take the quality of their water for granted, at least in terms of meeting minimal standards as defined by federal law. They should also be able to take for granted that the institutions for ensuring water safety and quality of are functional and committed to compliance. While there is no established human right to drinking water in the U.S., there is a legal right to water that is compliant with all applicable federal and state regulations. Although the crisis is frequently cast as a failure of infrastructure or a failure of local governance, it is primarily a manifestation of institutional failure and a demonstration of serial and catastrophic regulatory failure. In many respects, all infrastructure failure or risk thereof reflects institutional failure. While the people of Flint may not have been deliberately harmed, they were placed at risk and serious questions remain about risk awareness in key decision processes. The direct technical causes and devastating human consequences of the crisis are well documented. In its wake, public trust was broken and the ramifications for society, governance, and justice beyond Flint are profound. Rebuilding trust will be arduous and success is unlikely unless institutional failure is recognized as a risk factor and effort is devoted to reestablishing institutional integrity, capacity, and efficacy. This paper will explore substantial risk imposed by key dimensions of institutional failure.

W2-C.3 Bentolhoda Jafary, BJ*; Lance Fiondella, LF; University of Massachusetts Dartmouth, MA, USA; *bjafary@umassd.edu*

Optimal Checkpointing of Fault Tolerant Systems subject to Correlated Failure

Checkpointing is a technique to backup work at periodic intervals so that if computation fails it will not be necessary to restart from the beginning but will instead be able to restart from the latest checkpoint. Performing checkpointing operations requires time. Therefore, it is necessary to consider the tradeoff between the time to perform checkpointing operations and the time saved when computation restarts at a checkpoint. This paper presents a method to model the impact of correlated failures on a system that performs checkpointing. We map the checkpointing process to a state space model and superimpose a correlated life distribution. Examples illustrate that the model identifies the optimal number of checkpoints despite the negative impact of correlation on system reliability.

P.137 Besley, JC*; McCright, AM; Zahry, NR; Elliott, NE; Martin, JD; Kaminski, NE; Michigan State University; *jbesley@msu.edu*
Testing Procedures to Mitigate Perceived Unfairness Perceptions Associated with Research-Related Conflicts of Interest
Two between-subject experiments explored the perceived fairness of a hypothetical public-private research partnership to study the health risks of transfats. Fairness was measured as researchers' willingness to listen to a range of voices and minimize bias. The practical value of the research is that it clarifies the challenges that investigators who take industry funding may face in having their research seen as legitimate. Conceptually, the research speaks to considering scientific research as decision-making processes that people may judge based on their perception of the use of fair research procedures. Analyses include mean comparisons and General Linear Model estimation. Experiment 1 (n = 1,263) assigned research subjects to a partnership that included a random combination of an industry partner, a university partner, and a non-governmental organization (NGO) partner, as well as one of three processes aimed at mitigating the potential for conflicts of interest (COI) to harm the quality of the research. The procedures included an arm's length process meant to keep the university-based research team from being influenced by the other partners; an independent advisory board to oversee the project; and a commitment to making all data and analyses openly available. The results suggest that having an industry partner has substantial negative effects on perceived research fairness and that the benefit of adding a single COI-mitigation process may be relatively small. Subjects in Experiment 2 (n = 1,076) assessed a partnership that included a university and either a NGO or industry partner, as well as a combination of the three COI-mitigation procedures used in Experiment 1. Subjects could therefore be assigned to assess a collaboration without any mention of a COI-mitigation process, one of the three processes, two of the three processes, or all three processes. The results suggest there may be little value in combining COI-mitigation procedures.

P.167 Bhatt, S; Schuck, JA*; National Academies of Sciences, Engineering, and Medicine; *jschuck@nas.edu*
National Academies decadal survey of social and behavioral sciences for national security
The National Academies of Sciences, Engineering, and Medicine is conducting a decadal survey of research opportunities in the social and behavioral sciences that can contribute to national security. Decadal surveys are used to assess and project research possibilities for the coming decade. A committee of experts has been appointed to carry out this work, which will address a broad range of areas, including assessment, characterization, and communication of risk. This poster will identify the members of the committee and their statement of work in carrying out the decadal survey. It will also identify how the scientific community and other allied professionals can provide input to the decadal survey. More information on the decadal survey is available at http://nas.edu/SBSDecadalSurvey.

P.59 Bhattacharya, S*; Nagaraju, V; Fiondella, L; Spero, E; Ghoshal, A; University of Massachusetts, Dartmouth; *sbhattacharya@umassd.edu*
Minimizing Average Procurement Unit Cost for Rotorcraft Tradespace Exploration
In recent years, Tradespace Exploration (TSE) has emerged as a systematic strategy to assess the effectiveness and suitability of various alternative conceptual designs. One of the primary advantages of TSE is that it provides an environment for detailed consideration for various tradeoffs, which can be used by various stakeholders before committing to any configuration. TSE has gained a significant momentum for developing and conceptualizing products capable of performing in a wide range of adverse conditions commonly encountered by military systems. Combined with technology, TSE provides a collaborative environment between various stakeholders for analysis of alternatives. However, much of the previous TSE research emphasized on tradeoffs between functional requirements, especially those about performance. Our past work proposed models for rotorcraft TSE to quantify the impact of non-functional requirements such as reliability and availability, survivability. U.S. Army research lab in collaboration with Georgia Tech. developed Capability Assessment and Tradeoff Environment (CATE) tool. The primary aim of this tool is to perform tradespace exploration for Future Vertical Lift and Joint Multi-Role Rotorcraft Technologies. At the heart of CATE is NASA's Design and Analysis of Rotorcraft (NDARC) software application, a conceptual-level tool to design a rotorcraft for specified missions under designated conditions, and then conduct performance analysis under nominal as well as in scenarios that exceed anticipated mission conditions. We seek to further analysis and develop more rigorous quantitative RAM models that can be integrated with the present CATE system and benefit rotorcraft TSE efforts. This paper presents a model for rotorcraft TSE to explicitly consider the relationship between subsystem reliability improvement and average procurement unit cost. Examples illustrate how the model allocates resources to improve subsystem reliability in a manner that minimizes APUC for any fleet size specified.

W2-J.2 Bidwell, D*; Dwyer, J; University of Rhode Island; *dbidwell@uri.edu*
Thinking critically about public participation in renewable energy decisions: Insights from the first U.S. offshore wind development
Following risk management and other environmental fields, scholars and practitioners of energy transitions have advocated for greater public participation in decisions about renewable energy technologies. These calls for greater participation, however, are frequently light on specifics. In this presentation, four critical issues regarding the problem scope, purpose of participation, degree of inclusivity, and allocation of decision authority are considered. First, despite a focus on project-specific processes, transitions may require planning or policy discussions at a broader scale. Second, the way the purpose of participation is characterized may have significant effects on the character of a process. Third, participation can be open to all concerned parties or targeted as specific interests. Finally, the distribution of decision-making authority may facilitate or impede transitions. More research is needed to better understand how these features of participation interact and influence the outcome of participatory decisions. The authors use the case of the Block Island Wind Farm, the first offshore wind energy project in the United States, to illustrate the importance of these four issues. This project involved two distinct phases of participation, an inclusive regional ocean planning process and a site-specific permitting process, in which the four issues were addressed quite differently.

M4-D.2 Bier, VM; University of Wisconsin-Madison;
bier@engr.wisc.edu

Barriers to Proactive Population Relocation in Preparation for Coastal Flooding

Coastal flooding due to climate change may affect more than 10 million people in the U.S., and well over 100 million worldwide, creating a need for mass relocation and/or migration away from at-risk areas. Arguably, it would be preferable to gradually reduce the population living in vulnerable areas before they experience severe flooding (to reduce loss of personal property, disruption, and the cost of emergency response), but there seem to be numerous barriers impeding that goal. First, there are at least two different types of collective-action problems: collective action between jurisdictions; and collective action between current and future residents. There are also competing factors that may make moving inland undesirable, including not only coastal amenities, but also the economic benefits of agglomeration. The long time horizons involved in preparing for coastal flooding make investment in preparedness almost inherently a government problem (due to its relatively low social discount rate), but the wide range of federal, state, and local agencies involved may make it difficult for government to act effectively. Finally, psychic numbing may limit public support for measures that do not reduce the at-risk population by at least an order of magnitude or more.

T4-G.2 Bjerga, T*; Aven, T; University of Stavanger;
torbjorn.bjerga@uis.no

Emerging empirical research on risk perception and risk behavior using the new uncertainty–based risk perspectives

An impressive and vast body of research literature on risk perception and behavioral decision-making exists. Much of the research presented in this literature is empirical findings of people's evaluation of, and behavior towards, risk, which have given important new insights to our societies. Many of these empirical studies are founded on traditional perspectives on risk linking risk to probabilities, and in particular "objective" frequentist probabilities. However, for many of the current risk perspectives, uncertainty has replaced probability. This does not reduce the importance of the empirical research that has been conducted, but it calls for further research and new research questions. In this talk, we will present and discuss some preliminary ideas on what questions to ask and how such research can be conducted. We will outline what type of results to be expected and what are the new insights that can be gained.

P.159 Binder, AR; North Carolina State University;
arbinder@ncsu.edu

The salience of environmental hazards: Making sense of citizen concerns and their implications for risk communication

For the public policy process to respond successfully to citizen concerns about environmental hazards, an understanding of how citizens think about these hazards is paramount. A straightforward approach to an assessment would be to list a number of environmental hazards and ask citizens which one is the most important problem in their opinion. Indeed, this is the approach represented by a perennial question in the General Social Survey of citizens in the United States. An alternative to this approach would be to ask the question in a more open-ended way, e.g., "Of all the environmental problems that you might be able to think of, which one is the most important?" This inquiry compares and contrasts the usefulness of these different approaches for informing environmental policy and risk communication. Using a nationally representative survey of U.S. citizens from 2013, I take a multi-methodological approach. From a qualitative perspective, I analyze the open-ended responses (which had no space constraints on survey respondents) to identify common hazards named by survey respondents. This analysis lends itself to developing a typology of environmental themes (broader than specific hazards). From a quantitative perspective, I then test whether or not the environmental themes that emerged from the qualitative analysis are significantly related to a variety of independent variables: values (political ideology, environmentalism, religiosity), social trust (trust in scientists and other public figures), news media consumption, and factual scientific knowledge, among others. Finally, a comparison is conducted between the origins of the open-ended survey responses and the closed-ended responses to see how the question format influences different people in different ways. Implications for policymaking and risk communication are discussed.

P.171 Bogen, KT; Exponent, Inc., Health Sciences;
kbogen@exponent.com

Biphasic low-dose patterns of inhibition-activation for three nuclear receptors linked to suppressed apoptosis, cell proliferation, and tumorigenesis: HSP70, Nrf2, and CAR

Evaluations of potential health risks associated with low-level environmental exposures often hinge pivotally on low-dose dose-response extrapolations and associated mechanistically informed expectations that typically cannot be verified experimentally. The multistage somatic mutation (MSM) theory of cancer underlies default regulatory assumptions that increased cancer risk—which often dominates other potential impacts—may occur from chronic, low-level exposures to genotoxic chemical carcinogens with a linear-no-threshold (LNT) dose-response. Recent observations challenge this assumption, and thus also challenge recent proposals to apply LNT risk extrapolation for non-cancer endpoints. Examples illustrated here are significantly biphasic (U-shaped) patterns of activation by three highly conserved ultrasensitive nuclear-receptor-type molecular switches: a heat shock protein (HSP70) involved in chaperoning misfolded proteins, the Nrf2 anti-oxidant response pathway, and the human constitutive androstane receptor (hCAR). Via weighted nonlinear model regression implemented using Mathematica software, biphasic in vitro activation patterns are shown to occur for HSP70 in murine embryo fibroblast NIH-3T3 cells (using data presented by Beckham et al., Photochem Photobiol 2004; 79(1):76–85), for seven Nrf2 agonists in human liver HepG2 cells (using data obtained by Shukla et al., Environ Health Perspect 2012; 120(8):1150–6), and for two rodent-liver-tumor promoting aminoazo hCAR agonists (4-aminoazobenzene and ortho-aminoazotoluene) also in HepG2 cells (using hCAR activation data archived in 2017 by the National Center for Biotechnology Information). Each such low-dose pattern of inhibition/activation is shown to incorporate a highly significant negative initial linear slope and an overall U-shaped response. These observations highlight sources of fundamental uncertainty in dose-response extrapolation that complicate health risk assessment and management for environmental chemicals that induce toxic endpoints mediated by these important nuclear receptors.

M4-J.7 Bornstein, K*; Williams, A; Hobbie, K; Cawley, M; Feiler, T; Henning, C; Turley, A; ICF; *audrey.turley@icf.com*

DRAGON ONLINE: Tool for Systematic Literature Review

ICF's DRAGON ONLINE enables scientists and researchers to work collaboratively on literature screening, data extraction, and study quality evaluations for systematic literature reviews. Documenting data and decisions supporting the review is critical to a systematic approach, increases transparency, and preserves institutional knowledge. What strengthens evidence-based scientific conclusions? More evidence? Higher quality evidence? Evidence from more than one data stream or study type? The answer varies based on the decision context (e.g., regulatory, scoping) and the decision framework (e.g., risk assessment paradigm, meta-analysis), but having well-organized, well-annotated data facilitates evaluation and development of conclusions. DRAGON ONLINE enables the organization, evaluation, and annotation of scientific data to support assessments. By standardizing the data elements evaluated across scientific studies, we can reach conclusions more readily because understanding data across studies and even evidence streams is easier. DRAGON ONLINE supports – Literature categorization based on user-defined key words – Data extraction from a variety of scientific studies – Study quality evaluation – Data visualization – Overall assessment management

W3-F.4 Bostrom, A*; Ahn, A; Vidale, J; Abramson, D; University of Washington; *abostrom@uw.edu*

Earthquake risk experiences, expectations, early warnings, planning, and preparedness in Washington State

Earthquake early warning is rapidly being developed for the US West Coast. Here we present the results of new survey research on risk perceptions, preparedness and interest in making tradeoffs between risk mitigation activities for seismic risk in King County. Survey data include state and King County samples.

T2-H.4 Boué, G*; Cummins, E; Guillou, S; Antignac, JP; Le Bizec, B; Membré, JM; Oniris / INRA; *geraldine.boue@oniris-nantes.fr*

Methodological lessons learnt from developing a risk-benefit assessment applied to infant milk-based diet

The objective of this study was to develop a conceptual and methodological framework to assess quantitatively the overall impact of food on human health, including microbiological, chemical and nutritional dimensions. This methodology was developed using a case study related to infant milk-based diet (breast milk and infant formulas) taking into account the following selected factors: Cronobacter sakazakii, Cryptosporidium, arsenic, dioxin-like polychlorinated biphenyls and docosahexaenoic acid. Five probabilistic mathematical models were developed to quantify risks / benefits associated with these factors. In this communication main outputs obtained on the case-study will be presented as well as lessons learnt in terms of "Risk-Benefit Assessment" methodology. Probabilistic techniques enabled the consideration of the variability (heterogeneity between individuals of the same population) and the uncertainty linked to the lack of knowledge and data. Separation of variability and uncertainty, using second-order Monte Carlo simulation, strengthened the evaluation by enabling a more accurate interpretation of results and by providing more comprehensive information to policy makers. The DALY metric was used in this study to compare the health effects originated from different factors. Although very attractive in integrating the whole complex RBA issue within a simple figure, this metric might not be an intuitive metric to communicate results to stakeholders (too integrative to be understood). Finally, a multi-criteria table was built to incorporate in a transparent and comprehensive manner the various outputs of the risk-benefit assessment (e.g. DALY, number of case, individual probability of illness, etc.), a promising technique to facilitate decision-making. The methodological framework developed in the present study can be considered as a robust basis for risk-benefit assessment in foods and results obtained will enable to progress on the evaluation of infant milk-based diet.

T2-D.1 Bouder, F*; Strijbosch, K; Maastricht University; *f.bouder@maastrichtuniversity.nl*

The vaccines we want : perception and expectations of Syrian refugees in the Netherlands

Globalization as well as international conflicts and poverty are giving rise to migrants from places such as Syria, Eritrea, Afghanistan and Iraq. New immigrants and refugees could be particularly susceptible to vaccine preventable diseases because they may be lacking adequate immunization and may be more vulnerable to disease. This can be a result of their journey, the lack of knowledge or ignorance of their vaccination status. Furthermore they might be afraid to disclose any personal information to what is perceived as 'authority'. Risk communication plays an important role in developing a two-way communication process for improving awareness of immunization and vaccine preventable diseases, and in helping people to assess the risks and benefits of both the vaccine and disease. The goals of this innovative pilot study that was conducted in the Maastricht area (The Netherlands) were twofold. First, to determine the requirements for targeted risk communication for immigrant populations, and, second, to promote informed decision-making. The paper presents an analysis of (1) the knowledge level and perceptions of immigrant populations on infectious disease immunity and vaccines; (2) the reasons behind immunization decisions made by immigrant populations for themselves and their families; (3) the effect of different cultural perspectives on immunization decisions; and (4) the relevance of this information to develop innovative and directed risk communication strategies that promote informed decision making. Data was collected from two main sources: via face-to-face interviews of professionals working at institutions in charge of public health and refugees; and via Syrian parents or caretakers with young children (under five years old) who arrived after the start of the Syrian civil war in 2011. This project is part of an international collaboration with researchers in Canada, New Zealand, Australia, the Netherlands, the United States and Germany (The Monarch Collaboration).

T4-K.1 Bourne, K; Curtis, A; Borsuk, ME*; Chen, CY; Duke University; *mark.borsuk@duke.edu*

Characterizing co-contamination in marine and freshwater fish and shellfish using generalized joint attribute modeling

To protect human health from contaminant exposure, fish consumption advisories have been established throughout the US for freshwater and coastal ecosystems. Although advisories are contaminant-specific, the reality is that, through fish consumption, humans are exposed to multiple contaminants simultaneously. The co-occurrence of contaminants in fish tissue has not been systematically examined. This is largely due to the "silos" in which contaminant research is often conducted. Yet, to understand the totality of exposure from fish consumption and begin to evaluate the risk of exposure to multiple contaminants, it is critical to investigate the patterns of co-occurring contaminants in fish from a range of ecosystems. In this study, we utilize the wealth of available fish tissue data to quantitatively characterize the patterns of contaminant co-occurrence using a new approach called generalized joint attribute modeling (GJAM). GJAM allows for analysis of multivariate data that can include combinations of presence-absence, ordinal, continuous, discrete, zero-inflated, and censored values. Importantly, GJAM does this by representing the joint distribution of response variables. GJAM also provides estimates of the effect of covariates on the individual response variables and their correlations, thus allowing for inference on the processes that drive co-occurrence of contaminants in the fish and shellfish that humans consume.

T3-H.2 Bouwknegt, M*; van 't Hooft, BJ; Koppen, K; Rietveld, H; Straatsma, G; Heres, L; Vion, Boxtel, the Netherlands; Stegeman, Deventer, the Netherlands; Dutch Meat Products Association, Zoetermeer, the Netherlands; Zwanenberg, Almelo, the Netherlands; Sonac, Son, the Netherlands; *martijn.bouwknegt@vionfood.com*

Ordinal QMRA to prioritize pork products that may contribute to foodborne hepatitis E virus transmission

Hepatitis E virus (HEV) is an opportunistic zoonotic virus that can cause liver inflammation especially in transplant recipients, immunocompromised people and those with underlying disease. The majority of exposed individuals develop no clinical symptoms. Reported case numbers rose in several European countries recently. Domestic pigs, wild boar and deer are local reservoirs for HEV and suspected transmission routes to humans include environmental, direct contact and foodborne transmission. We, as meat industry, therefore initiated a prioritization of food groups for the contribution to foodborne HEV transmission, to develop intervention measures when needed. Seven food groups were considered: fresh meat, porcine liver (whole), liver sausage, raw meat products, cooked meat products, fermented products and blood sausage. A quantitative microbiological risk assessment model was developed to compare exposure doses among food groups. As data scarcity made characterization of parameter distributions and the generation of absolute risk estimates impossible, parameters were quantified as ordinal, order-of-magnitude levels, analogous to a multi-criteria decision analysis approach. Preliminary results showed that of the two sources of HEV-introduction in meat, i.e. blood and liver, the contribution of blood was negligible. The model is now being completed for the remaining parameters and the full prioritization will be completed in the summer of 2017. The results will be presented to the members of the Dutch Meat Products Association, comprising the major companies in meat production, in September. The effectivity of feasible intervention measures will be estimated with the model and proposed to the industry. Furthermore, results will be compared to other ongoing studies to estimate which part of all human cases can be attributed to meat in comparison to other possible transmission routes and other food products.

P.139 Boyd, A*; Mayeda, A; Paveglio, T; Flint, C; Washington State University; *amanda.boyd@wsu.edu*

Media Representations of Water Issues as Health Risks

Water is a natural resource that is critical to sustaining human life. Media representations may impact public risk perceptions and inform water conservation or health promotion behaviors. The objective of this research is to identify how the media frames public health risks associated with water resource issues. A content analysis of newspaper articles focusing on water resource issues was conducted for a three-year timeframe from January 2012 to December 2014. Articles were gathered from eight newspapers in four Western U.S. states using the search term 'water' and subsequently reduced to a set of articles with any mention of human health. Articles were coded to determine what health related issues were discussed and the environmental issues they were connected with (e.g., drought, climate change, contamination). The search initially returned 3,338 articles with a major focus on water issues. Approximately 10% of these articles contained any mention of a health-related issue. The three major health themes present in water-related newspaper coverage were: (1) risks from water contamination, (2) general health risks, and (3) illness or disease. The results indicate that while health risks are seldom mentioned, the risks most frequently discussed in relation to water resources are those with direct and immediate impacts. These findings suggest the issues being reported in the media may not be consistent with the nature of health impacts associated with water resource issues, which are most often long-term and indirect.

W4-D.3 Braley, GS; Colorado State University; *bralex@colostate.edu*

Radiation Risk in Evacuation and Reoccupation Decision Making

Abstract: Planners and emergency managers can turn to a large body of national and international guidance on evacuation, dose projection, and cleanup in order to prepare for a radiological or nuclear disaster. Relatively little guidance, however, addresses the net risk of evacuation, and little to no guidance exists integrating the risks of long-term displacement with the residual hazards of low-level radiological contamination. Examples of evacuation risks include increases in traffic fatalities and loss of life expectancy in nursing home and elderly communities, as well as hospital in-patients. Long-term displacement has been shown to increase negative health outcomes like depression and suicide, obesity and diabetes, along with economic harm at the individual and community level. Radiation has discernible and well-documented health effects at dose levels greater than 100 milli-Grays over a short time frame, and a wide array of policy guidance is in place to limit exposures to the general public. In the United States, the Environmental Protection Agency suggests that "[e]xposure limits in a range of one in a population of ten thousand (10-4) to one in a population of one million (10-6) excess lifetime cancer incidence outcomes are generally considered protective." Internationally, 20 milli-Sieverts per annum is a common "reference dose," utilized by policymakers as an evacuation threshold. The author examines some of the assumptions underlying risk and dose calculations in evacuation decision making, along with recent research on the risks of long-term evacuation, with the objective of improving emergency response policy.

T4-D.2 Brame, JA; Alberts, E; Poda, AR; Kennedy, AJ*; US Army Engineer Research and Development Center; *Jonathon.A.Brame@usace.army.mil*

Quantifying release from nano and advanced material enabled products

The same unique properties of Manufactured Nanomaterials (MNs) and Advanced Materials (AMs) that make them desirable for new product applications may also increase their environmental health and safety (EHS) uncertainty, leading to high risk prioritization under the reformed Toxic Substances Control Act (Frank Lautenberg Chemical Safety for the 21st Century Act), and potential delays in production. EHS testing and risk assessment of MNs—and more recently AMs—now necessarily includes understanding the fate and transport of these materials in complex matrices as well as additional knowledge about how the product is used and the release of MNs/AMs from the product during use, including any transformations that occur during those releases. However, these release testing processes constitute one of the least studied sources of EHS risk for MN/AM-enabled products, and therefore contribute significantly to EHS uncertainty. Abrasion testing is an aggressive form of release testing (that can be performed in combination with other environmental challenges, such as weathering) to identify potential release and entry of MNs/AMs into the environment, where they can interact with human and ecological receptors. In this presentation, we use a modified Taber abrader system to test release of MNs from several case studies, including an anticorrosive paint containing CNTs, a self-cleaning cement containing TiO2, a nitrocellulose material, and several reference materials. Results show the capability of the analytical methods for assessing and characterizing released materials, and provide relevant examples of how to use this type of testing to make risk-informed decisions. Additionally, we will present a novel calibration method to establish a "limit of detection" for identification of released NMs. This analysis is the first of its kind, and starts to resolve some of the uncertainty inherent in risk assessment and EHS impacts of MNs/AMs, particularly in providing some level of confidence in cases where no material is released (i.e., trying to prove a negative).

T3-I.3 Brandon, NV*; Price, PS; Dionisio, KL; Isaacs, KK; US Environmental Protection Agency; *brandon.namdi@epa.gov*

Predicting Exposure to Consumer-Products Using Agent-Based Models Embedded with Needs-Based Artificial Intelligence and Empirically -Based Scheduling Models

Information on human behavior and consumer product use is important for characterizing exposures to chemicals in consumer products and in indoor environments. Traditionally, exposure-assessors have relied on time-use surveys to obtain information on exposure-related behavior. In lieu of using surveys, we create both an agent-based model (ABM) that simulates longitudinal patterns in human behavior and a scheduling model (SM) that simulates longitudinal patterns in consumer product use. By basing our ABM upon a needs-based artificial intelligence (AI) system, we create autonomous agents that mimic human decisions on residential exposure-relevant behaviors. The model predicts behavior patterns for the following actions: sleeping, eating, commuting, and working/schooling. The SM uses these behavior patterns in scheduling the use of 300+ types of consumer products during periods of idle time (i.e. when the agent is not doing the aforementioned behaviors). The ABM uses 4 different types of agents representing the following U.S. demographic groups: working and non-working adults, school-age and pre-school children. The parameters for the ABM are calibrated using survey data from the Consolidated Human Activity Database (CHAD). The SM's predictions of daily product use are based on both seasonality of product use and also estimates of prevalence, frequency, and duration of product use derived from publicly available data on consumer habits and practices. The combined ABM/SM approach produces product use histories for individuals in the general US population that are consistent with longitudinal predictions of human behavior, reflect demographic information, and are consistent with the day of the week and season of the year. We propose that by simulating both human behavior and product use, this ABM/SM approach may allow exposure-assessors to characterize exposures from use of consumer products quicker and in ways not possible with traditional survey methods.

W2-A.3 Brand, KP*; Lin, Z; University of Ottawa; *kbrand@uottawa.ca*

Population Health Impact Estimates: Unplugged

A variety of yardsticks are available for measuring the health of populations. These in turn form the basis for quantifying health impacts, as in Environmental Burden of Disease (EBD) enterprises. Two broad classes of yardstick prevail including Health expectancy (HE) measures (e.g., Health Adjusted Life Expectancy) and Health Gap (HG) measures (e.g., Disability Adjusted life Expectancy). Whereas HE measures can be conceptualized as focusing on the proverbial `glass half full' (counting how much a health a population enjoys), their HG counterparts focus on the `glass half empty' (counting up how a population's health state falls short of a specified norm). The algorithms for computing these measures can be quite onerous and data-intensive. The barriers to entry may on occasion discourage public health decision makers from capitalizing on such "bottom line" yardsticks, but perhaps more importantly may occlude (through their complexity) knowledge translation efforts. Ongoing work demonstrates that health impacts expressed in either class (HE or HG) of measure can be approximated by a reduced set of inputs (e.g., the status-quo incidence-rate of the event being perturbed by the risk factor of interest). The key inputs are intuitive. Moreover they combine together intuitively taking on the form: impact=likelihood x consequence (echoing a definition of risk). The heuristics for computing HG and HE measures are demonstrated (using data from the Human Mortality Database; http://www.mortality.org). Attention in this work is restricted to the case where Mortality dominates morbidity. The promise of the heuristics for enabling/extending knowledge translation efforts is highlighted.

M2-G.2 Bratasz, LB*; White, TW; Sease, CS; Uthrup, NU; Butts, SB; Boardmann, RB; Simon, SS; Yale University; *lukasz.bratasz@yale.edu*

Evaluation of environmental risks and environmental costs at Yale Peabody Museum of Natural History

Yale's Peabody Museum of Natural History (YPM) has a long tradition of improving the environmental conditions for preserving its collection of more than 13 million objects. However, results are unexpected and far from what the museum hoped for as was shown by an analysis of the current environmental conditions in three museum buildings, built in 1925, 1963 and 2001. Analysis of energy use for climate control showed that the Environmental Studies Center, the most modern Peabody Museum building, is the least energy efficient of the three and one of the least energy efficient building at Yale University. Therefore, YPM decided to reevaluate its current climate control strategy towards a more practical and responsible approach, which takes into account the historic character of the buildings and the high cost of climate control. The assessment of climate related risks to collections was the main element in the transformation process towards a new strategy of climate control. It allowed preservation priorities of the YPM collections to be identified. Finally, guiding principles of climate control were proposed that meet the preservation targets of the museum's vast collections and at the same time reduce energy consumption and lower CO2 emissions.

M3-I.4 Brody, JG*; Boronow, KE; Susmann, H; Ohayon, JL; Morello-Forsch, RA; Brown, P; Rudel, RA; Silent Spring Institute (Brody, Boronow, Susmann, Ohayon, Rudel), Northeastern University (P Brown), University of California, Berkeley (Morello-Frosch); *brody@silentspring.org*

Pollution gets personal: Reporting personal exposure to environmental chemicals when health implications are uncertain.

Ethical norms in medicine and research increasingly call for right-to-know as the default for sharing test results with individuals. In environmental health studies, sharing results often has particular benefits, because it enables people to take action to reduce exposures, based on their personal risk values. However, studies often involve chemicals – for example, many endocrine disrupting compounds – for which the health effects are uncertain. The Personal Exposure Report-Back Ethics (PERE) Study, supported by the National Institutes of Health and National Science Foundation, interviewed participants, researchers, and IRB members in nine environmental health studies to learn about experiences and effective practices for returning results for chemicals that lack health guidelines. Results to date show that participants want to receive their results. They learn from reports about basic principles of environmental health as well as noting key findings from their own samples. Researchers found the process challenging, because interpreting results requires greater contextual understanding compared to medical results that have clear thresholds for safe or typical levels. To make environmental chemical reports more efficient and effective, we developed DERBI, the digital exposure report-back interface, as a framework for providing curated contextual information and using digital tools to personalize results reports in studies of any size. Reports can be disseminated on paper or online. In an experiment using DERBI in the Child Health and Development Studies cohort, participants spent twice as much time on personalized reports as they did on reports limited to aggregated data. To be effective, reports need to develop participants' environmental health literacy, and personal data can engage participants in the learning process.

W2-G.3 Bronfman, NC; Cisternas, PC*; Gonzalez, D; Universidad Andres Bello and National Research Center for Integrated Natural Disaster Management; *pamecisternaso@gmail.com*

Quantitative Risk Analysis in a Multirisk Scenario of Natural Hazards

The frequency and magnitude of hydrometeorological events worldwide has been increasing. According to the Global Climate Risk Index for 2017, Chile ranks 10th in the list of the most affected countries by climate change. In addition, Chile's location in the Pacific Ring of Fire derives in a high seismic activity. In the past 60 years, 33 earthquakes of magnitude over 7.0 in the Richter scale have occurred, seven of which have generated tsunamis. The main goal of this work is to develop a quantitative risk analysis of natural events under a multi-risk scenario to support public decision-making about land-use planning and preparedness measures to strengthen the resilience of the potentially affected communities. The coastal city of Chañaral in northern Chile was selected as case of study due to the massive landslide by rainfall event in March 2015 and its exposure to seismic activity. For the multi-hazard scenario, earthquakes, tsunamis and landslides by heavy rainfall were assessed. The results showed that a large part of the population lives at the landslides flow and near the coast. This means that those inhabitants have the highest level of total risk. Although landslides have caused more deaths in the study area in recent years, individual risk is higher for tsunamis than for landslides. The foregoing highlights the relevance of considering multi-risks scenarios in the design of preparedness and mitigation strategies. These results also provide valuable information for the development of acceptability and tolerability criteria for natural hazards.

W4-A.1 Broughel, J; Mercatus Center at George Mason University and Antonin Scalia Law School; *jbroughel@mercatus.gmu.edu*

Individual and Social Discount Rates in Policy Analysis

Economists discount future benefit and cost flows for a variety of reasons, including time preference, diminishing marginal utility of consumption, opportunity cost of capital, and risk aversion. This paper argues that discounting approaches grounded in individual discounting behavior, such as time preference or diminishing marginal utility, are problematic when forming the basis for a social discount rate (SDR) used in benefit-cost analysis (BCA). A more useful discounting framework is one that is guided by the time value of money, where discounting is used as a way to compare potential investments to their most likely alternative investment. Such an approach ensures that the alternative that maximizes net benefits can be identified, and it avoids many of the thorny aggregation and ethics controversies that arise in discounting approaches grounded in individual behavior. An SDR of about 7 percent appears to be reasonable given recent data, which is consistent with current guidelines from the Office of Management and Budget. However, a modified shadow price of capital approach is also available for those analysts that wish to be guided by the time value of money whilst avoiding discounting altogether.

M4-D.3 Brown, JT; Congressional Research Service; *brown.jaredt@gmail.com*

Evaluating the Preparedness of the U.S. Emergency Management System for Managing Global Catastrophic Risk

Within the United States, there is a relatively robust emergency management system that manages the risk of "typical" natural and manmade disasters. To evaluate the nation's preparedness for global catastrophes, the first step is to begin with an assessment of whether the existing emergency management system can manage more extreme global catastrophic risk. This presentation frames an assessment of whether the nation can "scale up" its emergency management system through the lens of three typical emergency management categories: authorities, capabilities, and capacities. The assessment suggests that with some revision, broad emergency management authorities, especially the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act, P.L. 100-707, et seq.), the National Emergencies Act (NEA, P.L. 94-412, et seq.), and the Defense Production Act (DPA, P.L. 81–774, et seq.), may be sufficient to address a more extreme subset of global catastrophic risk. However, the current system lacks both key capabilities and the enormous capacities necessary to manage global catastrophic risk. The presentation concludes with suggested priorities for improving the existing system to scale up its ability to manage global catastrophic risk. DISCLAIMER: The views expressed are those of the presenter only and are not presented as those of the Congressional Research Service or the Library of Congress.

P.53 Brown, L*; Reichle, L; Klein, R; Ginsberg, G; Abt Associates, Inc.; Partnership for Pediatric and Environmental Health; *lauren_brown@abtassoc.com*

Evaluating the Association between Alterations in Maternal Thyroid Hormones and Adverse Neurodevelopmental Outcomes

In utero exposures to endocrine disrupting chemicals can impact a range of health outcomes for the offspring. Specifically, when considering potential disruptions to proper maternal thyroid functioning due to chemical exposures there is increasing concern that adverse neurodevelopmental outcomes may be seen in the offspring. This is especially true early in pregnancy, before the fetus has its own functioning thyroid. Results of a comprehensive literature review on the associations between maternal thyroid hormone levels and offspring neurodevelopmental outcomes will be presented. Specifically, we found that altered free thyroxine (fT4) in early pregnancy has the most evidence regarding the relationship between potentially altered thyroid hormone homeostasis in pregnancy and adverse neurodevelopmental outcomes. We will present multiple approaches to utilize data from the identified literature to evaluate the magnitude of potential impact from altered maternal fT4 levels on offspring neurodevelopment. These approaches consist of both evaluating dose-response relationships between maternal fT4 and offspring neurodevelopmental and examining how shifts in distributions of thyroid hormone levels may place additional proportions of a population at risk for adverse neurodevelopmental outcomes. The presented methods can be used to assess the potential neurodevelopmental impacts on the fetus of a pregnant mother exposed to a chemical that may potentially alter homeostatic thyroid functioning (e.g., PCBs, perchlorate, PBDEs, PFAs, BPA)

T4-A.4 Cabrera, C*; Cifuentes, LA; Pontificia Universidad CatÃ³lica de Chile; *lac@ing.puc.cl*

EPR for plastics packaging: does it make sense to distinguish among plastics types?

The production, use and disposal of products impacts the environment. An attractive alternative to reduce them is to reuse or recycle the products and materials, in line with SDG 12, Responsible production and consumption. Extended Producer Responsibility (EPR) is a strategy that makes the producers responsible for the entire life-cycle of the product, especially for the take-back, recycling and disposal. Producers are responsible for recycling a given percentage of the products/materials they put in the market. Usually the recycling targets for each class of product/material are defined based on the status of each one. Those products that are recycled in greater proportion receive higher goals that those with a smaller fraction, or that are no recycled at all. This kind of allocation produces a gradual increase in recycling, indirectly considering the costs (collection, treatment and material recovery), but does not consider the environmental impacts produced throughout the life cycle of the products. In this work we study the recycling of plastic packaging, one of the products prioritized in the EPR implementation in Chile. Two situations are compared: one in which plastic is considered as a single material, independent of its type, subjected to a global recycling target; and another in which different types of plastic are considered separately, and assigned an individual recycling target. Net environmental impacts avoided in each alternative are compared, considering global impacts (GHG emissions) and local impacts (use of landfill space and emissions of local pollutants) during the life cycle of the product. The results show that considering different types of plastics as different materials can reduce overall impacts to a significant extent, and has a greater effect on reducing the use of material in products through eco-design. Although the results are specific for plastics packaging, they underscore the importance of not aggregating products with different characteristics.

M2-F.1 Bruss, B.C; Nateghi, R*; Zaitchik, B; Purdue University; *rnateghi@purdue.edu*

Why the well runs dry: Assessing global trends in groundwater stress

Groundwater is a key element of global access to water resources; and has important implications for political stability, economic growth and public health in every society. Rapid population growth, and accelerated rates of urbanization in recent decades have led to groundwater stress in many parts of the world. Identifying the national-scale drivers of groundwater storage trends is the key first step for understanding water availability and devising sustainable water management policy in a changing climate. In this research, we conducted extensive data mining and predictive analytics to identify the key predictors of the observed groundwater storage trends using agricultural, climate, demographic, land-use and economic variables in 81 countries across the globe.

W4-E.1 Cains, MG*; Henshel, DS; Landis, WG; Indiana University; *mgcains@indiana.edu*

Evaluation of Risk Models for the Holistic Integration of Social Science Metrics into Watershed-Scale Risk Assessment

Risk assessment in its traditional implementation is the simplification of a complex problem in order to better understand and predict from the basic cause and effect relationships of a system. This approach allows risk assessors to distill a complex issue into a manageable equation that produces quantitative, semi-quantitative, or qualitative answers. Defining characteristics (i.e. emergent properties) of complex systems are not easily distilled down to the component level (e.g. target organisms, stressors); rather, the most critical and defining risk characteristics emerge from the organization and interaction of components in the system. Many large scale risk assessments are limited by the focus on only a single risk domain within the interacting, complex system. This research emphasizes the inclusion of multiple influencing factors within a specific landscape of interest, not just singular and/or siloed risk assessments for ecology, human health, social studies, economic development, or policy impact. Such an endeavor requires the incorporation of all key aspects and risk domains (e.g. human health) of the landscape, combined with metrics reflecting the human infrastructure in order to understand the interactive relationships and effects of processes and stressors within the complex system. One of the challenges of integrating multiple domains and interactive relationships is the need to reconcile dissimilar assessment metrics and measurement metrics. This challenge is further amplified by differing scales of spatial, temporal, and biological units of organization for each domain. We discuss risk modeling challenges posed by the integration of societal and policy related assessment and measurement metrics. A suite of progressively integrative models (e.g. Total Environment, One Health Frameworks) are evaluated for their ability to holistically integrate social science metrics with human health and ecological metrics into a holistic and quantitative risk model.

W3-I.2 Cakmak, S*; Hebbern, C; Cakmak, JD; Dales, ED; Government of Canada; *sabit.cakmak@canada.ca*

The influence of polycyclic aromatic hydrocarbons on lung function in a representative sample of the Canadian Population

We investigated the associations between exposure to polycyclic aromatic hydrocarbons (PAHs) and selected respiratory physiologic measures in cycles 2 and 3 of the Canadian Health Measures Survey, a nationally representative population sample. Using generalised linear mixed models, we tested the association between selected PAH metabolites and 1-second forced expiratory volume (FEV1), forced vital capacity (FVC), and the ratio between the two (FEV1/FVC) in 3,531 people from 6 to 79 years of age. An interquartile change in urinary PAH metabolite was associated with significant decrements in FEV1 and FVC for eight PAHs, 2-hydroxynapthalene, 1-, and 2-hydroxyphenanthrene, 2-, 3-, and 9-hydroxyfluorene and 3- and 4-hydroxyphenanthrene. Exposure to PAH may negatively affect lung function in the Canadian population.

P.15 Calazans, B; Pessoa, RWS; Coutinho, IBS*; Oliveira-Esquerre, KPR; Kiperstok, A; Federal University of Bahia - UFBA; *asaicaro@gmail.com*

Reliability as a method for risk assessment in hemovigilance

The Brazilian hemotherapy service has approximately 2000 institutions. The National Health Surveillance Agency (ANVISA) has developed a semi-quantitative method called Potential Risk Assessment Method in Hemotherapy Service (MARPSH) to evaluate the hemotherapy services through control items defined by the legislation. However, these items often lack support from scientific evidence, so, they are defined by experts. Furthermore, their compliance is binary evaluated, despite the continuous empirical nature of the problem. Thus we propose a method of evaluating the reliability of the hemotherapy entities on the actual potential risk evaluation based on a more flexible metrics within reliability theory. Failure mode is connected with prevention barrier. An escalation factor is here proposed for each barrier as a function of the degree of conformity to the ideal state. The failure rate is defined a priori by expert opinion and may have its value continuously updated through objective evidence. Finally, the institution result for the evaluation is ranked among the levels of potential risk already practiced by ANVISA. Through the MARPSH simulations and the reliability method, the analysis of the methods indicated that using reliability does not negate current practices, but rather allows optimizations in the sensitivity of the evaluations. The absence of a cause-effect structure of the failures obtained by using MARSPH underestimates the importance level of some items or its whole set. The practice of continuous assessment based on data allows the reliability analysis to be optimized and sensitized. Among the benefits of this metric are an opportunity to incorporate to it blood bank risk assessment, failure propagation and possibility of updating the risk due to the improvements incorporated in the process.

M2-I.5 Camacho-Ramos, I; U.S. Environmental Protection Agency; *camacho.iris@epa.gov*

Challenges in Implementing Systematic Review in TSCA Risk Evaluations

The amended Toxic Substances Control Act (TSCA) requires EPA to develop fit-for-purpose risk evaluations to determine whether a chemical substance presents an unreasonable risk of injury to health or the environment. The risk evaluation must integrate and assess available information on hazards and exposures for the conditions of use of the chemical substance, including information that is relevant to specific risks of injury to health or the environment, and information on potentially exposed or susceptible subpopulations. To meet these requirements, EPA is implementing systematic review across various multi-disciplinary lines of evidence supporting the risk evaluation (i.e., exposure, fate, ecological hazard, and human health hazard). This presentation discusses the challenges of conducting systematic review within the TSCA regulatory framework and explores opportunities geared towards establishing a sustainable systematic review environment under TSCA.

W4-F.3 Camp, JS*; Hoover, PA; Vanderbilt University; *janey.camp@vanderbilt.edu*

Building Resilience into the Water Treatment Process Under a Changing Climate

As climate change evolves, many areas are experiencing more intense, short duration rainfall events and extended periods of drought. While much focus has been placed on the changing availability of water resources for agriculture and other uses, little consideration has been given to the changing quality of these water sources under these conditions and the implications for water treatment for human consumption. Dosing of chemicals such as alum and others to ensure high-quality, safe drinking water is likely to change as water availability and quality changes occur under current and future climate trends. We propose that as shifts in climate occur, so will the demands for certain chemical additives to meet public water quality standards and/or expectations. Emperical data on intake water and treatment for 10 years is compared with historical weather data to discern the extent to which these shifts are occurring already in the Middle Tennessee region and preliminary results will be presented along with a forward look at what the future may hold based upon downscaled climate projections for the mid-century.

W4-B.2 Campbell-Arvai, VEA*; Hart, PS; Raimi, KT; Wolsje, KS; University of Michigan; *vcarvai@umich.edu*

Does learning about carbon dioxide removal (CDR) strategies alter support for climate mitigation? The role of tradeoffs, trust in technology, and beliefs about tampering with nature

Many believe that carbon dioxide removal (CDR) strategies provide our best chance at meeting the temperature and greenhouse gas emission targets set out in the Paris Agreement. Others caution, however, that a reliance on 'carbon negative' technologies and processes may only serve to dampen concern about climate change and lessen motivation to engage in actions that can reduce or eliminate anthropogenic carbon emissions. Our previous research provides some evidence for this risk compensatory effect. In that study we found that learning about certain carbon dioxide removal strategies indirectly reduces support for mitigation policies by reducing the perceived threat of climate change. This was true for participants who read about CDR in general, bioenergy with carbon capture and storage, or direct air capture; this pattern was more pronounced among political conservatives than liberals, although in some cases was partially offset by positive direct effects. Learning about reforestation had no indirect effects on mitigation support through perceived threat, although this form of CDR was found to directly increase support among conservatives. We build on this research by presenting study participants with a more detailed accounting of the tradeoffs associated with each of these CDR technologies and approaches (in the form of a simulated news story). As past research suggests that support for carbon dioxide reduction strategies may be strongest among those who prefer technological solutions over lifestyle changes, and may be weakest among those who express concern about human interference with nature and natural processes, these items (trust in technology and tampering with nature) are included in our study as potential moderators of the relationship between learning about CDR, climate risk perceptions, and mitigation policy support. Implications for climate change communications and the development of policies to address climate change are discussed.

W3-C.3 Cegan, JC; US Army Corps of Engineers; *jeffrey.c.cegan@usace.army.mil*

Geospatial Decision Analysis for Military Base Camp Siting

The US Army is in need of the ability to rapidly plan and site base camps in order to maximize the combat effectiveness of deployed forces. By defining mission specific site requirements prior to the deployment and construction or base camps, commanders and planners are able to optimize base camp site selection and design. Currently, existing doctrine and guidance for contingency basing (CB) are not developed to support deployment in dense urban environments. Without this doctrine, the U.S. military falters when deployment is desirable or necessary in a dense urban environment. Preliminary research reveals the inadequacy of current doctrine for conducting operations in such an environment (Chief of Staff of the Army, 2013). The CB-SITE project seeks to address these problems by developing a comprehensive tool for base camp site suitability assessment. CB-SITE progress includes (1) interviewing a dozen current and former US Army personnel with active duty contingency basing experience (2) analyzing a dozen documents describing existing US Army policy and recommended good practice, (3) developing a preliminary set of spatial criteria (i.e., standards that influence CB siting), and (4) developing a preliminary framework set of design choices, i.e., factors that will influence how criteria are interpreted. As a screening tool, CB-SITE will assist with optimal selections of promising locations for detailed investigation through the use of multi-criteria decision analysis. The tool will guide users on factors that require consideration during site selection and help avoid unintended consequences following site placement.

M3-G.1 Canjar, HA; X; *helen.canjar@sympatico.ca*

Disruptive technologies and physical security - good, bad, or indifferent?

The physical security world is historically thought to be concerned with the protection of bricks and mortar structures and VIPs from relatively known bad guys. Although still true, this world is now more realistically defined by the trillions upon trillions of data files, unimaginable amounts of video surveillance, and constant evolution of risks and threats to previously "safe" entities, such as cargo shipments and electricity grids. Disruptive technologies, such as artificial intelligence and autonomous vehicles, have the potential to change how physical security risk analysis is conducted in fields ranging from border security to critical infrastructure protection. Ideally, an arsenal of tools will be created that helps analysts bridge the gap between their efforts and the rapid growth of threats impacting the world today. This presentation seeks to explore the potential benefits and consequences of several game changing technologies and provide insight into their possible usefulness in practical applications.

P.116 Chabrelie, AE*; Zhang, L; Bornhorst, G; Mitchell, J; Michigan State University and University of California, Davis; *chabreli@msu.edu*

Horizontal Gene Transfer Under Dynamic System Conditions for Understanding Dose-Response Relationships for Antibiotic Resistance Risks

Antimicrobial resistance (AMR) is a looming global concern and the associated genes are now considered emerging hazards because of their ability to proliferate antibiotic resistance. Understanding how horizontal gene transfer (HGT) occurs under system conditions is a powerful step in determining how AMR is spread in the environment and in humans. Traditional pathogen dose-response models do not consider the potential body burden of AMR strains, which is the result of replication and gene transfer. There is a lack of information about HGT within dynamic systems like the animal and human gut as most studies are done under static conditions. In this study, in vitro experiments were conducted to quantify how different parameters impact E. coli. AMR transmission through HGT. E. coli. was selected as it represents one of the most common commensal bacteria in large intestine of humans and animals, as well as in environment. Parameters investigated are the time, nutrient concentration, donor-recipient ratios, and viscosity. These factors correlate with the digestion process, diet, the amount of resistant and susceptible bacteria ingested and the conditions within the gut. Preliminary results obtained showed a clear correlation between the HGT transfer and these parameters, allowing researchers to refine their model for better estimating development of AMR in animals and humans.

P.56 Chang, PH*; Chou, YJ; Yin, MC; Chu, YR; Tsan, YT; Chan, WC; Ho, WC; Chen, PC; China Medical University; *peipei10220312@gmail.com*

Statin Use and Temperature on Transient Ischemic Attacks among Diabetes Mellitus Patients

Ischemic stroke (IS) is the major stroke in Taiwan. Studies indicate that transient ischemic attack (TIA) has similar mechanism to ischemic stroke, and may serve as early stage prevention of ischemic stroke. Diabetes mellitus (DM) patients tend to have increased risk for stroke. Statins are widely used medicine for their cholesterol-lowering effect in patients with hyperlipidemia to prevent vascular diseases. Studies show that temperature affects arterial pressure, cholesterol concentration and then can cause thrombosis. The objective of this study is to investigate whether statin use and temperature have the impact on transient ischemic attacks among DM patients. The study design was a retrospective cohort study. The medical records of subjects including TIA events and statin use were collected by Longitudinal Health Insurance Database applying for 2million people with DM. The meteorological factors including temperature and air pollution data were obtained from the Taiwan Environment Protection Administration monitored at 77 air pollution monitoring stations. The exposure of statin and temperature analyzed by the time stratified case cross-over approach. Conditional logistic regression model was used to correlate average daily meteorological factors and concentration of daily air pollution. The results showed that temperature change are associated with TIA. Statin has a protective effect on transient ischemic episodes. The modifying effect of temperature changes on statin related to transient is chemic episodes can be on important topic.

W3-D.4 Chang, BS; Wu, KY; Chen, YJ; Chuang, YC; Lin, JW; Ho, WC; Chiang, SY*; China Medical University; *tsgrdam621@gmail.com*

Risk assessment of combined exposure to multiple organophosphorus pesticides

Cumulative risk assessment for pesticides has been an important international trend, nevertheless, there is very few relevant research in Taiwan. Organophosphorus pesticides (OPs) are commonly used pesticides. This study conducted risk assessment of combined exposure to 12 OPs on the basis of the mode of action to assess potential impact on human health. The approach of relative potency factor (RPF) in cumulative risk assessment was used for OPs with a common mechanism of inhibition of acetyl cholinesterase. According to the residual data of agricultural products in 2010 to 2015 released by Council of Agriculture in Taiwan, the statistical distribution of residues of 12 commonly used OPs (Acephate, Chlorpyrifos, Diazinon, Dimethoate, Fenthion, Marathion, Methamidophos, Phorate, Terbufos, and Fenitrothion) was established using Monte Carlo simulation method to simulate the total exposure risk. We estimated the distribution of OP residues in vegetables and fruits and applied RPFs to transform each pesticide to the compound-specific residue concentration of index compound methamidophos. In this approach, each pesticide was calculated out to lifetime average daily dose (LADD) based on methamidophos, index compound and then to surplus them into total LADD. The results show that in general food intake rate, the mean of margin of exposure (MOE) and 95% lower bound of MOE are greater than 100. In contrast, MOEs (mean, 95% lower bond) in consumer only food intake rate are smaller than 100. Actually, the real risk is located in this interval and across 100. Therefore, the result of combined exposure to multiple OPs suggests the regulation of OPs should be scrutinized and revised carefully in the future.

P.44 Chappell, G*; Welsh, B; Harvey, S; Harris, M; Wikoff, D; ToxStrategies, Inc.; *gchappell@toxstrategies.com*

Validation and Application of a Text Mining Tool for Identification and Categorization of Mechanistic Data Related to the Key Characteristics of Carcinogens: Case Studies of a Problem Formulation Tool

Efforts to determine efficacious methods for identification and categorization of information in toxicological systematic reviews are ongoing. We assessed the utility of a text-mining and machine learning tool (SWIFT) in the characterization of mechanistic data associated with carcinogenic endpoints organized by ten key characteristics of carcinogens (KCC) (Smith et al., 2016). Objectives included: 1) validation of a process that employs a text-mining and machine learning tool (SWIFT) to literature by the KCC using five systematic review datasets, and 2) assessment of the approach as a problem formulation method via characterization of literature for 20 substances of varying carcinogenic potential. With respect to validation, we found that the text mining strategy returned ~60% of the KCC-relevant studies that were identified by an analyst via title and abstract screening demonstrating the utility (and limitations) of the method as a problem formulation tool. Search syntax optimization was highly influential, with the internally-developed syntax returning different results than the default KCC search strings. Regarding machine learning, we found that the prioritization tool did not adequately reduce the screening effort for relatively small datasets (

M2-H.4 Chen, Y*; Pouillot, R; Luchansky, JB; Porto-Fett, ACS; Catlin, M; Kause, J; Gallagher, D; Van Doren, JM; Lindsay, JA; Dennis, S; FDA Center for Food Safety and Applied Nutrition, USDA Agricultural Research Service, Virginia Polytechnic Institute and State University, and USDA Food Safety and Inspection Service; *yuhuan.chen@fda.hhs.gov*

Interagency Listeria monocytogenes Market Basket Survey – results and critical considerations for developing surveys to support quantitative risk assessments

An interagency Listeria monocytogenes Market Basket Survey (Lm MBS) was conducted 2010-2013 for 16 categories of ready-to-eat foods purchased at retail in four U.S. FoodNet states. The study collection and microbial analysis protocols were designed to maximize their utility to assess the current status and potential changes in L. monocytogenes prevalence and levels in the selected foods that could have resulted from regulatory and industry interventions over the previous decade. Published L. monocytogenes surveys often focused on the proportion of positive samples, but few reported metadata or how metadata were considered in analyzing results. The Lm MBS took a structured pragmatic approach based on stratification by predictors with the greatest anticipated impact on reducing uncertainty, and collection of multiple samples per food category from the same store for efficiency (total 27,389 samples from 1042 stores). This approach required planning and recording appropriate metadata, such as the food types within each category, the FoodNet sites, the retail store identification number, the type of store (e.g., national chain vs. independent), and packaging location (prepackaged vs. deli-packaged). The target number of samples required careful review of historical data. Analytical sample size, which varies from study to study (e.g., 25g and 125g), was also considered to allow comparison of results from different surveys. With the metadata and microbial testing data from the Lm MBS, generalized linear mixed models, with consideration of sampling stratification and potential clustering effects with regard to stores and states, determined that prevalence ranged from 0.11% [95%CI:0.03,0.34] for sprouts (pre-packaged) to 1.01% [95%CI:0.58,1.74] for raw cut vegetables (pre-packaged). Developing, documenting, and analyzing survey data in this way allows direct comparison to other studies, even when the study design is different, as long as the design has been specified.

P.51 Chen, Q*; Shao, K; Indiana University; *chenqira@umail.iu.edu*
The Correlation between Liver Tumor Incidence and Early-stage Liver Weight Change - An Analysis Using NTP Data
Liver tumor is a significant and complicated disease in human. Various studies have focused on the cause and biomarkers of early detection of the liver tumor occurrence. In this study, we aim to investigate whether there is a correlation between short-term liver weight change in rodents and liver tumor incidence. We screened all 593 published NTP technical reports and found 174 compounds that have at least one species/sex combination with positive or clear-evidence liver tumor. Next, we searched the data of absolute liver weight and relative liver weight at early stages for these compounds and finally enrolled 79 chemicals which have both long-term cancer data and short-term liver weight data. For the data analysis, we employed the benchmark dose (BMD) method to analyze the corresponding dichotomous and continuous dose-response data of each compound to determine the dose level that causes significant change in each endpoint, which is followed by a calculation of the Pearson correlation coefficient to determine the correlation between these two sets of BMDs. Multiple models were applied to take model uncertainty issue into account. Preliminary results show that the correlation coefficients range from -0.26 to 0.86, with a mean of 0.53 for 3-month relative liver weight. In addition, more than 43% of correlation are greater than 0.6, which indicates a fairly strong association. Generally, although considerable uncertainties still exist, there is a relatively high agreement between the BMD estimates from the tumor data and short-term liver weight data. These results suggest that liver weight increase can be used as a risk indicator for liver tumor to give a warning signal in early stage.

W3-I.3 Chien, J*; Lemay, JC; Gradient; *jchien@gradientcorp.com*
Benzo(a)pyrene Toxicity Value Updates: Implications for Human Health Risk Assessment
Polycyclic aromatic hydrocarbons (PAHs) are commonly detected in soil and sediment at former industrial sites and are often the focus of remediation efforts. However, toxicity criteria are not available for all PAHs. For carcinogenic endpoints, human health risks are assessed by assigning toxicity equivalency factors (TEFs) to carcinogenic PAHs (cPAHs) relative to toxicity of benzo(a)pyrene (BaP), which is the best characterized of the cPAHs. In January 2017, the United States Environmental Protection Agency (US EPA) published new toxicity values for BaP in its Integrated Risk Information System (IRIS). The new oral cancer slope factor (CSF) is lower than the previous CSF by approximately 7-fold. The new IRIS inhalation unit risk (IUR) for cancer is approximately 2-fold lower than the IUR developed by the California Office of Environmental Health Hazard Assessment, which had previously been used in US EPA risk assessments. US EPA also published, for the first time, non-cancer Reference Dose (RfD) and Reference Concentration (RfC) values. We examined the impacts of these updated BaP toxicity criteria on results of a human health risk assessment at an example site, where PAHs were detected in soil and groundwater. For demonstration purposes, we calculated risks from PAHs for the construction worker and the resident. As expected, the calculated incremental lifetime cancer risks (ILCRs) for both receptors were lower using the new toxicity values compared to the old values. More importantly, non-cancer hazards due to PAHs exceeded US EPA's target risk limit of one. This demonstrates that use of these new toxicity values in human health risk assessments, particularly for non-cancer endpoints, may have remediation implications for PAH sites.

P.85 Chiger, A*; Lynch, MT; Houlihan, J; Abt Associates and Healthy Babies Bright Futures; *andrea_chiger@abtassoc.com*
Inorganic Arsenic Exposures Associated with Consumption of Infant Rice Cereal
Inorganic arsenic is a developmental neurotoxicant that is commonly found in a variety of foods, particularly those containing rice. However, there is currently no standard for arsenic in infant rice cereals sold in the United States. We investigated inorganic arsenic exposures in U.S. children as a result of infant rice cereal consumption. We first compiled data sources on infant rice cereal consumption, inorganic arsenic concentrations in infant rice cereal, and estimates of dietary exposures in children. We then evaluated the available data and created arsenic exposure estimates for average and high consumers of infant rice cereal. To place these estimates into context, we compared them to the existing EPA reference dose for the dermal effects of arsenic, and to estimates of a reference dose for its neurodevelopmental effects, which were based on the primary literature. Further details of our dose-response assessment will be presented in a companion poster entitled "Estimates of IQ Loss in Infants due to Exposure to Arsenic in Infant Rice Cereals" by Meghan Lynch, Andrea Chiger and Jane Houlihan.

W3-I.4 Chrostowski, PC; CPF Associates, Inc.; *pc@cpfassociates.com*
Alternative Methods for Assessing Human Health Risks from Exposure to Polycyclic Aromatic Compounds
Polycyclic aromatic compounds (PACs, including PAHs) typically occur as complex mixtures in the environment ranging from petroleum (crude and products) to coal products (tar, creosote) to food (grilled meats) to combustion products (tobacco smoke, tailpipe emissions). It is common for 50-200 individual PACs to be present in these mixtures. Advances in analytical chemistry have enabled reliable and mostly complete identification and quantitation of components of PAC mixtures, however, regulatory human health risk assessment methods have not kept pace. For example, traditional USEPA site-specific risk assessments focus on 16 priority pollutant PAHs originally designated in the 1970s. Routine regulatory analytical methods may add yet a few others (e.g. carbazole) although other commonly available non-regulatory analytical methods can easily measure >50 PACs. Thus, environmental human health risk assessments exclude most PACs present in common mixtures. Many of these compounds lack high-quality dose-response relationships, the methods fail to recognize the toxicological impact of the matrix, and rely on methods of assessment that cannot account for toxicological interactions (other than additivity) in the mixtures. Alternative methods, both biological and chemical, have been proposed by the petroleum industry and academic researchers, however, have not gained traction for regulatory health risk assessments. In some cases, the different methods yield contradictory results which detracts from the credibility of the methods being compared. This paper will review the current state-of-practice in PAC human health risk assessments, characterize the pros and cons of the different methods, apply alternative methods to real-world datasets, critically review the outcome of these applications, and present potential ways that these methods may be reconciled and used in routine regulatory risk assessments.

P.107 Chu, YR*; Yin, MC; Chang, PH; Luo, RY; Ho, WC; Il'yasova, D; China Medical University; *rayray0508@gmail.com*

Association Between Melanoma and Glioma Risk A nationwide Study in Taiwan

Glioma incidence has been increased in these years. The etiology of brain tumor is still largely unknown. In a previous study, it was shown that melanoma patients have a greater incidence of glioma as compared to the general population in United States. Because glioma and melanoma do not have common environmental risk factors, this observation suggests a common genetic predisposition shared by glioma and melanoma that may be used to lead future research of the specific genes and drug targets for both malignancies. However, this observation has to be confirmed in other populations. The aim of this study was to investigate the association between melanoma and glioma in Taiwanese population. We used claim data of Taiwan's National Health Insurance Research Database (NHIRD) from year 1998 to 2010. The study population included 1,000,000 randomly selected men and women ages 20 and older from the NHIRD database. Glioma was defined by ICD-9-CM codes 191, 192.0-192.3, 192.8, 192.9, 225 and 237.5. Melanoma was defined by ICD-9-CM codes 172, 173, 190.0, 190.9, 216.X (X=0, 3-7, 9), 224, 223.2, 235.1, 235.2, 237.6, 238.2, 238.3, 238.8. We excluded participants under ages 20 at 1998 and unknown gender (n=324,879). Cox's proportional hazard regression analysis was conducted to estimate the association between the history of melanoma on glioma risk. The hazard ratio of developing glioma was significantly higher in patients with melanoma than in those without melanoma (hazard ratio (HR) = 6.18; 95% confidence interval (CI) = 5.57-6.85) and was lower in male patients than in female patients, with the hazard ratio of 0.77 (95% CI = 0.71-0.84), adjusted covariables. The hazard ratio increased with age peaking at age group from 60 to 69 and decrease after 70 and older. The present study showed that Taiwanese patients with melanoma are at a higher risk of developing glioma. The exact underlying etiologies require further investigation.

P.154 Chu, H.*; Yang, J.; University at Buffalo, State University of New York; *hchu5@buffalo.edu*

Who moved my coffee? Using psychological distance to frame climate change impacts

Framing is an effective communication technique to motivate the public to engage in climate change mitigation and adaptation behaviors (Nisbet, 2009). However, existing empirical evidence has been inconsistent (e.g. Hart, 2011; Hart & Nisbet, 2012). Among different framing strategies, those assuming stronger personal relevance usually demonstrate higher effectiveness in motivating people to acknowledge the anthropogenic causes of climate change (ACC) or to support mitigation policies (Myers et al., 2012; Spence & Pidgeon, 2010). Although not consistently examined in these studies, psychological distance may be the underlying mechanism behind issue framing effects identified in various existing studies (Liberman & Trope, 2008; Rickard et al., 2016). Building on existing research, this study employs audiovisual messages highlighting climate change impacts that are either close or far in spatial and social distance, to investigate whether psychological distance is indeed an effective lens through which to frame climate change impacts. Results are largely consistent with existing research. Theoretical and practical implications of the findings will be discussed.

P.5 Chuang, YC*; Huang, SZ; Wu, C; Wu, KY; National Taiwan University; *mcyc1979@gmail.com*

Risk-based National Standards of the Republic of China (CNS) on Chemical Level in Consumer Products: A Suggested Framework

National Standards of the Republic of China (CNS) was developed by the Bureau of Standards, Metrology and Inspection (BSMI) in Taiwan which is the authority responsible for standardization, metrology and product inspection. As the rising of risk perception, BSMI launched the review project and expected to harmonize the local health risk impact and international standards into current CNS of consumer products initially. The suggested framework of risk-based CNS was referred to international organizations with the framework in product risk assessment and was identified with nine major steps and a core concept. The step-by-step approach are including product definition, hazard identification, subject identification, scenario construction, potential harm identification, severity assessment, probability assessment of harm, risk characterization, and uncertainty analysis with the concept of real-time information updating to propose the comprehensive risk assessment framework of consumer products. The feature of Suggested Framework can harmonize local regulation and consumer behavior in National Standards to reduce the risk concerns of local consumer from international standards. Recently, a practical project in BSMI have be launched to evaluate the Violate Organic Compound level of consumer products for CNS with risk-based Framework.

M4-F.3 Collier, ZA*; Lambert, JH; University of Virginia; *zac4nf@virginia.edu*

Emergent and Future Conditions Disrupting PERT/CPM Schedule Analysis of Infrastructure Systems

Combinations of emergent and future conditions can bring about singular disruptions of project schedules in infrastructure development and management. Existing methods of project management fail to link such disruptions with mission outcomes such as cost, schedule, and quality. This currently limits the efficacy and timeliness of corrective or precautionary actions for interdependent projects with durations of years and expenditures up to billions of US dollars. From a view of risk analysis, this paper will provide understanding of key disruptive conditions for project-activity networks (e.g., PERT/CPM), reprioritizing the constituent activities of projects subject to precedence and other constraints. The approach is critical to guide strategic decision making and system operations to identify and avoid potential deviations from schedule and budgetary targets. The approach will be demonstrated for capacity expansion and operations of a maritime container port with millions of container transactions per year. The demonstration will involve adoption of a schedule analysis, identification of key scenarios and hundreds of candidate emergent and future conditions (technology, economy, demographics, markets, regulation, environment, etc.), and scenario-based preference analysis. The results will characterize the emergent and future conditions that are most and least disruptive to schedule, cost, and technical goals. The paper provides recommendations for revision of associated standards in systems engineering and process operations. The approach is transferable across applications of systems engineering and risk analysis, e.g., environment, health, commerce, regulation, and others.

W3-J.2 Conklin, DJ; University of Louisville; *dj.conklin@louisville.edu*

Getting a "Flavor" for Cardiovascular Effects of New and Emerging Tobacco Products

Emerging tobacco-derived products including electronic cigarettes, smokeless tobacco (e.g., snus) and hookah (water pipe) contain, deliver and/or generate a number of harmful or potentially harmful constituents (HPHCs). Moreover, these products often contain flavorants that are generally regarded as safe (GRAS) for ingestion, however, most GRAS flavors have never been tested for their toxicity when heated and inhaled, which leaves uncertainty regarding the health risks of these products. An enormous (>8,000) number of flavors in e-juices/e-liquids are on the market including fruity, spicy and buttery flavors that attract youth to try these products. Moreover, there is precedent for concern of inhaling flavorant compounds, e.g., inhalation exposure to diacetyl, a component of buttery flavoring, is associated with a serious, fatal lung disease known as bronchiolitis obliterans in workers at a microwave popcorn manufacturing plant. Similarly disconcerting is that flavorants when heated can decompose into HPHCs, e.g., aldehydes. The cardiovascular effects of these HPHCs are understudied. Thus, there is a need to assess cardiovascular toxicity of flavors in general, and thus, we developed a screen to identify flavors with high cardiovascular toxicity in vitro. We used cardiomyocytes, endothelial cells, and platelets in cardiovascular toxicity assay. A series of flavor compounds were used based on chemical class and prevalence/abundance in tobacco products, such as cinnamaldehyde and menthol. We also tested whether flavorant toxicity was altered by low (<200 ºC) and high >700 ºC) temperature heating, which simulated temperatures encountered in tobacco products. Flavorant toxicity profiles in cardiovascular targets in vitro provides a starting point for assessing flavor-induced cardiovascular toxicity in vivo, and these data may inform future human studies to better estimate cardiovascular disease risk.

T4-E.2 Corderi Novoa, D*; Hori, T; Yarmin, L; Inter-American Development Bank; *david.corderi@gmail.com*

Selecting Investment Strategies for Disaster Risk Reduction in Developing Countries: The case of Flood Protection in the Rio Rocha Basin

Despite the increasing evidence of the return to disaster risk reduction, investments to reduce risks have often been inadequate in developing countries. Previous analysis on risk reduction measures have focused on the evaluation of specific measures in isolation, failing to provide an assessment of the potential tradeoffs and interaction among alternative measures. The lack of understanding about the returns of alternative investment options has precluded policy-makers in developing countries to make investment decisions in a context of limited public funding. This article presents an integrated assessment model to help decision makers prioritize investments to reduce flood risks from a range of measures available. We develop a multi-disciplinary approach to evaluate investment alternatives. Combining probabilistic risk assessments, hydrologic, engineering and cost-benefit analysis with optimization techniques, we consider a wide array of measures and their interactions over a multi-year planning horizon. Our model incorporates the estimated costs and benefits of measures into a mixed integer linear program to explore the desirability of alternative flood reduction investment strategies using different performance criteria for a set of future scenarios. The model analyzes the optimal combination of measures and their sequencing within a planning horizon. We present the results of the local study and model application in the Rio Rocha Basin of Bolivia.

W2-A.4 Copes, R; Public Health Ontario; *ray.copes@oahpp.ca*

Communicating the results of an environmental health burden to decision-makers, the public, and the media

Estimating the burden of disease attributable to various risk factors, whether environmental or behavioural, can help provide a useful context for priority setting and policy making. The metrics used to express the burden must be understandable and "important" to the target audience, who may include policy makers in distinct sectors (e.g., health, environment, labor), health professionals, the public, and the media. There will also be significant differences in terms of which metrics work best for target audiences at the international, national and subnational scales. Furthermore, certain metrics for expressing burden (e.g., disability-adjusted life years or DALYs, deaths, adverse health outcomes and their associated costs) may work better at influencing some audiences than others. This presentation will discuss some of the metrics used to summarize burden of disease estimates, as well as their advantages and disadvantages with respect to influencing specific target audiences. The presentation will also summarize the published materials (e.g., report, infographic, technical supplement) and selected metrics used in the "Environmental Burden of Cancer in Ontario" report released in 2016 by Public Health Ontario and Cancer Care Ontario, and discuss the lessons learned in communicating the results of this report. (Report available at https://www.publichealthontario.ca/en/BrowseByTopic/EnvironmentalandOccupationalHealth/Pages/Environmental-Burden-of-Cancer-ON.aspx)

W2-H.3 Cox, LA; Cox Associates and University of Colorado; *tcoxdenver@aol.com*

What is an effect?

Much of risk analysis is concerned with calculating how exposures to hazardous substances or activities change the frequency or severity of undesired effects. But what exactly is meant by an "effect" of an exposure? Counterfactual approaches that seek to define effects as differences in frequencies or severities of adverse outcomes with and without exposure, or between higher and lower levels of exposure, are limited by the fact that the difference depends on seldom-specified details of the counterfactual world, such as why and how a hypothetical reduction in exposure occurs. Regression models and other statistical methods for quantifying effects are limited by the fact that no regression coefficient for exposure can represent both the direct effect of exposure (holding all other variables fixed) and the total effect of an exogenous change in exposure allowing other variables (e.g., wealth or income or residential location) to adjust, as well as the exposure-mediated effect of changes brought about by exogenous changes in other variables. A typical regression coefficient represents an unknown mixture of different types of effects (and possibly interactions) and may be useless for predicting how future exogenous changes in exposure alone would affect outcome frequencies and severities. This talk first discusses the impossibility of uniquely defining and measuring effects via regression models or counterfactual models and then proposes an alternative based on predicting the changes in all variables in response to exogenous changes in exposure in causal graph models.

M4-H.1 CRAGIN, DW*; GALLOWAY, SM; HOLLICK, ND; Merck & Co. and Peking University; *david.cragin@merck.com*
Mutagenic impurities and Human Pharmaceuticals: A discussion of ICH M7 and negligible risk
The process of manufacturing drugs involves the use of reactive chemicals, reagents, solvents, catalysts, and other processing aids. In addition to the importance of the safety and efficacy of the active ingredient in a drug product, ensuring that drugs have safe levels of impurities is equally important. To support this, the International Conference on Harmonisation issued guidance entitled: “Assessment and Control of DNA Reactive (Mutagenic) Impurities in Pharmaceuticals to Limit Potential Carcinogenic Risk” (ICH M7). This guideline provides “Threshold of Toxicological Concern” (TTC) levels as default limits and also discusses compound specific approaches and adjustments for shorter, “less than lifetime”, exposures. When compared to typical daily life exposure to mutagenic substances such as formaldehyde, it’s evident that the TTC levels provide a large margin of safety for patients. We will show how most compounds associated with drug syntheses are not in the classes of potent carcinogens on which the default TTC was based, illustrating the conservative nature of the TTC and the rationale for not applying the guidance retrospectively to marketed compounds. Also, while safe doses of carcinogens that are mutagens have traditionally been calculated assuming a linear dose response, we will discuss the substantial evidence for non-linear dose responses or tumors that are not relevant to humans, and the increasing evidence for “thresholds” in dose responses for DNA reactive mutagens. Examples will be provided including discussion of some individual chemicals addressed in ICH M7(R1). This assessment will show how companies assess and control potential mutagenic impurities and quantitatively illustrate the level of protection provided to patients by the ICH M7 limits.

W1-E.2 Crowther, KG; MITRE Corporation; *kcrowther@mitre.org*
Improving Complex Security Risk Analysis with Computational Creativity
Many strategic security initiatives call for capabilities to manage "emerging risks" or "evolutionary risks." However, existing risk analyses in the security and defense domains have failed to apply modern methods for improved anticipation of emergent risks - resulting in many risk assessments being a paper exercises that provide little value to discriminating countermeasures for improved security, defense, and resilience. This presentation reviews and evaluates methods for modernizing risk assessment for application to security and defense challenges where there are complex, dynamic systems with adaptive adversaries. It particularly focuses on the application of computational creativity to risk analytics in the security and defense domains. Computational creativity is the process of traversing multiple data sets to find attacks and/or mitigations that are both novel (non-traditional or outside of the scope of "typical" design") and valuable (consistent with historical evidence or could have significant impact). This presentation will summarize the results of several experiments to test computational creativity algorithms within the scope of several government security and defense problems (including vehicle-borne attacks, use and defeat of explosives, and ransomware). The final part of the presentation provide a research pathway by which this area could provide a methodology to monitor for the emergence of low-probability, high-impact events in the security and defense arena where business and protection systems are complex and dynamic, and adversaries are adapting.

W2-K.4 Cuite, CL*; Hallman, WK; Shwom, RL; Demuth, J; Morss, R; Rutgers University; *cara.cuite@gmail.com*
Differing perceptions of hurricanes and nor'easters
While meteorologists name hurricanes, they do not name nor’easters, even though both types of storm can be deadly. Recent studies indicate that named storms may seem more serious to the public, encouraging more protective action. The current research investigates whether, when all other features of a storm are held constant, coastal residents perceive differences in the severity of nor’easters and hurricanes, and whether there are differences in the likelihood of their taking protective action. We conducted an online survey of 1,700 residents of NJ, NY, and CT living in coastal zipcodes. A series of experiments about hypothetical storm scenarios was used to test message variables, including the type of storm (hurricane vs. nor’easter). Respondents were told that there was an evacuation order in their area, and that the storm was expected to be severe. While message comprehension was similar across both the hurricane and nor’easter conditions, we found small but significant effects on a range of other dependent measures. Those who were told the storm was a hurricane were more likely to believe the storm would be severe (p

M2-J.6 Cummings, CL; Nanyang Technological University, Singapore; *ccummings@ntu.edu.sg*
Information asymmetry: The heuristic function of nano-food labels
In most communication environments, at least one party holds less pertinent information than others, which may leave that party susceptible to making judgments without adequate resources to consider all relevant information. Information asymmetry may be exacerbated for potential nano-food product consumers who hold little information when exposed to products and messages and must attempt to comprehend and make decisions about products under uncertainty. Many consumers use product labels when forming perceptions or making purchasing decisions. Product labels are symbolic risk messages aimed to distinguish one product from another while conveying salient concepts from which consumers can derive greater comprehension of the what the product is, what it means to the consumer, and its value. Labelling of food products and other consumer goods serve a heuristic function that influences consumers’ comprehension under low information contexts. Proposals for “nano-lables” have been petitioned of certification organizations and governmental agencies, and proposals for nano-food labels note that they would likely incur extra costs to the producer, which in turn may be passed on to consumers at higher market pricing. However, like all information, comprehending labels can be challenging for many consumers and labels are often miscomprehended, or go unnoticed or unused by consumers as they process information. This presentation discusses how nano-labels are a politicized locus where motivations of audiences are inscribed onto sense-making and decision-making processes regarding nano-foods. Informed by Protection Motivation Theory, this presentation reports recent representative survey data regarding the attitudes and use of food labels for nano-food products and uncovers dual functions of labels as being used from either a “right to be informed” premise or as “do not buy” cautionary marker. Such data is of use to improve risk communication initiatives and inform future governance of this burgeoning market.

T2-C.2 Cummings, CL; Nanyang Technological University, Singapore; *ccummings@ntu.edu.sg*

Secondary Risks of Vaccine

This experimental study evaluates the influence of secondary risks on behavioral intentions to vaccinate against dengue fever. Secondary risks are novel potential harms caused from interventions taken to reduce initial primary risks—in this case evaluating secondary risks of vaccines as a response to the primary health risk of dengue fever. Informed by Protection Motivation Theory, this study experimentally assesses the role of communication regarding vaccine characteristics including vaccine effectiveness, likelihood of vaccine side effects, and vaccine production methods—whether it is communicated that the vaccine is created using synthetic biology. Results demonstrate that secondary risk in the form of the likelihood of side effects has significant influence on vaccine intentions and also alters perceived vulnerability to the dengue fever virus itself. This carryover effect from a secondary risk to new evaluations of a primary risk has significant implications for health communication initiatives that aim to improve patient and public understanding of viruses and vaccines. Vaccine production method was found to have no effect on intention and threat appraisal of dengue fever. These results provide new theoretical implications that suggest a possible extension to the existing Protection Motivation Theory, and offer practical implications for the manner by which governments and health authorities craft health messages pertaining to vaccines.

P.173 Dalaijamts, C*; Cichocki, JA; Luo, YS; Rusyn, I; Chiu, WA; Texas A&M University; *cdalaijamts@cvm.tamu.edu*

Physiologically Based Pharmacokinetic (PBPK) Modeling of Interstrain Variability in Perchloroethylene Metabolism in Mice

Perchloroethylene organ-specific toxicity has been associated with both oxidative and conjugative metabolism pathways. Previous perc PBPK modeling could accurately predict oxidation but suggested the need to better characterize glutathione (GSH) conjugation as well as toxicokinetic uncertainty and variability. We updated the previously published “harmonized” perc PBPK model for mice to characterize the uncertainty and variability of perc toxicokinetics, with particular emphasis on modeling GSH conjugation metabolites. The updated PBPK model includes physiologically based sub-models for conjugation metabolites trichlorovinyl glutathione (TCVG), tricholorvinyl cysteine (TCVC), and N-acetyl trichlorovinyl cysteine (NAcTCVC), and added a brain compartment for perc and the oxidative metabolite trichloroacetic acid (TCA). Previously compiled mouse kinetic data on perc and TCA in B6C3F1 and Swiss mice was augmented to include data from a recent study in male C57Bl/6J mice that measured perc, TCA, and GSH conjugation metabolites in serum and multiple tissues. A hierarchical Bayesian population approach was used to estimate model parameters and characterize the uncertainty and interstrain variability, implemented using Markov chain Monte Carlo (MCMC) simulation. All convergence criteria were satisfied with four MCMC chains, each 100,000 iterations long. The updated model performed as well or better than the previously published model. Tissue dosimetry for both oxidative and conjugative metabolites were successfully predicted across the three strains of mice, with estimated residuals errors of 2-fold for the majority of data. Inter-strain variability across the three strains was evident for oxidative metabolism; GSH conjugation data were only available for one strain. Updated PBPK model fills a critical data gap in quantitative risk assessment by providing predictions of the internal dosimetry of perc and its oxidative and GSH conjugation metabolites. It also lays the groundwork for future studies to characterize perc toxicokinetic variability.

W1-E.3 Davenport, C*; Smith, DS; University of Maryland; *cdavenpo@umd.edu*

Deterrence or Deflection? Gauging Perceptions of Defensive Deterrence and Target Substitutability

The extent to which a defensive implement has a deterrent impact depends, in part, on how adversary success is defined; deterrence measures in one specific city may have a deterrent impact but, this may mean little for national security writ large if an adversary simply opts to attack another major city instead. This facet of the adversary’s decision-making process, which involves substitutability of targets, highlights the importance of deflective versus deterrent effects. No experimental research investigates the role of risk perception in willingness to carry out a terror attack against a particular target, much less multiple potential targets within a country. A survey/experiment was conducted in which respondents were asked to role-play as a cult organization seeking to carry out a dirty bomb attack against one of five potential U.S. cities with knowledge of a bomb-detection network present in some or all of those five cities. Data were collected through a web-based survey experiment with participants randomly assigned to one of twelve experimental conditions. Following the experimental manipulation, individuals answered questions pertaining to the main dependent variables of interest. Specifically, respondents were prompted to rate “secureness” and how likely they were to attack in general as well as in relation to specific cities. Respondents are also prompted to answer a series of questions gauging baseline risk aversion, political ideology, and various demographic attributes. An analysis reveals support for the notion that robust implementation of a defensive system in a limited number of potential target cities does not have an appreciable impact on perceptions of net security when implementation is uneven across potential targets and those targets are perceived as substitutable.

M4-J.5 Davis, JA*; Gift, J; US Environmental Protection Agency; *davis.allen@epa.gov*

EPA's Benchmark Dose Software and Related Dose-Response Models and Methods

The EPA developed the Benchmark Dose Software (BMDS) as a tool to help Agency risk assessors facilitate applying benchmark dose (BMD) method’s to EPA’s human health risk assessment (HHRA) documents. The application of BMD methods overcomes many well know limitations of the more traditional NOAEL/LOAEL approach, and its use has expanded internationally to include thousands of users world-wide. The current version of BMDS allows users to model a number of different types of data, including quantal data, continuous data, and clustered developmental toxicity data. Advanced models that incorporate time as a variable into the modeling scheme are also offered, including models for time-to-tumor analysis, repeated-response data, or concentration × time data. To stay current with the state-of-the-science in this field, EPA has continued to research and implement new dose-response methods for inclusion in BMDS or development as stand-alone products. Recently, EPA released the new user interface for its Categorical Regression software, facilitating the analysis of severity data and the use of meta-analytical methods. Other current projects include the development of frequentist and Bayesian model averaging approaches to address model uncertainty, Bayesian meta-regression methods for modeling data from multiple epidemiological studies, and using BMD modeling to assess the toxicological similarity of chemical mixtures. Other research projects include the implementation of the hybrid approach for defining risk for continuous endpoints in a dichotomous fashion, implementation of log-normal distributions for continuous data, and further development of probabilistic dose-response methods. Disclaimer: The views expressed in this abstract are those of the authors and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

P.152 De Marcellis-Warin, N*; Peignier, I; Ecole Polytechnique de Montreal; *ingrid.peignier@cirano.qc.ca*
Food Fraud and Consumer Risk Perception in Quebec (Canada)
Food fraud occurs when there is intentional misrepresentation to consumers as to the nature, the origin or the ingredients of a food product. This may involve diluting a product with lower-quality materials or ingredients (as an example, an olive oil cut by hazelnut oil and sold as an extra-virgin oil or the 2013 horse meat scandal involving beef burgers containing horse meat), adding foreign substances to the original product (like the 2008 Chinese milk scandal involving infant formula being adulterated with melamine), selling non-organic products as "organic", misrepresenting the animal or fish species or using a misleading label. Food fraud can therefore not only lead to economic consequences but also to consequences in term of public health. What are the concerns and the perceptions of the risks associated with food fraud? How well informed are consumers regarding the risks surrounding food fraud? What are the willingness to change their purchasing behaviour in case of a specific «Zero Food Fraud» certification? The Barometre CIRANO 2017 tends to answer to all of these questions for Quebec population. It is a unique tool for a better understanding of Quebecker's current concerns and risk perceptions and for identifying the determinants of the social acceptability of more than 40 major issues. It consists on a large online survey conducted each year since 2011 on more than 1000 persons representative of Quebec population. The 2017 Edition covered more deeply Food Fraud in including a specific case study. Taking into account of consumer risk perception, their level of confidence and their level of knowledge before choosing or implementing solutions to manage food fraud is very important in order to ensure that the means being built to manage food fraud and also those planned are effective and receive all the trust needed from the public. Measures in place must not only be an expenditure for industry but must also represent a value for the consumer.

W1-H.2 De Roos, AJ; Dornsife School of Public Health at Drexel University; *aderoos@drexel.edu*
Is hazard identification a scientific process? Recent evaluations of glyphosate suggest room for interpretation.
Hazard identification, posed as the first step of risk assessment in the National Research Council's 1983 'Red Book', seeks to identify adverse health effects caused by a chemical, by conducting a "weight-of-evidence" evaluation of various types of scientific data. The hazard identification process was recently undertaken for consideration of glyphosate as a potential carcinogen by several agencies, with some divergent conclusions. Glyphosate was classified as a probable carcinogen by the International Agency for Research on Cancer (IARC) in 2015, based on sufficient evidence in experimental animals and limited evidence in human studies, with supportive mechanistic data indicating genotoxicity and induction of oxidative stress. In contrast, later assessments from both the European Food Safety Authority (EFSA) and the European Chemicals Agency (ECHA) concluded that glyphosate is not carcinogenic. Contradictory statements from these agencies have led to sensationalist news reports and confusion among the public. How did the evaluations arrive at such different conclusions? The review procedures of the groups differ, as do their memberships, and not all data were available for all reviews. Nevertheless, the different conclusions seem to stem, to a large extent, from differing interpretation of the same studies. Furthermore, even with interpretations that are similar on the surface (e.g., "limited" evidence of carcinogenicity from epidemiology studies), certain types of information were weighted differently between the review bodies. In my presentation, I will discuss where the evaluations differ in their procedures and conclusions, and I will illustrate differences in interpretation by highlighting specific data from animal, human, and mechanistic studies. Hazard identification for glyphosate will be used as an example of inconsistencies introduced by the inherent need for subjective opinion in weighting scientific evidence.

T2-E.3 Decker, DK; Stimson Center; *ddecker@stimson.org*
Risk Governance for Security: International Challenges for the Nuclear Sector
The Nuclear Security Summits, initiated by former President Barack Obama, highlighted the need to better address risks in the nuclear sector. Parallel to the summits of the heads of state, nuclear operators held official side summits; these Nuclear Industry Summits considered various risks of specific concern to operators, such as cyber. Although the series of summits concluded in 2016, both governments and industry agreed on the need to continue work to improve nuclear security. This presentation will give a brief overview of the summits and the governance challenges facing international organizations tasked by governments for follow-on work and will report on industry's own risk governance challenges and how they are being or should be addressed. Based on interviews with regulators, standards developers, insurers, operators and others, we found that regulatory or standards compliance, e.g., with ISO 90001 or ISO 14001, is not sufficient. Good leadership and oversight are needed to inspire a culture that leads to good performance and security, with this being especially of concern in different national systems. The Stimson Center's nuclear security group is helping the international nuclear industry develop a good governance template that would potentially reduce risks and attendant liabilities (see: https://www.stimson.org/content/demonstrating-due-care-cyber-liability-considerations-nuclear-facilities) and gain benefits from insurers, regulators and the public, if good governance is appropriately demonstrated. This presentation will share some of the initial work toward this board-level risk governance framework, including a discussion of what selected nuclear operators as well as other industries are doing to demonstrate good risk management, with a focus on security and other tail risks.

T4-A.2 Decker, Debra; Stimson Center; *ddecker@stimson.org*
Nuclear Energy Economics: Valuing Strategic Security
The nuclear industry is challenged today by many market dynamics. This includes international deregulation of energy markets making for steep price competition among sources of electric power generation. Some plants in the United States are being closed rather than upgraded for life extensions and added safety requirements. New reactor designs under construction in some countries are inherently safer, something the public and regulators value; but their first-of-a-kind nature have helped cause cost overruns and long schedule delays. This has affected the very viability of large companies like Westinghouse and AREVA. So how should nuclear energy be valued beyond current direct market forces? This presentation will consider that: the benefits of nuclear as a carbon-free reliable baseload electricity source are not calculated into commercial market assessments; the uncertainties of waste disposal make for unclear accounting; and requirements for enhanced safety and security have focused on tail risks with no true actuarial data. Meanwhile, a newly-amended convention on nuclear security places more requirements on nuclear licensees, even as these licensees face evolving cyber risks that they have yet to appropriately value and address. Without public support, US domination of the nuclear power industry looks to be ending. Most nations' nuclear industry is state-owned, and some states such as Russia and China support export operations as strategic investments. This has implications for international security and proliferation. The presentation on costs and risks is based on the work we have been doing at the Stimson Center on nuclear security over the past three years - https://www.stimson.org/programs/nuclear-security.

T2-J.2 Delaney, D; University of Maryland Center for Health and Homeland Security, Carey School of Law; *ddelaney@law.umaryland.edu*

Overcoming the Prominence Effect in Transnational Security Decisions

Senior public officials must frequently decide among competing policy interests that are rooted in complex assessments of morality, the rule of law, politics, and many other things. Whether to intervene militarily to prevent or stop a humanitarian crisis is one example. Decision researchers describe a prominence effect that leads those facing complex policy tradeoffs to decide in favor of the more inherently important, defensible attribute. This article presents prominence as an impediment to faithful application of transnational humanitarian law. It explores opportunities to identify and quantify the law's welfare interests, make those interests more salient to decision makers, and design decision-making environments with greater opportunity to mitigate the prominence effect. Public choice theory, choice architecture, and behavioral ethics are central to this approach. The article also considers these issues from a practitioner's perspective and proposes that federal attorneys be subject to a more rigorous ethics rule on advising public officials about economic, moral, and other dimensions of transnational legal issues.

W2-J.3 Demski, C*; Spence, A; Pidgeon, N; Cardiff University and University of Nottingham; *DemskiCC@cardiff.ac.uk*

Public participation in energy transitions: what we can learn about public attitudes from diverse engagement methods

Increased public participation in energy transitions is thought to foster more inclusive and socially accepted energy policy. Alongside this, the question of public acceptability and preferences with regards to energy choices has received a lot of attention in recent years. These two agendas have led to an array of innovative methods and tools for engaging members of the public, supporting deliberation and decision-making, thus enabling meaningful participation. In our own research we have used deliberative workshops, focus groups, biographical interviews, surveys, experiments and online interactive tools to engage participants with energy transitions issues and elicit their preferences and values. These diverse forms of participation have led to new insights into public preferences for energy system change. They also reveal something about the nature of public preferences and acceptability, which has important implications for approaches to public participation, and the interpretation of outcomes and responses. Here we present analysis comparing public attitudes and preferences for key aspects of energy policy across multiple elicitation methods used in our recent projects. We compare both within individuals (e.g. stated preferences in a survey and in an online interactive tool) as well as across individuals. Through this analysis we show that substantial public ambiguity and uncertainty exists and that attitudes can change depending on framings and context. Importantly, public preferences towards complex issues such as energy transitions need to be conceptualized as being constructed through the process in which participation takes place. Nonetheless, we also find stability in expressed preferences despite the diverse ways we used to foster public participation. As such we discuss why differences might occur (or not) across different modes of engagement, how these might be interpreted, and what implications this has for public participation within energy policy.

W2-K.3 Demuth, JL*; Morss, RE; Jankov, I; Alexander, C; Alcott, T; Nietfeld, D; Jenson, T; National Center for Atmospheric Research; *jdemuth@ucar.edu*

Weather forecasters' use of ensemble-based uncertainty information for communicating risks of extreme weather

The weather community is leveraging improved understanding of atmospheric processes and observations and enhanced computational ability to develop numerical weather prediction model guidance. Further, due to limited predictability of weather, model ensembles--i.e., guidance from multiple models or that uses different initial conditions--are being developed to generate an envelope of possible future states (i.e., forecasts). These future possibilities are used to provide uncertainty information in the form of deterministic outputs from different ensemble members (e.g., multiple forecasts of precipitation amount), or as statistically post-processed probabilities (e.g., a probability density function of different precipitation amounts). Such ensemble guidance is being developed at increasingly higher spatial and temporal resolutions. This guidance has the potential to offer tremendous value to National Weather Service (NWS) forecasters who assess and communicate the risk of extreme weather. Yet, very little is known about when and how forecasters access, interpret, and use this guidance--especially high-resolution ensemble-based guidance. To address these knowledge gaps, participant observations and semi-structured interviews were conducted with NWS forecasters from several forecast offices throughout the U.S. to elicit data pertaining to risks of heavy precipitation, winter weather, and severe convective weather (e.g., tornadoes, flash flooding). Data were collected about forecasters' role and forecast process; current use of model guidance and associated verification information; needs for information from high-resolution ensembles; and interpretations of example products from high-resolution ensembles. This presentation will discuss how forecasters do (and do not) use ensemble-based uncertainty information for communicating these different weather risks and the moderating effects of their expertise, experience, cognitive heuristics, and other factors.

W3-E.3 Denkenberger, DC*; Taylor, AR; Black, R; Pearce, JM; Tennessee State University; *ddenkenb@Tnstate.edu*

Recent Advances in Feeding the Earth in Global Catastrophes

Several catastrophes could block the sun, including asteroid/comet impact, super volcanic eruption, and nuclear war causing the burning of cities (nuclear winter). This represents roughly a 10% probability this century that agriculture would be nearly obliterated. Previous work has shown that it is feasible given cooperation to feed everyone in these scenarios by producing "alternate" food that is not dependent on sunlight, but instead on stored biomass and fossil fuels. Previous work has also shown that preparation for these alternate foods would be a very small cost, so it would be very cost-effective and there is great urgency for this preparation. Continuing work includes estimating the cost of producing the alternate foods during a catastrophe. Additional work has been writing response plans at different levels. Several "war games" have been performed, with revealing results. An organization, Alliance to Feed the Earth in Disasters, has been started to coordinate research and planning work. Since this work demonstrates that people have much to gain from cooperation during a catastrophe, this should promote peace.

M3-A.2 Diaz, D; Electric Power Research Institute; *ddiaz@epri.com*
Quantifying economic risks from climate change: research opportunities and challenges
Climate change poses an extremely wide-ranging set of risks to society that cut across multiple dimensions. Quantifying and aggregating these climate risks is extremely challenging due to the complex uncertainty that pervades the coupled human-earth system, the long time horizon of the problem with temporal dynamics like thermal inertia and other lags, and the heterogeneous nature of climate impacts across regions, sectors, and generations. Nevertheless, estimating the economic damages of climate change is critically important for policy decisions and climate risk management: it tells us how the benefits of reducing greenhouse gas emissions stack up against the costs, as well as the value of spending on climate mitigation relative to other social investments. The social cost of carbon (SCC) is a metric that is increasingly being used to explore trade-offs between the welfare costs and benefits (avoided risks) of climate change mitigation. The SCC value is estimated with integrated assessment models (IAMs) designed for cost-benefit analysis that represent key components of the human and earth system and monetize climate impacts. Current modeling approaches use damage functions to parameterize a simplified relationship between climate variables, like temperature change, and economic welfare. These damage functions are often dismissed due to a number of limitations that we review and synthesize here but could be substantially improved by incorporating recent advances and empirical findings from impacts, adaptation and vulnerability (IAV) research. This, in turn, would substantially improve the robustness of SCC values estimated with these damage functions. This talk will describe the opportunities and challenges associated with integrating these research advances into decision-support integrated assessment models, in the context of the recent National Academy of Sciences recommendations for climate damage functions.

P.93 Diola, MD*; Resurreccion, AC; Fujimura, M; University of the Philippines Diliman and National Institute for Minamata Disease; *mddiola@up.edu.ph*
Human Health Exposure and Risk Assessment of Mercury in Camp 6, Benguet, Philippines
Humans can be exposed to mercury in the environment thru different pathways such as ingestion, inhalation and dermal contact. One of the primary sources of mercury (Hg) emission into the environment is artisanal gold mining. This study aims to estimate the health exposure, daily intake and risk of mercury of the residents in Camp 6, Tuba, Benguet, Philippines, a small community which is known for artisanal mining activities. Hair samples, considered as the best indicators of human mercury contamination, from residents were collected and analyzed for mercury content. Residents were also surveyed to gather socio-economic, demographic, and site-specific exposure data. Residential Hg intake dosage was quantified using Hg measurements from the hair samples of 111 residents. Hair Hg concentrations from the participants range from 0.03 to 24.17 ppm with a geometric mean (GM) of 0.224 ppm. Male residents were found to have significantly higher hair Hg concentrations (GM=0.263) as compared with the females (GM=0.179) suggesting that there are many factors affecting Hg levels in hair such as hormones, occupational exposure, and the amount of fish consumed. It was also observed that miners have significantly higher Hg concentrations as compared to non-miners which signify additional mercury exposure to miners due to direct external exposure to mercury vapour, which may be released during small-scale mining activities. Using Monte Carlo Simulation, daily Hg intake was found to follow a lognormal distribution with a mean, median and standard deviation of 25.66 ng/kg-bw/day, 22.36 ng/kg-bw/day, and 14.48, respectively. The average daily Hg intake dose is within acceptable limit set by US EPA (100 ng/kg-bw/day). This corresponds to a non-carcinogenic risk and hazard index of 0.22, which indicates that the residents of Camp 6, at present, is not potentially at risk and they are not likely to have adverse health effects due to Hg exposure.

T4-C.3 Diola, MBLD; Resurreccion, AC*; Bautista, CC; Quiocho, RE; University of the Philippines Diliman; *acresurreccion@up.edu.ph*
Ecological Risk Assessment of Heavy Metals in Soil, Water and River Sediments in and around Bued River
Heavy metals in the environment may cause harmful effects not only to humans but also to ecological receptors. This study performs an ecological risk assessment at a small scale mining community in Camp 6, Tuba, Benguet, Philippines as part of the Mineral Extraction for Sustainability and Responsibility (MiNERS Project) following the Ecological Risk Assessment Framework established by the United States Environmental Protection Agency (US EPA). This study aims to quantitatively measure risk to non-human receptors due to possible exposure to lead and arsenic in and around Bued River in Benguet, Philippines. Arsenic and lead in soil were detected and observed to range from 3.22-50.72 mg/kg and 50.68-641.21 mg/kg, respectively. Average bioconcentration of arsenic and lead to plants were calculated to be 0.085474 and 0.001472, respectively. Chronic and Acute Hazard Quotients and Hazard Indexes of media receptors were also calculated with exposure variables set to media concentration of the dwelling. Similarly, mentioned parameters were also calculated for terrestrial receptors. Based on the Hazard Quotients and Hazard Indexes, it was found that media receptors will likely to have Moderate Impact affecting sensitive and standard species whereas terrestrial receptors will probably experience Negligible Impact concerning only sensitive species.A spatial analysis was also performed using the Ecological Risk Assessment software Spatial Analysis and Decision Assistance (SADA). With the use of SADA software, contoured ecological dosage maps for broilers and laying fowls are produced. The maps cover all five points where vegetation and soil samples were collected, providing a more graphic illustration for the distribution of intake of receptors with respect to space.

T3-I.2 Dionisio, KL*; Isaacs, KK; Phillips, K; Lyons, D; Brandon, N; Levasseur, J; Hubbard, H; Vallero, D; Egeghy, P; Price, PS; Environmental Protection Agency; *dionisio.kathie@epa.gov*
Human Exposure Model (HEM): A modular, web-based application to characterize near-field chemical exposures and releases
The U.S. EPA's Chemical Safety and Sustainability research program is developing the Human Exposure Model (HEM) to assess near-field exposures to chemicals that occur in various populations over the life cycle of a consumer product. The model will be implemented as a web-based, modular system that will produce estimates of population distributions of chemical exposure by route and releases to the environment. One intended use is to support human health impact assessments in Life Cycle Impact Assessments (LCIAs). The model determines aggregate doses of thousands of chemicals from the use of over 300 categories of consumer products over one year. Fundamental components of the model included in the beta-HEM release are the Residential-Population Generator (RPGen), Human Behavior, product formulation, and Source-to-Dose modules. The HEM model has been built to integrate the fundamental model components in a manner which facilitates ease-of-use for a user. Aggregated and cleaned data sets from other sources (e.g. census data, product composition information, habits and practices for product use) which are required as model inputs are built into the model itself. The model currently supports investigation of >200 consumer product types (formulations only) including >1,000 unique chemicals. By interacting with a simple web tool and specifying only a population of interest (by age and gender) and chemical(s) or product category(ies) of interest, the user can generate a population distribution of aggregate doses to the chemicals identified from the use of consumer products. A user is then able to compare the contribution to aggregate dose from different product category types, and to see how population distribution of dose varies by age and gender. Future plans include incorporating occupational exposures and exposures from articles (e.g. furniture) in the model, and to expand functionality of the web tool with additional options for interacting with model output.

P.145 Dixon , GN*; Hart, PS; Clarke, CE; O'Donnell, N; The Ohio State University; *graham.n.dixon@gmail.com*

Forecasting Barriers to Wide Scale Adoption of Self-Driving Car Technology

Recent advances in automotive technology have made fully automated self-driving cars possible. Despite offering many benefits, such as increased safety, improved fuel efficiency, and greater disability access, public support for self-driving cars remains low. While previous studies find that age and sex influence self-driving car support, factors influencing support likely go beyond these demographic variables. Using a national survey of American adults (N = 1008), we find that age and sex do not significantly associate with support for self-driving car policies when controlling for psychological traits and cultural values. Instead, significant predictors of support included trust in automotive institutions and regulatory bodies, recognition of self-driving car benefits, positive affect toward self-driving cars, and a greater perception that manual-driven cars are riskier than self-driving cars. Importantly, we also find that individualism is negatively associated with support. Thus, people who value personal autonomy and limited government regulation may perceive policies encouraging self-driving car use as threatening to their worldviews. Altogether, our results point to solutions for encouraging greater public support of self-driving vehicles, while also forecasting potential barriers as self-driving cars emerge as a fixture in transportation policy.

W4-E.3 DONG, YUE*; XU, LINYU; Beijing Normal University; *lvcanger@163.com*

Urban agglomeration nitrogen ecological risk assessment based on risk information model in Pearl River Delta

The nitrogen cycle of urban agglomeration ecosystems have been widely altered by human activities which in turn cause the endangerment at the whole city level. Ecological risk assessment(ERA) is capable of modeling and quantifying the potential impact on ecosystems and their components initiated by human disturbance In this study a conceptual conversion of flow currency in network was accomplished i.e. from the material flow to the risk information flow Based on the introduction of control allocation analysis and the estimation of the components' sensitivities to the stressor we developed a new type of network analysis for urban agglomeration ecological risk assessment.so-called risk information-based network model The nitrogen ecological risk information network in urban agglomeration was used as a case study The initial ecological risks were calculated based on the changes of nitrogen and the propagation of resultant risk between all functional components of the ecosystem was tracked By incorporating both direct and indirect ecosystem interactions the risk conditions of the whole ecosystem and its components were quantified and illustrated in the information networks The results showed that (1)on both ecosystem level and component level there were significant differences between integral risk and initial risk after disturbance due to network amplification effect (2)almost all components had multiple sources of risk rather than solely received from the original input source(except the absolute controller who only gives off risks but never receive one from other components) (3)the number of risk flow pathways notably increased from the input situation to network direct situation and to integral situation implicating that the dynamics of the ecosystem are better manifested through a network perspective

P.122 Dotson, GS*; Chosewood, LC; Middendorf, PJ; CDC/National Institute for Occupational Safety and Health ; *fya8@cdc.gov*

Integrating NIOSH Efforts to Protect Workers: Linking Cumulative Risk Assessment, Exposome, and Total Worker Health®

The nature of work has shifted greatly in the last century to reflect changes in the economy, population demographics, and the availability of advanced technologies. The changing nature of work has resulted in a modern work environment that consists of both recognized and emerging occupational risk factors. Occupational health professionals are in need of innovative approaches and tools capable of characterizing the risk workers encounter in the modern work environment. For this reason, the National Institute for Occupational Safety and Health (NIOSH) is exploring the integration of three novel initiatives: 1) cumulative risk assessment (CRA), 2) exposome, and 3) Total Worker Health® (TWH). CRA attempts to characterize the cumulative, or combined, risk associated with co-exposures to multiple stressors. The term exposome refers the exposures of an individual in a lifetime and how those exposures relate to health. TWH is defined as policies, programs, and practices that integrate protection from work-related safety and health hazards with promotion of injury and illness prevention efforts to advance worker well-being. Each of these initiatives reflects independent, but complementary, research programs that focus on better understanding and addressing risk factors that impact worker safety, health and well-being. This poster will: 1) provide an overview of each of these research initiatives; 2) illustrate the links between CRA, exposome, and TWH; and 3) explore the challenges and benefits of integrating the initiatives.

T3-D.3 Drew, NM*; Kuempel, ED; Pei, Y; Yang, F; National Institute for Occupational Safety and Health; *vom8@cdc.gov*

Exploring Categorical Occupational Exposure Limits with a Quantitative Framework to Group Nanoscale and Microscale Particles by Hazard Potency

The large and rapidly growing number of engineered nanomaterials (ENMs) presents a challenge to assessing the potential occupational health risks. An initial database of 25 rodent studies including 1,929 animals across various experimental designs and material types was constructed to identify materials that are similar with respect to their potency in eliciting neutrophilic pulmonary inflammation, a response relevant to workers. Doses were normalized across rodent species, strain, and sex as the estimated deposited particle mass dose per gram of lung. Doses associated with specific measures of pulmonary inflammation were estimated by modeling the continuous dose-response relationships using benchmark dose modeling. Hierarchical clustering was used to identify similar materials. The 18 nanoscale and microscale particles were classified into four potency groups, which varied by factors of approximately two to 100. Benchmark particles microscale TiO2 and crystalline silica were in the lowest and highest potency groups, respectively. Random forest methods were used to identify the important physicochemical predictors of pulmonary toxicity, and group assignments were correctly predicted for five of six new ENMs. Proof-of-concept was demonstrated for this framework, although more comprehensive data are needed for further development and validation for use in deriving categorical occupational exposure limits.

W1-A.1 Duan, X*; Wang, B; Cao, S; Jiang, Y; Wang, L; University of Science and Technology of Beijing; *jasmine@ustb.edu.cn*

Activity patterns of exposure to indoor and outdoor air pollution in Chinese population

Environmental health risks are associated with not only the stress of environmental pollutants but also the characteristics of human exposure. Environmental exposure related human activity patterns, which are usually defined as ways of behavior and time use related to various environmental medium, are crucial parameters in exposure/risk analysis. With the rapid economic development, China is facing with deteriorating environmental situation especially the air pollution problem in some areas. To understand the activity patterns of people exposure to air pollution is prerequisites for China to make risk based policy decisions like standard making and risk control measures. This study focuses on the activity patterns of exposure to indoor and outdoor air pollution in Chinese population based the first Environmental Exposure Related Human Activity Patterns Survey of Chinese Population (Adults) (CEERHAPS-A). Totally 91,527 adults from 9108 villages in 159 counties in 31 provinces were sampled as subjects using a multi-stage cluster random sampling method in which stratified factors are six regions (with different geographical and economic situation), rural/urban and gender. Face to face questionnaires interview was used for each individual subject about time-activity patterns in different environmental media and other related information. Responding rate was 94.6% in this survey, this is about 30% higher compared with former telephone based survey in other countries. We found that Chinese population in urban and rural area spend 12.5% (180min/day) and 17.7% (255min/day) of a day outside respectively (time in vehicle without a roof was included). For most provinces, outdoor time for rural population is longer than urban, except Chongqing and Sichuan. Season is an important factor influences time spend outside. The median value of outdoor time in summer is 1.17 and 1.71 times longer than spring/autumn and winter.

T4-D.3 Ede, JD*; Shatkin, JA; Vireo Advisors, LLC; *jede@vireoadvisors.com*

Important Considerations in the Risk Assessment of DOD Relevant Nanoscale Materials

Nanoscale materials are being incorporated in an increasing number of technologies, but have challenges associated with assessing their safety over traditional chemicals. The US Department of Defense (DoD) has spear-headed several efforts to advance the risk assessment of nanomaterials and nano-enabled technologies. Among these efforts is the development of a framework to evaluate the safety of nanoscale materials by guiding the collection of chemical, physical and toxicological information relevant for nanomaterial risk evaluation. Several resources were created that aided in the development of this framework, and highlight important considerations in the risk assessment of DOD relevant nanoscale materials and nano-enabled technologies. This talk will describe some of these important efforts, their contribution to the framework, and how they help inform the risk assessment of nanomaterials.

T2-D.4 Ekezie, W*; Timmons, S; Siebert, P; Myles, P; Pritchard, C; Bains, M; University of Nottingham, United Kingdom; *winifred.ekezie@nottingham.ac.uk*

Assessment of health-related risk factors in internally displaced person populations living in camp settings in Nigeria

Since 2014, armed conflict in Nigeria has resulted in about 2 million internally displaced persons (IDPs). Generally displaced people, despite the region, live in poor conditions with likely similar basic needs which include food, water, shelter and healthcare. However, risk priorities for IDPs may be unique to specific locations. Our objective was to determine if healthcare and other facilities available to IDPs in camp-like settings in Nigeria met agreed international and national standards. A camp audit was conducted in September 2016 in 9 camps across 7 states where IDPs had settled. An audit tool was developed using the United Nations High Commissioner for Refugees Rapid Assessment FRAME Toolkit and the Collective Center Guidelines, and was directed to camp managers. Data on camp details including population, resources and interventions were collected. The findings were reviewed against the Sphere minimum standards used in humanitarian assistance. Across all the camps 5 of 15 standards assessed were met to some extent, including availability of water and shelter. Sanitation, vaccination, planning, and community involvement standards were unmet in over half of the sites. In 5 camps overcrowding was severe but inadequate provision of waste disposal facilities for excreta solid waste and drainage was observed in all 9 camps. Health program implementations were uneven across the states. IDP leaders responsible for managing camp affairs had no recollection of a needs assessment being conducted. The issues identified suggest likelihood of high risks of water, food and air related diseases; especially malaria, diarrhea and respiratory infections. Due to the dynamic nature of displacement, for optimal protection of IDPs, frequent assessments with active IDP involvement is required by the government and humanitarian aid providers. A joint approach would help reduce health risks, control spread of infectious diseases, and increase service uptake and cost-effectiveness.

W4-A.4 Ellis, SF*; Kecinski, M; Messer, KD; University of Delaware; *ellis@udel.edu*

Produce Irrigated with Various Types of Nontraditional Water: Detecting Consumer Preferences through Cross-Regional Field Experiments

In 2015, approximately 29% of the U.S. was experiencing some level of drought, conditions that are predicted to spread as climate change hastens shifts in the global water cycle. While using traditional sources of fresh water effectively is key to maintaining agricultural output, U.S. farmers are increasingly utilizing nontraditional sources, such as recycled wastewater. However, questions remain about how the public will perceive this practice. Will they look favorably on it, or will they have concerns, perhaps perceiving it as “polluted” or disgusting? This study uses field experiments, involving 600 adult participants, in the U.S. Mid-Atlantic (no drought), U.S. Southwest (drought), and Eilat, Israel (using nontraditional irrigation water for decades) to determine if consumer preferences vary by region (drought impact) and type of nontraditional irrigation water. To assess consumers’ willingness-to-pay (WTP), we presented them with “yes” or “no” options to purchase produce that was irrigated with different types of water (conventional, desalinated, recycled gray, recycled black, recycled produced). Participants earned $10, which they could either keep or use to purchase produce, and were randomly assigned to one of four information treatments—no information about recycled water, positive, negative, and both (randomized order). Results show significant effects with type of nontraditional irrigation water, region, and produce, but not with the information treatments. While participants prefer produce irrigated with conventional water over nontraditional, WTP is higher for produce irrigated with recycled gray (U.S.) and desalinated (Israel) over other types. In the U.S., those who had heard of gray water before participating in the experiment were more likely to purchase produce than others, while individuals who had heard of produced water were less likely. However, in Israel, previous knowledge about nontraditional irrigation water had no significant effect.

P.119 Elmontsri, M*; Banarsee, R; Azeem, M; Imperial College London; *m.elmontsri10@imperial.ac.uk*
Risk Analysis and Patient Safety: A tool for Improvement
The delivery of healthcare process is complex and require integration of different functions and stakeholders to ensure patients are provided with high quality and safe care. Risks that exist in the healthcare environment could lead to significant negative outcomes to the process of care. Statistics of harm done to patients show the untold story of healthcare delivery. The consequences of poor health care delivery are unacceptable. Risk analysis can help healthcare providers to ensure that their services are provided in accordance with the patient's expectations. Risk analysis can be used as an integral tool in the overall governance and management process to ensure that all different types of risks are captured, evaluated, analysed and controlled. Healthcare providers can enhance strengthen their health systems through involving different stakeholders in the process of risk analysis including patients, health professionals, policy makers, families, nurses and administrators. Patient involvement in the risk analysis will also highlight new insights about the process of care as patients have different perception to the different types of risks that exist within the healthcare environment.

M4-A.1 Evans, JS; Hammitt, JK*; Rojas-Bracho, L; Harvard Center for Risk Analysis, Toulouse School of Economics; *jkh@harvard.edu*
Controlling diesel emissions in Mexico City: a benefit-cost analysis
Despite significant improvement in recent years, air pollution in Mexico City remains an important contributor to health and mortality risk. Emissions from diesel vehicles are a significant contributor to air pollution, and these could be mitigated by retrofitting vehicles with emission-control technology or replacing them with newer, cleaner vehicles. We present analysis of the changes in mortality risks, costs, and net benefits of a range of emission-control technologies as applied to vehicles of different types (e.g., buses, small and large trucks) and model years. Preliminary results suggest that many control technologies are cost-beneficial and that reductions in emissions of primary particles dominate, with smaller contributions of reductions in sulfur dioxide and nitrogen oxides. Results are sensitive to uncertainty about the relationship between emissions and concentrations and the economic value of reduced mortality risk.

W1-H.4 Eude, T*; Gangemi, A; Travadel, S; Guarnieri, F; MINES ParisTech, PSL - Research University France and UniversitÃ© Paris Nord France and ISTC-CNR Italy; *thibaut.eude@mines-paristech.fr*
The Deepwater Horizon disaster; data and causality from the investigation reports revisited through ontologies
Adopting an expert-based approach to study data on the Deepwater Horizon accident, we show that researches on disasters and risk analyses might be jeopardized by a lack of critical view on data sources and crucial social mechanisms that led to the accident might be obscured by the complexity of data and their contradictory analyses. Our study pinpoints two epistemological issues illustrating the social construction of knowledge: the need to elucidate causality expressions in the investigation reports and the management of massive datasets, from which discrepancies eventually surface. Concerning causality, we acknowledge its diversity, ranging from "logical" to "counterfactual" or "historical" causation. Each carries specific consequences in terms of knowledge and inferred preventive actions. Also, although accident investigations are conducted according to investigative methodologies, the conclusions depend largely on the authors' assumptions on the physical and social world. This questions the findings of industrial accident studies built on a limited number of uncharted sources. To tackle these issues, we propose a methodology to record and assess the available knowledge on a given accident, in the form of a knowledge graph. This approach takes into account the assumptions supporting the findings of investigation reports. The technological framework is based on an extension of the DOLCE DnS UL semantic web ontology, modified to fit research on disasters, populated using the formal knowledge extraction tool FRED applied to investigation reports. We illustrate our methodology with an analysis of the official conclusions on the Deepwater Horizon case. The accident was analyzed through more than 32 investigation reports; Our aim is to provide the risk analysis community with a tool to manage the integrity, robustness and reliability of data sources, as well as to critically assess what is known and what needs further understanding regarding the accident causation.

W4-K.5 Evans, B; Odisee University College and UniversitÃ© Saint-Louis in Brussels
Understanding the Role of Trust in Risk Perception
As technologies develop beyond our understanding and risk perceptions alienate a vulnerable and increasingly technophobic population, we find ourselves in a world where complex risks are being imposed on communities demanding simple solutions. Social media communities, rejecting the authority of the experts, are rallying around gurus who build trust through reassurance of certainty and simplicity of solutions: we can feed the world without agri-technology, cure cancer through juicing and solve climate change with efficient lightbulbs. Risk perception is a non-rational process, normatively driven with a justified illogic built around benefits identification. People afraid of pesticides will readily toss back large mugs of coffee; those who refuse vaccinations will happily inject Botox into their faces; and chemophobes terrified of endocrine disrupting chemicals take birth control pills or HRTs every morning. As our benefit-driven narratives influence our risk acceptance, we need to better understand how benefit perceptions are integrated. A proper management of risk perception requires a clear process of benefit communications. This entails a proper understanding of trust-building concepts and the public need for fear narratives. In the end, it all comes down to trust, an emotional concept whose tools will need to be better defined.

W3-H.3 Evers, EG*; Pielaat, A; Smid, JH; van Duijkeren, E; Vennemann, FBC; Wijnands, LM; Chardon, JE; RIVM The Netherlands; *eric.evers@rivm.nl*

Comparative exposure assessment of ESBL-producing Escherichia coli through meat consumption

The presence of extended-spectrum β-lactamase (ESBL) and plasmidic AmpC (pAmpC) producing Escherichia coli (EEC) in food animals, especially broilers, has become a major public health concern. The aim of the present study was to quantify the EEC exposure of humans in The Netherlands through the consumption of meat from different food animals. Calculations were done with a simplified Quantitative Microbiological Risk Assessment (QMRA) model. The model took the effect of pre-retail processing, storage at the consumers home and preparation in the kitchen (cross-contamination and heating) on EEC numbers on/in the raw meat products into account. The contribution of beef products (78%) to the total EEC exposure of the Dutch population through the consumption of meat was much higher than for chicken (18%), pork (4.5%), veal (0.1%) and lamb (0%). After slaughter, chicken meat accounted for 97% of total EEC load on meat, but chicken meat experienced a relatively large effect of heating during food preparation. Exposure via consumption of filet americain (a minced beef product consumed raw) was predicted to be highest (61% of total EEC exposure), followed by chicken fillet (13%). It was estimated that only 18% of EEC exposure occurred via cross-contamination during preparation in the kitchen, which was the only route by which EEC survived for surface-contaminated products. Sensitivity analysis showed that model output is not sensitive for most parameters. However, EEC concentration on meat other than chicken meat was an important data gap. In conclusion, the model assessed that consumption of beef products led to a higher exposure to EEC than chicken products, although the prevalence of EEC on raw chicken meat was much higher than on beef. The (relative) risk of this exposure for public health is yet unknown given the lack of a modelling framework and of exposure studies for other potential transmission routes.

W4-D.2 FAN, SW; Central University of Finance and Economics; *fsw04.thu@gmail.com*

How command-and-control system works in China's environmental protection: an empirical study of Two Control Zones policy of China

Over the past four decades, China has witnessed an unprecedented economic growth which comes at the cost of heavy environmental pollution. Due to excessive coal-burning, sulfur dioxide (SO2) becomes a major air pollutant which poses serious threats to public health and ecosystems. In order to mitigate the hazards caused by SO2, a policy named "Two Control Zones" (TCZ) characterized by the command-and-control system was established. According to the TCZ policy guideline, 162 out of 286 prefectural cities were assigned to be TCZ cities that were imposed stricter environmental regulations than the non-TCZ regions. The objective of this research is to evaluate the effect of TCZ policy and demystify the mechanisms behind it. My research is based on empirical work, conducting a DID (difference-in-difference) regression analysis to estimate the causal effect. The city-level data including the generated and emitted amounts of SO2, NOx and dust, social-economic as well as local governors' statistics from 2011 to 2013 are collected. The preliminary results indicate that the emitted SO2 rather than generated SO2 were significantly curtailed in TCZ cities after 2012. The robustness checks find no similar patterns in terms of NOx and dust pollutants. The target-based performance evaluation is proved to be effective to facilitate local governments to invest more efforts on environment protection. Moreover, those local governors who had longer official tenure are found to have more incentives to exert stricter regulation on SO2 emissions. This research seeks to shed light on how command-and-control system works in environmental risk governance in China.

W1-C.2 Fanaselle, W*; Pouillot, R; Liggans, G; Williams, L; Van Doren, J; Federal Government/ U.S. Food and Drug Administration ; *Wendy.Fanaselle@fda.hhs.gov*

Restriction of recently ill food-preparation employees in retail food establishments: Evaluation of risk assessment results on foodborne norovirus transmission

In 2017, an FDA risk assessment evaluated the risk associated with norovirus transmission to consumers through food contaminated by infected food employees in retail food establishments. The assessment focused on the risk of norovirus transmission from ill or recently ill food employees preparing foods, and evaluated the potential public health impact on viral transmission from ill or infected food employees, based on compliance with exclusion and prevention strategies. Some retail food establishments use a public health intervention strategy called "restriction" that involves limiting work activities of recently ill food employees and is a recommendation in the FDA Food Code (§2-201.12). In this presentation, we will discuss further evaluation of the 2017 risk-assessment model, regarding the public-health impact of restriction; specifically, examining different applications of limited hand contact in retail food establishments, handwashing frequency, glove use, and bare-hand contact of non-food-contact equipment for the restricted food employee. We evaluated the risk to consumers from restricted food employees who are asymptomatic or who return to work before their symptoms end. The quantitative model uses a discrete-event framework that allows descriptions of various consecutive tasks of food employees. The results provide further insights and information for risk managers to consider when developing strategies for limiting transmission of foodborne norovirus illness in retail food establishments.

T2-F.1 Fang, Y; Sansavini, G*; ETH Zurich; *sansavig@ethz.ch*

Emergence of Antifragility by Optimum Postdisruption Restoration Planning of Infrastructure Networks

A system is antifragile if its performance improves as the result of exposure to stressors, shocks or disruptions. This behavior is typical of complex systems and it is not usually exhibited by engineered technical systems. In fact, technical systems can display anti-fragility when new investments are allocated, e.g. after disasters. This study proposes an optimization model for the post-disaster restoration planning of infrastructure networks, taking into account the possibility of combining the construction of new components and the repair of failed ones. The strategic goal is to determine the optimal target system structure so that the performance of the target system is maximized under the constraints of investment cost and network connectivity. The problem is formulated as a mixed-integer binary linear programming (MILP) and an efficient Benders decomposition algorithm is devised to cope with computational complexity of its solution. The proposed approach is tested on a realistic infrastructure network: the 380kV power transmission grid of Northern Italy. The results show that the restored network can achieve an improved functionality as compared to the original network if new components are constructed and some failed components are not repaired, even when the former is much more expensive than the latter. Therefore, antifragility provides an opportunity for the system to meet future service demand increases, and a perspective under which disruptions can be seen as chances for system performance improvements.

T3-F.4 Feighner, B; Mitchell, JB*; Michigan Department of Environmental Quality, Michigan State University; *jade@msu.edu*
Discussion of Lessons Learned from Flint about Risk Assumptions in the Lead and Copper Rule
The Flint Water Crisis brought national attention to the risks associated with aging infrastructure and inadequate drinking water treatment. The progression of events that resulted in high lead levels at customer taps will be examined. The numerous chemical and physical factors, many of which are not well-known, will be discussed. The extraordinary response efforts and large numbers of tap samples for lead analysis in Flint provide important data that challenges certain risk assumptions in the Safe Drinking Water Act under the Lead and Copper Rule (LCR), specifically with respect to prioritized sampling locations and effective corrosion control treatment. These assumptions will be discussed along with proposed changes for the LCR.

T3-C.3 Ferretti, V; Guney, S; Montibeller, G*; von Winterfeldt, D; Loughborough University; *g.montibeller@lboro.ac.uk*
How to Debias Overprecision in Probability Elicitations?
The appraisal of complex policies often involves alternatives that have uncertain impacts, such as in health, counter-terrorism, or urban planning. Many of these impacts are hard to estimate, because of the lack of conclusive data, few reliable predictive models, or conflicting evidence. In these cases, decision analysts often use expert judgment to quantify uncertain impacts. One of the most pervasive cognitive biases in those judgments is overconfidence, which leads to overprecision in the estimates provided by experts. In this paper we report on our findings in assessing the effectiveness of best practices to debias overconfidence in probabilistic estimation of impacts. We tested the use of counterfactuals, hypothetical bets, and automatic stretching of ranges in three experiments where subjects were providing estimates for general knowledge questions. Our findings confirmed results from previous research, which showed the pervasiveness and stickiness of this bias. But it also indicated that more intrusive treatments, such as automatic stretching, are more effective than those merely requiring introspection (e.g. counterfactuals).

M4-H.2 Fernandes, F*; Lin, XG; Duffield, SM; Codyre, J; Civil Aviation Safety Authority, Australia; *xun.lin@casa.gov.au*
Introduction to sector risk profile methodology – application to civil aviation sectors
Sector risk profile (SRP) is a process of presenting a risk picture specific to a sector by assembling all available characteristics of the sector and exposure to events, estimating the likelihood and severity outcomes and crafting optimal risk responses. SRP is an essential part of risk management for an aviation safety regulator. The SRP methodology adopts ISO31000 Risk Management Standard. It contains three phases. Phase 1 establishes the sector context and state through data analysis. A workshop is conducted with participants include sector operators, safety regulator and sector stakeholders. At this workshop sector objectives are developed and a SWOT analysis is developed which leads to the identification of hazards for the sector and the risk associated with those hazards. The principal task in Phase 2 is to transform the hazard table into a risk register. At a Phase 2 workshop the participants engage to develop a sector risk register. The register identifies causes, impacts and existing controls for each risk, along with an evaluation of the current likelihood, consequence and risk rating. If the rating is outside the ALARP limits additional risk treatments are identified with accountability assigned to owners to treat the risk. The residual risk is assessed assuming treatments in place. Sector operators who did not participate in the workshops are encouraged to provide feedback. Phase 3 consists of sector assurance mapping, including a gap analysis between the sector risk register and each operator's risk register. This assurance mapping contributes to the regulator's surveillance program including the development of safety performance indicators. Phase 3 includes a risk review to incorporate changes in environment, existing and new controls and emerging risks. The SRP methodology will be demonstrated in detail through an application for civil aviation sector. However, SRP methodology is not limited to aviation, it can be applied to any industry sector.

M4-G.4 Ferson, S*; O'Rawe, J; University of Liverpool and Applied Biomathematics; *sandp8@gmail.com*
Quick Bayes Offers Performance Guarantees and Easy Risk Communication
Quick Bayes is a variant of robust Bayesian analysis that is especially convenient for risk analysts because it does not require them to choose a prior distribution when no prior information is available (the noninformative case). In repeated use, the quantitative results from Quick Bayes exhibit frequentist coverage properties consistent with Neyman confidence intervals at arbitrary confidence levels, which conventional Bayesian analyses generally lack. These coverage properties mean that results from Quick Bayes exhibit guaranteed statistical performance that is especially attractive to engineers and policymakers. The numerical results from Quick Bayes can be matched to Gigerenzer's natural frequencies for easy and intuitive communication to decision makers and the lay public. We illustrate the application of the Quick Bayes approach in the context of fault tree analysis in which we can characterize an event probability estimated from an imperfectly specified fault tree with a terse, natural-language expression of the form "k out of n", where $0 \leq k \leq n$. These natural frequencies condense both the probability and analyst's epistemic uncertainty about the probability into a form that psychometric research suggests will be intelligible to humans. Preliminary evidence collected via crowd-sourced science shows that humans natively understand the implications of these natural frequencies, including what the size of n says about the reliability of the probability estimate.

W4-B.4 Findlater, KM*; Kandlikar, K; Satterfield, T; Donner, SD; University of British Columbia; *k.findlater@alumni.ubc.ca*

The unquestioned assumption of equivalence in farmer perceptions of weather and climate change risks

The literature on climate resilience emphasizes that climate-adaptive planning should be mainstreamed into existing decision-making processes as a matter of risk management best practice. However, it is often assumed that commercial farmers have done so already, intuitively treating climate change risks as an equivalent, long-term extension of risks stemming from weather and climate variability. In fact, there is only tangential evidence that they perceive and respond to these categories of risk similarly. A small but growing number of in-depth case studies suggests that they do not. This paper seeks to quantitatively test the proposition that farmers treat the two risks as equivalent. Using a risk ranking exercise in a national survey of South African commercial grain farmers – a group with the demonstrated incentive, capacity and willingness to adapt to climate change – we found that weather and climate change were not perceived similarly. Individual farmers tended to prioritize one over the other, but the risk that they prioritized varied; similar proportions of farmers selected each risk as a high priority and not the other. In ordinal regression, the ranks of the two risks were driven by different demographics, farm characteristics and farming practices. These differences were often amplified when we analyzed the distance between the weather and climate change ranks using multivariate linear regression. The findings suggest that the assumption of equivalence between weather and climate change risks is inaccurate, at best. This suggests a major, unrecognized risk communication challenge for climate scientists and policymakers. Farmers will have difficulty mainstreaming climate change adaptation under risk communication regimes that assume the integration of weather and climate change in decision-making. They are therefore less likely than previously thought to respond to climate change risks rationally and proactively in transforming their farming practices.

P.158 Findlater, KM*; Peterson St-Laurent, G; Hagerman, S; Kozak, R; University of British Columbia; *k.findlater@alumni.ubc.ca*

Perceptions of risk and uncertainty in climate-adaptive forestry

Climate change is increasingly impacting ecosystems worldwide, notably by shifting species distributions and increasing the frequency and severity of natural disturbances. In the forest sector – economically vital to the province of British Columbia (BC), Canada – climate-adaptive practices can address the risk that trees planted today will be mismatched with future local climates. Ongoing advances in genetics are enabling forward-looking and genomically-informed reforestation programs that assist with the migration of trees to better match predicted future climates and better withstand changes in pest and pathogen regimes. However, public and stakeholder perceptions of risk and uncertainty in reforestation strategies like assisted gene flow (within species range) and assisted migration (beyond species range) are largely unknown, with the potential for hesitation, concern and resistance to climate-adaptive practices stemming from biotechnological advances. This study seeks to understand public and stakeholder conceptions of risk and uncertainty in climate-adaptive forest management practices, broadly, and genomically-informed reforestation, in particular. It evaluates perceptions of such practices in BC through structured focus groups (stakeholders) and an online survey (public). This mixed-methods approach provides a rich understanding of the drivers of perceived risk and uncertainty created by climatic and technological changes, and important sources of misalignment with experts' perceptions. In this talk, we present preliminary results about how the malleability of support might play out in a deliberative context. In particular, the survey data suggest that even brief consideration of ecological, economic and scientific trade-offs shifts participants' expressed risk perceptions. These findings will help policy-makers better understand sociocultural and political barriers to climate-adaptive practices in mixed natural/managed landscapes.

T4-J.1 Finkel, AM; Univ. of Pennsylvania and Univ. of Michigan; *afinkel@law.upenn.edu*

Disinfecting Cost-Benefit Analysis of Hidden Value-Laden Constraints

At every phase of scoping, circumscribing, conducting, refining, and using a cost-benefit analysis (CBA), value-laden judgments seep into the work. The existence of these judgments is not the problem; that they are hiding, or openly masquerading as neutral or "natural" assumptions, is. This presentation develops a typology of 10 phases in CBA; it offers selected examples from each phase showing where value judgments are injected, how each is hidden so that the public fails to see that there are preferences driving the analysis, and how various alternative (equally value-laden, just different) assumptions could be substituted for each. I identify four common ways in which hidden value judgments permeate evidence-based decision-making: (1) analysts refuse to "assign differential weights" to different people or effects, which forces them to be valued exactly equally; (2) they report only the "best estimate" of some quantity, which imposes strict preferences upon the decision; (3) they treat "unquantifiable" effects outside the decision calculus; and (4) they impose linear functions upon variables that have more complicated relationships. Because, as I show, it is impossible to replace any of these value judgments with something truly value-neutral, it is far better for agencies to publish a list of their hidden values—much as they've been urged by the National Academy of Sciences and others in the past to publish lists of (and rationales for) the science-policy default assumptions they also use.

M4-G.5 Finkel, AM*; Gray, GM; Univ. of Pennsylvania/Univ. of Michigan (A.F.); George Washington Univ. (G.G.); *afinkel@law.upenn.edu*

Taking the Reins: How Decision-Makers Can Stop being Hijacked by Uncertainty

Several decades after the mechanics of quantitative uncertainty analysis (QUA) for risk assessment and regulatory cost analysis were developed and refined, QUA still rarely reaches the minds of decision-makers. The most common justification for this situation is that "decision-makers want a number, not a set of statistical distributions." This may be an accurate assessment of their druthers, but one obvious though perhaps impractical retort is to say that if decision-makers insist on misleading point estimates, then we need new and better decision-makers. This presentation offers a way out of this dilemma. Decision-makers do not have to understand (or even receive) all the information contained in a complete QUA, but they do have to drive the QUA. They need to instruct analysts which phenomena to analyze (parameter uncertainty, model uncertainty, interindividual variability, offsetting effects, and the value of future uncertainty reductions), they need to insist that uncertainties in cost be treated as exactly as important as uncertainties in risk, and — even more importantly — they need to instruct analysts which estimator(s) to seek, report, and explain. Here we offer 12 detailed principles to guide decision-makers into a new relationship with risk and cost analysts — 12 observations about how "eyes wide open" point estimates can vastly outperform point estimates handed to the decision-maker without context, justification, or honesty about the value judgments they enforce upon the decision. A decision-maker who explains "I chose Option A because its benefits of 2.345 exceed its costs of 1.234" can be replaced by a dollar-store calculator. We need decision-makers who can say "I chose Option A because the spectrum of benefits it likely offers, to these citizens, considering the range of costs it likely imposes, makes it a superior choice to any other." QUA, performed carefully and following clear policy instructions, can empower decision-makers to earn their influential roles.

M2-D.4 Finster, M*; MacDonell, M; Chang, YS; Argonne National Laboratory; *mfinster@anl.gov*

Practical considerations for recycling mercury-impacted scrap metal

The recycling of mercury-impacted scrap metal can emit measurable amounts of mercury; however, existing characterization data are insufficient to fully understand the origin, key sources, and concentrations of mercury within scrap metal and the recycling process. Currently, industry-specific mercury emissions guidance values exist for many known anthropogenic mercury sources (e.g., coal-fired utility plants and waste incinerators), but are largely nonexistent for scrap metal processing and recycling facilities. Given the lack of significant guidance for recycling mercury-impacted scrap metal, these other values can provide a useful framework to potentially guide the development of mercury acceptance and release criteria/limits for recycling facilities. Of particular importance to occupational health and safety professionals, additional information on the origin, source, nature, and extent of mercury-impacted metal in scrap is important for assessing measures to protect scrap metal recycling workers from potential health and safety hazards that might be posed by the processing and melting of mercury-impacted metal.

W1-K.1 Fizer, C*; MacDonald-Gibson, J; Bruine de Bruin, W; University of North Carolina; *jackie.macdonald@unc.edu*

Barriers to Private Well and Septic Management in Under-Served Communities: An Analysis of Homeowner Decision Making

Some African-American communities in the American South are excluded from nearby municipal water and sewer services and therefore rely on private wells and septic systems. These communities are disproportionately exposed to water contaminants and have an elevated risk for poor health outcomes. Outreach efforts encouraging proper well testing and maintenance are needed to protect health in these communities. To identify knowledge gaps and misconceptions that such outreach programs should target, we conducted semi-structured interviews with 18 residents of such communities in Wake County, North Carolina. Only one interviewee tested and inspected their well annually as recommended by the county health department. Interview results suggest that testing is inhibited by lack of awareness of well maintenance guidelines, over-reliance on sensory information, poor understanding of exposure pathways, and cost. Links between private septic systems, well water contamination, and health are poorly understood, hindering proper septic maintenance. These findings highlight the need for risk communication materials targeting at-risk communities.

M4-G.3 Flage, R; University of Stavanger; *roger.flage@uis.no*

Risk assessment assumptions – Uncertainty and bias

Making assumptions is inevitable in any type of risk assessment and in modelling in general. Assumptions are thus a key, generic risk assessment concept. The results of a risk assessment is valid conditional on the assumptions. In practice, the specification of an assumption can have a more or less strong justification, and there may be greater or lesser degree of uncertainty related to whether the assumption will hold true. Moreover, unless specified to reflect the analyst's "best judgement", an assumption can have either a conservative or an optimistic bias. This talk will review different ways to frame and define assumptions in a risk assessment context, discuss the concepts of uncertainty and bias in relation to assumptions, and present and discuss some recently proposed methods for handling uncertain assumptions in risk assessment.

P.101 Fleischer, JG*; Whittaker, MH; ToxServices LLC; *jfleischer@toxservices.com*

Toxicological risk assessment of toluene and formaldehyde in a consumer product packaging material

Manufacturers/distributors causing exposures to substances included on California's Proposition 65 list of substances known to cause cancer or reproductive toxicity must provide specific warnings to consumers. Notices of Violation are issued for an increasing variety of consumer products that may cause exposure but do not provide the warning. ToxServices calculated exposure to formaldehyde and toluene emitted from a multi-layered consumer product packaging material to determine if exposure levels exceed established Proposition 65 safe harbor levels of 40 µg/day (formaldehyde gas) and 13,000 µg/day (inhaled toluene). Exposures below a carcinogen's NSRL or a reproductive toxicant's MADL do not pose significantly increased cancer or reproductive toxicity risks and therefore have safe harbor from Proposition 65. We conducted two-compartment, quantitative inhalation exposure assessments using California Code of Regulations methodologies. Analytical testing (headspace GC for toluene, UV-VIS spectrophotometry for formaldehyde) measured detectable levels of both substances. We calculated air concentrations of formaldehyde and toluene in the direct area of use of the packaging material and in the entire home for residents ranging in age from infancy to adulthood, including pregnant women. Additional variables included in age- and life stage-specific exposure calculations included air change rate, packaging material life-span, whole home and room air volumes, inhalation rate, and daily exposure duration. Formaldehyde exposure ranged from 0.0106 µg/day (0-2 year olds) to 1.43 µg/day (>18 year olds), with a lifetime average exposure of 1.93 µg/day. Toluene exposure ranged from 0.00432 µg/day (pregnant women) to 0.77 µg/day (>18 year olds). Since daily formaldehyde exposure is less than the 40 µg/day NSRL and daily inhaled toluene exposure is less than the 13,000 µg/day MADL, the distributor of the packaging material has safe harbor from Proposition 65 warning requirements.

W3-D.2 Flores-Serrano, RM*; Pérez-Casimiro, G; Álvarez-Florentino, E; Ramírez-González, A; Ruiz-Piña, HA; Rendón-Von Osten, J; Aké-López, R; Flores-Guido, JS; Universidad Nacional AutÃ³noma de MÃ©xico, Universidad AutÃ³noma de YucatÃ¡n, and Universidad AutÃ³noma de Campeche;
rfs@pumas.iingen.unam.mx

Management of pesticides and their containers in a irrigation district in Yucatan, Mexico: risk factors for human health

The presence of pesticides in the state of Yucatan has been poorly studied due largely to the fact that its agricultural production is low because of its shallow and stony soils. For this reason, the present study was proposed with the following objectives: 1) to determine the types of pesticides used by the farmers in the municipality of Maní, Yucatán, b) to assess the pesticide use practices and the management of the empty containers, and c) to identify the risk factors for human health associated with these practices. A common practice among farmers is the disposal of the containers directly in the soil of their crop plots, therefore the methodology consisted in selecting 5 plots, in which the containers were counted and classified by type of pesticide. Surveys were conducted on pesticide application practices and the management of empty pesticide containers. The surveys were applied to the owners of 7 of the plots (14% of the plots constituting the irrigation district). The results indicated that the pesticides used were: glyphosate (51.86%), paraquat (35.68%), 2-4, D dichlorophenoxyacetic acid (5.47%), chlorpyrifos (2.07%), methamidophos (1.24%), methamyl (1.24%), captan (0.4%) carbofuran (0.4%), and metalaxyl (0.4%). Surveys on pesticide management practices indicated none or minimal protection when applying pesticides, as well as in the management of work clothes impregnated with pesticides. In the same way, the surveys indicated that the main practice in the handling of the containers is the direct disposal in the soil (within their work plot) and the open burning. These practices are a major risk factor for farmers' health, as pesticides enter their bodies through ingestion, inhalation and dermal contact during the application of pesticides. When the containers ar burned, inhalation is the main route of contact, and when the containers are disposed in the soil, there is risk for the groundwater pathway (residues of pesticides washed from the containers to the soil and infiltrating into the aquifer).

T2-G.2 Florin, MV; van de Poel, I*; TU Delft;
marie-valentine.florin@epfl.ch

Risk Governance and "Responsible Research and Innovation"

To increase its relevance to some of the challenges that managers face, risk governance must constantly adapt to objectives and priorities of organisations. One of those priorities, at least in the European Union, is that organisations develop research and innovation in a way that is "responsible". Responsible Research and Innovation (RRI) is thus defined by the EC Horizon 2020 programme as "an approach that anticipates and assesses potential implications and societal expectations with regard to research and innovation, with the aim to foster the design of inclusive and sustainable research and innovation". How can risk analysis and governance support RRI? The links between RRI and risk governance and the contribution that risk governance can make to the RRI priority and challenge will be addressed in this presentation. Two specific aspects will be developed: - how the field of risk governance can provide substance to the concept of RRI. Here we will discuss how risk governance can contribute to enhancing innovation, rather than constraining it, and how innovation can contribute to reducing risks; - how to embed RRI in the practice of organisations. Here we will discuss questions that researchers can consider to ensure that their work is in line with expectations from both risk governance and RRI.

T3-G.1 Florin, MV*; Pfeiffer, S; IRGC, EPFL;
marie-valentine.florin@epfl.ch

How can organisations deal with systemic risks?

IRGC is developing guidelines for the governance of systemic risks. This on-going work suggests a process for identifying and dealing with uncertain and sudden negative consequences when risks cascade in complex systems, focusing on what organisations can do to prepare and develop response strategies. Interconnectivity between systems is one of the defining and determining features of our modern world, which is becoming ever more complex and dynamic. While this interconnectivity can increase system efficiency and service delivery, it can reduce resilience and expose the various layered systems to risk of shocks, stresses or even system failures and collapses. Shocks to interconnected systems may cause feedback and cascading effects, extreme events, and unwanted side effects. A better understanding of the dynamic of risks in complex systems is essential for decision makers in order to prepare their organisation for future challenges, when disruptions are often unforeseen and transitions are in progress. In particular, the presentation will discuss the draft IRGC guidelines, developed as a set of overarching recommendations for recognizing and navigating the undergoing transitions that come with change. The guidelines will thus also address the positive side of transitions in complex adaptive systems, focusing on adapting or transforming the organisation to the system in which it will operate in the future, in view of avoiding undesirable consequences of change, or triggering other desirable changes.

P.8 Florin, MV*; Linkov, I; Trump, B; IRGC, EPFL;
marie-valentine.florin@epfl.ch

This is the titleThe IRGC approach to risk and resilience assessment – the IRGC Resource Guide on Resilience

Responses to disasters, both natural and technology-related, often show the limitations of traditional risk assessment and management. In the context of risk, resilience has been discussed as both a supplement and an alternative to conventional risk management. IRGC describes resilience building as a possible risk management strategy when there is much uncertainty about impacts and the need to prepare to cope with unexpected shocks. Both governments and industry explicitly call for resilience-based risk management. The IRGC annotated 'Resource Guide on Resilience' is a collection of authored papers about resilience, guiding to a selection of best literature sources. It highlights both the variety of approaches to resilience as well as common features and dynamics. It stresses the importance of including resilience as an important component of the risk governance process, including in research, policy, strategies, and practices. It maps risk and resilience in the context of governance, and reviews how resilience has been manifested, managed and measured in different fields and sectors. IRGC's objective with the guide is to help scientists and practitioners working on risk governance and resilience evaluation and building. It does so by providing background information on the various perspectives and tools for integrating risk and resilience, and for measuring resilience and the effectiveness of actions taken to build it.

P.128 Fortt, A*; Gutierrez, V.V; Universidad Diego Portales and GreenRiver; *antonia.fortt@greenriver.cl*

Influence of industrial activities emissions on mortality rates in Chile: An ecological study.

Chilean population is exposed to significant pollution from different industrial activities, mainly mining, agriculture, energy industries, power plants, paper production, and transportation. The aim of this research is to determine if higher cancer mortality rates are associated with the presence of these different industrial activities along the country. Following the method used by Ruiz-Rudolph et al (2016), we conduct an ecological study that uses Chilean communes as small-area observation units to assess cancer mortality. Public data for mortality rates is available at the commune level, which are the smallest units of local administration in Chile. For each commune, data on cancer mortality were aggregated for the 2000-2016 period. Public database are available for pollution emissions for different industries. The impact of the pollution from different economic activities on cancer mortality rates is estimated using a model proposed by Besag, York, and Mollie (BYM) (Besag et al., 1991), wich has been used extensively in spatial epidemiology. Significant higher rates of cancer mortality were observed in communes with large industrial emitters.

T3-D.1 Fox, MA; Spicer, KE*; Susi, P; Chosewood, LC; Johns, DO; Dotson, GS; Johns Hopkins University, Murray State University, Avanti Industrial Hygiene, and The National Institute for Occupational Safety and Health; *kspicer@murraystate.edu*

Implications of applying cumulative risk assessments to the workplace

There are many changes influencing work, workplaces and workers in the US. Broad changes in the economy have caused shifts in the main types of work from manufacturing to services. Other industries, such as construction, remain important but demographics, tools, processes, materials and the way work is organized is changing and will likely continue to change. Work and workplace changes have tracked with a decline in unions and associated advocacy for improved safety and health conditions. Risk assessment has been the primary method to inform occupational and environmental health policy and management for many types of hazards. Although developed and applied typically to address one hazard at a time, risk assessment frameworks and methods have advanced toward cumulative risk assessment (CRA) recognizing that exposures to a single chemical or non-chemical stressor rarely occur in isolation in the ambient environment or the workplace. To date, CRA has been primarily applied to address exposures in the ambient and social environments to evaluate ecological or general population health. Little attention has been paid to the impacts of cumulative risks in occupational environments. We explore: 1) how CRA approaches may change the roles of workers and employers as they pursue improved health and safety; 2) barriers and benefits to adoption of the CRA approach among workers; and 3) the challenges and opportunities that might arise for employers with adoption of a CRA approach. Application of CRA should result in better understanding of complex exposures, health risks and related modifying factors, with the possibility of attributing risk across multiple domains. Addressing exposures in this comprehensive manner should lead to the development of more effective controls and improved safety and health risk management overall. A range of policy and practice options to address the barriers and challenges identified are presented.

T3-A.1 Fraas, A*; Lutter, R; Wietelman, D; Porter, Z; Wallace, A; Resources for the Future ; *lutter@rff.org*

Assessing the Energy Paradox in Reasonably Competitive Markets: New Evidence from Heavy Duty Trucking

The EPA and the DOT recently issued a final rule mandating that heavy-duty trucks meet certain new fuel efficiency standards. The supporting economic analysis concluded that the fuel savings to truckers would greatly exceed the costs of acquiring the new technology, implicitly raising questions about the efficiency of seemingly competitive markets. The economic analysis also suggested that one reason for this result could be that owners of trailers would incur the costs of some of the fuel efficient devices, while owners of tractors, who are often independent entities, would enjoy the savings. This paper analyses new data from 2015 to 2017 to test the association between split ownership and use of fuel efficient devices in a model that also controls for a variety of characteristics of the firm owning the tractor and the market where it operates.

T3-A.2 Fraas, AG; Miller, SE*; George Washington University; *sofiemiller@gwu.edu*

Assessing the Risk of Product Failure in Regulatory Analysis: Case Studies from Energy Efficiency Lawsuits

Federal regulation in the energy, environmental, and product safety areas often requires the adoption of new technologies. However, incorporation of a new technology in products is not without risks, as evidenced by several examples of notable product failures (e.g., Whirlpool clothes washers and Subaru engines). In such cases, the costs and benefits to consumers may vary significantly from initial agency estimates. This presentation includes several case studies of products that are regulated for energy efficiency and discusses 1) regulatory agency treatment of the risk of resulting product failures, 2) the nature of identified product failures, and 3) the effectiveness of market and legal institutional responses to these problems. Ex post responses include manufacturer warranties, market information channels like Consumer Reports, and legal remedies like class action lawsuits. Finally, we consider the extent to which the risk of potential product failures deserves further consideration in the rulemaking process and in prospective benefit-cost analyses.

M4-K.5 Frey, HC; North Carolina State University; *frey@ncsu.edu*
Denying Denialism: Uncovering the Methods and Institutions of Climate Change Denial
A denialist is a person who refuses to admit the truth of a concept that is supported by the majority of scientific evidence. Denialism typically contains a few or more of the following institutional or methodological elements: (a) stakeholders interested in preserving a status quo, usually for short-term profit; (b) front groups; (c) use of fake "experts"; (d) information laundering; (e) cherry picking and taking information out of context; (f) red herrings (e.g., mass murderer Ted Kaczynski believes in climate change, do you?); (g) creation of an "echo chamber" that repeats false messages; (h) over-emphasis or manufacturing of uncertainty; (i) conspiracy theories; and (j) outright lying. Although denialism violates principles of rational inference and critical thinking, it is persuasive to many target audiences, such as the lay public and politicians. Denialist organizations are effective at empowering individuals to believe that they can quickly enter public discourse on complex scientific issues. With well over half a billion dollars funneled to front groups, climate change denialism is active and well-funded. Journalistic media amplify the voices of deniers, leading to false equivalency of "two sides" of climate science. Ideological beliefs and lack of critical thinking contribute to acceptance of denialist messages. Denialism seeks to obliterate the distinction between science and values in policy debates. For instance, rather than admit to not caring about climate change or not wanting to take action, a 'skeptic' instead asserts that the science is not valid. Conspiracy theorist deniers accuse 'alarmists' and 'warmists' of an ulterior "desire to control people's lives" or desire to pad their resumes with more scientific grants. Denialism also leads to an inaccurate perception of controversy, which itself impedes action. Although this seminar focuses on raising awareness of the methods and institutions of denial, some responses to denialism are discussed.

P.104 Fueta, PO*; Zhang, Q; Emory University; *drpatrickfueta@gmail.com*
Dynamical Systems Modeling of the Human Hypothalamic-Pituitary-Thyroid Axis: Developing Quantitative Adverse Outcome Pathways for Thyroid Endocrine Disruptors
While cell-based assays are making headway to replace animal-based approaches for chemical toxicity testing, a major challenge lies in translating in vitro results into in vivo health risk. Predicting the organism-level dose response of endocrine disrupting chemicals (EDCs) is particularly challenging, where the perturbations observed in vitro may be buffered in vivo by homeostatic regulation common to endocrine systems. Using the human hypothalamic-pituitary-thyroid (HPT) axis we present a dynamical systems modeling approach to mechanistically link toxicological and epidemiological data across multiple physiological scales, which will help extrapolate and predict the risks and mechanisms of EDCs. Specifically, an ordinary differential equation (ODE)-based model of the HPT axis was constructed to capture the feedback regulation between T3, T4, and TSH, their synthesis, metabolism, and plasma buffering. The model represents an average euthyroid condition and can simulate primary or secondary hyper- or hypothyroidism induced by EDCs. A select parameter space was then sampled to optimize the model against the NHANES thyroid profile data (2007-2012). The resulting correlated parameter distributions established a virtual reference thyroid population. Pearson correlation and multiple linear regression of the thyroid data and optimized model parameters vs. urinary EDCs including sodium iodide symporter (NIS) inhibitors, environmental phenols, and perfluorinated chemicals were then performed. These analyses confirmed the thyroid-disrupting mechanisms of well-known EDCs such as perchlorate and predicted novel thyroid-disrupting mechanisms for chemicals such as thiocyanate and BPA. Hierarchical clustering demonstrated the optimized model parameters can be used as additional features to refine chemical grouping. Lastly, using in vitro NIS inhibition data, we demonstrated how the dynamical model can be applied to predict in vivo dose response of thyroid hormone disruptions.

P.37 Gallo, SA*; Thompson, L; Schmaling, K; Glisson, S; American Institute of Biological Sciences; *sgallo@aibs.org*
Risk Evaluation in Peer Review of Grant Applications
The process of peer review is used to identify the most scientifically meritorious research projects for funding. Most research funding agencies would like to fund the most highly impactful research, however much criticism of peer review focuses on the perception that panelists are biased against innovation. Some recent evidence, from our group and others, suggests that review scores of funded projects are only moderately correlated with citation impact and one study found that reviewers systematically assigned poorer scores to highly novel work. Moreover, it is clear that reviewers' definitions for excellent research and paradigm-shifting research are different; innovative research may not always be considered excellent. But it is clear more needs to be done to understand the decision-making processes of reviewers, both as individuals and as a panel, in evaluating high-risk research. In an effort to address this gap, the American Institute of Biological Sciences developed a comprehensive peer review survey that examined, in part, the differences in applicant and reviewer perceptions of review outcomes. The survey was disseminated to 14,138 reviewers and applicants (9% response rate). Only 19% of respondent applicants indicated innovation potential as an area addressed in review feedback, while 84% of respondent reviewers indicated that they factored innovation into selecting the best science and 74% viewed innovation as an essential component of scientific excellence. Similarly, while only 33% of respondent applicants received comments on the riskiness of their grant applications, 63% of respondent reviewers indicated that the risks associated with innovative research impacted the scores they assigned to the grant applications. These results suggest a disconnect in perception between how innovation is evaluated in grant applications and how the feedback is received.

M4-C.1 Ganin, A*; Kitsak, M; Eisenberg, DA; Alderson, DL; Linkov, I; University of Virginia and U.S. Army Engineer Research and Development Center; Northeastern University; Arizona State University; Naval Postgraduate School; U.S. Army Engineer Research and Development Center; *alexander_a_g@outlook.com*
Robustness and Resilience of Large-Scale Command and Control Networks
Command and control (C2) systems used in military and rescue operations enable coordinated efforts of personnel to complete the mission in complex and time-sensitive environments. Successful coordination requires stable communication channels both among individuals comprising the social domain of the system and hardware components in the physical domain. We represent C2 systems as multilayered networks and study how their topological properties affect their connectivity. A classical percolation model characterizes the size of the largest connected component (LCC) of the network after an adverse event, modeled as a random removal of links or nodes. Well-known results highlight the importance of the distribution of links among nodes (degree distribution) for this form of robustness. We extend the above model to determine the persistence of nodes in the LCC in multiple stochastic realizations of the adverse event. First, we introduce the concept of the persistent largest connected component (PLCC) defined as the set of nodes which belong to the LCC over the course of many adverse events. We derive analytic equations to define the probability that a node of a certain degree belongs to the PLCC as well as the size of the PLCC itself. We support the analytical equations with high performance computing simulations and observe that the stability of the LCC is significantly different for link percolation (removal of links) and node percolation (removal of nodes). Whereas in the case of node percolation it is not possible to maintain a persistent LCC, in the case of link percolation the connectivity of the network may be ensured with high probability by adjusting the network's degree distribution. We also propose and discuss a recovery model to evaluate the resilience of the system. Our results have implications for optimal allocation of communication channels between the most important command and control agents under constrained resources.

T3-F.2 Garner, E*; Rhoads, WJ; Edwards, MA; Pruden, A; Virginia Tech, 418 Durham Hall, Blacksburg, Virginia 24061, United States; *elipsco1@vt.edu*

Links between physical and chemical water quality, reported incidence of Legionnaires' disease, and waterborne Legionella pneumophila in Flint, Michigan

When the city of Flint, Michigan began using the Flint River as a drinking water source without properly implementing federally mandated corrosion control in April 2014, a prolonged period of drinking water quality problems were triggered, including red water and elevated disinfection by-products, coliform bacteria, lead, and Legionella. After the problem was exposed, the city switched back to Detroit Water and Sewer Department drinking water, with enhanced orthophosphate corrosion control, in October 2015. In January 2016, the Michigan Department of Health and Human Services and Genesee County Health Department announced an unprecedented Legionnaires' Disease outbreak had also occurred while Flint River water was used. In total, 91 cases of legionellosis and 12 deaths were attributed to the outbreak. A lack of clinical isolates has, to date, hindered direct epidemiologic linkage to the Flint River water source. Here we present several lines of evidence linking the treated Flint River water usage to the outbreak. Flint River water was more conducive to Legionella growth, as evidenced by historic monthly water quality reports, our own sampling of homes and businesses in Flint, and bench-scale experiments replicating key aspects of the Flint River water chemistry. Together, these data demonstrate that the corrosive Flint River water generally deteriorated water quality by leaching elevated iron nutrients from water pipes, dissipating disinfectant residuals, and increasing water temperatures within the growth range of Legionella. Together, these factors likely triggered growth of Legionella in Flint's drinking water system. Whole genome sequencing (WGS) is currently underway to characterize L. pneumophila isolates from Flint tap water and to compare to clinical isolates responsible for past waterborne Legionella outbreaks. WGS will provide insight in to the potential virulence, pathogenicity, and speciation of L. pneumophila isolates obtained from Flint drinking water.

W2-C.2 Gasser, P*; Suter, J; Cinelli, M; Lustenberger, P; Wansub, K; Spada, M; Burgherr, P; Hirschberg, S; Stojadinovic, B; Singapore-ETH Centre; *patrick.gasser@frs.ethz.ch*

Development of an indicator set for resilience quantification of electricity supply

As our societies increasingly depend on electricity, security of electricity supply has become a central aspect in research and for policy-makers. The present study consists in an analysis of indicators for the assessment of electricity supply resilience on national levels. Resilience was framed as a combination of four biophysical functions, namely the abilities to (1) resist, (2) restabilize and (3) rebuild after disruptions, and (4) reconfigure the biophysical architecture of a system. Hence, unlike previously published security of supply studies, resilience incorporates post-disruption behaviors. As a case study, twenty-six countries in Europe, Asia and North America were chosen according to their electricity generation mixes, economic development, and geographical location. Through an extensive literature survey, an initial indicator set for resilience quantification was established. Each indicator was then assessed using four criteria, namely relevance, credibility of data, accessibility of data, and applicability and comparability, and assigned to the above-mentioned resilience functions. The final set of indicators was validated through correlation analysis and additional statistical tests such as scale reliability. Results show that indicators to characterize pre-disruption behaviors are more developed than the ones for post-disruption behaviors. The latter are represented by the two resilience functions rebuild and reconfigure. Many indicators, especially for the ability to rebuild, are related to financial and qualified personnel resources. Next to conventional diversity indicators, other indicators relate to the political stability of governments, their effectiveness and corruption levels. The indicator set developed can be used for comprehensive resilience assessment. It can support decision-makers in understanding their overall performance, identifying trade-offs between indicators and improvement strategies to achieve higher electricity supply resilience.

W4-J.1 Gentry, PR; Ramboll Environ; *rgentry@ramboll.com*

The State of the Science of QRA in Support of Different Tobacco Product Submission Types

Quantitative risk assessment (QRA) is an important tool used by multiple regulatory agencies. QRA informs decision-making by using the available scientific evidence to describe the potential impact to public health of exposures to individual chemicals and to mixtures. QRA techniques can be applied to tobacco products to address questions regarding human health risk and the potential influence on public health of different products. Specifically, QRA can be informative in substantial equivalence evaluations, premarket tobacco product applications, and modified risk tobacco product applications, the regulatory pathways for tobacco products in the US. When developing a QRA approach for tobacco products, it is important to understand both the available data for addressing public health questions, as well as the state of the science of QRA. Current regulatory approaches applied by, for example, the US EPA, incorporate decades of research, consider the available data that can be used to understand the potential for health effects, as well as consider the potential variability and uncertainty in the process and how this may impact decision making. This presentation will focus on a description of the data and methods available for conducting each step of the QRA process for tobacco products and the potential uncertainties/challenges with each step, considering the current state of the science and the use of QRA for other applications (e.g., environmental).

P.65 Ghaedi, H*; Reilly, A; University of Maryland; *hghaedi@umd.edu*

Understanding the growing costs for FEMA's Public Assistance Program: The role of repeated hazards and institutional knowledge by applicants

Federal Emergency Management Agency (FEMA) is responsible for providing assistance to qualified entities before, during, and after a disaster occurs to reduce the impact of hazards. One of the important types of assistance provided by FEMA is Public Assistance (PA). PA provides funding for debris removal, repair, and restoration of damaged public infrastructure caused by hazards. The Government Accountability Office recommends an overhaul of how PA is funded because of its rising and unsustainable costs. In the current study, we shed light on whether institutional knowledge developed by applicants who experience to repeated hazards increases the likelihood that they will apply for PA in the future and ultimately the amount of funding they qualify for. This could suggest that rising costs borne by FEMA after disasters partially results from more entities discovering that they are entitled to funding and from a better understanding of the bureaucratic complexities of filing for assistance, making entities more likely to file.

M3-F.5 Gillespie-Marthaler, L*; Nelson, KS; Baroud, H; Abkowitz, M; Vanderbilt University; *leslie.gillespie-marthaler@vanderbilt.ed*
Community Resilience: Establishment of Foundational Indicators and Variables for Use in an Integrated Dynamic Assessment Framework
Communities are complex systems that are subject to a variety of hazards, often resulting in partial or total disruption to critical functions. The concepts of vulnerability, resilience, and sustainability are increasingly applied to community assessment as a means to better evaluate abilities to prepare for, respond to, and recover from disruption. Linkages identified between concepts resulted in development of an integrated dynamic assessment framework to evaluate complex systems' ability to resist systemic disruption, recover, adapt, and/or transform given adverse situations in order to maintain desired performance while simultaneously considering intra-system and inter-generational distribution of impacts and sustainability capital, defined by authors as complex system resilience. Literature on community resilience and resilience assessment provides a large pool of indicators and measures to choose from when conducting resilience assessment. Variations in definition, categorization, and use can lead to challenges in operationalizing assessments. This work provides a review of current literature on community resilience indicators and a synthesis of associated indicators sets in order to operationalize complex system resilience assessment for the above-mentioned framework. Efforts resulted in consolidation of over five hundred separate indicators into a set of foundational indicators with associated qualitative and quantitative measures. Indicators and measures are classified according to: 1) association with various community sub-systems; 2) alignment with attributes of complex system resilience, and 3) resilience priority. These results are intended to improve communities' ability to consistently measure resilience by providing a starting point for resilience indicator selection that can be tailored to specific communities, and by identifying indicators that align with fundamental aspects of complex system resilience in order to ensure assessments are balanced.

T2-F.4 Gillespie-Marthaler, L*; Camp, J; Baroud, H; Abkowitz, M; Vanderbilt University; *leslie.gillespie-marthaler@vanderbilt.ed*
An Indicator-Based Assessment of Community Resilience to Failure of Flood Protection Infrastructure
Community resilience is defined herein as the ability to resist systemic disruption, recover, adapt, and/or transform given adverse situations in order to maintain desired performance while simultaneously considering and the availability of sustainability capital. Flood, in its many variations, is a significant hazard for communities worldwide. This presentation examines flood hazard associated with failure of flood protection infrastructure within the U.S. through a case study approach. Criteria are developed for risk characterization, and an initial assessment is conducted using multiple methods to identify study locations considered to be at high risk. Hazard scenarios and expected consequences are evaluated for these locations, from which community resilience is determined using a foundational set of indicators and associated quantitative and qualitative measures. The efficacy of using these indicators and associated measures is considered based on their sufficiency and appropriateness with regard to: 1) association with various community sub-systems; 2) alignment with attributes of complex system resilience, and 3) resilience priority. Results from this work are used to develop community resilience strategies and to assist in operationalizing assessment processes for community resilience.

P.177 Gilmore, J*; Jugloff, D; Onica, T; Grant, C; Schroeder, J; Ontario Ministry of Environment and Climate Change ; *James.Gilmore@Ontario.ca*
Framework for Managing Risks under Ontario's Local Air Quality Regulation
Ontario's local air quality regulation regulates contaminants released from industrial and commercial facilities. Air standards under the regulation are used to assess the environmental performance of regulated facilities and, when exceeded, drive actions to reduce emissions through technology and best practices. Risk is managed according to a framework developed in cooperation with public health agencies. Under the framework, modelling and monitoring information around a facility is evaluated and risk management actions are defined according three levels of a contaminant: The air standard level – set for contaminant at concentrations that are protective against adverse effect. As low as reasonably achievable (ALARA) level – exceeds a negligible risk but within an acceptable range for risk management - and requires actions by a facility to reduce as low as reasonably achievable. Upper risk threshold level (URT) – exceeding the URT level requires reporting and prompts timely action to reduce risks. For carcinogens, the standard and URT are set at a risk specific concentrations equivalent to a one-in a million (or 10-6) and one in ten thousand risk level (or 10-4) respectively. For non-carcinogens, standards are set at concentrations well below levels where effects are observed and URTs are generally set at 10 times the air standard. Using modelled receptor concentrations as maximum annual average levels, examples of carcinogens (Benzene, Benzo[a]pyrene and Chromium VI) are used to categorize various facilities. This characterization can then be used direct actions through improvement in pollution control technologies and to develop communication material for the public. The framework allows the ministry to work with facilities to reduce risk - as much as possible- in local communities in an open and transparent process.

M3-A.4 Gilmore, EA; Clark University; *gilmore@clarku.edu*
Projecting violence and unrest under climate change
The potential for climate change to increase or alter occurrences of violence, such as civil war, riots, and crime, are amongst the more contested endpoints. While a few prominent studies have found statistical support for strong and direct associations between climate and many diverse forms of violence, other analyses have revealed more inconsistent and conditional relationships. Here, we provide a critical review of the state of the understanding across a number of endpoints drawing upon evidence from a range of disciplines. Further, we investigate the state of projecting these endpoints over future socioeconomic and climate scenarios with a specific focus on capturing the endogeneity of conflict and economic growth as well as other interactions between climate change, socioeconomic conditions and adaptive capacity. We conclude by making recommendations on how to model these relationships for efforts, such as the Social Cost of Carbon (SCC).

M2-F.2 Gjorgiev, B; Sansavini, G*; ETH Zurich; *sansavig@ethz.ch*
Water-Energy Nexus: Impact on Electrical Energy Conversion and Mitigation by Smart Water Resources Management
The water-energy nexus refers to the water used to generate electricity and to the electric energy used to collect, clean, move, store, and dispose of water. Water is used in all stages of electric energy conversion making power systems vulnerable to water scarcity and warming. In particular, a water flow decrease and temperature increase in rivers can significantly limit the generation of electricity. This paper investigates the issues to energy conversion stemming from the water-energy nexus and mitigates them by developing a model for the smart utilization of water resources. The objective is to minimize power curtailments caused by a river water flow decrease and a temperature increase. The developed water-energy nexus model integrates the operational characteristics of hydro power plants, the environmental conditions, the river water temperature prediction and thermal load release in river bodies. The application to a hydraulic cascade of hydro and a thermal power plants under drought conditions shows that smart water management entails a significant reduction of power curtailments. In general, the full coordination of the power outputs of the units affected by the hydrological link provides the most effective mitigations of the potential issues stemming from the water-energy nexus. Finally, critical temperature and flow regimes are identified which severely impact the energy conversion and may cause systemic risks in case the generators in one region must be simultaneously curtailed.

W2-H.4 Goble, R; Clark University; *rgoble@clarku.edu*
Concepts and connections, choices and conundrums: the boundary between what is inside and what is outside a risk assessment
In practice, when an analyst conducts a risk assessment she or he rarely starts from scratch. The purpose of the assessment will constrain what is included and what is not. The purpose, together with past experience is likely to determine the underlying conceptual framing and models. There may appear to be little reason, incentive, or opportunity to question these. Furthermore, almost certainly there will be constraints of time and resources on how much can be included as the analysts struggle to meet their deadlines. There are, however, several practical reasons why analysts should take the time and make the effort to consider and question what possibilities are included and what aren't. The first and obvious reason is that such questioning may uncover risk pathways that might otherwise be neglected. A second, and only slightly less obvious, reason is that such considerations may also reveal other risks that deserve attention. Even when, after consideration, there appears to be no reason for making significant alterations in the risk pathways and the risks analyzed, the consideration may be used to strengthen the basis for the assessment. After presenting a few illustrations from nuclear safety analysis, other infrastructure risk, emergency planning, and terrorist threats, I will argue that the choice of boundaries is a foundational as well as a practical concern. Boundaries affect both the nature and the strength of the claims that a risk analysis can support. More complicated boundary considerations arise in assessing risks within interconnected systems; the analysis of management possibilities may expose conundrums. Over time "living risk assessments", risk assessments that are kept up to date as new information and knowledge emerge or new applications are found, should prove valuable. Effective updating will require revisiting the boundaries of the assessments.

P.103 Goeden, HM*; Greene, CW; Jacobus, JA; Minnesota Department of Health; *helen.goeden@state.mn.us*
Application of an Excel-based Toxicokinetic (TK) Model for Deriving Health-based Water Guidance for PFOS and PFOA.
Perfluorinated compounds have been widely released and human exposure is ongoing and ubiquitous. The Minnesota Department of Health (MDH) released revised noncancer health-based water guidance (nHBG) for PFOS and PFOA in May 2017. Traditionally, noncancer health-based water guidance values are calculated using a reference dose, a relative source contribution factor, and intake rate. During MDH's review it became clear that traditional nHBG derivation methods would be inadequate due to maternal transfer at birth and potential accumulation of PFOS and PFOA in breastmilk at higher levels compared to drinking water. The revised values are based on a novel Excel-based TK model tailored to the physical-chemical properties, exposure parameters, and human transfer coefficients especially critical for evaluating early life exposures. Although exposures during infancy are short-term, this life stage is of particular concern because: (1) infants consume a much greater volume of liquid per unit body weight than older children and adults; and (2) due to the long elimination half-lives, the body burden instilled in infancy may take years to eliminate. To address these concerns, MDH developed an Excel-based, one-compartment TK model to predict serum levels of PFOS and PFOA from birth through attainment of steady-state conditions. Two exposure scenarios were evaluated: 1) an infant exclusively fed with formula reconstituted with contaminated water starting at birth, followed by a lifetime of drinking contaminated water; and 2) an infant exclusively breastfed for 12 months, followed by a lifetime of drinking contaminated water. In both scenarios, infants began life with a pre-existing body burden through placental transfer from a mother at steady-state conditions. Based on modeling results, breastfed infants were the most heavily exposed, and predicted serum levels early in life exceeded steady state levels.

P.14 GOIS , LHB; MONTEIRO, LKS*; JORQUERA, O; COHIM, E; KIPERSTOCK , A; Universidade Federal da Bahia ; *lorenamonteiro.ufba@gmail.com*
Quantitative Microbial Risk Analysis (QRMA) on risk's estimative associated with infectious waste in Blood Centers
The blood cycle in health sector is part of a supply chain which has a lot of specificities, adding losses and generating too much waste to the related processes. Not only the economic loss associated with the lack of generated hemocomponents use, the supply chain also needs a lot of financial and energetical resources to process the waste. They are classified as microbiologic and potentially infectious, and treated through special methods of waste management. In Brazil, Blood Centers do the blood collect, and after, the nonconforming blood bags are destinated to the waste discard stage. Their treatment is made by incineration or autoclaving, and after that they are discarded in landfill. In health services, plenty of risk minimization and control actions have been adopted based on the Precautionary Principle. Admitting a risk without knowing it makes it merely potential, and real evidences are missing when it comes to the effects of the Blood Center waste in human's health. The Quantitative Microbial Risk Analysis (QRMA) is a tool which is being used by Institutions to make decisions, and it can be successful used to estimate the risk to the society considering a certain event. The present work has the goal to show evidences, using the QRMA Method, of the risk involved with the Blood Center's waste, opening the possibility to reduce the costs and energy losses involved with the current discard process.

M4-H.4 Goldstein, RER*; Suri, MR; Dery, JL; Brassill, NA; Pee, DG; Goeringer, LP; Rock, CM; University of Maryland; *rerosenb@umd.edu*

Nontraditional Irrigation Water: Understanding Farmers' Needs and Risk Perceptions

As climate variability continues, it is prudent to explore alternative water sources available to irrigated agriculture. To facilitate adoption, understanding of both farmers' needs and perceptions of risk is critical. CONSERVE (COordinating Nontraditional Sustainable watER Use in Variable climatEs): A Center of Excellence at the Nexus of Sustainable Water Reuse, Food, and Health is a USDA-funded project spanning the U.S. Mid-Atlantic and Southwest focused on conserving groundwater through nontraditional irrigation water quality analysis, assessing concerns, developing on-farm treatment technologies, and analyzing legal, economic and social constraints to adoption. Nontraditional water (recycled, brackish, agricultural runoff, livestock wastewater and process waters) as a viable option for agricultural irrigation largely depends on grower buy-in and consumer preferences. However, to date, no studies exist on farmers' knowledge, willingness to use, or real or perceived risks of nontraditional water. A needs assessment survey was distributed to farmers (n=375) in 2017 both online and at stakeholder meetings. Questions covered current irrigation water sources, familiarity with nontraditional water, and concerns. Survey data was collected with Qualtrics and analyzed with STATA. The majority of growers were concerned with water availability (75%), consider nontraditional water in agriculture at least moderately important (81%), and would use nontraditional water to supplement current water sources (83%) if available. Water quality and health risks were among the top concerns related to nontraditional water with factsheets, workshops, and approval from trusted sources ranking highest as methods to address real or perceived risks of nontraditional water. Results indicate farmers value water planning and are open to using nontraditional water for irrigation. Education and outreach will be important to communicate benefits and manage risks related to nontraditional water.

P.178 Goodman, JE*; Lynch, HN; Prueitt, RL; Mohar, I; Gradient; *jgoodman@gradientcorp.com*

Evaluation of ACGIH TLVs for Toluene Diisocyanate

In 2016, the American Conference of Governmental Industrial Hygienists lowered the 8-hr Threshold Limit Value - time-weighted average (TLV-TWA) for toluene diisocyanate (TDI) from 5 parts per billion (ppb) to 1 ppb, and the 15-minute short-term exposure limit (STEL) from 20 ppb to 5 ppb, with the intention of protecting against respiratory effects. We critically reviewed the human and animal evidence on which the TLVs were based and found that the human evidence indicates that maintenance of the previous 8-hr TLV-TWA and 15-minute STEL (5 ppb and 20 ppb, respectively, which were in effect from 1983 to 2016) is protective of occupational asthma (OA) in most workers, and is also protective of lung function decrements and other respiratory effects. Although some studies suggest OA cases may occur at TWA concentrations less than 5 ppb, many studies acknowledge the possibility that very high peak exposures, well above 20 ppb, may have contributed to OA onset. Advances in industrial hygiene measures have reduced peak exposures and the incidence of upset conditions such as spills and accidents, so these high peak exposures are unlikely to occur in modern TDI facilities. The animal literature supports the human evidence and indicates that TDI-induced asthma is a threshold phenomenon. The evidence does not indicate that the lower TDI TLVs will result in a lower incidence of respiratory effects, including OA.

P.30 González-Ortega, J*; Ríos Insua, D; ICMAT; *jorge.gonzalez@icmat.es*

An algorithmic adversarial risk analysis aproach for bi-agent influence diagrams

In his landmark paper, Shachter (1986) proposed extending the computation of optimal decision policies in influence diagrams to the multi-agent case as a fundamental problem. So far, this suggestion has been faced from a (non-cooperative) game theoretic perspective, stemming from Koller and Milch (2003) who introduced Multi-Agent Influence Diagrams (MAIDs) and provided algorithms for finding Nash equilibria in problems modelled as MAIDs. A main drawback of such methodology is its underlying common knowledge assumptions, criticized in e.g. Raiffa et al. (2002). Most versions of non-cooperative game theory assume that adversaries not only know their own payoffs, preferences, beliefs and possible actions, but also those of their opponents. However, in many contexts, including counter-terrorism or cybersecurity, these premises will not generally hold. Adversarial Risk Analysis (ARA) provides a way forward. Instead of addressing the problem simultaneously for all agents, a single decision maker (defender, she) is supported. Her problem is viewed as a decision analytic one, but procedures which employ the game theoretic structure are used to estimate the probabilities of the opponent's (attacker, he) actions resulting in a maximized expected utility solution. Many different attacker rationalities may be considered in the ARA framework, though a level-2 thinking strategy is adopted, see Stahl and Wilson (1995), so that the defender will ponder over the attacker's strategy but assume that he will not do the same about hers. The uncertainty in the assessments about the attacker's probabilities and utilities propagates to his random optimal decision which constitutes the required attack forecast. General adversarial problems between two agents are studied, consisting of intermingled sequential and simultaneous movements, spanning across the corresponding planning period. The approach is illustrated through a driving example in critical infrastructure protection.

W4-C.2 Goto, SK*; Arvai, JL; University of Michigan; *saragoto@umich.edu*

The Influence of Generational Differences on Loss Aversion and Risk Taking

Prospect theory describes decision-making behavior where individuals place higher relative value on losses than they do on equivalent gains. However, because prospect theory relies upon reference points for judging the value of losses, it stands to reason that intergenerational variability will influence the magnitude of loss aversion felt by decision makers. For example, over the course of a lifetime, individuals will experience multiple losses. Older adults have had more opportunities to experience loss and may make decisions and take risks that are distinct from those made by younger adults who have experienced fewer losses. As such, people could be expected to fall into patterns of loss aversion based on generational cohort as this classification sorts individuals by age, experience, and values. It is this generational difference and its impact on present day decisions that were the focus of this research. Specifically, we predicted that the value function described by prospect theory in the loss domain will differ according to the variables that ultimately define generational cohorts. For example, we hypothesized that individuals from older generations will behave according to value functions that are less steep in the loss domain due to greater adaptation to losses when compared to participants from younger generations who have not yet come to terms with their losses. To explore these hypotheses participants were asked to read and respond to short scenarios describing either a small or large loss in the context of global change risks. Data collected regarding the small and large losses was then used to construct a linear proxy for the loss specific value function. The potential difference in attitude towards loss between generations can be reflected in the strength of preference towards risk taking. As prospect theory states, those in the loss domain are generally risk seeking, but the measure of risk seeking may be higher for those in the younger generations.

T3-A.4 Graham, JD*; Julian, AA; Kin Lu, A; Duncan, D; Siddiki, S; Carley, S; Indiana University; *grahamjd@indiana.edu*

Are Auto Consumers Rational about Conventional Hybrids?

Despite major engineering investments in vehicles similar to the Toyota Prius, few consumers decide to purchase hybrids. This paper explores consumer purchasing decisions about conventional hybrid-electric vehicles to determine whether consumer decision making is consistent with the energy paradox. Using 2004-2017 data on 54 new hybrid models that have a similar gasoline comparator, the authors estimate a total cost of ownership model that accounts for vehicle price, applicable federal tax credits, interest rate on car loan, fuel price, rated fuel economy, vehicle miles of travel, vehicle survival rates and other factors. Ancillary information is also assembled on performance, cargo space, and upgrade packages offered on standard hybrid and gasoline models. The financial aspects are summarized in the consumer payback period, which may be smaller or larger than the average longevity of the vehicle. Implications for rational choice theory, risk aversion, and behavioral economics are discussed.

W3-F.3 Grant, A*; Abramson, D; Bostrom, A; Gonzales, F; Leveque, R; Greenfield, M; University of Washington; *abostrom@uw.edu*

Engaging communities in tsunami risk planning with probabilistic hazard information

We present the development of probabilistic tsunami hazard maps for a coastal community, Aberdeen, Washington, and the testing of those maps in the Aberdeen Coastal Resilience Workshop. Participants were divided into four groups, all of which identified frequently-occurring hazards in Aberdeen and the Port as a major economic driver for their community and key to community resilience. The edge of the probabilistic map was essentially treated as the deterministic map. There was mild interest in the lower likelihood of inundation at the port. Groups had one of two framings for their discussions, asset-framed, or hazards framed. The asset-framed discussion groups focused on ties with community more than hazards-framed discussion groups, and were more open to positive aspects of community, and more open to relocation and cooperation with other communities than the hazard framed-groups. The experience included successful participatory GIS.

W2-A.1 Greco, SL*; Kim, JH; MacIntyre, E; Copes, R; Public Health Ontario; *sue.greco@oahpp.ca*

An overview of estimating the environmental burden of disease in Ontario, Canada

Public Health Ontario (PHO), a Crown corporation dedicated to protecting and promoting the health of the approximately 14 million residents of Ontario, is currently working to estimate the environmental burden of disease (EBD) for the province. In the first phase of the EBD project, PHO collaborated with Cancer Care Ontario to estimate the burden from exposure to 23 carcinogens, of which ultraviolet radiation, radon, and fine particulate matter (PM2.5) were the major contributors. The results are summarized in the "Environmental Burden of Cancer in Ontario" (2016). For the second phase, PHO will focus on 12 groups of hazards (e.g., air pollution, pathogens causing foodborne illness) associated with adverse health outcomes other than cancer. These outcomes range in severity from allergic rhinitis to premature death. Challenges with the "non-cancer" EBD estimation for Ontario include: selecting hazards in the absence of internationally accepted classification schemes for adverse health endpoints outside of cancer; determining valid hazard-outcome pairings; developing specific analysis plans for a large number of pairings; and deciding upon and developing an appropriate metric to convey the results to decision-makers, the public, and the media. Robust data are a strength of the EBD estimation: extensive health records are available for nearly all residents of the province (e.g., physician office visits, hospitalizations, deaths) and environmental monitoring data are available to help assess exposure. This presentation will provide an overview of the entire EBD project for Ontario, present the findings from the cancer burden phase of the project, and discuss the approach for the non-cancer burden phase. (Report available at https://www.publichealthontario.ca/en/BrowseByTopic/EnvironmentalandOccupationalHealth/Pages/Environmental-Burden-of-Cancer-ON.aspx)

W4-I.4 Greco, SL*; Kim, JH; Copes, R; Public Health Ontario; *sue.greco@oahpp.ca*

Approaches to estimating the burden of outdoor air pollution in Ontario

As part of a multi-year effort to estimate the environmental burden of disease (EBD) for the province, Public Health Ontario (PHO; a Crown corporation dedicated to protecting and promoting the health of the approximately 14 million Ontario residents) is estimating the burden of outdoor air pollution for the province. The burden of outdoor air pollution has figured prominently in previous EBD analyses (e.g., the Global Burden of Disease study). For our burden estimation, a number of analytical decisions had to be made: which pollutants to include (fine particulate matter, PM2.5; ozone; nitrogen dioxide), how to assess exposure (data from ambient monitoring stations versus satellites), how to model the dose-response relationship (slope factors, hazard ratios), which studies to obtain data from (a single site-specific epidemiological study versus a meta-analysis including regions around the world), which health outcomes to consider (ischemic heart disease, lung cancer, all-cause mortality), and which approaches to use (attributable fraction, single- or multi-pollutant models). To examine the influence of our assumptions, we performed sensitivity testing whenever possible. For example, for lung cancer from diesel PM2.5 exposure, we found a three-fold difference in estimated cases when using an attributable fraction approach compared to a slope factor approach. This presentation will outline how PHO made analytical decisions to estimate the air pollution burden and what impacts differing assumptions may have on the estimates of burden.

P.13 Greenberg, GI*; Beck, BD; Gradient; *ggreenberg@gradientcorp.com*

YPLL: A Comprehensive Quantitative Tool to Evaluate Worker Risk Under Green and Sustainable Remediation

The goal of hazardous waste site remediation programs is to reduce risks to populations potentially exposed to chemicals or radionuclides. Environmental remediation practices have evolved to incorporate workers' health and safety in the remedy selection process under Green and Sustainable Remediation (GSR) principles. Many quantitative GSR tools evaluate risk to workers from remediation and transportation of waste and other materials (e.g., traffic accidents). These risks are calculated for various remedial options to help select a remedy that ideally minimizes worker risk while maximizing the effectiveness of the selected remedy. One GSR tool not commonly used is "years of potential life lost" (YPLL), an epidemiological measure of premature mortality that is calculated as the difference between a predetermined age, such as life expectancy, and the age at premature death. YPLL can aid in evaluating risks to workers from remediation activities and transportation and can be useful in selecting a remedy that aligns with GSR principles. We propose using this metric in the remedy selection process to help select a remedy that produces the greatest net public health benefit. An advantage of YPLL over other quantitative tools is its ability to quantitatively assess the public health benefits (i.e., reduced risks to nearby residents exposed to chemicals at a hazardous waste site) of remediation in comparison with the public health costs (i.e., increased risks) experienced by remediation workers. YPLL is a well-established metric that uses the same underlying data as other GSR tools. We will compare YPLL for remediation workers with two models (SiteWiseTM and SRT) commonly used to evaluate workers' health and safety by focusing on their most important differences and similarities. We will also present some of the key assumptions used and how they can influence YPLL results, and discuss the advantages/disadvantages of using YPLL in the remedy selection process.

P.79 Greene, CW*; Suchomel, AE; Minnesota Department of Health; *christopher.greene@state.mn.us*

Public Health Implications of EPA's UCMR3 Sampling of Contaminants in Drinking Water

The Minnesota Department of Health (MDH) has conducted an analysis of community water supply data gathered under the EPA's Unregulated Contaminant Monitoring Rule 3 (UCMR3) program between January 2013 and September 2015. The UCMR3 analyte list included several chemicals with no previous data in finished drinking water in Minnesota, as well as chemicals with recently revised drinking water standards. MDH viewed the UCMR sampling as an opportunity to estimate potential impacts to public health from exposure to drinking water contaminants. Analytical results for each chemical were compared to the best available Minnesota or EPA health-based standard. Hazard indices (HI) were calculated for individual chemicals and summed for each community sampled. Chromium VI, manganese, and chlorate were the major risk drivers at locations throughout the state. In areas known to be impacted by perfluoroalkyl substances (PFAS), PFOS, PFOA, and PFHxS were important contributors to total HI, but these communities often had other individual contaminants, such as chromium or cobalt, with an HI greater than 1. MDH conducted a basic additivity analysis on the basis of common health endpoints, and found that in two community water systems, the HI summed by endpoint exceeded 1 even when no individual chemical's HI exceeded 1. Although there are limitations inherent in the sampling process (i.e., the number of samples per facility was small), the UCMR3 data were useful for chemical prioritization (identifying risk drivers) and for geographic analysis (identifying the scope and extent of contamination). MDH also identified three contaminants (1,2,3-trichloropropane, 1,3-butadiene, and 17alpha-ethinylestradiol) whose analytical reporting limits were higher than MDH's health-based criteria, indicating a need for improved analytical methods. As EPA prepares for the next round of UCMR analysis (UCMR4), MDH is working to develop health-based drinking water standards for the UCMR4 target analytes.

W1-D.3 Grieger, KD; RTI International; *kgrieger@rti.org*

Moving from risk assessment to risk governance and decision support for nanomaterials: Lessons learned from select case studies

Developing engineered nanomaterials (ENMs) in a responsible, sustainable manner has been the pursuit of a significant amount of research over the past decade. Among other areas, research efforts have been directed towards refining risk assessment frameworks for ENMs as well as developing new, alternative risk analysis and risk evaluation approaches, as there is no "gold standard" for ENM risk assessments to date. One approach to help ensure sustainable ENM development initiated from a collaborative research project between RTI International and North Carolina State University has been the development of a decision support tool applied during the ENM design phase for nano-enabled water treatment technologies. The aim of this decision support tool is to help facilitate real-time decisions regarding ENMs, providing material developers and engineers access to real-time data and information on impacts to health, the environment, as well as social and ethical issues using an iterative multi-disciplinary team approach. Initial findings and challenges will be highlighted. In addition, this presentation will also review diverse risk assessment and risk governance approaches based on work performed in a European project, caLIBRAte, that aims to develop robust risk governance strategies for ENMs relevant for all innovation gate stages. In this work, an overview of the process to select, screen, and score alternative risk assessment and risk governance tools and models will be provided. Finally, this presentation will wrap-up by identifying "lessons learned" over the past decade and will highlight next steps for ENM risk assessment, governance, and decision support.

P.91 Guerrette, ZN*; Fleischer, JG; Whittaker, MH; ToxServices LLC; *zguerrette@toxservices.com*

Dietary Contaminant Exposure Estimates Should Reflect Risks to Sensitive Sub-Populations: A Case Study of Lead and Hot Tea Consumption in Persons of Reproductive Age Participating in NHANES 2013-2014

Dietary exposure estimates are typically calculated as usual intake estimates, a product of food frequency questionnaire data and the amount consumed per consumption event. While these estimates are suitable to express exposure to dietary contaminants whose risk is a function of exposure duration, these estimates likely underestimate risk of adverse effects from chemicals whose toxicity is predicated on exposure during critical windows of susceptibility, especially developmental toxicants. Due to the nature and the potential severity of developmental impacts, which are dependent more on exposure timing rather than exposure duration, a more conservative approach to the assessment of chemical exposure is warranted if the chemical being evaluated is a developmental toxicant. This approach does not normalize consumption across time, but instead includes data only for days on which the dietary item is consumed. We have demonstrated differences in exposure estimates using these approaches applied to hot tea consumption data from the NHANES 2013-2014 dataset and compared exposure estimates to the 0.5 µg/day MADL for lead, which is based on this chemical's reproductive and developmental toxicity. Tea consumption is a significant non-occupational route of lead exposure. Among men and women of child-bearing age (15-49 years old) participating in NHANES 2013-2014, the single day arithmetic mean hot tea consumption was 0.416-0.436 L/day for hot tea consumers. Across both sampling days, the arithmetic mean hot tea consumption considering only days in which tea was consumed was 0.402 L/day. As the average lead content in a 200 mL beverage is estimated as 10 µg/L, an average hot tea consumption of 0.402 L/day would produce a daily lead intake of 4.02 µg/day, a value eight times greater than the MADL for lead. To protect sensitive sub-populations, the exposure estimation method chosen needs to reflect the nature of the toxicity induced by the contaminant being evaluated.

M2-D.1 Guidotti, TL; Occupational + Environmental Health & Medicine; *tee.guidotti@gmail.com*

Continuous Quality Improvement (PDCA) in risk management: the Deming cycle in achieving risk reduction beyond fixed standards

Current approaches to regulatory risk management based on standard-setting assume that the standard represents a permanent best practice and a level of risk that is appropriate for the level of protection required by the community at risk. However, new information, improved scientific methodology, and the identification of novel risks often require review and modification of standards for significant hazards. As well, social attitudes change and society generally becomes more risk-averse over time and with increasing awareness and affluence. An alternative approach that recognizes these realities is "continuous quality improvement" (CQI), which is an on-going process for the optimization of risk, efficiency of operations, and consumption of resources. The the "Deming Cycle" (Plan Do Study Act [repeat]), for example, is the standard management approach for quality assurance in the private sector. CQI has theoretical and practical advantages over fixed standard setting in improving the quality of the environment and worker health and fits better with good management practices. The theoretical disadvantages may be business concern over an ever shifting target for compliance and the opportunity cost of making improvements when performance is already sufficient. However, in practice, CQI has shown such great benefit in improving the operations of enterprises from small business to large corporations that it is standard procedure and typically results in large unanticipated gains beyond quality, in efficient operations, lower cost, and reduced risk. The mandated periodic review of ambient air quality standards by the EPA and of high-priority chemicals under the Lautenberg Chemical Safety Act are broadly compatible with CQI. The approach is also one means of effectively operationalizing the Precautionary Principle. It is suggested that CQI should be considered as an alternative regulatory approach and adopted as a fundamental approach to risk management.

T4-F.1 Guikema, SD*; Quiring, S; Buckstaff, K; Beck, M; Nateghi, R; McRoberts, B; Logan, T; University of Michigan; *sguikema@umich.edu*

Forecasting Storm-Induced Power Outages and Restoration Personnel Needs

Most past work on predicting power outages due to storms has focused on wind-related weather events such as hurricanes. In addition, past research has primarily focused on predicting power outages and has not dealt with estimating the level of resources needed to restore electric power service. In this talk we will provide an overview of recent work done to develop a power outage risk model for a major west coast utility. This model forecasts power outages at the level of utility service districts for any type of potentially damaging weather event. It also forecasts the total person-hours needed for restoration by different job classes. These forecasts are fully probabilistic, capturing the considerable uncertainty present in any forecast of power outages due to weather events. The model approach used is a hybrid three-stage model. The first stage is a classification model to estimate the probability of having weather-induced damage on any given day. The second stage is uses a quantile random forest to estimate the conditional probability density function of the number of damaged assets in each of the four primary asset classes, poles, transformers, overhead wire spans, and underground cable runs. The third stage then forecasts the conditional number of labor hours by labor class given the damage forecasts. This approach provides substantially more information to support storm-response planning than previous approaches, and it is an explicitly probabilistic approach, better characterizing power outage risk due to storms.

M4-G.1 Guikema, SD*; Flage, R; University of Michigan; *sguikema@umich.edu*

Data Analytics, Risk Analysis, and Uncertainty

Data analytics has become increasingly popular within many areas of research, including risk analysis. There is much promised by this approach, including better leveraging data for predictive and inferential modeling. This applies in risk analysis as well where data analytic methods have bee used for a variety of predictive modeling applications. While these approaches make a strong contribution, there is a weakness common to many of these approach: how they handle uncertainty. This talk first gives an overview of predictive data analytic methods. It then summarizes how these methods are often used in risk analysis, focusing on the types predictions given and whether or not they include uncertainty in these predictions. The talk then gives an overview of a recently developed approach for predictive modeling in which uncertainty is represented in the predictions. Finally, the talk discusses implications for a path forward for considering how to better represent uncertainty in predictive analytics methods for risk analysis.

M3-K.3 Gupta, K*; Nowlin, M; Ripberger, J; Jenkins-Smith, H; Silva, C; University of Oklahoma; *kuhikagupta@ou.edu*

Crisis Events, Risk Communities, and the Evolution of Public Support for Nuclear Energy in the United States

Public support for nuclear energy in the United States has been a topic of interest for many decades, generating hundreds of public opinion polls and corresponding articles, books, and reports that explore the factors that influence variation in support between groups of individuals and in aggregate, over time. Many of the group studies highlight the role of risk and benefit perceptions in shaping opinions on nuclear energy; groups with high risk perceptions oppose nuclear energy, whereas groups with high benefit perceptions support it. Many of the aggregate studies focus on crisis events, such as Three Mile Island, Chernobyl, and Fukushima, that erode public support for nuclear energy. In this study, we undertake a meta-analysis of these studies to accomplish three things: (1) develop a long-term measure of public support for nuclear energy in the US that aggregates data from 229 different surveys from a variety of polling organizations; (2) use this measure to re-assess the impact of crisis events on the evolution of support for nuclear energy in the US from 1973-2016; and (3) explore the moderating effect of risk and benefit perceptions on support for nuclear energy before and after the Fukushima event. We conclude by discussing the implications of this research for risk communication and the future of nuclear energy policy in the US.

P.20 Gurian, PL; Drexel University; *pgurian@drexel.edu*
Primary Voting Risk Management
Voting is often seen as an expression of values, but it is also a consequential act with risky outcomes. The study evaluates primary voting under two different objective functions. The first values a vote by its ability to increase the probability of a candidate winning. The second objective function values a vote by the changes in proportion of votes for each candidate. Both valuation approaches are applied to a set of six hypothetical voters in the Pennsylvania and Indiana 2016 presidential primaries using polling data that was available to voters at the time of the primary and the actual number of voters in each primary. Result indicate that voters will not necessarily vote for their preferred candidate or in the primary of the party with which they are most ideologically aligned. For example, a voter in the Indiana primary with preferences intended to represent a "conventional Democratic" voter (Clinton > O'Mally > Sanders > Kasich > Cruz > Trump) would vote for their second least preferred candidate, Cruz, based on the probability of winning objective function. This is driven largely by the closeness of the Republican primary polls compared to the strong lead Clinton had in the Democratic primary. Under a proportional utility objective function the "conventional Democrat" would vote for Kasich with the driving factor in this case being the large difference in utility scores for the Republic candidates. This approach to primary voting will tend to: 1) favor voting in the primary with fewer expected voters, 2) favor voting in the primary with the greater difference in preferences among candidates, 3) discourage strategic voting to advance a weaker candidate from the opposing party's primary to the general election, and 4) limit the pool of viable candidates to the two front runners in each party primary for the marginal probability of winning objective function. It is argued that if adopted more widely, this approach would decrease the polarization of the primary electorate and reward candidates with broad appeal.

P.95 Gutierrez, VV; Fortt, A*; Universidad Diego Portales and GreenRiver; *antonia.fortt@greeriver.cl*
Impact of industrial activities emissions on mortality rates in Chile: An ecological study
Chilean population are exposed to significant pollution from different industrial activities, mainly mining, agriculture, energy industries, power plants, paper production and transportation. The aim of this research is to determine if higher cancer mortality rates are associated with the presence of these different industrial activities along the country. Following the method used by Ruiz-Rudolph et al (2016), we conduct an ecological study that uses Chilean communes as small-area observation units to assess cancer mortality. Public data for mortality rates is available at the commune level, which are the smallest units of local administration in Chile. For each commune, data on cancer mortality were aggregated for the 2000-2016 period. Public database are available for pollution emissions for different industries. The impact of the pollution from different economic activities on cancer mortality rates is estimated using a model proposed by Besag, York, and Mollie (BYM) (Besag et al., 1991), wich has been used extensively in spatial epidemiology. Significant higher rates of cancer mortality were observed in communes with large industrial emitters.

P.33 Haegeli, P*; Statham, G; Birkeland, KW; Greene, E; Simon Fraser University, Parks Canada Agency, USFS National Avalanche Center and Colorado Avalanche Information Center; *pascal_haegeli@sfu.ca*
Untangling the mystery of assessing snow avalanche hazard - a conceptual model
Snow avalanches claim about 150 lives in the western world every year, more than any other natural hazard. Most victims are backcountry recreationists, but avalanches also threaten villages, utility lines, resource operations and cause traffic hazard and economic loss by blocking highways and railways. Avalanche risk is managed in real-time by continuously monitoring weather and snowpack conditions to assess the hazard and determine its effect on the element(s)-at-risk. Mitigation measures are then chosen based on objectives, such as warning the public, skiing a slope or keeping a road open. Assessment methods using a combination of hazard, exposure and vulnerability to determine and compare risks are widely used in natural hazards. Despite recent advances in the adoption of explicit risk concepts among avalanche forecasters, the process by which observations and data are combined into hazard assessments has so far not been formally described. This lack of formal structure makes the process vulnerable to human errors and posed a significant hurdle for evaluation, targeted improvements, and effective communication. We introduce a conceptual model of avalanche hazard that describes the assessment process by decomposing the intuitive, judgment based reasoning process of experts. Starting from a qualitative, risk-based framework, we progressively break down the practice of avalanche hazard assessment into its core components. We then define these components before reassembling them into a probability-consequence framework. The resulting model offers a tangible pathway from observations to hazard assessments that is universally applicable in any type of avalanche risk management context. This makes the model extremely valuable for operational application, training and communication. We conclude with a discussion of our practical experience with the model, its potential for future research and ideas about the benefits of our approach for other dynamic risk environments.

W2-H.2 Haimes, YY; University of Virginia; *haimes@virginia.edu*
Quantitative Risk Modeling and Management of Interdependent Complex Systems of Systems
In this presentation, we focus on characterization and modeling of complex SoS ("Complex SoS"); namely, on their interconnectedness and interdependencies (I-I). Current models for risk analysis of Complex SoS are insufficient because they often rely on the same risk functions and models used for single systems. By their essence, multifarious characteristics, and emergent nature of the complexity of systems of systems (SoS), cannot be defined, packaged and modeled via the simplicity of our language and models. Rather, we have to develop multiple methods and modeling approaches to better our understanding of their essence, and thus their risk modeling, assessment and management. The key to evaluating the risk to Complex SoS lies in understanding the genesis of characterizing I-I of systems manifested through shared states and other essential entities within and among the systems that constitute Complex SoS. "Essential entities" include the following sample: decisions, resources, functions, policies, decisionmakers, stakeholders, organizational setups, location, and others. This undertaking can be accomplished by building on state-space theory, which is fundamental to systems engineering and process control. We identify two innovations: (i) Building on shared states and other essential entities enables analytical modeling, and thus identifying critical I-I within and among the Complex SoS; and (ii) Reinventing the use of fault trees: The required reliability of each subsystem in the fault tree is replaced with the shared states and other essential entities, representing the I-I that characterize the Complex SoS. Analyzing connections in parallel or in series results in the identification of minimal cut sets. Performing five major case studies has solidified our theoretical and methodological premises on the centrality of shared states and other essential entities in modeling the complexity of SoS, and the process through which to interpret the modeling results.

M3-G.2 Hall, IS; University of Northampton; *Ian.hall@northampton.ac.uk*

New game,new rules: Responding to disruptive trends in Financial Services

Traditional Financial Services providers have increased levels of competition from innovators who are able to enter the market through the creation of new operating models. Innovation in six core functions (payments, market provisioning, investment management, insurance, deposits & lending and capital raising), when combined with big data and advances in technologies such as AI allow new entrants to the market who are able to change the 'rules of the game' How then should incumbents and regulators react to these trends? This presentation seeks to explore several of the game changers and provide strategies for the identification, management and mitigation of risk.

P.181 Hallman, CN*; Portacci, K; Miller, RS; Sellman, S; Brommesson, P; Beck-Johnson, L; McKee, C; Gorsich, E; Tsao, K; Tildesley, Wennergren, U, Lindström, T, Webb, C, M; 1,2,3,9 U.S. Department of Agriculture, 2150 Centre Ave, Fort Collins, CO; 4,5,11,12 Linkoping University, Linkoping, Sweden; 6,7,8,13 Colorado State University, Fort Collins, CO; 10 University of Warwick, Coventry, UK; *clayton.n.hallman@aphis.usda.gov*

Application of Livestock Shipment Models to Address Regional Risk of Disease Spread and Detection

National patterns of livestock shipment play an important role in disease transmission risk and development of surveillance strategies intended to mitigate the risk. The US Animal Movement Model (USAMM) is a Bayesian model that simulates annual national-scale networks of county-level shipments of beef and dairy cattle. USAMM incorporates data from cattle shipments moving across state lines (Interstate Certificate of Veterinary Inspection) with covariates on cattle industry information from the national census (National Agricultural Statistics Service). The hierarchical Bayesian framework of the model allows for both within-state shipments and between state shipments to be modeled at the county level. Simulated shipment networks are publicly available and a web-based interactive shiny application is available to visualize shipment patterns (https://usamm-gen-net.shinyapps.io/usamm-gen-net/). The USAMM is valuable to a broad range of risk assessment projects and represents the only data available to represent livestock movements between counties. We illustrate the utility of USAMM to support risk assessments addressing foreign animal disease spread, movement of at-risk livestock, and risk-based targeted disease surveillance. We also illustrate how USAMM generated shipment networks can be used in conjunction with a disease spread model (US Disease Outbreak Simulator) to determine the potential National scale disease spread. We expect that USAMM will support a diversity of risk assessment and risk identification activities.

P.66 Halper, SH*; Saadat, Y; Ayyub, BM; University of Maryland, College Park; *shalpe25@terpmail.umd.edu*

Costs of Seismic Retrofits of Existing Federal Buildings for Disaster Resilience

Throughout the history of the United States many buildings were designed according to building codes which predate seismic provisions. As a result, a lot of older buildings are not adequately equipped to withstand loads produced form earthquakes. This creates a safety hazard to the occupants of these buildings and their surroundings, and therefore retrofitting is required, especially for those buildings which are most vulnerable. Multiple retrofit methods exist that are suited for different types of building structures to address different structural deficiencies. The purpose of this work is to determine which retrofit methods are most economical for a particular building type. This involves identifying a system of classifying building structures, developing a method of estimating costs of each retrofit method for each building structure type, developing a method of estimating benefits gained as a result of the retrofit, and ultimately computing benefit/cost ratios. Costs estimates include direct and indirect costs. Costs are extremely dependent on factors like seismicity (low, moderate, high, very high), performance objective (life safety, damage control, immediate occupancy), occupancy class (parking, retail, residential, industrial, institutional/educational, commercial, assembly), and occupancy during construction (in place, temporarily removed, vacant). Benefits are determined by losses avoided, including loss of life, and property losses. The benefit cost ratios provide a basis for selecting economically justifiable and effective solutions. This work concentrates on buildings belonging to the United States Federal Government, and outlines a methodology for producing cost benefit ratios for such buildings.

M4-I.3 Hamilton, KA*; Gurian, PL; Drexel University; *kh495@drexel.edu*

Reverse QMRA for opportunistic pathogens in premise plumbing

The opportunistic premise plumbing pathogens (OPPPs) Legionella, Non-tuberculous Mycobacteria (NTM, including the Mycobacterium avium complex or MAC), Pseudomonas aeruginosa, Naegleria spp., and Acanthamoeba spp. are ubiquitous in water sources and occur widely in engineered water systems. Despite widespread exposure, human disease is relatively uncommon, except under circumstances where pathogen concentrations are high, host immunity is low, or exposures meet certain criteria such as inhalation of small-diameter aqueous aerosols. Still, OPPPs are key contributors to the United States waterborne disease burden and are responsible for a large portion of recent drinking-water related outbreaks. Water quality guidance values for Legionella and some other OPPPs are available for building water quality managers. However, these criteria are generally not risk-based. As a result, risk-based strategies for direct monitoring would be beneficial because pathogen monitoring can be costly. This study uses newly developed dose response models for OPPPs to conduct a “reverse” quantitative microbial risk assessment (QMRA) in which target risk values are used to back-calculate corresponding environmental exposures. These results can help to identify candidate ranges and influential data gaps that need to be addressed in order to develop meaningful water quality targets for use in larger-scale building water quality modeling efforts. This process is conducted for three different building types: conventional, water-efficient “green” buildings, and hospitals, in order to developed nuanced, location-dependent risk management guidance that takes into account differences in habitant exposure patterns and fixture types. A scenario analysis was conducted to investigate the impact of microbiological quality vs. an individual’s immune status or exposure pattern for the various fixture types. As a result, the feasibility of risk-based water quality targets is critically examined and alternative approaches are proposed.

W3-C.4 Hamilton, M*; Morath, D; Curran, R; Hughey, E; Green , J; Batzel, J; CCRi; *mhamilton@ccri.com*

A Regional Risk and Vulnerability Assessment with Multiple Criteria Decision Analysis to Support Evidence-Based Investment

The aim of this research is to inform the investment of humanitarian assistance projects to build more resilient regions. The first part of this research is to conduct a multi-year regional Risk and Vulnerability Assessment (RVA). The RVA provides a risk profile for the region along with drivers of risk within individual countries, thereby identifying areas in need of investment. 51 indicators are used to assess three main components of risk: hazard exposure, vulnerability and coping capacity. Hazard exposure measures the historical population and economic exposure to multiple hazards. The vulnerability component measures the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. The coping capacity component measures the ability of people, organizations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters. The second part of this research uses multi-criteria decision analysis to help potential humanitarian assistance investors to prioritize investment based on their mission for addressing needs. The approach defines multiple factors for investments by aligning the RVA indicators with stakeholder mission areas which include: governance and rule of law; economic stability; transportation & communication infrastructure; public health; public welfare; education & information; and environmental stability. Given stakeholder priorities and limited resources, some of these factors may be more suitable for investment than others. Analytic hierarchy process is used to elicit stakeholder preferences for the seven factors for investment. Given the factor weights and the indicator scores for each country, the result is a ranked prioritization of countries for investment. The method is demonstrated in the 10 ASEAN countries of Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam.

T2-E.5 Hartnett, E*; Payette, P; Paoli, G; Risk Sciences International; *ehartnett@risksciences.com*

Exploring Optimal Risk-Based Strategies for Medical Countermeasure (MCM) Stockpiles

Medical Countermeasures (MCMs) are therapeutic products (i.e., drugs, vaccines and medical devices, as defined by the Food and Drugs Act) that may be used in response to events causing widespread public harm. These events may by terrorism related, unintentional events (e.g. accident at a nuclear power plant), or naturally occurring threats (e.g. hurricane). Should an event occur, time is of the essence to minimize the public health impact, and usual medical resource levels may not be sufficient, or even appropriate, to meet the needs of individuals requiring medical attention. To address this, governing bodies are developing stockpiles of MCMs to enable rapid and appropriate response by health authorities should an event occur. Several challenges are present when designing and maintaining a stockpile in preparation for such low-probability high-consequence events, some of which have never been directly observed, but may be considered a legitimate threat. The most obvious challenge is which MCMs to stockpile, and at what levels. Once these decisions have been made, the next challenge is to design a purchasing/procurement strategy that provides the optimum public health protection achievable. Such a strategy should take into consideration factors that affect the viability and sustainability of the stockpile. These factors include yearly budget limitations and fluctuations, product shelf-life, and availability. This presentation discusses general issues and challenges when exploring MCM stockpile development. We will describe a methodology to explore optimal risk-based procurement strategies using cost-effectiveness metrics based on quantitative estimates of public health burden. The methodology enables exploration of alternative strategies that minimize the residual public health risk year-over-year in the face of finite funds, limited shelf life, and other constraints.

W2-C.5 Hassler, ML*; Collier, ZA; Bier, V; Lambert, JH; University of Virginia; *madison@virginia.edu*

Resilience of Food, Energy, and Water Infrastructure for Coastal Cities and Displaced Populations

Mass relocation of individuals in coastal disasters amplifies stressors to food, energy, water, (FEW) and other infrastructure systems. Critical situations become more devastating and unpredictable in their cascading effects. It is important to identify and monitor the most impactful emergent and future conditions for the interdependent infrastructures. Emergent and future conditions include economics, demographics, environment, technology, regulations, agriculture, disease, population and workforce behaviors, and many others. This paper identifies the combinations of conditions that are most and least disruptive to priorities for investments, assets, policies, locations, and organizations. The paper utilizes methodologies of scenario-based preferences, network modeling, and economic value chains to identify strategies to mitigate the adverse effects of population displacements on infrastructures. The approach addresses the resilience of systems on several time scales. The approach considers interrelated phenomena including energy and resource usage in the food-distribution sector, environmental contamination, congestion of passengers and freight, and continuity of governance and emergency services. The impactful scenarios for FEW systems guide the selection of topics for ongoing and future risk analyses that involve multiple domains of expertise.

W4-B.3 Hathaway, JH; George Mason University; *jhathaw3@gmu.edu*

Challenges in communicating the slow onset crisis of climate change

Climate change is one of the most important societal challenges we face. Absent significant near-term reductions in greenhouse gas emissions, we risk large-scale, irreversible damage to planetary systems, with severe consequences for the inhabitants of the earth. Yet Americans are not taking action commensurate with these risks. Climate change communication involves several specific barriers which, in the aggregate, make communicating the risks of continued inaction uniquely challenging. Two theoretical lenses hold promise for understanding the communication barriers to responding to climate change. The CAUSE Model for Risk Communication (Rowan, 1991, 1994; Rowan et al., 2008; 2009) was developed in recognition of five fundamental challenges and goals of risk communication, each of which is indicated in the acronym "CAUSE." First, communicators need a way of creating confidence in the messengers. Second, effective communication about the slow-onset risks of climate change must address the lack of awareness of the immediacy and proximity of the problem. Third, because climate change is an unprecedented threat involving technical, political, and legal questions, practitioners need to foster understanding of what the phenomenon means to individuals, their families, their communities, and society at large. In addition, cultural theory contributes to explaining why we are beset with a lack of satisfaction with not just response options but whether there is a problem at all. Finally, risk communicators need strategies to stimulate enactment of behavioral, structural, and institutional response options. In this paper, I describe the obstacles to communicating those hazards, drawing on existing research and interviews conducted with a small group of climate change communication practitioners. I suggest next steps for further research and hypothesis testing about ways to increase confidence in messengers, awareness, understanding, and satisfaction with both the analysis of the crisis and potential response options, and enactment of those options.

W2-E.1 Henshel, DS*; Cains, MG; Taber, DL; King, ZM; Indiana University, Bloomington; *dhenshel@gmail.com*

Expert Elicitation of Cyber Security Experts: What is Cyber Security Risk?

Cyber security risk assessment has traditionally been narrow in focus and often based on a business risk assessment approach (quantifying replacement costs). Within a defensive environment, cyber security risk assessment requires holistic consideration of impacts well beyond the financial costs of replacing hardware and software by explicitly accounting for the user, analyst, defender, and attacker as risk initiators and risk mitigators. A holistic cyber security risk assessment approach is being developed within the Cyber Security Collaborative Research Alliance (CSec CRA). Based on guidelines used in other risk assessment fields (e.g. human health, ecology), rigorous problem formulation and the development of assessment goals are crucial for constructing a representative risk assessment. Due to the diversity of disciplines and number of participants in the CSec CRA, semi-structured interviews were conducted to determine the collective definition of cyber security and cyber security risk, as well as a baseline goal for a more holistic cyber security risk assessment approach. Twenty-seven principal investigators and researchers from the U.S. Army and within academia participated in the interview process. Data-driven thematic analysis was performed on the interview corpus; interviewees remarked that much of cyber security risk arises from a lack of understanding of the interactions, motives, and effects of human factors on cyber security. Nearly all of the interviewees stated that the traditional vulnerability triad of confidentiality, integrity, and availability encompasses the risks posed to cyber security. Academic interviewees indicated a need for more military-specific information from their Army counterparts (e.g. specific military operation scenarios) to allow more military-relevant cyber security risk modeling. We will discuss the CSec CRA's collective definition of cyber security and cyber security risk.

P.176 Hibbert, K*; Tulve, NS; U.S. Environmental Protection Agency; *hibbert.kathleen@epa.gov*

A Review of Non-Chemical Stressors and Their Importance in Cumulative Risk Assessment

Non-chemical stressors are factors found in built, natural and social environments including physical factors and psychosocial factors. Extant research has shown correlations between non-chemical stressors found in a child's social environment (e.g., food security, violence) and changes in children's health and well-being. However, limited data are available on the interrelationships between chemical and non-chemical stressors and children's health. Children may be more vulnerable to combined interactions of chemical and non-chemical stressors due to their developmental stage and lifestage-specific activities/behaviors. Objectives of this review were to 1) examine the state-of-the-science of non-chemical stressors found in a child's social environment and 2) statistically rank and prioritize those stressors. A systematic review of non-chemical stressors found in a child's social environment was performed on extant literature. Combinations of search strings (i.e., acculturation + health + child) were entered into PubMed and PsychInfo. Inclusion criteria resulted in 244 articles. The available non-chemical stressor data from articles were extracted for statistical analysis and were classified into 11 topic categories: acculturation, adverse childhood experiences, economic, education, food, greenspace, overcrowding, social support, stress, urbanization, and exposure to violence. Depending on the topic category, initial analyses suggested significant positive and negative impacts on children's health. Preliminary analyses identified most frequently reported non-chemical stressors, sub-categories of non-chemical stressors, proportion of studies that considered multiple exposures involving at least one chemical and non-chemical stressor, and correlations between a non-chemical stressor and health outcome. Our research suggests that non-chemical stressors, in combination with chemical exposures, should be considered in cumulative risk assessment for children's health.

P.63 Hilgard, J*; Nucci, ML; Hallman, WK; Annenberg Public Policy Center, University of Pennsylvania; Illinois State University; Rutgers University; *jhilgard@gmail.com*

Consumer Approval of Nanomaterials in Food and Medicine

This study examines consumers' approval, evaluation, and policy stances regarding the use of nanotechnology in food and medicine. Although nanotechnology may provide useful innovations in product design, packaging, and supplementation, consumers often see novel food technologies as risky, as exemplified by opposition to genetically modified foods. To understand public awareness and opinion towards nanotechnology, we conducted a web-based survey on a nationally-representative panel (N = 1058). Participants evaluated a variety of nanotechnology applications in terms of their approval for the product, their behavioral intentions towards the product, and whether the product should require special labels. Embedded experiments manipulated attributes of some products in a randomly-assigned, between-subjects fashion. Overall, awareness of nanotechnology is low, and attitudes are generally ambivalent or mildly supportive. Products that provided solutions to serious problems, such as disease, were seen more favorably than products that embellished existing functionality, such as vitamin supplements. Furthermore, results indicate that attitudes are more favorable to nano-products that are not directly ingested by humans or by livestock. Taken together, it appears that consumers see ingested nanoparticles as a source of risk. Nanotechnology may find greater approval when fed to pets rather than humans, used in packaging rather than the food itself, or used to address serious problems that conventional products cannot solve.

P.55 Ho, WC*; Yin, MC; Chu, YR; Peng, YH; Tsan, YT; Chen, PC; China Medical University; *whocmu@gmail.com*

Association with Using Statins and the Risk of New Diagnosis Diabetes Mellitus in Transient Ischemic Attack Patients

Diabetes Mellitus (DM) is a major public health issue in Taiwan, and worldwide, affecting the health of people and quality of life. Transient Ischemic Attack (TIA) is an important cerebrovascular disease in Taiwan, the third leading mortality cause in Taiwan. Statins are the widely used for hyperlipidemia by their cholesterol-lowering effect, also potentially with pleiotropic effect. Statins potentially can reduce the risk of TIA patients developing more severe stroke. Some studies have shown statins use maybe related to the risk of developing DM but the results remain controversial. Therefore, the aim of this study was to investigate the risk of developing DM after using statins among TIA patients. The study design was a retrospective cohort study based on Taiwan Longitudinal Heath Insurance Database 2000 (LHID2000). This study subjects were newly diagnosed cases of transient ischemic attack from January 1, 1997 to December 31, 2011. Statin dose is assessed and evaluated according to the cumulative daily defined dose (cDDDs). Cox proportion hazard regression models were used to investigate the relationship between the use of statins and the risk of newly diagnosed DM among TIA patients. Considering the differences within the time period of personal use statins, the Cox proportional hazards model with time-dependent covariate was used to calculate the hazard ratio (HR) and 95% confidence interval (95% CI) after adjusting the sex, age, income and urbanization degree. Sensitivity analysis and subgroup analysis were also conducted. All hypothesis tests for statistical significance were 2-sided using p

M4-J.8 Hobbie, K*; Cawley, M; Turley, A; Varghese, A; ICF; *audrey.turley@icf.com*

DoCTER: Text Analytics to Prioritize Literature Search Results for Review

Comprehensive literature searches conducted for systematic reviews may result in tens of thousands of results. Distinguishing relevant literature from background noise is time and labor intensive. ICF's tool, DoCTER, uses text analytics to move rapidly from literature search to risk analysis. Among DoCTER's analytics capabilities are topic extraction, supervised clustering, smart clustering, and machine learning. Topic extraction requires no a priori knowledge. It assigns each reference to a single cluster and generates a topic signature (a set of keywords) for each cluster. Subject matter experts review the keywords and assign priority levels to each cluster. Supervised clustering requires a set of known relevant studies to add to search results when clustering; these are the "seeds." Clustering with seeds takes the guesswork out of determining which clusters to prioritize and generates unbiased forecasts of retrieval accuracy. Smart clustering uses unsupervised semantic similarity algorithms and user-specified keywords to create a set of words and phrases that best define the topic of interest; it then ranks the relevance of each document in terms of these keywords. Smart clustering is an improvement over traditional clustering in some contexts because the process of cluster formation is directed and focused on the user's objectives. Machine learning potentially delivers the greatest accuracy of these methods but requires a time investment to develop a training dataset following which relevance scores are generated for each study. The DoCTER pipeline combines these elements to prioritize review of the most relevant references only and is flexible to all user contexts, including situations in which no training data are available. In simulations, the DoCTER pipeline has demonstrated a five-fold increase in efficiency compared to a purely manual approach at an equivalent level of accuracy.

T2-E.1 Hoffman, M*; Turnley, J; Wachtel, A; Speed, A; Gauthier, J; Muñoz-Ramos, K; Kittinger, R; Sandia National Laboratories and Galisteo Consulting Group Inc.; *awachte@sandia.gov*

A System of Systems Approach to Layered Security at a Foward Operating Base

Discrete event System of Systems (SoS) modeling approaches emerged from the engineering field and are still strongly oriented towards engineered rather than human systems. If humans are included, it is in peripheral roles as system managers or as participants with assumed performance parameters. A Sandia team has developed a prototype SoS model that fully incorporates both the engineered and human systems and their interactions, and allows for the analysis of performance features and a novel method of assessing failure risk at the SoS level that might not be evident with either an engineering- or a human-focused model. The model use case is perimeter security at a military forward operating base (FOB) focusing on entry check points (ECPs), a layered security application. The focus on ECPs required that the modeling team have a reasonable understanding of the full FOB security system, ranging from activities of guards in towers to the level and points of involvement of indigenous personnel in FOB security, the communication among all elements of the FOB involved in perimeter security, and the various required technologies for all tasks, including weapons. The team also needed domain knowledge of the included technologies and military activities and policies. A multidisciplinary modeling team was assembled to elicit the business rules and tasks of a FOB from interviews and secondary sources. The model itself is built in FlexSim, an off-the-shelf discrete event simulation software that can handle a wide array of model and logic structures and flows. Overall effectiveness of the SoS perimeter security system was assessed by the team through a novel approach based on the concept of d' from signal detection theory, extended to psychophysics. This new approach shows that, although each functional element involving human-technology interaction may be highly effective, the effectiveness of the SoS as a whole can still be relatively poor.

M4-A.3 Hoffmann, S; USDA Economic Research Service; *shoffmann@ers.usda.gov*

Monetizing Benefits of Preventing Global Deaths from Foodborne Illness

There is increasing demand for monetary estimates of population health impacts in middle and lower income countries both for use in evaluating national programs and for making global comparisons. There is particular interest in estimates of the value of reducing mortality risk, the most significant benefit from many population health and environmental programs (World Bank and IHME 2016 (air pollution), WHO 2015 (foodborne disease)). Yet as a practical matter for most countries, analysts must use benefits estimates developed in other settings (see OECD 2012). Such "benefits transfer" is most accurate when benefits comparisons are drawn from studies conducted in settings as similar as possible to those in which they are being applied (Johnston et al. 2015). A relatively large number of studies have been conducted in high income countries (OECD 2012). Unfortunately, there is a paucity of primary VSL studies in low and middle income countries, which makes either finding appropriate country-specific VSL estimates or using benefits transfer from other low or middle income countries or from high income countries difficult. Recent research has raised a number of methodological issues with benefits transfer from high to low income countries. This paper uses recently developed estimates of deaths from foodborne illness by WHO subregion to explore the implications of alternative methods for valuing the benefit of reducing deaths for a major global health problem.

W4-K.3 Holsapple, M; Director and Endowed Chair of Center for Research on Ingredient Safety, Michigan State University and Director, CRIS Bits; *holsappl@msu.edu*

Communicating Real Risk in a Complex World

Michigan State University's Center for Research on Ingredient Safety is an independent academic center that was established to serve as a hub for objective science that adds rigor and data to the highly visible discourse on consumer product and ingredient safety. As such, an important purpose for CRIS is to make science accessible to enable evidence-informed decisions. Included among the principle target audiences for CRIS are consumers. Broadly speaking, consumers think of chemicals in food as any ingredient added to foods. Consumers are generally unfamiliar with ingredient safety, and are becoming increasingly interested in learning more about the potential risks of chemicals in food. Even though scientists note that food itself consists of chemicals, the phrase, 'chemicals in food' has a negative connotation. In today's complex world, the majority of consumers think that the absence of artificial additives is important, that they don't want ingredients in their foods that they can't pronounce, and that fewer ingredients is associated with healthier food. This presentation has two goals: 1) to summarize the results from a number of recent surveys aimed at gauging how consumers view the potential risks of chemicals in our food supply, 2) to provide insights as to how to most effectively communicate to an audience which doesn't generally differentiate between 'hazard-based approaches' and 'risk-based approaches'. Consumers should be informed about why certain chemicals make their way into our food supply, and, most importantly, at what levels chemicals in food could potentially cause adverse health effects. Consumers should be encouraged to ask, 'is this chemical supposed to be in our food?' As risk assessors, we need to reassure consumers that the risks to health mostly depend on the duration, frequency, and level of exposure to a chemical, that low level exposures are often of no or negligible risks, and that the mere presence of a chemical in a food does not constitute a risk.

P.21 HONG, J; SEOG, S*; Seoul National University; *seogsh@snu.ac.kr*

Moral Hazard in Loss Reduction and the State Dependent Utility

We consider a state dependent utility model with binary states where moral hazard occurs in loss reduction. We find different results depending on the relative sizes of the marginal utilities between the loss state and the no loss state. (i) If the marginal utilities are equal between the two states, the optimal insurance involves full insurance up to a limit and coinsurance above the limit, which corresponds to the case of the state independent utility. (ii) If the marginal utility in the loss state is greater than that in the no loss state, then the optimal insurance includes full insurance, and the moral hazard problem becomes less severe than under the case of the independent utility. (iii) If the marginal utility in the loss state is less than that in the no loss state, then the optimal insurance includes the deductible up to a limit and coinsurance above that limit, and the moral hazard problem becomes more severe. We extend the model into a two period setting, and apply it to the cases of a debt contract of a firm and a wage contract.

M2-C.2 Hoogendoorn, G*; Sütterlin, B; Siegrist, M; ETH ZÃ¼rich; *gea.hoogendoorn@hest.ethz.ch*

Biased risk and benefit perception of human and nature-caused climate change

The recent climate changes on Earth have a strong impact on humans and nature. The public opinion regarding the cause of climate change is inconsistent, and both human interference and natural processes are named as possible causes. However, previous studies have shown that the consequences of human-induced and nature-induced hazards are differently perceived. In multiple experiments, we found the same bias in the perception of the consequences of human- or nature-induced climate change. In the first experiment, we demonstrated that the exact same positive consequences are perceived to be more beneficial when caused by nature-induced climate change rather than human-induced climate change. In the second experiment, we showed that the exact same negative consequences of climate change are estimated to have a larger negative impact on the environment when they are human-induced rather than nature-induced. Moreover, in this second experiment, we revealed that people estimate the perceived need to act upon the consequences of climate change to be larger when the climate change is human-induced rather than nature-induced. These results have strong implications for both the perception of the consequences of climate change as well as the willingness of the people to take action.

M3-I.3 Hoover, MD*; Snawder, JE; National Institute for Occupational Safety and Health; *mhoover1@cdc.gov*

Direct Reading and Sensor Technologies: Opportunities to Advance Occupational Risk Management

The recent National Research Council report on Exposure Sciences for the 21st Century identified direct reading methods and monitors as being an important driver for the future of exposure sciences. SRA provides a robust forum to collaborate and address how these technologies can advance risk assessment and risk management decision-making, especially in occupational settings. Major questions include: Do these methods accurately measure what they are supposed to be measuring? How can they be adequately calibrated and validated? When are they limited to use for screening and when can they provide accurate characterizations of specific hazards? Given the large amounts of sensor data that may be collected, how can those data be feasibly analyzed and interpreted? To advance its capabilities and partnerships to anticipate, recognize, evaluate, control, and confirm effective development and application of new technologies to address relevant workplace hazards and exposures, the National Institute for Occupational Safety and Health has established the NIOSH Center for Direct Reading and Sensor Technologies. The center serves as a home for NIOSH's longstanding work in the area of exposure assessment devices—work that is done across the Institute to address occupational hazards of all types. Activities include 1) developing guidance documents pertinent to direct reading methods and sensors such as validation and performance characteristics, 2) developing training protocols, 3) establishing partnerships to collaborate in the Center's activities, and 4) fostering a national research agenda for direct reading and sensor technologies. NIOSH sensor activity examples include the Personal Dust Monitor; Coal Dust Explosibility Meter; MethChek and MethAlert direct readout units; Portable Aerosol Mobility Spectrometer; smart phone Sound Level Meter application; Intelligent Proximity Detector; Portable Assessment System for Slips, Trips and Falls; and the Helmet Cam and Evade Software.

P.90 Horng, RL*; Chuang, YC; Hsiao, JL; Lin, YT; Wu, KY; Chiang, SY; China Medical University ; *ny88021@gmail.com*

Risk Assessment of Arsenic in Prescriptions of Traditional Chinese Medicine.

The use of complementary and alternative medicine is increasing worldwide and the safety of Traditional Chinese Medicines (TCMs) is of concern. Different levels of heavy metals have been detected in TCMs. Among them, arsenic is classified by the International Agency for Research on Cancer as Group 1 carcinogen. Due to high prevalence of chronic insomnia in Taiwan, TCMs are widely used to treat insomnia. The most common prescriptions of TCMs for the treatment of insomnia are Jia Wey Shiau Yau Saan (Formula #1), Suan Tzao Ren Tang (Formula #2), Chair Hwu Jia Long Guu Muu Lih Tang (Formula #3) and Uen Dann Tang (Formula #4). Therefore, the objective of this study was to conduct a probabilistic risk assessment on arsenic in 4 prescriptions of TCMs. We assumed that people used TCMs a quarter of year and the average decoction transfer rate for arsenic after boiling was 10%. The Monte Carlo simulation was used to simulate the distributions of the Life-time Average Daily Dose (LADD), Hazard Index (HI) and Cancer Risk (CR). The mean LADDs of Formula #1 to Formula #4 are 4.54E-05, 3.47E-06, 1.18E-04 and 6.21E-06 mg/kg-day, respectively. The mean HIs of Formula #1 to Formula #4 are 0.15, 0.01, 0.39 and 0.02, respectively. The HI for 4 prescriptions of TCMs were all less than 1, indicating the absence of a non-carcinogenic health hazard. The carcinogenic risk of 4 prescriptions of TMCs were all higher than1E-06, indicating potential risk of cancer. The residue data of arsenic in TCMs are composed of inorganic arsenic and organic arsenic. If the residues of inorganic arsenic and organic arsenic are separated, the uncertainty of risk assessment will be reduced.

M3-D.1 Howard, J; US Government; *zkz1@cdc.gov*
Occupational Safety and Health of Nanoscale Materials
Occupational Safety and Health of Nanoscale Materials John Howard Risk characterization of a new technology to quickly determine if it raises safety and health issues for workers should be a priority for occupational health researchers and practitioners. Engineered nanomaterials and devices demonstrate novel size-dependent properties and behavior and hold great promise in many areas of benefit to society, such as new lightweight but stronger materials, new pharmaceuticals, enhanced water filtration, and advances in regenerative medicine. The challenge of nanotechnology from a risk perspective is 2-fold. First, does the nature of engineered nanomaterials present occupational safety and health hazards? If so, how can the benefits of nanomaterials be realized while proactively minimizing or eliminating the potential risks? NIOSH has identified 10 critical topic areas to guide in addressing knowledge gaps, developing strategies, and providing recommendations. These ten areas are: toxicity; risk assessment; epidemiology and surveillance; engineering controls and PPE; measurement methods; exposure assessment; fire and explosion safety; recommendations and guidance; global collaborations; and applications. Applications of nanotechnology is moving faster than the knowledge base about risk can be built. For instance, additive manufacturing is an increasingly prominent part of modern industry due to its utility in product development and precision manufacturing, with further growth in applications and adoption expected in coming years. A key component in additive manufacturing is the use of nanoscale metal powders. Although the occupational health implications of advanced manufacturing involving nanomaterials are not yet clearly understood, it is prudent to take precautions to protect workers until the risks can be fully characterized.

M4-J.1 Howard, BE*; Tandon, A; Phillips, J; Shah, R; Sciome, LLC; *itsbehoward@hotmail.com*
SWIFT-Review: A Text-Mining Workbench for Systematic Review
Here, we introduce “SWIFT-Review” (SWIFT is an acronym for “Sciome Workbench for Interactive computer-Facilitated Text-mining”), a freely available, interactive workbench that provides numerous tools to assist with problem formulation and literature prioritization. SWIFT-Review can be used to search, categorize, and visualize patterns in literature search results. The software utilizes statistical modeling and machine learning methods that allow users to identify over-represented topics within the literature corpus and to rank-order titles and abstracts for manual screening. We have tested the automated document prioritization feature on 20 previously conducted systematic review datasets, and the results presented clearly suggest that using machine learning to triage documents for screening has the potential to save, on average, more than 50% of the screening effort ordinarily required when using un-ordered document lists. In addition, the tagging and annotation capabilities of SWIFT-Review can be used to produce “scoping reports” or “scoping studies,” a type of knowledge synthesis undertaken to guide the direction of future research priorities or to help with problem formulation when conducting a systematic review. As a result, users can more quickly assess the extent of available evidence, prioritize health outcomes and chemical exposures for systematic review, and understand the degree of evidence integration that may be required. In addition, the resulting visualizations can help to identify topics that have been extensively studied as well as emerging areas of research. SWIFT-Review integrates seamlessly with other text-mining platforms including Active-Screener and HAWC. The software remains under active development with several new features planned.

M4-J.2 Howard, BE; Miller, K; Phillips, J; Tandon, A; Phadke, D; Mav, D; Shah, R*; Sciome, LLC; *brian.howard@sciome.com*
SWIFT-Active Screener: Reducing Literature Screening Effort Through Machine Learning for Systematic
Evidence-based toxicology is an emerging discipline in which researchers within government, industry and non-profit research organizations are increasingly employing systematic review in order to rigorously investigate, analyze and integrate the evidence available in peer-reviewed publications. A critical and time-consuming step in this process is screening the available body of literature to select relevant articles. To address this problem, we introduce SWIFT-Active Screener, a web-application which uses novel statistical and computational methods to prioritize relevant articles for inclusion while offering guidance on when additional screening will no longer yield additional relevant articles. We tested Active Screener on 20 diverse systematic review studies in which human reviewers have previously screened, in total, more than 115,000 titles and abstracts. When compared to a traditional screening procedure, this method resulted in substantial savings (50-75% for large projects) in terms of total number of articles screened. While these results are very promising, machine-learning prioritization approaches such as this can only be deployed confidently if users are ensured that no critical article will be missed in the process. Accordingly, Active Screener also employs a novel algorithm to estimate recall while users work, thus providing a statistical basis for decisions about when to stop screening. In Active Screener, these unique methodological advancements are implemented as a user-friendly web application that allows users to manage their review, track its progress and provide conflict resolution. Together, these tools will enable researchers to perform literature screening faster, cheaper and in a more reproducible manner.

P.24 Howard, B*; Kenney, M; Gerst, M; Giraud, R; American Chemistry Council; *brett_howard@americanchemistry.com*
Practical Multi-Criteria Decision Analysis with an Alternatives Assessment Framework
Alternatives Assessments afford value chain stakeholders an opportunity to evaluate a chemical or product holistically – providing an advantage over traditional single attribute determinations. To date, however, AAs have experienced sporadic application with common complaints being they’re too difficult to implement and don’t capture tradeoffs accurately. Much of this stems from an “apples to oranges” comparison mindset -- for example, how does one relate reduced environmental impact to increased hazard? Multi-criteria decision analysis (MCDA) is one method stakeholders can use to analyze tradeoffs in otherwise incomparable criteria. And by combining MCDA approaches with existing LCA, hazard, exposure, and performance information databases, the process can drastically reduce the time required to perform an AA and increase the informational value of the output. The Value Chain Outreach division within ACC has recently explored applying MCDA techniques in real-world circumstances – today’s talk will discuss some of our findings and the challenges that remain.

M2-K.4 Howell, EL*; Kohl, P; Scheufele, DA; Xenos, MA; Brossard, D; University of Wisconsin-Madison; *elhowell@wisc.edu*

Ethics and risk in human gene editing: how type and use of gene editing impacts public risk perceptions

Development of the gene editing tool CRISPR Cas-9 accelerated gene editing research and heightened public attention on the potential for human gene editing. Support for research, applications, and regulation will depend on public perceptions of potential risk, benefit, and ethical concerns from human gene editing. Research on these perceptions, however, is sparse, especially on how public opinion might vary depending on different types of proposed gene editing applications. Potential edits can be heritable (germline) or not (somatic) and used for therapeutic (treating or preventing illness) or enhancement (going beyond "normal" human characteristics) purposes. This study examines how these dimensions might differentially shape public perceptions and what those differences mean for advancing public discourse and the scientific research itself. In a nationally representative survey (N=1,600; completion rate=41.7%) U.S. adults randomly received a control condition or one of four vignettes explaining one of the following types of gene editing: 1) somatic edits for therapy uses; 2) somatic edits for enhancement uses; 3) germline edits for therapy uses; and 4) germline edits for enhancement uses. We examine how each vignette influenced perceptions of risk, benefit, and ethical concerns around human gene editing for the public as well as for relevant subgroups, such as respondents with higher levels of religiosity and knowledge. Initial results indicate that, compared with the enhancement conditions, the therapy conditions are positively related to perceptions that human gene editing is morally acceptable and likely beneficial and negatively related to perceptions that human gene editing allows humans to play god, messes with nature, and poses risks. Overall, the therapy-enhancement distinction shaped views more than the somatic-germline distinction did. The germline enhancement condition, however, tended to be most strongly associated with negative views of gene editing.

P.89 Hsiao, IL*; Wu, KY; National Taiwan University; *kuenyuhwu@ntu.edu.tw*

Risk assessment of imported canned foods in Taiwan: take Bisphenol A (BPA) as an example

In canned foods, chemical migration from packages and microorganism growth are the two factors that have potentially impacts on human health. The imported canned foods especially raised the concerns because of the poor hygienic condition and material quality in canned foods manufacturing in developing countries. In this study, we conducted a risk of imported canned foods in Taiwan and took one of most important toxic chemicals Bisphenol A (BPA) as an example. BPA can migrate from epoxy resin-coated canned foods. Exposures to BPA have been associated with reproductive, developmental, and cardiovascular effects. The European Food Safety Authority (ESFA) has re-evaluated the Tolerable daily intake (TDI) of BPA from 50 to 4 μg/kg bw/day in 2015 due to the new evidences on immune system. By integrating the currently available BPA data in canned food from publications and using Taiwan FDA canned food import statistics data, we evaluated the risk of canned foods from ten major import countries. Using Monte Carlo simulation to simulate great variability of data, the results showed that an upper limit of 95 % confidence interval of overall exposure for the adults (19–64 years old) was 14 ng/kg-day, corresponding to a hazard index (HI) of 0.0035. The BPA concentration is the most sensitive factor in the exposure assessment (+37.3 to +77.7%, variance between countries). The potential dose is very low in comparison to our previous study in evaluating aggregate health risks on BPA in Taiwan by CalTOX multimedia model (1.05 μg/kg-day).

P.172 Hsieh, NH*; Reisfeld, B; Bois, FY; Weihsueh, WA; Department of Veterinary Integrative Biosciences, Texas A&M University; *nhsieh@cvm.tamu.edu*

Applying A Global Sensitivity Analysis Workflow to Improve Computational Efficiency in Physiologically-Based Pharmacokinetic Model

Population physiologically-based pharmacokinetic (PBPK) models have come to play a key role in toxicological dose-response assessments, but can be computationally intensive to calibrate. The purpose of this study is to apply global sensitivity analysis (GSA) to ascertain which PBPK model parameters are nonidentifiable, and therefore can be assigned fixed values in Bayesian parameter estimation, increasing computational efficiency with minimal bias. We illustrate this approach using a published human population PBPK model for acetaminophen (APAP) and its two major metabolites APAP-glucuronide and APAP-sulfate. The Morris Elementary Effects method and variance-based Sobol indices (estimated using three different algorithms) were used to determine the sensitivity of parameters in the original model. Unsupervised hierarchical clustering was used to distinguish between sensitive and insensitive parameters. We compared Bayesian model calibration results using the "original" versus "original sensitive" parameters. We then expanded our GSA to encompass all PBPK parameters, including those fixed in the published model, comparing the model calibration results using "all" versus "all sensitive" parameters. The three variance-based GSA estimators gave similar results, which different from the results of the Morris method. We found that 12 of the 21 original parameters have low sensitivity, and could be fixed to improve computational efficiency without discernable changes in prediction accuracy or precision. We further found 10 additional sensitive parameters among the parameters that were previously fixed in the published PBPK model. Adding these additional sensitive parameters improved model performance beyond that of the original publication, while maintaining similar computational efficiency. We conclude that GSA provides an objective, transparent, and reproducible approach to improve the performance and computational efficiency of PBPK models.

P.67 Hu, H*; Ayyub, BM; University of Maryland, College Park; *hhu3@umd.edu*

Validating and Improving Downscaling Methods of Global Climate Model Results in Predicting Extremes using Copula

The ability to analyze and predict future precipitation plays a key role in risk and damage management. Huge effort has been spent to build Global Climate Models that provide climate projections in the global scale. However, when applying the global-scale projection to a local scale, a downscaling procedure is required, which transforms a global trend to a local trend. Methods have been proposed by previous works to perform downscaling, but none of them have fully validated in terms of their accuracy using historical data for extreme events. In this work, the validation of three downscaling methods, namely Global Daily Downscaled Projections, Localized Constructed Analogs, and Multivariate Adaptive Constructed Analogs, are studied and compared in the context of extreme precipitation. It is observed from this work that all three downscaling methods work well when used to analyze non-extreme precipitation. However, when used to analyze extreme precipitation, the accuracy decreases significantly. To further explore the underlying reason, probabilistic methods based on copula is used. Copula is a probabilistic tool that decouples the marginal distribution and the joint-dependency among random variables. Using copula, it is found that existing downscaling methods produce marginal distribution, which is important for average precipitation, with high precision. However, they perform worse for copula dependency, which plays a key role in extreme precipitation projection and analysis. Inspired by the above observation, a novel method is finally proposed that is able to fix existing downscaling result to be extreme-climate friendly. The method is nonparametric and works better if more downscaling methods are incorporated.

M2-F.4 Hu, H*; Ayyub, BM; University of Maryland, College Park; *hhu3@umd.edu*

Extreme Precipitation Analysis and Prediction for a Changing Climate

Extreme precipitation is one of the most important climate hazards that pose significant threat to various infrastructures. Understanding extreme precipitation events helps to manage its risk to society, and hence reduce potential losses. Many previous methods model daily precipitation as a series of independently and identically distributed random variables, in which case the day-to-day dependency is ignored. Although it does not pose significant impact on the analysis of average precipitation, the influence to extreme precipitation analysis is high. This work provides two new stochastic methods to analyze and predict various extreme precipitation events based on non-stationary models with or without the consideration of serial dependency associated with different days. The methods feature a novel way by incorporating Markov Chains with dynamic optimization. These methods bridge non-extreme precipitation and extreme precipitation so that abundant non-extreme precipitation data can be used for extreme precipitation analysis thus obtaining prediction with higher accuracy and reliability. On an annual basis, the analysis produces distributions for three important extreme precipitation indicators: maximum daily precipitation, number of days with heavy rainfall, and maximum number of consecutive days with heavy rainfall. The accuracy of the new methods is examined, using ten decades of empirical data in the Washington metropolitan area. The analysis shows that there is a significant dependency for precipitation between different days. Based on the new methods, predictions of various extreme events are also provided under different assumptions about serial dependency. Finally the impact of serial dependency on the analysis is also discussed. The results show that for the area studied, taking serial dependency into consideration improves the accuracy of the analysis by up to 16 percent.

P.121 Huang, SH*; Chuang, YC; Wu, KY; National Taiwan University; *d04841012@ntu.edu.tw*

Incorporating Health Risk Assessment into Facility Layout and Process Design

Facility planning and process design have a significant impact on occupational health and safety. Factors such as the use of raw materials, storage, machine equipment, etc. will affect the workers' exposure to hazardous substances in the condition. Considering occupational health risks during the planning and design phase allows better anticipation of potential hazards and implementation of appropriate control or contingency measures. Current practice of occupational exposure assessment is often only monitored once the occupational setting is in operation. Even when incompliance is discovered, site revisions are confronted with challenges due to the potential impact on production line efficiency and cost. The objective of this study is to incorporate occupational health in facility layout design by characterizing potential health risks of an exposure scenario at an early stage when limited information is available. Using the Stoffenmanager exposure modeling webtool, we predict the potential exposure level of exposure scenarios. By collecting past domestic exposure assessment data from various processes, we integrate this information with the predicted exposure levels using Markov chain Monte Carlo sampling to conduct health risk assessments for evaluating chemical hazard index (HI) or carcinogenic risk. The resulting risk characterization provides a reference for future establishments of new plant process designs. Preliminary finding used existing exposure scenarios obtained from an optoelectronic semiconductor-manufacturing factory in Taiwan to conduct the health risk assessment of chronic exposure to positive photoresists, a material used in the optoelectronic semiconductor industry. By-product benzene, in particular, had the highest HI and cancer risk. These results demonstrate that applying the method during process design may help further incorporate occupational health and provide insights to design improvements.

P.87 Huang, YC*; Wu, KY; National Taiwan Univertisy; *Mirroronthewall_tw@hotmail.com*

The risk assessment of Furan residue in commercial baby formula in Taiwan for infants and children under age of three

Breast feeding is the most ideal feeding choice for infants longterm emphasized by pediatrics. However, most women in Taiwan are career women with long working hours and little friendly environment for day care and breast feeding facilities. Furan is known to be both hepatoxic and carcinogenic in rats and mice and has been classification as a possible human carcinogen (Group 2B) by the International Agency for Research on Cancer (IARC). However, risk of Furan within dietary items has not been well established. In 2010, total 12 items of baby formula from Taiwanese markets was quantified by Static headspace sampling technique. The result enables us for further risk assessment of Furan exposures specifically from baby formula to children under age of three. Benchmark dose of BMDLh 0.36217 mg/Kg in accordance to the data from Incidence of liver tumors in B6C3F1 mice exposed to furan in the National Toxicology Program Bioassaya conducted in 2008. Concerning age of objects in this study, the 10-fold uncertainty factors are applied for extrapolation from adult to children, hence the final reference dosage was further divided 10 into 0.036217 mg/Kg. We obtained average consumption of baby formula for infants and children age under 3 base on the data in 2015 provided by National Food consumption data base in Taiwan. Estimation of possible exposure of Furan from baby formula for infants and children under age 3 achieved by using Markov chain Monte Carlo (MCMC) methods. Median exposure for children under/including 3 is 0.00897 mg/Kg. This study provides important information for risk assessment of Furen residues in baby formula. It can help raise awareness of the general public and give people a quick overview of what we feed to infants and children under age of three, who are vulnerable and have no abilities to select their own food. Further more, we would like to urge the government to provide more regulation to improve friendly environment of breast feeding in public as well as in work place.

W4-H.1 Huang, T; National Cheng Kung University; *tailinhuang@mail.ncku.edu.tw*

Facilitating disaster risk reduction through community-based resilience building

Risks are part of our societal development process. There are numerous risk analysis tools, showing us where and when conflict is likely, which areas are exposed to natural disasters, modeling how economic shocks and pandemics might spread, or how certain risk events will affect different communities and regions. Unavoidable natural and environmental events are amplified by long-term changes such as sea level rise and shifting climate patterns, and exacerbated by decisions—for example, urban planning and building codes—made years or decades ago. How we plan for these uncertain risks will determine how great the impacts could be for us and future generations. To reduce disaster risk, scientists must understand the systemic and dynamic linkages of environmental, socio-economic and health risks and how these are impacted by different policy measures. This will enable risk management and governance systems to be improved in order to facilitate long-term sustainable development. However, we do not yet share a vision of what to do about those risks. As a result of these concerns, a newly forming, more systems-oriented perspective to adaptation considers development and adaptation risks as strongly complementary. A community-based resilience building considers that adaptation strategies must be generated through participatory processes, involving local stakeholders and development and disaster risk reduction practitioners, rather than being restricted to impacts-based scientific inputs alone. As such, expertise in resilience building must come from local community-based case studies and indigenous knowledge of locally appropriate solutions to climatic variability and extremes.

T3-H.3 Huang, Y*; Lane, C; Rios, M; Fares-Gusmao, R; Chancey, C; Forshee, R; Yang, H; Food and Drug Administration; *Yin.Huang@fda.hhs.gov*

Risk Assessment for Transfusion Transmission of Dengue

Dengue viruses (DENVs) are known to be transmitted from person to person through the bite of an infected mosquito. Cases of dengue after receipt of blood products or donor organs or tissue have been also reported. We developed a quantitative risk assessment model to estimate the dengue risk from pre-clinical (during incubation period) and subclinical (infected but never showing symptoms) blood donors. We derived predictive coefficients from model simulations for predicting the risk outcomes such as monthly infectious blood units and transfusion-transmitted dengue (TT-DENV) cases based on the rate of reported clinical cases. The model was validated with a previous study where donor blood samples from the 2012 dengue transmission season in Rio de Janeiro, Brazil were tested for DENV RNA by a transcription-mediated amplification (TMA) assay. In that study about 69.4% donations were tested by the TMA assay and 78 samples were found positive during March, April and May, the peak period of the outbreak, indicating that 112 DENV RNA-positive donations would have been detected if testing screening had been performed on all donations. Our model estimated a mean of 93 (2.5th%ile-97.5th%ile: 47 - 186) infected units among the donations, which was consistent with the reported numbers. We applied the model to estimate the risk in the US. For year 2013, 2014, 2015 and 2016, based on the annual reported dengue cases of 543, 470, 751 and 764, respectively, a mean of 2, 1, 2 and 2 annual TT-DENV infections were estimated.

P.168 Huang, J*; Wu, KY; National Taiwan University; *jessewww@gmail.com*

The risk assessment of pesticide residue, Fluopyram, in tea in Taiwan

Fluopyram, a novel broad-spectrum fungicide from the pyridinyl-ethyl-benzamide class, acts by inhibiting the enzyme succinate dehydrogenase (SDH). In chronic and carcinogenicity expose, fluopyram can damage liver with the effects noted at lower doses increased liver weights and hepatocellular hypertrophy, whereas at higher doses included hepatocellular degeneration or necrosis. Also, the existing database on fluopyram is adequate to characterize the potential hazards to reproductive systems of fetuses, infants and children. This study focused on conducting a risk assessment of fluopyram in Taiwan to examine what an appropriate MRL is for tea intake. . We determined the intake (unit:grams/person/day) of 29 kinds of fruit and vegetables with Taiwanese consumption data from National Food Consumption Database in 2016, which were fluopyram legally allowed. The MRLs data (unit:ppm) were provided by Food and Drug Administration (FDA). Furthermore, we attempted to calculate the maximal daily intake and estimate the unknown MRL of tea. We used benchmark dose to calculate a reference dose (RfD) to replace NOAEL. Then, we got the final result which is 6.586951216 ppm for the MRL of tea. Comparing to the reference dose 6 ppm set by Council of Agriculture, it is a little higher but closed number. Moreover, we could judge whether it is appropriate to allow using fluopyram on tea, and explore the risk communication to society. This study demonstrates the relationship between the amount of residues and health risk. We suggest government investigate long-term qualitative and quantitative studies of fluopyram in foods and call for decrease on abuse of fluopyram.

P.88 Huang, YC*; Chuang, YC; Wu, KY; Chiang, SY; Department of Public Health, China Medical University; *u105070003@cmu.edu.tw*

Probabilistic risk assessment of Fipronil in vegetables and fruits in Taiwan.

Fipronil is a broad-spectrum phenylpyrazole insecticide that blocks of the GABA-gated chloride channel of insects. Fipronil has been widely used for controlling insects on various crops including vegetables and fruits. Fipronil causes neurological and developmental toxicity and was classified as Group C (possible human carcinogen) based on the increase of thyroid tumors in rats. In recent years, some studies have estimated the risk of fipronil residues in tea in Taiwan. But few studies evaluate the risk in vegetables and fruits. This study was using Monte Carlo simulation to conduct a probabilistic risk assessment of fipronil in vegetables and fruits in adulthood (age 19-65 years old) in Taiwan. The fipronil residues in 47,585 samples of vegetables and fruits were cited from reports released by Council of Agriculture in Taiwan. The vegetable and fruit consumption data was cited from the National Food Consumption Database of Taiwan. The distribution of fipronil residues, and the Lifetime Average Daily Dose (LADD) and Hazard Index (HI) was estimated by Monte Carlo simulation. The total LADD of fipronil for the consumer with age 19-65 years old is 3.28E-05 mg/kg/day. Based on the reference dose of 0.0002 mg/kg bw/day for fipronil, the mean HI and the upper bound of 95% confidence interval of HI are calculated to be 0.164 and 0.447, both below one. This study shows that consumers may not be subject to the adverse health effects from fipronil exposure via diet. Farmers often use multiple insecticides at the same time. Thus, the risk of fipronil should not be disregard.

W2-C.4 Huang, L, LH; Chen, J, JC; Zhu, Q, QZ*; New York University; *qz494@nyu.edu*

Factored Markov Game Theory for Secure and Resilient Infrastructure Networks

With the integration of modern information and communication technologies (ICTs) into critical infrastructures (CIs) such as 5G networks and the Internet of Things (IoTs), the CIs are becoming vulnerable to cyber threats at the same time improving its connectivity and functionalities. Hence it is essential to understand the risk of ICTs on CIs holistically as a cyber-physical system and design efficient security hardening and optimal resiliency mechanisms to reduce the cyber risks. With limited resources, there is an inherent tradeoff between security and resiliency in the mechanism design. To this end, we establish a game-theoretic framework to capture the system behaviors of the CIs under malicious attacks and the security and resiliency design objectives. We propose the factored Markov game theory to enable a computationally scalable modeling of large-scale infrastructure networks and provide approximate algorithms for designing optimal mechanisms. The proposed theory builds on the factored graphs that exploit the dependency structure of the nodes of CIs and the approximate dynamic programming tools for stochastic Markov games. We use electric power networks and transit networks as examples to illustrate the new design paradigm and show the proactive security and adaptive recovery response at the time of unanticipated attacks.

T3-G.4 Hudson, DW; Johns Hopkins University; *dhudson6@jhu.edu*
Risk-based analyses of a hypothetical expansion in the scope of the U.S. Nuclear Regulatory Commission safety goal policy for nuclear power plants
The Nuclear Regulatory Commission safety goal policy defines an acceptable risk level for nuclear power plant (NPP) operations. It guides agency evaluations to determine whether proposed regulatory actions to enhance NPP safety should be rejected before performing cost-benefit analyses if: (1) the potential safety benefit is judged to be not substantial; or (2) the existing risk is determined to be acceptably low. Two gaps in this policy have been highlighted since the 2011 Fukushima nuclear accident. First, it is comprised of two qualitative safety goals, each supported by a quantitative health objective (QHO) that can be compared with NPP probabilistic risk analysis (PRA) results to evaluate goal attainment. However, these QHOs are limited to measures of average individual risk of radiological health effects. Thus, there is no QHO that addresses the societal risks of potential nuclear accidents, including risks posed by implementation of protective actions to avert radiation exposures among the affected population. Second, the safety goals and QHOs are applied strictly to individual reactors, even for the 57% of US. NPP sites that include multiple reactors. Concurrent accidents involving multiple reactors have thus been excluded from NPP PRAs and safety goal evaluations. Yet lessons learned from operational experience indicate such multi-unit accidents can occur with non-negligible frequency. These gaps together may cause the true residual risk to the public from potential nuclear accidents to be underestimated or mischaracterized. Thus, proposed regulatory actions that aim to further enhance NPP safety may be prematurely rejected, before performing cost-benefit analyses to determine whether they would result in a net societal benefit. This paper presents a policy analysis of a hypothetical expansion in the scope of the safety goal policy to include consideration of: (1) multi-unit accidents; and (2) a proposed set of societal risk metrics.

T3-I.4 Isaacs, KK*; Dionisio, KL; Phillips, KA; Price, PS; United States Environmental Protection Agency; *isaacs.kristin@epa.gov*
Leveraging Publicly-Available Consumer Product and Chemical Data in Support of Exposure Modeling
Near-field contact with chemicals in consumer products has been identified as a significant source of human exposure. To predict such exposures, information about chemical occurrence in consumer products is required, but is often not available. The Chemicals and Products Database (CPDat) has been developed by the U.S. EPA's Chemical Safety and Sustainability research program in an attempt to fill these data gaps using information from publicly-available sources. CPDat currently includes qualitative and quantitative information on reported product ingredients from Material Safety Data Sheets and published ingredient lists. In addition, the database contains results of new predictive models for chemical function and product chemical weight fractions. The consumer products included in the database have been mapped to over 300 product use categories (PUCs) that allow linkage to consumer use (i.e. habits and practices) data. CPDat has been integrated with the U.S. EPA's Computational Toxicology Dashboard (https://comptox.epa.gov/dashboard), which allows for linking of the specific product information in CPDat (e.g. ingredient, weight fraction, PUC) with chemical-specific information (e.g. structure, property) available through the Dashboard. These data and linkages allow for the parameterization of EPA's human exposure models for thousands of chemicals in consumer products. Future refinements to CPDat will include addition of data obtained via targeted or non-targeted analyses of consumer products. As the database grows, it will increase our ability to characterize chemicals in consumer products and articles rapidly and defensibly for use in exposure and risk evaluations.

P.12 Hughes, B*; Cox, K; Bhat, V; NSF International; *bhughes@nsf.org*
Qualitative Risk Assessment for Drinking Water Standards Using TTC Approach
NSF International evaluated whether the Threshold of Toxicological Concern (TTC) was "fit for purpose" for setting total allowable concentrations (TAC) and single product allowable concentrations (SPAC) for drinking water contaminants with limited toxicology data under NSF/ANSI Standard 61 (NSF 61). Currently, a threshold of evaluation (TOE) of 3 ppb for TAC and 0.3 ppb for SPAC are assigned for chemicals that lack toxicology data and genotoxic structural alerts. If negative mutagenicity and clastogenicity data exists, qualitative TAC and SPAC are set at either 10 ppb (genotoxicity data only) or 50 ppb (additional

W1-K.5 Jardine, CG*; Cooper, A; University of the Fraser Valley, University of Alberta; *cindy.jardine@ufv.ca*
Exploring Concepts of Risk and Safety in a University Setting through PhotoVoice
Universities recognize their responsibility to promote health, safety, protection of the environment, and regulatory compliance in the context of their diverse activities and environments. Many universities have operationalized risk management and safety through the formation of formal units and dedicated staff. However, concepts of risk and safety can have many interpretations which are seldom explicitly examined and discussed. The Environment, Health and Safety (EHS) unit in Risk Management Services at the University of Alberta was interested in exploring how faculty and staff understand the concepts of safety and risk on campus as a means of starting a discussion on current perspectives, activities and opportunities for improvement. To make the project engaging and promote critical thought, the research was done using PhotoVoice. This method involves asking people to take photos on a specific theme with the goals of: (1) enabling people to reflect upon and record issues in their environments; (2) promoting critical dialogue and enhancing knowledge about issues through discussions of the photographs; and (3) taking action. Participants were drawn from members of the various EHS committees and safety leaders at the university. They were asked to take pictures in two areas: 1) what does safety mean to you?; and 2) what does risk mean to you? Participants then completed a short form answering the following: (1) why did you take this picture (i.e. what about this picture specifically represents (safety or risk) to you)?; and (2) what does this picture mean to you (i.e. is it a strength? Is it a problem? What could be done about this issue)? Representative pictures and descriptions were subsequently presented at an internal 'EHS mini-conference', generating active discussions and opportunities for enhanced actions and services. Both the PhotoVoice thematic results and the results of the ensuing dialogue will be presented.

W3-J.3 Jaspers, I, I; University of North Carolina at Chapel Hill; *ilona_jaspers@med.unc.edu*

Human studies to determine the effects of flavored E-cigarettes on Respiratory immune responses

While cigarette smoking impairs innate host defense responses, how vaping e-cigs modifies respiratory immune responses is completely unknown. Using non-invasive sampling of the nasal mucosa, ex vivo analyses, human in vivo infection models, as well as in vitro experiments our studies are designed to determine how vaping e-cigs affects respiratory host defense responses. Analysis of the nasal mucosa from non-smokers, cigarette smokers, and e-cig users showed that suppression of immune genes was larger in magnitude and broader in number than those seen in cigarette smokers. Assessing nasal mucosal mediators in non-smokers, cigarette smokers, and e-cig users showed enhanced levels of inflammatory cytokines, while mediators associated with recruitment and activation of immune cells were decreased in e-cig users. In addition, we used infection with the live attenuated influenza virus (LAIV) vaccine in humans in vivo to determine how vaping e-cigarettes affect antiviral host defense responses. Our data indicate that antiviral responses are significantly modified in e-cig users with a suppression of interferon-dependent host defense responses. In separate in vitro experiments, we examined the effects of flavored e-cigs on respiratory mucosal immune responses, specifically focusing on flavored e-cigarettes containing the popular flavoring agents, such as cinnamaldehyde, menthol, and vanillin. Our data indicate that cinnamaldehyde-containing e-liquids significantly suppress innate immune cell function in a dose-dependent manner without causing overt cytotoxicity, resulting in inhibition of immune cell function (IC50) at levels well below those causing cytotoxicity (LC50). In summary, using translational human in vitro and in vivo approaches, our studies examined whether exposure to flavored e-cigs has an immune suppressive effect on the respiratory mucosa in humans in vivo and whether specific flavoring agents induce dose-dependent effects in mucosal immune cells.

M3-I.1 Jenkins, S*; Mannshardt, E; Stone, S; Keating, M; Brown, J; Long, T; United States Environmental Protection Agency Office of Air Quality Planning and Standards; *jenkins.scott@epa.gov*

Interpreting and Communicating Short-Term Sensor Data

Highly time-resolved (e.g., 1-minute) information on local concentrations of air pollutants, such as O3 and PM2.5, is increasingly available from portable pollution sensors. There is a need for guidance on the appropriate interpretation and communication of these data because the scientific evidence does not indicate health impacts following such short-term pollutant exposures. Using data from Village Green benches and from ambient monitors in other locations across the U.S., the EPA has developed pilot 1-minute sensor breakpoints and messages for O3 and PM2.5. These breakpoints and messages can provide the public with tools to aid understanding of local air quality. Goals of the pilot project are to guide the interpretation of sensor data and encourage this interpretation to be consistent with available health effects evidence and air quality information. Future efforts will incorporate lessons learned from the pilot and potentially expand the development of sensor breakpoints and messages to additional pollutants.

M2-J.7 Jia, H*; Schuldt, J; Zhou, S; Deng, L; Cornell University; *hj352@cornell.edu*

Framing, Social Stigma and Scientific Controversy: Exploring Effect and Mechanism of Question Wording about Genetically Modified Food

Although the US Congress has eventually passed the law to label foods with genetically modified (GM) ingredients, few have investigated the term's framing effect on the public attitude to the technology. In this paper, we investigated the framing effect of the word choice of the alternative names "biotechnology food" and "genetically modified food." An analysis of websites of anti-agribiotech activist groups and industrial organizations suggested that activists preferred the term ''genetically modified food'' whereas industrial organizations preferred ''biotechnology food.'' A question wording experiment illustrated participants had more negative responses when the question referred to "genetically modified food" than "biotechnology food," but there was no statistical difference among participants' support for labeling such foods. People's deference to scientific authority, naturalness and genetics knowledge seemed to moderate the framing effect of "biotechnology/genetically modified food," but the moderation took place in different conditions. The deference to scientific authority strongly negated the framing effect of the alternative word choice on people's harm perception of transgenic foods while genetics knowledge mildly negatively moderated the framing effect on the benefit perception. On the other hand, naturalness tended to moderately enhance the framing effect both on people's harm perceptions. The study indicates that with intensified debates on GM food labeling, there is a polarizing attitude to the food. The deference to scientific authority may be motivated when pro-GM food people encounter negative information of the food. For practical purpose, the study suggests that when labelling GM food, using different wording plus cues priming either the deference to scientific authority, naturalness or other sociopsychological constructs may lead to people's changing acceptance.

P.60 Jiang, HZ*; Tiffany , Paul; Northeast Yucai School; University of California Berkeley; *zhanzhansy@outlook.com*

Economic recession of old industry base in Northeast China

From the so-called "traditional old industry base" which played the most important role in supporting the whole country's economy in China since the 1950s to today's last place in GDP, the northeastern part of China (i.e. Lianong, Jilin and Hei Long Jiang provinces) is experiencing a chronic serious economic downturn. The GDP growth rate of the first season of the year 2016 in Liaoning shows that the province is the only one with negative growth among more than thirty provinces. The general poor economic condition almost affected everyone living in the region spanning from large enterprises and local government to homeowners. The risk of a further recession is still very high especially for Liaoning province. We raised up a question: What are primary and secondary reasons that Northeastern China suffered such a regional recession in recent years? We investigated many relevant factors that could contribute to explain the recession and the future risk of a further and more severe recession. These factors include: regional superiority at national-level policy in China, the aging of industrial structures, feasibility and challenge in transformation of traditional industry (e.g. steel, petroleum), funding shortage and financial credit crisis, crisis in trust on local government, Unemployment, inter-regional competition, talent migration, and environment deterioration (e.g. air pollution). We employed two main methodology in this study. First, we collected relevant data and built up econometric models to find out important factors. Then, we used qualitative method (including focus group and interview on local policy makers, economists and laymen) to understand why. This study provides a comprehensive and first detailed analysis focusing on the economic recession in Northeastern China and gives insight to the local and national policy makers.

W2-J.1 Jobin, M*; Visschers, VHM; van Vliet, OPR; Siegrist, M; ETH Zurich; *marilou.jobin@hest.ethz.ch*

Are decision support systems practical tools for public participation? Insights from tracing laypeople's decision processes regarding the future energy portfolio

Public participation engages participants in real-world settings, whereby deliberation on a subject takes place in face-to-face interactions, such as round-tables. However, new technologies allow citizens to be involved while not being physically present; it rather enables them to communicate their preferences through an interactive application, such as a decision support system (DSS). The main goal of a DSS is to stimulate a deliberate examination of the topic at hand. Using a DSS, knowledge on future energy portfolio preferences of citizens can be gathered, so that the energy transition can be made towards a portfolio of energy sources that the majority of citizens accept. How people decide for a certain energy production portfolio in a DSS usually remains concealed, not allowing inference in how they engage with the topic. However, it is crucial to assess the type and level of engagement a person has in order to take the stated preferences as indicative of what the public prefers. For example, a deeper level of processing is an indication that preferences for a portfolio composition are founded on a deliberate decision-making process. We examined to what kind of energy production portfolio a sample of 100 Swiss people would like to transit, using a DSS on energy production in Switzerland that shows real-world constraints and environmental, financial, and social consequences of people's choices. Moreover, we assessed laypeople's information processing in the DSS by so-called mouse tracking. In our talk, the information processing data will be related to their energy portfolio choice. Our aim is to show that a DSS can be used as an additional tool for public participation, as it induces in-depth elaboration among its users. As a multiplicity of persons can have access to a DSS and indicate their preferences, it allows the wider public to educate itself on and participate in energy policy issues.

M3-E.1 John, RS; University of Southern California; *richardj@usc.edu*

A Signal Detection Model and Analysis of Risk-Based Threat Assessment

Increasingly Big Data analytics are being utilized to assess the terrorism threat of individuals. Such "risk based" approaches are designed to bin individuals in order to apply differential levels of scrutiny based on individual characteristics related to terrorism threat. Decades of previous research on violence risk assessment has demonstrated the limitations in how accurately future violent behavior can be predicted from individual characteristics and past behavior. In many respects, the terrorism case is a greater challenge due to the presence of low base rates, the lack of highly diagnostic indicators, and the ability of an adaptive adversary to learn how to attenuate their predicted threat level. We formulate this generic problem in a Signal Detection framework, and conduct sensitivity analysis to determine conditions in which such threat assessments are useful. Results depend on the prior probability that a randomly selected individual is a terrorist, the likelihood function associated with the predicted threat level, and the relative cost of false-positives and false negatives. Further sensitivity analyses explores the impact of attenuated diagnosticity resulting from an adaptive adversary capable of learning the characteristics required for a "low-risk profile" and either acquiring a low-risk profile, or recruiting an accomplice with a low-risk profile. Risk-based approaches to threat assessment are not effective for assessing terrorism threat due to low base-rates and adaptive adversaries capable to learning the predictive algorithm and appearing as low-risk individuals.

T3-C.4 John, RS*; Baucum, M; University of Southern California; *richardj@usc.edu*

Contingency, Causality, and Risk

The way people evaluate risks and hazards heavily depends on how they attribute causality; controversial issues in risk perception, ranging from genetically modified foods and health defects to immigration policies and terrorism, are largely governed by how people infer causal relationships. Psychologists have long distinguished between two types of evidence involved in causal inferences: contingency evidence, which highlights the covariation between a cause and a supposed effect (e.g., drunk drivers often get into accidents), and mechanism evidence, which focuses on the process by which a cause is capable of producing an effect (e.g., intoxication impairs perception, which can cause accidents). Yet research comparing the relative effects of these two evidence types on causal inferences has not been extended to the risk perception domain. Thus, in two experiments (n=257, 172), we presented MTurk participants with varying degrees of contingency and mechanism evidence for 1) a drug's ability to cause health problems, and 2) the ability of increased security guard presence in U.S. cities to prevent terror attacks. Both studies found that, on average, participants treated contingency and mechanism evidence equally when inferring causality, and evidence against the presence of a causal mechanism or statistical covariation did not hinder the effect of evidence supporting the other. In fact, causality judgments based on both evidence types were well-predicted by an additive, non-interacting regression model based on participants' responses to each evidence type individually (R-squared=0.76), contrary to the normative conception of each evidence type being a necessary precondition for causality. There was also substantial inter-individual variability in the weight placed on the two evidence types. We discuss implications of the group- and individual-level results for risk communication, and highlight the important role of evidence type in characterizing hazards.

T3-D.2 Johns, DO*; Virji, MA; Park, JH; MacDonell, MM; Cox-Ganser, JM; Centers for Disease Control and Prevention and Argonne National Laboratory; *djohns@cdc.gov*

A Prelude to a Cumulative Risk Assessment: Qualitative Analysis of Work-Related Asthma among Healthcare Workers

Workers in the United States and throughout the world are exposed daily to combinations of chemical, biological, physical and psychosocial stressors specific to their occupation. Recently, there has been a formal effort by some within the occupational health community to expand the integration of components of cumulative risk assessment into the occupational domain, and to encourage the inclusion of occupational risk factors in community-based cumulative risk assessments. However, attempting to characterize, either quantitatively or qualitatively, the health effects resulting from complex interactions among chemical and nonchemical occupational and non-occupational stressors is, in many cases, simply impractical. Nonetheless, efforts to encourage the consideration of multiple key stressors in human health risk assessments in occupational settings will greatly inform the development of strategies to efficiently reduce exposures of greatest concern, and may establish the information needed to conduct formal quantitative cumulative risk assessments. Factors to be considered in prioritizing targeted stressors include the number of individuals exposed, known health outcomes resulting from these exposures, and the level of understanding of the mode of action of the stressors of interest. As an example of such an evaluation, an effect-based approach was utilized to identify two key and common stressors among healthcare workers associated with work-related asthma: work-related stress and occupational exposure to chemical disinfectants. This approach is described and highlights the benefit of undertaking less complex, targeted assessments to illustrate the concepts, toward ultimately having greater impact and serving to advance practical applications of cumulative risk assessment. Disclaimer: The views expressed are those of the authors and do not necessarily represent the views or policies of the National Institute for Occupational Safety and Health.

W4-F.2 Johnson, CA*; Flage, R; Guikema, SD; University of Stavanger and University of Michigan; *caroline.a.johnson@uis.no*
Characterising and predicting the robustness of coupled power-law networks
Many networks exhibit a power-law configuration where the number of nodes connected to a node follows a power-law distribution. Such networks are also referred to as scale-free networks. Examples of power-law networks include the Internet, terrorist cells and species relationships. Given the prevalence of power-law networks, the effects of failures or disruptions on the performance of the network is of interest. Previous work has been conducted on the influence of network topology in relation to the effects of random nodal failures. However, this was limited to independent networks. Many networks depend on others to function and thus, the influence of network topology on the effects of random failures on interdependent networks can be explored. The set-up has been extended to coupled networks or interdependent scale-free networks. Failures in the coupled system are simulated and the effects on the system performance were analysed in relation to the network topology. The results are compared with those of the single system set-up to indicate their potential relevance to the design of interdependent networks.

T4-J.4 Johnson, BB; Decision Research; *branden@decisionresearch.org*
Public cues to relative credibility of disputing scientists.
When large groups of scientists disagree over the causes or consequences of a phenomenon—such as climate change, marijuana, or dark matter in the universe—public certainty, trust in science, or cooperation with expert advice can suffer. One little-examined issue in understanding public interpretations of and reactions to such disputes is the nature of cues laypeople might use to decide which position in the dispute is more likely to be correct. Cues might include such categories as use of replication, credentials, nationality, experience, and the proportion of scientists on each side. This paper reports experiment results that explore the effects of varied cues manipulated in mock news articles about real scientific disputes over the topics cited above. Dependent variables included choices of the "correct position," trust in the dueling scientists, and support for research funding. Results advance understanding of the dynamic interactions between dispute attributes and lay interpretations of scientific disputes.

M4-E.2 Johnson, MJ*; Braydich-Stolle, L; US Army Public Health Center, US Air Force Research Laboratory; *mark.s.johnson.civ@mail.mil*
Integration of Emerging Science into Characterizing Toxicity for Ecological & Human Health
Understanding the potential for toxic effects from exposures to chemicals is critical for estimating risk for public health and ecological outcomes. Recently, new science has greatly expanded the tools that are available to define toxicity, and these read-across techniques can assist in refining in vivo study designs to investigate specific tissues and mechanisms of interest. To begin, modeling (in silico) approaches can provide dose estimates and predictions on toxic mechanisms that can be used quickly for emergency response applications. Secondly, in vitro cell lines, cultures and other techniques have been refined for human-derived tissues and many alternative animal cultures are also now available. Furthermore, cell cultures incorporating three dimensional growth environments and media flow have increased physiological relevance and predictive power. Lastly, pharmacological ligand-binding assays can provide non-cell alternatives in either confirming or ruling out neurological or endocrine disruption potential. Together, these new technologies can provide refined predictions on thresholds and mechanisms of toxic responses to better define risk for exposed populations. Examples on how these tools can be used in screening and refined risk applications will be discussed and examples will be provided.

W2-G.2 Johnson, DR*; Fischbach, JR; Kuhn, K; Purdue University and RAND Corporation; *davidjohnson@purdue.edu*
Storm surge-based flood risk in coastal Louisiana: impacts of Louisiana's 2017 coastal Master Plan and methods for uncertainty propagation
Louisiana's 2017 Comprehensive Master Plan for a Sustainable Coast is a $50-billion set of 124 projects intended to reduce flood risk and land loss across the coastal zone over the next 50 years. The plan allocates $19 billion to structural flood protection projects and $6 billion for nonstructural measures such as home elevations and floodproofing. A series of systems models was used to evaluate flood risk in terms of the expected annual damage (EAD) with and without projects, under current conditions and at three future time periods (10, 25, and 50 years into the future). Future time periods were evaluated in multiple scenarios with varying assumptions about factors such as sea level rise, future storm characteristics, population growth, and system fragility. The Coastal Louisiana Risk Assessment model (CLARA) uses a variety of methods for uncertainty propagation to generate integrated confidence bounds around estimates of flood depth and damage exceedances, as well as EAD. Sources of uncertainty addressed include the small observed sample of historic storms, variability in levee and floodwall overtopping rates, response surface predictions of surge and wave behavior, noise in hydrodynamic models and digital elevation models, and geospatial correlations in surge and wave heights. CLARA strikes a balance between tackling the complexity of the physical system and its attendant uncertainties, while maintaining computational efficiency that allows for exploration of risk in the wide range of future scenarios needed to inform policy-making and project selection and prioritization. We discuss these new, state-of-the-art methods for modeling uncertainty in flood risk and place them in the context of top-line results regarding future flood risk in coastal Louisiana and the benefits of the 2017 Master Plan.

P.36 Johnson, KL*; Luhmann, CC; Stony Brook University; *kelli.johnson@stonybrook.edu*

Probability Distortion is an Optimal Response to Imprecise Probabilities

When making choices under uncertainty, people behave as if small probabilities are larger than they were said to be and large probabilities are smaller than they were said to be. In other words, people's subjective probability representations are regressive with respect to nominal probabilities. This phenomenon is known as probability distortion, and is generally considered to reflect limitations in human perception or decision making. However, probabilities are often imprecise, in which case distorting probabilities represents an advantageous decision-making strategy. For a sample drawn from a distribution, the sample proportion serves as the nominal probability. The nominal probability therefore represents the mode of the likelihood function, otherwise known as the maximum likelihood estimate. Alternatively, the weighted probabilities observed in probability distortion are regressive with respect to the nominal probability, and therefore represent the weighted mean probability. Whereas maximum likelihood estimates (nominal probabilities) result in more instances of zero error, weighted mean probabilities result in less error on average. Consequently, regressive probability distortion is advantageous when probability estimates are uncertain. The current work demonstrates this effect via agent-based computational modeling. Conditions under which various measures of the likelihood function should be used for decision making were also simulated. These results have implications regarding human decision-making research, as well as optimal strategies for making decisions based on uncertain probabilities.

M3-I.2 Jones, L*; Schaefer, H; Lange, S; Texas Commission on Environmental Quality; *lindsey.jones@tceq.texas.gov*

Understanding the Ambient - Personal PM2.5 Correlation: Integrating from Across Different Studies

The federal Clean Air Act requires that the United States Environmental Protection Agency (US EPA) set National Ambient Air Quality Standards (NAAQS) for certain widespread pollutants that can endanger public health. Particulate matter with a diameter of less than 2.5 micrometers (PM2.5) is arguably the most important of these pollutants because the projected health benefits (i.e., avoided or deferred premature mortality) of decreasing ambient levels have justified the cost of many environmental rules that have been finalized in the last decade, even those unrelated to the NAAQS. Despite the widespread claim that reductions in ambient PM2.5 would result in population-level health benefits, there is still considerable uncertainty in the amount of PM2.5 to which the public is realistically exposed. The appropriateness of using ambient PM2.5 concentrations as a surrogate for personal exposure in epidemiology studies that are often used as the basis of risk and benefit calculations is a significant concern worthy of an in-depth investigation. The TCEQ thus conducted a systematic review of studies that collected PM2.5 personal exposure data in the US or Europe. The review included an evaluation of the relationship between personal exposure to PM2.5 and ambient concentrations, and how various factors affect PM2.5 personal exposure. In these studies, we found considerable variability in the types of personal monitors, technical limitations, and monitoring scenarios. This variability made it difficult to compare the findings between studies and, therefore, to reach a consensus on the relationship between personal exposure to PM2.5 and ambient concentrations of PM2.5.

M4-J.4 Jones, RM*; Thacker, S; United States Environmental Protection Agency; *jones.ryan@epa.gov*

HERO: Tools for Systematic Review to Support U.S. EPA Science Assessments

• The Health and Environmental Research Online (HERO) database is a module-based database system constructed to support assessments by helping researchers to systematically identify, compile, organize, manage, characterize, and prioritize new relevant published research, as well as extract and report on data for use in U.S. the Environmental Protection Agency's development of science assessments. HERO currently stores metadata for two million citations and has been used in over three hundred assessment documents, both drafts and final versions. HERO serves as a central repository for results from literature searches, and fosters team collaboration to transparently share their process of screening citations from the beginning of the process to the final selection of relevant material. HERO has introduced multiple tools to expedite the process of systematic review, such as a software modification that links the bibliography of an assessment back to HERO, allowing reviewers to evaluate each draft of an assessment more efficiently. Another example tool is a system to automatically categorize citations by academic discipline, making the efforts of multidisciplinary teams more efficient. A third example tool is 'citation mapping,' a keyword free search technique that uses aggregation of bibliographic coupling relationships to present a set of search results that is self-ranked by probability of relevance. Used in coordination with traditional screening techniques, these tools improve the efficiency of scientific experts by focusing their resources on the most relevant material. HERO is working with the providers of third party tools to incorporate efficient processes to perform screening tasks on HERO citations. • Disclaimer: The views expressed in this abstract are those of the authors and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.

M3-K.9 Joo, J*; Hmielowski, J; Boyd, A; Washington State University; *jinho.joo@wsu.edu*

Risk Perceptions of Smart Meters: Examining the Role of Privacy Concerns, Technological Readiness, and Technological Norms

Smart meter installation is an increasing issue of concern relative to U.S. and international energy systems. The successful deployment of smart meters will in part depend on public perceptions of the technology. Some proponents argue that the installation of smart meters will help companies effectively manage energy grids, and lead to greater energy efficiency and cost savings for consumers. Despite the benefits of smart meters, some oppose the installation of this technology. In particular, there is concern about threats to public privacy because the technology collects data in real time. In addition to privacy concerns, people's beliefs about technology and social norms tied to new technologies may influence support for installing smart meters in their homes. The main objectives of this study are to investigate three sets of variables that may influence support for installing smart meters including: (1) concerns about and experience with privacy violations; (2) technological readiness (i.e., perceptions of technology-based systems), and (3) technological norms (e.g., norms that influence support for technology). This study is based on a survey of 1,035 Americans in 17 states. Our results show that individuals who were more concerned about privacy were less likely to support the installation of smart meters. In terms of technological readiness, individuals skeptical about new technologies was less likely to support smart meter installations, while those with more positive perceptions of new technologies were more likely to support the installation of smart meters. Finally, we found that technological norms did not correlate with support for smart meter installation. Overall, support for smart meters varied depending on people's concerns about privacy and their perspectives about new technologies. We conclude with a discussion of why the public may or may not support smart meters and provide recommendations for effective risk communication about the technology.

M4-G.2 Jore, S.H.; University of Stavanger, Norway; *sissel.h.jore@uis.no*

How to address uncertainty in security risk management

Probabilities and uncertainties are commonly mentioned aspects within safety risk management, but are often excluded in definitions of security risk. Standards and guidelines for how to conduct security risk analysis acknowledge uncertainty as a major aspect of the process and the need for addressing uncertainties. However, what uncertainty means in a security context and how to actually address and express uncertainties are generally not well accounted for. Assessing security risks e.g. terrorist attacks are different from assessing safety risks. First, the risk is dynamic and characterized by low frequency, high-consequence attacks committed by strategically thinking human beings who adapt and alter targets and modus operandi to changing realities. Second, limited available historical data exists and are often not reliable and representative. Third, there are not enough resources to eliminate all risks. Forth, there are a large number of possible attack scenarios, making it difficult to assess the complete effects of mitigating and protective measures. In recent years, several perspectives on risk have been developed that replace probability with uncertainty in their definition claiming more weight should be given to the knowledge dimension, the unforeseen and potential surprises. In accordance with these perspectives, measures for low, medium and high uncertainty have been suggested based on the factors of the strength and level of simplification of assumptions made, the degree of reliable and representative data, and the level of consensus among experts. In line with this perspective, we outline a framework for how to express uncertainty on a more detailed level. We propose a framework that also incorporate the uncertainty dimensions of likelihood, threats, values, vulnerabilities and consequence aspects since the uncertainty dimension also is present inn all these factors in the risk analysis.

M4-F.5 Jovanovic, AS*; Oien, K; EU-VRi, Steinbeis Advanced Risk Technologies, Germany; *jovanovic@risk-technologies.com*

Current efforts to establish a common methodology and common database for the resilience indicator based assessment

The resilience of modern societies is largely determined by and dependent on resilience of their critical infrastructures such as energy grids, transportation systems, governmental bodies and water supply. This is clearly recognized by the EU in its policies and research agenda, such as the DRS (Disaster-Resilience) actions and projects safeguarding and securing society, including adapting to climate change. In this context, the issue of “measuring resilience” has an important place and it is tackled primarily by means of indicators. The overall goal of the current research agenda is to improve current approaches by providing an innovative methodology for assessing resilience of critical infrastructure. The EU research project SmartResilience propose a common methodology across all critical infrastructures and all types of hazards or threats based on resilience indicators. The results of the resilience assessment can be used to compare with previous assessment, to provide trends showing how the level of resilience is progressing. Since the calculation is performed on all levels of the model (indicator, issue, phase, threat, critical infrastructures and area/city level), it is also possible to "drill down" and identify the reason for an increase or decrease in resilience compared to the previous assessment. Another use is to compare with other cities, areas or critical infrastructures, i.e. to benchmark against others. The resilience of a city/area or a critical infrastructure can also be assessed by imposing a set of threats (including defined challenges such as interactions and cascading effects), i.e. stress testing the resilience ability of the city/area/critical infrastructure, and compare the results with predefined criteria. The concept presented is practically supported by new tools: the large database of indicators, tools for the assessment of the resilience level, tools for resilience monitoring, big data analysis tools and the advanced visualization tools.

W1-D.2 Jovanovic, A*; Qunitero, FA; Ahmad, M; Steinbeis Advanced Risk Technologies GmbH, Stuttgart, Germany; *mahmad@risk-technologies.com*

Development of Nano-Risk Radar for emerging risks related to nanotechnology/ nanomaterials for the EU Project caLIBRAte

The emerging risks are always difficult to assess due to huge amount of uncertainty associated with them. The uncertainty is mainly due to lack of scientific knowledge and past evidence about risks. A horizon scanning tool like Nano-Risk Radar can fulfill this knowledge gap by providing sophisticated/ systematic predictions and insights. The Nano-Risk Radar scans the available scattered web-information using the textual and data mining approaches. The methodology used in Nano-Risk Radar was initially developed inside the EU Project iNTeg-Risk. Within the scope of caLIBRAte project, an interactive Nano-Risk Radar is under development focused on the nanotechnology and (engineered) nanomaterials. The Risk Radar provides the interactive maps based on user-defined relevant search queries (i.e. “Topics”). The identified “Keywords” and “Articles” are sorted according to their “Relevance” and “Novelty”, respectively. Further the “Topics”, “Keywords” and “Articles” are presented inside a connected matrix. The Nano-Risk Radar under the scope of caLIBRAte has added advantages for the industry, end-users, regulators, insurers and the wider research fraternity. It can provide a foundation for various stakeholders to get more information about a specific topic. This Risk Radar can also potentially interact with the decision making tools in a respective domain and the wider risk governance framework. The Nano-Risk Radar will be used inside the caLIBRAte System of Systems (SoS) risk governance framework.

W4-D.4 Julias, C; CDM Smith; *JuliasC@cdmsmith.com*

Lead Cleanups at Superfund Sites

Office of Solid Waste and Emergency Response (OSWER) Directive 9355.4-12 issued a Soil Guidance in 1994 and a clarification to the guidance in 1998 for cleaning up lead-contaminated soil that present unacceptable human health and/or ecological risks from lead concentrations exceeding lead screening levels (SLs). The SL and the subsequent preliminary remediation goal (PRG) and cleanup level are calculated using the Adult Lead Methodology (ALM) and the Integrated Exposure Uptake Biokinetic (IEUBK) models for residential and non-residential scenarios, respectively, at Superfund sites. The United States Environmental Protection Agency’s (EPA) Office of Land and Emergency Management (OLEM) released a memorandum on December 22, 2016 titled “Updated Scientific Considerations for Lead in Soil Cleanups,” which highlights recommendations for implementing the soil lead guidance. The recommendations include basis for deriving SLs, PRGs, and cleanup levels; variation of default parameters to the ALM and IEUBK models; and role of natural or anthropogenic background levels. In addition to the memorandum, there are three other directives released on August 2, 2016 that provide recommendations for parameters used in the ALM and IEUBK models based on current scientific literature and national public health recommendations. The previous default parameters and current recommended parameters used to calculate SLs, PRGs, and cleanup levels in the ALM and IEUBK models are presented. In addition, the impact of background levels on these values is presented to provide side-by-side comparison of final lead cleanup values recommendation.

M3-H.4 Jung, J*; Schaffner, DW; Rutgers University; *jiin.jung@rutgers.edu*

Development of a mathematical model for the influence of relative humidity on the survival of Salmonella on cucumbers

Fresh cucumbers have recently been recognized as a vehicle in foodborne disease outbreaks, but little is known about the environmental factors that influence the survival of Salmonella on cucumbers. The objective of this study was to develop and validate a mathematical model that predicts the survival of Salmonella on cucumbers at different relative humidity conditions. Fresh cucumbers were spot inoculated with a four-strain cocktail of Salmonella enterica. Inoculated cucumbers were dried for two hours and placed in desiccators containing saturated salt (lithium chloride, potassium carbonate, and potassium sulfate) used to create controlled RH environments (~15, 50, 100 % RH) at 21 °C. Samples were enumerated at appropriate time intervals ranging from 0 to 72 h. Cucumber weights were recorded, and the percentage weight loss was calculated. DMfit was used to model the survival of Salmonella from experimental observations fitting the data to the Baranyi model. Predictive models for the survival of Salmonella on cucumbers under different RH conditions were developed using Baranyi and Roberts models as a primary model. The R2 values for the primary models ranged from 0.70 to 0.85 indicating relatively good fit. Salmonella populations on cucumbers decreased by approximately 0.88, 0.41, and 0.33 log CFU/cucumber after 72h at 15, 50, and 100 % RH, respectively. Overall visual quality of cucumber declined over time and weight loss from cucumbers increased. Weight loss of cucumbers was significantly highest at 15 (15.3 %), followed by 50 (11.5 %) and 100 % RH (2.8 %) at the end of 72h ($p < 0.001$). Although further research is needed to develop secondary models for survival of microorganism on cucumbers under varying storage time, temperature, and relative humidity, the models in this study will be useful for future microbial risk assessments to develop accurate risk analysis for food borne outbreaks related to fresh produce.

W2-G.4 Kabir, E*; Guikema, S; University of Michigan; *ekabir@umich.edu*

learning from imbalanced data sets for estimating power outages

Storms regularly have substantial, wide-spread impacts on power systems, posing many risks and inconveniences to the public. While these impacts cannot generally be prevented, utilities can prepare for the post-storm restoration process to more quickly recover from the event. Having accurate prediction of power outages based on the weather forecast before the storm event can help utility companies to make better decisions regarding their restoration procedures, particularly the number of external crews to request. In many situations the power outage data are highly zero-inflated; that is, the number of zeroes are significantly higher than one would expect based on standard probability distributions. With zero-inflated data, standard statistical models struggle to appropriately model the data and make accurate predictions. In our study, we examine several statistical learning theory models for imbalanced power outage data. We show that modern statistical learning theory methods, particularly two-stage methods, can offer strong predictions with zero-inflated data. Such zero-inflated data is common in risk analysis, where (thankfully) there are far more non-events than events.

W1-I.1 Kaden, DA; Ramboll Environ; *dkaden@ramboll.com*

Hazard vs. Risk: Blurring of the Lines

Risk assessment involves the estimation of the probability, impact, and other attributes of an adverse effect, through multiple components including hazard identification, dose-response, and exposure assessment. This approach evolved in the 1970's, with the desire to replace bright-line approaches with quantitative risk assessments. Since then, there have been many improvements on basic risk assessment methods, including significant advances in exposure science. Advances in risk assessment methodology also incorporate problem formulation, mechanistic data, and mode-of-action considerations. Methods for performing systematic reviews and evidence integration allow for comprehensive, neutral reviews of the state of the science. Such guidance for better risk assessment conduct and management have improved the process and better descriptions of uncertainties in the risk calculations have informed our understanding of how confident to be in the results. In recent years, however, either due to lack of data or a desire to rapidly assess risks, there has been a trend towards using hazard identification as a surrogate for risk. Although this may appear attractive due to the simplification of the process (which either downplays or removes exposure from the equation), the result may lead to unfounded public fear and, sometimes, regulatory decisions being made without a true understanding of relative risks. In order to make informed decisions in risk management, all steps of the risk assessment process are necessary. Exposure pathways must be understood, and exposure magnitude estimated. The dose-response must also be understood. The talks in this session will present different examples and perspectives on the use of hazard identification as a surrogate for risk, and the pros and cons of the approach.

P.106 Kajihara, H*; Higashino, H; National Institute of Advanced Industrial Science and Technology (AIST); *kajihara.hideo@aist.go.jp*

Development of an Indoor Consumer Exposure Assessment Tool (ICET) and case studies by using ICET

We developed an indoor consumer exposure assessment tool, named "ICET", which is a software to estimate inhalation, dermal, and oral exposure from consumer products in the indoor environment. The tool estimates concentrations of chemicals in indoor air, in house dust, and the amount of substances migrated to the surface of the skin, from both articles and mixtures. A database reflecting the Japanese lifestyle is included in the tool, such as types of houses, bodyweight, respiratory volume, and some default data sets concerning products. The tool estimates not only personal exposure in individual house but also nationwide exposure distributions of houses and residents in Japan using Monte Carlo simulation. Case studies were conducted on inhalation exposure of paradichlorobenzene contained in bug repellent set in closet, and on dermal exposure of plasticizer contained in PVC film. In the case of the bug repellent, indoor concentration estimated by ICET was roughly agreed with the measured concentration. On the other hand, the dermal exposure amount of plasticizer estimated by ICET was about 30 times greater than the measured value. Though, the exposure amount estimated by ICET was closer to the measured amount than the exposure amount estimated by ECETOC-TRA. It was found that the main cause of estimation error is the transfer rate from product to skin surface. We considered the cause of estimation error on transfer rate from product to skin surface.

T2-I.2 Kapraun, DF*; Schlosser, PM; US Environmental Protection Agency; *kapraun.dustin@epa.gov*

Assessing Uncertainty and Variability in Biochemical Parameters in a PBTK Model for Perchlorate

Physiologically based toxicokinetic (PBTK) models can serve an important role in chemical risk assessments because they allow for extrapolations across different species and dosing regimens and between in vitro and in vivo conditions. In order to make predictions, however, such models require various physiological and chemical-specific parameters that can only be known to finite precision and whose values tend to differ between individuals in a population. We sought to quantify intra-individual uncertainty and inter-individual variability for four biochemical parameters in a PBTK model relating perchlorate exposures and thyroid hormone levels in women of child-bearing age. Using data from a previously published controlled human perchlorate exposure study, we applied Markov chain Monte Carlo (MCMC) sampling to obtain Bayesian distributional estimates of the following: urinary clearance rates for (1) perchlorate and (2) iodide, (3) the Michaelis-Menten constant for perchlorate's competitive inhibition of thyroid iodide uptake, and (4) the maximum thyroid iodide uptake rate. The resulting probability distributions for these four parameters for each of 12 adult female subjects illustrate intra-individual uncertainty and inter-individual variability. Unlike point (single value) estimates, distributional estimates allow for quantification of uncertainty and variability in the parameters. Furthermore, propagating parameter uncertainty through a PBTK model allows one to quantify uncertainty and variability in model outputs, such as serum concentrations of perchlorate or thyroid hormones. Using credible intervals for quantities of interest that are based on distributional estimates provides an alternative to the standard practice of applying uncertainty factors, and may improve confidence in risk analyses and assessment conclusions. The views expressed herein do not necessarily reflect the views or policies of the US EPA.

T3-D.4 Kashuba, RO*; Menzie, CA; Buonagurio, JE; Exponent; *rkashuba@exponent.com*

Why many field-based toxicity thresholds are unreliable: Statistical artifacts affecting causal inference

Environmental biomonitoring involves sampling biological media or communities in the field. By design, these samples are composed of mixtures of taxa or chemicals. The individual taxa or chemicals which comprise these mixtures, however, are sampled disproportionately. Some taxa or chemicals may be present in a sample much more often than rarer mixture components. Because sample size affects the accuracy of summary statistics, disproportionate sampling across mixture components affects derivation of stressor thresholds from these samples. The smaller the sample size, the more uncertainty there is in inferences made from that sample, and the more likely it is to calculate an extreme (i.e., very high or very low) estimate of a summary parameter attempting to characterize the sub-population of that mixture component. This is due solely to random chance and the properties of statistical inference. When such monitoring datasets composed of mixtures are used to calculate distribution summary statistics for individual mixture components, the concern is that differences in sample sizes among components create statistical artifacts misinterpreted as meaningful and accurately quantified relationships between chemical stressor levels and biological community response. This may cause some taxa to appear tolerant or intolerant by chance, which affects assignment of toxic effects thresholds. We demonstrate the effect of disproportionate sample size among groups on threshold calculation via mathematical simulation in concert with examining several existing water and sediment quality criteria examples. This shows that statistical artifacts present in field samples can suggest unreliable relationships, pointing to a need for multiple, different lines of evidence in the development of causally reliable regulatory guidelines for environmental stressors.

P.112 Karanth, S*; Mishra, A; Pradhan, AK; University of Maryland College Park; *skm@mail.umd.edu*

Applicability of whole genome sequencing data for Salmonella risk assessment in poultry meat

Salmonella is a major foodborne pathogen with an annual estimate of 1.2 million illnesses and 450 deaths, and $365 million in direct medical costs in the USA according to the Centers for Disease Control and Prevention (CDC). It is also one of the most diverse pathogenic bacteria, comprising more than 50 serogroups and over 2500 named serovars, each with variable pathogenicity profiles. Whole genome sequencing (WGS), a rapid, cost-effective method to reveal the complete genetic make-up of an organism, can be used to identify specific pathogenic serotypes of microorganisms. This in turn could help better predict microbial behavior, which could be used to refine the existing microbial risk assessment (MRA) models for Salmonella. The aim of this study was to determine the applicability of WGS data in developing serovar-specific risk assessment models for Salmonella. In this study, data regarding the prevalence of different serovars of Salmonella in chicken (obtained by WGS) between 2000 and 2015 was obtained from the GenomeTrakr network and salmonellosis outbreak survey data was obtained from the CDC Foodborne Outbreak Online Database (FOOD Tool). An autoregressive moving averages time series model was developed to determine the prevalence of Salmonella spp. and some of its most common pathogenic serotypes over this time period for incorporation into a MRA model. Time series analysis of the prevalence and outbreak data indicated an increased prevalence of Salmonella spp. during spring (March–May). However, decomposition and linear regression of the prevalence data indicated different seasons for increased prevalence of some major pathogenic Salmonella strains, such as Salmonella enterica serovar Enteritidis (November–January), Heidelberg (February–April and October–December), and Typhimurium (June–August) at a 95% significance level. The results of this study can provide useful insights in incorporating genomic data in future microbial risk assessment studies.

W3-H.1 Keisler, M; Foran, C; Keisler, J*; Linkov, I; University of Massachusetts Amherst ; *mkeisler@umass.edu*

A Theoretical Approach to Network Modeling of Antibiotic Resistance

Multiple resistance or "multi-resistance" is when two or more anti-microbial measures would fail to kill a microorganism or colony. The rapid development of multi-resistance is a risk to all of society, because if antibiotic treatments of last resort become ineffective, patients will die from otherwise routine infections. Multi-resistance develops when a person infected with a microbe resistant to one one or more anti-microbial develops further resistance to other anti-microbials. This can happen either as a new resistance developing to the anti-microbial with which the patient is treated, or through infection with a second resistant microbial strain followed by horizontal gene transfer between microbes in the patient's body. We model the development of multi-resistance with a two-scale network model. Specifically, at any time, an individual is served by one hospital. From one long period to the next, individuals may become well, stay well, become ill or stay ill, and may stay in the same community or move to a new community. Within one long period, the sick individuals within a community may be cured of a microbial infection, may spontaneously evolve resistance to an antibiotic, may acquire a new microbe with resistance to an antibiotic, or may convey resistance present in one microbial infection to another microbial infection through horizontal gene transfer. Representing this network process using Markov chains, we can explore what the degree to various factors affect the risk of multi-resistance development. We can also explore how decisions about screening, hygiene, antibiotic choice, adherence management and other protocols may help.

W1-I.2 Kelly, ID*; Ryan, NM; Bayer Crop Science; *iain.kelly@bayer.com*

Global trends in risk assessment in pesticide regulation

For several decades the Environmental Protection Agency has been a key authority in the development and implementation of risk assessment and risk characterization as it relates to pesticides. The Agency has been a proponent of assessments that are risk rather than hazard based due to the clear anomalies that a hazard based system can introduce. The Delaney Clause was one such example. First introduced in 1958, and covering the use of food additives found to cause cancer in animals or humans, its application in the registration of crop protection chemicals was clearly limiting the introduction of new safe chemistries. The Food Quality Protection Act was passed in 1996 and put the assessment of human risk on a strong scientific basis. In recent years, however the European Union has become more active in pesticide regulatory processes. Cut-off criteria for "CMR" chemicals (carcinogen, mutagen or reproductive toxicant) have been introduced and criteria are also under discussion for endocrine disrupters. The anomalies and inconsistences this divergence causes in relation to global food production and the development of innovative technologies will be discussed. The case for an improved definition of the role of exposure in informing toxicological testing and risk characterization will be presented.

M2-K.6 Khan, KJ*; Begum, N; University of Vienna; *kkhan01.kjk@gmail.com*

Effective Communication – the fourth factor in Physician-Patient Relationship (PPR) in Cancer Treatment

The physician-patient relationship is being built on three factors: professional advice, medical treatment and care. The fourth factor that cuts across these three is the 'communication'. Whereas the first three are evidenced from the medical record of the patient, the fourth one is indiscernible or too small to be seen. As a result, it is difficult to establish what kind of information is being passed on to patients, particularly suffering from cancer and what impact does it have on patient's decision making about treatment. The very reason for this missing link is the potential risk associated with imaging technology and cancer treatment. Since due to physician-patient privacy accord, direct observation of conversation is not advisable although critical, therefore the researchers have to rely on the perception of parties involved. At social level, the word 'cancer' is still a taboo in many communities and is considered a painful experience through diagnosis to treatment and survival. During the last few decades, the cancer treatment has shown tremendous advancement positively affecting the survival rate and palliative care to improve the quality of life of cancer survivors. The perception about cancer can be changed by creating awareness among patients, their relatives and the general public audience. Thus the effort to highlight the importance of effective communication between physicians and patients is worth making. Doctors have the 'power of persuasion' to influence patients' decision making and could help in democratisation of culture. Therefore, a word from them on popular media through 'conversationalization' of the issue on the model of other themes such as politics, science and technology to make it 'marketized', could have an immense impact on the social understanding of the disease.

P.73 Kerr, SE*; Patwardhan, A; University of Maryland College Park; *siokerr@umd.edu*

Measuring the Impact of Socio-economic Status on Post-Hurricane Power Restoration

As we increasingly consider resilience as a central strategy for addressing climate change, recovery emerges as an important dimension that is often the focus of public policy. The progression of global climate change will cause an increase in the scale and magnitude of disasters, and it is therefore more important than ever to understand how we can not only prevent impacts, but also recover from them. Recovery processes can be very non-uniform; communities struck by similar levels of damages in the aftermath of a disaster can have very different outcomes. As a result, we must work to better understand the factors that make the recovery process more efficient and effective for some communities than for others. This project considers the impact of socio-economic status on post-hurricane recovery at the regional level, using power restoration as a metric by which to better understand short-term recovery of a specific infrastructure system on a broad spatial scale. The relationship is examined using a cross-sectional analysis that compares the duration and nature of recovery processes at the zip code level following Hurricane Matthew in the southeastern United States. The research uses outage data that was scraped from utility websites following the storm, and controls for the hazard and spatial characteristics that are expected to impact the restoration process. This research hypothesizes that there is a level of subjectivity inherent to the decision making process that guides power restoration efforts. This could cause deviations in recovery outcomes along socio-economic lines. There is little acknowledgment in the literature of the possibility that power restoration could be influenced by such factors, so positive results will be of great relevance to policy makers and utilities alike. More broadly, by establishing power restoration as a valid proxy for short-term infrastructural recovery the research sets the groundwork for future studies of this nature.

W2-A.2 Kim, JH*; Greco, SL; Copes, R; Public Health Ontario; *JinHee.Kim@oahpp.ca*

Estimating the burden of foodborne and waterborne illness in Ontario

Public Health Ontario (PHO), an arms-length government agency, is dedicated to protecting and promoting the health of the people of Ontario, who comprise approximately 40% of Canadians. As part of a project to estimate the environmental burden of disease for the province of Ontario, we produced estimates for foodborne and waterborne illness. For our population and project objectives, we adapted the approach used by the World Health Organization to estimate the global burden of foodborne disease. Essentially, foodborne and waterborne attributions (%) were applied to pathogen-based health outcome data to estimate the burden due to each source of illness. The attributions were based on previously conducted expert elicitations, while health outcome data were extracted from administrative databases containing healthcare utilization information for nearly everyone in the province. Specifically, data on physician office visits, emergency room visits, hospitalizations, and deaths (for health outcomes defined by ICD-9 or ICD-10 codes) were used. We selected the top 12 foodborne and top 11 waterborne pathogens to be analysed based on surveillance data and additional data sources as needed. In addition to estimating the burden due to specific pathogens (e.g., giardiasis, norovirus infection), we also estimated the foodborne and waterborne disease burden due to more general diagnoses (syndrome-based) such as gastroenteritis (i.e., "stomach flu). This presentation will describe our methods and preliminary results, as well as discuss the strengths and limitations associated with the analysis.

W4-G.3 Klinke, A; University of Newfoundland; *aklinke@grenfell.mun.ca*

Re-ordering risk and uncertainty: Implications for cosmopolitan risk governance

The world of uncertainty and risk is an encounter of precarious, transitory and contingent appearances of things, and patterns of regular natural and social processes that allow human interference and projection. Humans experience uncertainty in the lifeworld, present and future activities, collective codes of conduct, social life and organization of social being. I re-order uncertainty as of ontological, epistemological and teleological nature, which I correlate with an order of problematic risks that I distinguish as systemic, structural and transformative. Systemic risks, e.g. climate change and loss of biodiversity, are global threats that are highly complex and stochastic of nature, they can reach tipping points, and they are often ambiguously interpreted. Structural risks, e.g. corruption, modern slavery and social inequality, emerge through structures and processes of existing social and political orders, in particular in terms of prevailing values, norms, institutions, discourses and power relations. Transformative risks, e.g. energy transitions, transformation of democracy and transfiguration of socio-political orders, occur in the course of profound global changes that ignite dynamics, processes and forces inducing new challenges for traditional structures and orders because major changes in society and politics are shifting from established manners, customs, and modes of behavior to new norms and values. In this light, I draw implications for cosmopolitan risk governance. What can we learn for the configuration of cosmopolitan governance? I argue for a self-governing approach with a polyarchic network structure that succeeds by means of functional differentiation in the form of distributed and differentiated responsibilities. I demonstrate how ordering uncertainty and risk and cosmopolitan governance can reinforce each other and illuminate our thinking about the global governability of uncertainty and risk.

P.40 Kobylewski-Saucier, SE; Taylor, ML*; Lipscomb, JC; 1. Consolidated Safety Services, Inc; 2. WinTech, LLC; 3. US Environmental Protection Agency; *lipscomb.john@epa.gov*

Methodology for deriving provisional advisory levels (PALs) for chlorine

PALs are health threat characterizations (oral and inhalation threshold values) that estimate levels of harm from exposure to toxic industrial chemicals and chemical warfare agents (CWA) at various exposure levels and durations. PALs values inform options for emergency response and risk management decisions (e.g. temporary re-entry of contaminated areas and reuse of previously contaminated resources) and are not no-effect levels but provide “degree of injury” tiers. Exposure at PAL 1, 2, and 3 tiers are associated (respectively) with reversible, irreversible or escape-impairing, and/or lethal health effects for exposures of up to one day to up to two years. Chlorine is used in the manufacturing of numerous products and has been involved in several unanticipated releases, including its use as a CWA. The respiratory tract is the primary target for inhaled chlorine toxicity; effects range from sensory irritation to epithelial tissue damage to increased airway resistance to death at high doses. Chlorine hydrolysis products formed in the body can disrupt enzyme function and membrane structure and damage tissues. Based on its toxicity and general availability, chlorine is considered an important potential agent of harm in both accidental and subversive release scenarios. This project evaluates chlorine toxicity information within the context of the comprehensive methodology for PALs derivation, including consideration of direct and secondary mechanisms of toxicity in identifying critical effects (CE) and points of departure (POD). This paper will demonstrate how CE and POD are selected using a weight-of-evidence approach involving analysis of the relationship between toxicity mechanisms and characteristic physiological endpoints. The views expressed in this paper are those of the authors and do not necessarily reflect the views or policies of the Agency. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

P.183 Kobayashi, N*; Komatsubara, Y; Eriguchi, T; Ikarashi, Y; National Instutute of Health Sciences; *norihiro.kobayashi@nihs.go.jp*

Application of a 3-D chemical fate prediction model for risk assessment of agricultural chemicals in Japanese river water

In order to ensure the safety of drinking water, many agricultural chemicals are monitored by many of water suppliers in Japan. However, analytical methods for agricultural chemicals in tap water are complicated. Therefore, much labor and cost is required to apply these methods. In the present study, we have developed a 3-D chemical fate prediction model and applied the model to approximately 250 agricultural chemicals, which are the “Complimentary Items” in tap water in the Japanese Waterworks Act. This model takes into consideration two forms of agricultural chemicals (particulate-phase and dissolved-phase) in the estuary, and can simulate the diffusion and sinking processes of agricultural chemicals from the loading points of their sources. This model requires flow field data (current velocity, water temperature, etc.), particulate matter (phytoplankton and detritus) concentrations, loading flux, and physical-chemical property of agricultural chemicals (log Koc, and half-life in water) as input data for the calculations. Run-off ratio at the 30 km downstream from loading points and the mass balances of these agricultural chemicals in the river were estimated. The results obtained from this model can be used to select target chemicals for environmental monitoring in Japanese river water. Further, this model can be also applied to human health and ecological risk assessments of agricultural chemicals. The improvement of the model’s predictive capability shall be the focus of our next study.

P.125 Kojima, N*; Xue, M; Zhou, L; Machimura, T; Ebisudani, M; Tokai, A; Graduate School of Engineering, Osaka University; *kojima_n@see.eng.osaka-u.ac.jp*

Methodology for Policy Characterization based on the Multiple Risk Evaluation Results: Case Study for Japanese Chemical Replacements

For managing multiple risks more comprehensive methodology are required instead of risk management to specific target risk. Here we have been exploring practical method to carry our risk governance of chemicals. The objective of this research is developing methodology for policy characterization based on the policy evaluation analyzing risk-risk trade-offs: about not just target risk but also countervailing risks. This study composed two steps: the first step was each policy evaluation as a preparation of comprehensive policy comparison; and the second step was the definition of the way of illustration in order to grasp the profiles of target and countervailing risk reduction. In the policy evaluation step, we evaluated five (and more…) cases of chemical replacement in Japan. For example, we picked up adhesive replacements to the lower formaldehyde residue for wooden constructing material; several refrigerant replacements for reducing target risk such as ozone depletion potential (ODP); and home detergent replacements using LAS to using AE. Every chemical replacement inevitably included several endpoints for other populations, so we evaluated the risk by the life-stage, by the population along with time course, by the risk category using with the material flow (&stock) analysis, life-cycle assessment, and probabilistic risk assessment. Based on the results above, we set the trade-off ratio as a horizontal axis. Moreover, as a preliminary result, we set the flow-stock ratio as the vertical axis for checking which the risk from consumer products have increased or not. As a remarkable results of refrigerants in air conditioner, we could find that the replacement lead to decrease health risk of ODP as target and GWP (Global Warming Potential) as countervailing risk in the 2030, the improvement on longer lifetime lead to prolonged the risk occurrence. This work is supported by Ministry of Environment, Japan (1-1501).

M3-A.3 Kopp, RE; Rutgers University; *robert.kopp@rutgers.edu*
Current approaches to assessing risks of sea-level rise
Sea-level rise (SLR) and the associated amplification of the frequency of coastal flooding rank among the most prominent consequences of climate change. Over the last decade, driven by the needs of regional and national risk assessments, SLR projections have taken on an increasingly probabilistic and localized character. Attempts to assess the effects of SLR on tidal and storm-driven flooding have employed both extreme-value theory applied to tide-gauge data and also physical models, the latter primarily in the context of tropical cyclones. Despite these advances, SLR in the second half of this century and beyond remains an area of deep uncertainty, due primarily to limited understanding of ice-sheet physics. Some local decision frameworks for managing SLR risks have focused primarily on physical endpoints. SLR allowances, for example, assess the vertical increment of protection needed to maintain the current risk level for a certain time period. Adaptive management frameworks have also been used in some contexts. Economic risk analyses of SLR have taken several forms. The theoretically simplest rely on current spatial patterns of exposure and model the value at risk due to permanent and episodic flooding, with no or limited systematic treatment of coastal adaptation. Analyses grounded in the most detailed empirical data and storm modeling have tended to take this form. The next simplest use benefit-cost analysis to select optimally among a small number of idealized response options. One frontier approach in SLR economic risk analysis involves agent-based modeling of adaptation decision making; so far, this approach has only been applied at local scale. Another frontier approach involves high-resolution, dynamic modeling of the reallocation of population and technology from flooded areas and toward continental interiors. To date, this approach has only been applied in an idealized context neglecting intermittent flooding and adaptations other than retreat.

P.111 Kottapalli, B*; Butler, S; Peers, M; Holzhueter, D; ConAgra Brands; *bala.kottapalli@gmail.com*
Application of Principles of Failure Modes, Effects, and Criticality Analysis to Fluid Milk Food Safety Plan
Failure Modes, Effects and Criticality Analysis (FMECA) is a semi-quantitative risk assessment methodology designed to identify and address potential failure modes during manufacturing of a process or product. FMECA risk assessment tool can be used to verify the effectiveness of implementation of preventive controls in a manufacturing facility's food safety plan. The purpose of this study was to apply FMECA principles to analyze the effectiveness of critical control points (CCPs) and pre-requisite programs in mitigating food safety concerns during fluid milk production. Preliminary hazard analysis (using Ishikawa diagrams) was used to predict potential food safety issues occurring at different process steps throughout the manufacturing of fluid milk. The potential failure modes were ranked based on severity (S), likelihood of occurrence (O) and likelihood of detection (D) on a scale of 1-10 (for each of the variables S, O, D). A team comprising of subject matter experts, operations and quality assurance personnel were involved in ranking of the failure modes. Risk priority number (RPN = S X O X D) was calculated and a score of 130 or above was deemed high risk and required corrective actions. Pareto diagrams were created using MINITAB statistical software to identify high risk processing steps that require corrections and/or corrective actions. The results of FMECA indicated that the preventive controls implemented in the manufacturing of fluid milk process significantly minimize or prevent (RPNs < 130) food safety hazards from a public health standpoint. The FMECA tool used in this study can provide scientific basis for verifying the effectiveness of the implementation of preventive controls executed by Conagra Brands' fluid milk manufacturing facility and compliance with FSMA requirements.

T4-H.2 Kottapalli, B*; ConAgra Brands; *bala.kottapalli@gmail.com*
Application of Failure Mode Effects Criticality Analysis (FMECA) for Effective Implementation of Food Safety Plans
Failure Modes, Effects and Criticality Analysis (FMECA) is a semi-quantitative risk assessment methodology designed to identify and address potential failure modes during manufacturing of a process or product. FMECA risk assessment tool can be used to verify the effectiveness of implementation of preventive controls in a manufacturing facility's food safety plan. The purpose of this study was to apply FMECA principles to analyze the effectiveness of critical control points (CCPs) and pre-requisite programs in mitigating food safety concerns during low acid pudding, acid gels and dried milk products production. Preliminary hazard analysis (using Ishikawa diagrams) was used to predict potential food safety issues occurring at different process steps throughout the manufacturing of low acid pudding, acid gels and dried milk products production. The potential failure modes were ranked based on severity (S), likelihood of occurrence (O) and likelihood of detection (D) on a scale of 1-10 (for each of the variables S, O, D). A team comprising of subject matter experts, operations and quality assurance personnel were involved in ranking of the failure modes. Risk priority number (RPN = S X O X D) was calculated and a score of 130 or above was deemed high risk and required corrective actions. Pareto diagrams were created using MINITAB statistical software to identify high risk processing steps that require corrections and/or corrective actions. The results of FMECA indicated that the preventive controls implemented in the manufacturing of low acid pudding and acid gel processes significantly minimize or prevent (RPNs < 130) food safety hazards from a public health standpoint. The FMECA tool used in this study can provide scientific basis for verifying the effectiveness of the implementation of preventive controls executed by Conagra Brands' low acid pudding, acid gels and dried milk products production manufacturing facility and compliance with FSMA requirements.

P.50 Kratchman, J*; Gray, G; George Washington University; *gmgray@gwu.edu*
Estimating Chronic Toxicity Values from Short Term Tox Tests: Application to Chemical Substitution Decisions
With increasing demand for safer chemicals, more chemical alternatives assessment frameworks are being developed to replace target chemicals in products and processes. However, many chemical alternatives lack chronic toxicity data, leaving assessments imbalanced. In the absence of such data this study investigated whether short-term non-cancer toxicity data can be used to predict chronic toxicity effect levels by focusing on the dose-response relationship instead of a critical effect. This information is then applied to an alternatives assessment decision. Data from National Toxicology Program (NTP) technical reports have been extracted and modeled using a novel high-throughput processing approach and the Environmental Protection Agency's Benchmark Dose Software and. Best-fit, minimum benchmark dose (BMD) and benchmark dose lower limits (BMDLs) were modeled for all NTP pathologist identified significant non-neoplastic lesions, final mean body weight and mean organ weight for 41 chemicals tested by NTP between 2000 and 2012. Relationships between the short-term and chronic data were then developed using orthogonal regression techniques. The findings indicate that short-term animal studies may reasonably provide a quantitative estimate of a chronic BMD or BMDL. This can allow relative human toxicity comparisons for chemicals that lack chronic toxicity data. Next, two pairs target-alternative chemical recommendations were considered. The alternative chemical lacked chronic toxicity data, whereas the target had well studied non-cancer health effects. Using the established quantitative relationships chronic health effect levels were predicted for the alternative chemicals and compared to known points of departure (PODs) for the targets. The findings indicate some alternative assessment approaches can recommend substitute chemicals with greater toxicity concerns than the target chemical.

M2-I.4 Krewski, D; University of Ottawa; *cphra@uottawa.ca*
Systematic Review of Factors Affecting the Onset and Progression of Neurological Disease
As part of the National Population Health Study of Neurological Conditions initiated by the Public Health Agency of Canada in collaboration with the National Health Charities of Canada, systematic reviews of factors associated with the onset and progression of 14 neurological conditions were conducted according to a common core protocol The 14 conditions included: Alzheimer's disease, amyotrophic lateral sclerosis, primary brain tumours, cerebral palsy, dystonia, epilepsy, Huntington's disease, hydrocephalus, multiple sclerosis, muscular dystrophies, neurotrauma, Parkinson's disease, spina bifida, and Tourette's syndrome. The findings of this comprehensive review are summarized both within and across conditions. These results will be of value in developing strategies for mitigating the growing burden of neurological disease both in Canada and internationally.

P.180 Kruszewski, FH; American Cleaning Institute; *fkruszewski@cleaninginstitute.org*
Risk Assessment Guidance for Enzyme-containing Products
The purpose of this guidance is to describe the potential health hazards of enzymes present in consumer products and provide a framework for manufacturers of these products to conduct risk assessments to help ensure the safety of new products containing enzymes. Enzymes generally have good safety profiles. However, enzymes like many other proteins can act as allergens and induce the production of allergen-specific IgE antibody upon repeated inhalation or exposure to mucous membranes that may lead to allergy symptoms, including asthma. The primary challenge associated with enzyme use is preventing the generation of allergen-specific antibody and the development of symptoms of Type 1 hypersensitivity. This hazard is the primary focus for the risk assessment for enzymes and must be managed carefully. Another hazard that also should be addressed is primary irritation of the eye and skin. If the risks posed by enzymes are not managed appropriately, the consequences may spread beyond a single product or company. This could lead to unwarranted limitations on the use of enzyme technology in other consumer applications. It is recommended that companies using enzymes in consumer products responsibly consider how they are managing enzyme safety including the conduct of appropriate risk assessments and risk management programs. Such programs will include measures to manage exposures to enzymes. The program design should be developed on a case-by-case basis to address parameters specific to the type of product and its applications. Experience in the cleaning products industry demonstrates that the potential risk of adverse effects can be successfully managed by identifying the hazards, carefully assessing exposure, characterizing the risk and then applying appropriate risk management. This guidance document outlines strategies and methods that have been used successfully by the cleaning products industry. An updated guidance document will be available in 2018.

P.118 kuen yu hwu, JB; lai szu chi, *; taiwan University; *r04841017@gmail.com*
health risk assessment of cadmium in rice
The aim of this study was to assess the risk of edible crops in rice from 2010 to 2015. 19-65 years old adults are our target population, on behalf of the public. The average body weight is 62.96 kg. We used the reference dose to calculate the reference dose (RfD) instead of NOAEL. BMDL (baseline Pant (1995))derives lower confidence limits for dose. Reference dose software (BMDS) is from USEPA. The average concentration (MC), lifetime average daily dose (LADD) and hazard index (HI) were calculated by the Bayesian theorem in the Markov chain Monte Carlo simulation (MCMC). Cadmium oral dose response relationship is not clear, so in the carcinogenic risk factor estimates, we will estimate the slope of respiratory carcinogenesis, followed by 50% conversion rate, converted into oral carcinogenic slope. Dose Response Relationships The carcinogenicity of rat animal experiments in IRIS was assumed to be 0.25 kg in rats and BDML = 0.837 was calculated using Benchmark dose software. Human BMDL is estimated by animal experiments calculated BMDL, by the animal dose response relationship extrapolated to human dose response relationship, calculated human BMDL = 0.254. Furthermore, oral carcinogenicity was calculated assuming a daily dose of 20 m3 / day per day and an adult weight of 70 Kg, calculated to have a carcinogenic slope of 6.5 similar to that of the US EPA-published diet carcinogenic slope of 6.4.

W4-B.5 Kuttschreuter, M*; Jong-Kamphuis, N; University of Twente; *margot.kuttschreuter@utwente.nl*
Effectiveness of a serious game to encourage adequate protective behaviour in case of a freight train accident involving hazardous chemicals
The likelihood of a railway accident involving the transportation of hazardous substances might be small, but its consequences can be enormous. As it takes some time for the emergency service to arrive on site, individuals who happen to be close to the accident site are left on their own to decide on appropriate responses. This calls for an effective risk communication strategy to enable those nearby to take well informed decisions in case of such an emergency. To this end a prototype of a serious game was developed. The game aimed to make individuals aware of the hazards of a railroad accident involving hazardous substances and to encourage adequate behaviour in case of an accident. In the game, a serious accident with a freight train transporting hazardous chemicals takes place. The player happens to be walking close to the track and faces a number of dilemma's that involve a choice between staying at a safe distance versus approaching the train, e.g. in an attempt to try to warn or rescue other people. The research objective was to examine the effectiveness of playing the serious game. A two-group posttest-only randomized experiment was conducted. Participants were students at the University of Twente (n=181) who participated to earn credits and had no special interest in railroad safety issues. Results indicated that the game affected risk perception, self-reliance and the willingness to accept responsibility for one's actions. After playing the game, the participants perceived the likelihood of an accident involving hazardous substances to be higher and its consequences more severe. They also considered themselves more able to take appropriate actions and they were more willing to take responsibility for their own personal safety. Implications for the use of serious games in risk communication will be discussed.

T3-E.1 Kuzma, J; NC State University; *jkuzma@ncsu.edu*
High Risk Scenarios of Gene Drives in Ecosystems
Usually, an engineered gene will get diluted in the wild population if there is no selective advantage to it. However, "gene drive" systems allow for an introduced gene on one chromosome to copy itself into its partner chromosome so that nearly all offspring inherit the engineered gene. If just a few organisms with gene drives are released into the wild, theoretically the whole population could become engineered if there is random mating. Gene drives have not yet been released, but have been demonstrated in laboratory experiments with fruit flies and mosquitos. They have been proposed to destroy disease-carrying pests using killer genes or to immunize endangered species using protective genes. In some cases, gene drives might be the only option to save an endangered species or to protect humans from serious diseases. On the flip side, there is significant uncertainty and ambiguity in assessing the potential risks of gene drives in unmanaged ecosystems. Current environmental assessments for non-gene drive pest-control using engineered insects tend to downplay risk to advance regulatory approval. In contrast, this paper will construct a scenario for using a gene drive to destroy a natural population and then use fault tree modeling to illustrate how we might consider "worst case" scenarios of ecological risk. The analysis will highlight events with extreme uncertainty (probabilities virtually unknown) and other events for which some information is available to bound probability and impact estimates. It will advance future explorations of high risk scenarios of gene drive systems by identifying where future data collection might serve to reduce uncertainties and where countermeasures could mitigate risk if gene drives were to be released intentionally to cause harm.

P.86 Lai, TR*; Huang, YC; Chuang, YC; Wu, KY; Chiang, SY; China Medical University; *routinelai@gmail.com*
Risk assessment of exposure to Acrylamide from baby food in Taiwan
Acrylamide is commonly found in various high-carbohydrate food especially when processed at high temperatures.Many studies demonstrate that acrylamide possesses neurotoxicity,genotoxicity and reproductive toxicity.Acrylamide has been classified by the International Agency for Research on Cancer as probably carcinogenic for humans(group 2A).Previous data have shown that ingestion risk to children is 2-3 times higher than adults and acrylamide is detected in several baby food items.However,there is lack of research for assessing risk of acrylamide in baby food products in Taiwan.The aim of this study was to assess the risk of acrylamide in baby food products.The probabilistic risk assessment was conducted in 0-3 age group of general population group in Taiwan with Monte Carlo simulation.The residues of acrylamide in 93 baby food items were cited from a report of Taiwan Food and Drug Administration and the food consumption data was taken from the National Food Consumption Database in Taiwan.Our results showed that the mean and 95th percentile of margin of exposures for five specified items of baby foods were ranged from 217,507 to 58,480,130 and 388,346 to 115,232,718,respectively.The total and 95th percentile of hazard index were 0.185 and 0.690,both less than 1.The ranges of lifetime cancer risk at the mean and 95th percentile of Lifetime Average Daily Dose(LADD) of Acrylamide for 0-3 age of were estimated at 5.93 x 10-7 - 3.22 x 10-5 and 2.77 x 10-6 - 1.22 x 10-4, respectively.In conclusion,baby foods in general population with the 95th percentile LADD of acrylamide may pose potential carcinogenic.

P.146 Lambert, CE*; McComas, KA; Cornell University; *cel247@cornell.edu*
News media framing of the risk of induced seismicity in four U.S. states
In the past 10 years, earthquakes in the central and eastern US have increased, due to industrial activities like deep injection of oil and gas related wastewater. As seismic activity has risen, attitudes and responses in affected states have differed, with some placing limits on injection soon after seismic activity began, and others introducing regulations after a period of years. The unfolding debates about induced seismicity raise questions of how news media are covering seismic risk from induced earthquakes, an area of study that has received little attention. We investigate variability in news media framing of induced earthquakes across multiple states with different regulatory responses to assess what frames the news media use in their coverage, how the use of frames varies over time, and to compare framing and levels of coverage with earthquake activity and regulatory action. Our study consists of a content analysis of newspaper coverage of induced earthquake events in Arkansas, Oklahoma, Ohio, and Texas, chosen because they have experienced induced earthquake sequences within the last 10 years and have instituted a range of regulatory responses. We draw on previous literature to categorize whether coverage emphasizes earthquakes as either (1) a problem that needs to be solved, by referring to scientific information, public accountability, risk linkages, or causal attribution, or as (2) not a problem, which emphasizes the situation as a non-issue or as with a solution already in hand, by focusing on governmental statements, economic perspectives, scientific uncertainty, or denial of causal relationships. We present a timeline of media coverage and framing, earthquake activity, and regulatory action in each state. By designating frames as problem/no problem, the results provide a picture of how the debate over induced seismicity as a risk issue has unfolded over time in the media and how that discussion corresponds to sociopolitical and geological events.

T3-H.4 Lambertini, E*; Kowalcyk, BB; Ruzante, JM; RTI International; *elambertini@rti.org*
Assessing the impact of different microbiological criteria for Salmonella in raw poultry products
Contamination of not-ready-to-eat poultry products with Salmonella has been responsible for numerous foodborne illness outbreaks and recalls. In the U.S., despite initiatives to improve the safety of poultry products, progress has stalled and public health agencies have reported little to no improvement in recent years. Currently, poultry products performance standards for Salmonella and Campylobacter are implemented to identify and incrementally correct contamination issues at production plant level, thus reducing the risk of consumer exposure. Such standards are based on presence/absence pathogen detection. Different strategies have been discussed to identify and classify contamination at lot and plant level, based on detection methods ranging from qualitative to fully quantitative. However, production and public health impacts of such strategies have not been evaluated. This study sought to: 1) quantitatively assess the product management and public health impacts of a range of microbiological criteria to determine lot acceptability, in association with a hypothetical "test and divert" Salmonella control strategy in chicken parts, 2) compare the impact of a microbial criterion on different chicken part products, and 3) compare "test and divert" risk reduction strategies to non-divert strategies based on "continuous improvement" feedback driven by microbial criteria testing results. A probabilistic quantitative risk model was developed to describe relevant portions of a typical U.S. production chain for chicken parts, including consumer handling. Distributions of model variables and parameters were derived from microbial surveys, federal inspection data, and published literature. Model outcomes were expressed in terms of product contamination, percent of lots not meeting a criterion, and public health burden. Outcomes are expected to inform industry practices and provide a basis for future standard updates.

M4-E.3 Landis, WG*; Harris, MJ; Western Washington University (WGL) , Whatcom Conservation District (MJH);
wayne.landis@wwu.edu

Integration of ecological risk assessment with the assessment of risk to human health and well-being within a Bayesian network framework as applied to the Salish Sea.

An ongoing dilemma in risk assessment is the perceived duality between ecological risk assessment and the assessment to human health. More recently there has been the inclusion of ecosystem services and those factors that contribute to human well-being. Historically, the assessment of risk to human health was developed in the early 1980s and marked by the publication of Risk Assessment in the Federal Government: Managing the Process, 1984). Ecological risk assessment was codified in the 1990s by the EPA framework and then guidance documents in 1992 and 1998 respectively. From the late 2000s until recently, there has been an interest in defining ecosystem services and in the calculation of risk to these properties. Human well-being has become part of the lexicon to included endpoints such as a sense of place, education, employment, public safety and traditional activities. Now there are efforts to produce risk assessments that integrate all three of these domains. In a recent publication (Harris et al. 2017) we demonstrated that it is possible to estimate risk in a contaminated site to ecological endpoints, human health and ecosystem services using clearly defined causal pathways and Bayesian networks. We are expanding this process to a broader spatial scale, the Salish Sea. The Salish Sea is a term applied to both the Puget Sound and its watersheds in the United States and the Straits of Georgia in Canada. Vancouver, Seattle, Tacoma, major ports, numerous refineries, paper mills, and high tech industries contribute chemical and biological pollutants to these watersheds. The same area is also noted for intense agricultural use and outdoor recreation, activities that function both as sources of contamination and as endpoints for risk assessment. We will demonstrate strategies for estimating risks in this diverse transboundary region by applying the Bayesian network relative risk model for the long-term, sustainable, management of this region.

W3-D.3 Langeland, AL*; Neitzel, RL; Nambunmee, K; Sayler, SK; University of Michigan and Mae Fah Luang University;
aubreyll@umich.edu

Evaluation of risk of occupational injuries and hearing loss among informal electronic waste recyclers

Electronic waste, “e-waste”, refers generally to any electronic or electrical equipment that has reached the end of its usable life. The global burden of e-waste has increased exponentially as electronic products have simultaneously undergone a proliferation in type, shortening of lifespan, and increased access to electronics across the globe. E-waste generally flows from high-income countries to middle- and low-income countries, where e-waste recycling represents a transformative source of income. E-waste recycling workers recover valuable materials from electronics in unofficial settings using crude methods. In the process, workers expose themselves and the environment to hazardous chemicals. Additionally, workers are at risk of noise-induced hearing loss and physical injury as there is poor access to personal protective equipment and proper tools. A growing body of literature has explored the various types of chemical exposures in e-waste recycling. However, no task-based analysis has been conducted to evaluate the specific aspects of e-waste recycling that present the greatest physical hazards to workers, nor has sufficient research been conducted that evaluates occupational injury risks of these workers. The purpose of this study was to determine which tasks, products, and methods present informal e-waste workers with the greatest injury risk. To address this gap in the literature, our study examined individual and workplace characteristics among workers in Thailand and Chile. Forty informal workers were recruited from each country to participate in an occupational injury risk assessment. To determine the greatest risk factors in predicting injury, we designed a semi-quantitative, task-based, observational tool to assess the frequency of injuries experienced by informal e-waste workers. The tool was then implemented in our study population in Thailand and Chile. The information obtained in this study will be critical in identifying opportunities for interventions intended to reduce injury and health hazard risks in this vulnerable population.

W3-A.1 Lange, R*; Sassi, A; U.S. Food and Drug Administration;
rachel.lange@fda.hhs.gov

Sanitary Transportation of Food: Examining Industry Practices and the Costs and Benefits of the FSMA Regulatory Requirements

From the longer average time in transit, to decaying transportation infrastructure, to rapidly increasing food imports, when it comes to ensuring food safety during transport, the society is facing a wide range of factors that affect the safety of the food and feed supply. Poor practices increase the risks of microbial, bacterial, or physical contamination. These practices include the failure to protect food during transportation, to properly refrigerate food, and to adequately clean vehicles between loads, among others. The goal of the 2016 Food Safety Modernization Act (FSMA) Sanitary Transportation rule is to prevent such inadequate transportation and holding practices in order to reduce food safety risks. Specifically, the rule establishes the requirements for shippers, loaders, carriers by motor vehicle and rail, and receivers of food and feed. In examining the costs and benefits of this regulation, FDA faced several challenges, including incomplete information about industry’s best practices, shortages of available data, uncertainty about future volumes and composition of the food and feed supply, etc. In order to overcome these challenges and estimate the economic impact of the new regulatory requirements, a variety of methods and creative approaches was used to inform the cost and benefits of this regulation. We’ll also discuss lessons learned that could be helpful in conducting the retrospective analysis of this rule in the future.

P.174 Large, PJ*; Zouhair, F; U.S. Coast Guard;
paul.j.large@uscg.mil

Assessing the Risk of Maritime Accidents

As part of the rulemaking process, Federal Agencies need to identify, quantify, and where possible monetize the benefits of proposed regulations. This need becomes especially salient when the proposed regulation is intended to prevent or mitigate the impacts of accidents in an industry where this distribution is heavily skewed right. The maritime industry encounters risks of low probability and high consequence which are often difficult to model. The U.S. Coast Guard (USCG) is responsible for promulgating regulations that prevent or mitigate maritime accidents. Because the possible impacts from a these events can be significant, these accidents may be of particular interest to policymakers. The goal of the analysis is to predict the risks of worst-case accidents, identify return levels and return periods using extreme value theory along with its competitive models. Knowledge of the risk assessment is essential for policymakers to help design regulations that manage risk by mitigating Black Swan events and promote safety. This analysis is based on USCG commercial vessel accident data from 2007-2016 and models the risk curve for resulting fatalities and injuries. The USCG accident data contains information related to marine investigations reportable under 46 C.F.R. 4.03. The data reflect information collected by USCG personnel concerning vessel accidents throughout the United States and its territories.

T3-G.3 Larkin, P*; Leiss, W; Arvai, J; Dusseault, M; Gracie, R; Fall, M; Heyes, A; Krewski, D; University of Ottawa; *plarkin@xplornet.com*

Perspectives on risk assessment and risk management for carbon capture and storage

Wide ranging risk assessment and management (RA/RM) issues are relevant to carbon capture and storage (CCS) project implementation, a technological process aimed at mitigating point source CO2 emissions that contribute to climate change. Physical hazards in capture, transport, injection, and storage are associated with environmental and human health hazard and risk issues: for example, CO2 inhalation, causing occupational/public morbidity or mortality; drinking water, soil, or air contamination from amines, criteria contaminants, CO2, or brine; surface uplift or earthquakes; and an unanticipated CO2 leakage rate to the atmosphere potentially contributing to climate change sometime in the future. This presentation presents interdisciplinary perspectives on RA/RM and an integrated risk management framework (IRMF) for CCS. We consider worldwide environmental and human health CCS-related RM frameworks; the evolution of regulatory practice in Canada; results from an expert elicitation of relative risk and uncertainty for technical hazards in performance and containment, and RM of low probability high impact events; as well as best practice in risk communication and public engagement as foundations of public acceptability. Should policy makers and proponents choose to further advance CCS, key features of the IRMF are the ten-step rational and transparent process, options to engage with and integrate government and non-government stakeholders on an ongoing basis, and incorporation of independent external review at selected points in time. The place and execution of the IRMF is proposed as a blueprint to identify safe, effective, and acceptable risk control options, thereby leading to broader acceptance of CCS as a climate change mitigation technology. This would therefore also have an important part to play in protecting global population health and wellbeing in the long term.

W1-C.3 Lasher, A; FDA; *angela.lasher@fda.hhs.gov*

Evolution of the Value of the Burden of Foodborne Illness in Regulatory Analysis

As required by Executive Order 12866 and strengthened by Executive Order 13563, regulatory agencies are required to perform impact analyses to determine the societal costs and benefits of any proposed regulatory action. Since the early 1990s, FDA has made use of the Quality of Well-Being scale and then the EuroQol- 5 Dimensions scale to value pain and suffering from foodborne illness. Over this time period the value applied to this pain and suffering, in the form of a value of a statistical life (VSL), has varied. The purpose of this study is to demonstrate how evolving methods over time, and changes to the VSL used, can affect the net benefits of proposed regulatory actions in the realm of food safety. Results of previous regulatory actions are examined with changing values of statistical life. These hypothesized changes in VSL allow for a re-examination of the net benefits of previous food safety regulations.

W4-I.3 Lau, AKH*; Che, WW; Li, ZY; Frey, HC; The Hong Kong University of Science and Technology; North Carolina State University; *wenweicherren@gmail.com*

Commuter Exposure to Air Pollutants During Transportation in Hong Kong

Daily commutes contribute disproportionately to overall daily exposure to urban air pollutants such as fine particulate matter (PM2.5) and carbon monoxide (CO). The on-road and near-road microenvironments are of concern because of proximity to traffic emissions. Over the past three years, we have carried out a range of exposure measurements in several transportation microenvironments in Hong Kong, including the Mass Transit Railway (MTR) subway system, transit buses, trams, minibuses, pedestrians, bus terminal and stops. PM2.5 and CO concentrations were measured and compared across and within these microenvironments. Variability in the transportation mode concentration ratios of PM2.5 and CO is quantified. Factors affecting variability in PM2.5 and CO concentrations are identified. Preliminary results indicate that the on-road or near-road microenvironmental concentrations are sensitive to transportation mode, operation of ventilation, and proximity to nearby emission sources. Significantly higher PM2.5 concentrations were identified for tram, pedestrian, bus terminal and stops than other microenvironments, by a factor of 2 to 3 of that on MTR trains. The highest CO concentrations were observed on single- or double-decker buses, with average concentrations of 2.0 ppm and 2.5 ppm, respectively, indicating the influence of exhaust emission. Heterogeneity in exposure concentration was observed for bus and MTR based on simultaneous sampling at multiple locations inside the cabin. Spikes in PM2.5 concentrations were found on MTR during door opening period, indicating the influence of the pollution inside the track tunnel. Commuter's exposure to PM2.5 was elevated by 15% during a 35-minute journey on MTR if standing near door compared to the middle of the cabin. Inter-run variability in concentration was observed for each of the selected transportation modes, indicating that multiple runs are needed for a reasonable understanding of the transport exposure concentration.

W1-H.1 Lauder, M.*; Marynissen, H.; Summers, T.; Antwerp Management School and University of Maryland; *hugo.marynissen@ams.ac.be*

Normal Chaos in Managing Risks – Dealing with Complex Processes

There is wide recognition that the world we live in is complex. This can be seen in the many academic papers within the field of social science, which explore a plethora of issues that this complexity throws up. The aim of this presentation is to offer the 'normal chaos' paradigm as a basic premise for research into the management of complex processes. The idea of normal chaos emerged from research in the ways society learns from public inquiries. It demonstrates that those conducting inquiries have a clear view of how the world works. While not stated explicitly, their views come across very clearly within the comments they make and the recommendations they offer. This worldview has been labelled the 'perfect world' paradigm. The construct of normal chaos at first provided an alternative lens through which to theorise about resilient ways of organising and managing stressful situations. Subsequently, it has been seen to have much wider application. Normal chaos offers a direct challenge to work based on the premise that increasing control and coordination provides the way to manage complex situations. The new proposition suggests that control and coordination mechanisms are limited and that the pursuit of 'more of the same' soon reaches a point of diminishing returns. The construct suggests that we cope rather than control such situations. This initial research investigates how the boundary between order and chaos can be recognised and managed. It identifies two states: the first is normal chaos, where events generally work as planned and abnormal chaos where events are recognised as being dangerously out of control. The underpinning of this construct is an individual's limited mental capacity and the mental shortcuts used that often lead to an illusion of control. From a methodological perspective, this presentation offers an initial catalytic framework that stimulates thinking about these complex situations.

T3-A.3 Leard, B; Linn, J*; Zhou, YC; Resources for the Future; *linn@rff.org*

How Much Do New Vehicle Consumers Value Fuel Economy and Performance? Evidence from Technology Adoption

The recent literature has shown that tighter passenger vehicle fuel economy standards cause manufacturers to trade off vehicle performance for fuel economy. This paper is the first to evaluate the welfare consequences of these changes by estimating consumer valuation of higher fuel economy and foregone performance. Using a unique data set and novel statistical techniques to account for the endogeneity of vehicle attributes, we estimate the welfare cost of foregone performance to be approximately equal to expected fuel savings benefits. Therefore, the recently tightened standards have had approximately zero net effect on private consumer welfare, contrasting with the analysis by the US regulatory agencies that does not include lower performance and suggests large consumer benefits.

W4-H.4 Lee, CH; Yu, HL*; National Taiwan University; *hlyu@ntu.edu.tw*

Challenges and uncertainties of environmental risk assessment with respect to emission estimation

Petroleum refineries are a major source of toxic air pollution such as volatile organic compounds (VOCs). To perform the environmental risk assessment of hazardous air pollutants, it is necessary to estimate emission from petroleum refineries. Conventionally, emission estimation techniques for petroleum refineries are mainly based on emission factors. These factors include all activities and material sources in refineries. However, from the air quality monitoring system, the refineries can releases a huge number of different chemical compounds into ambient air. The formal procedures of emission estimation could not cover all kinds of air pollutants. In addition, the health risk of each chemical compound need to be calculated individually. Hence, the purpose of this study is to develop a thorough emission estimation process. This study area is an offshore industrial park in Yunlin county, Taiwan. Observations of hourly VOCs concentrations came from the nearby Taiwan EPA's air quality monitoring site and air monitoring mobile station. While data exploratory analysis, the study found that all chemical compounds have unusual peaks occurred occasionally. Since the dispersion model in the study is a steady-state model, the peaks would influence the simulation results. Moreover, the environmental risk assessment evaluates the health effects based on the annual averaged concentration. Hence, the study altered the objective of simulation from hourly to annual average. However, due to the limited observations, this approach can induce significant uncertainties in the emission estimation. Furthermore, too many parameters in the inverse model caused performance issues. It would encountered over-fitting. To overcome this issue, this study developed a "surrogate model" to represent the inverse model. Based upon the emission and associated exposure estimation, the risk management plan is proposed to increase the resilience of the community nearby the study area.

P.27 Lee, RC*; Crowe, B; Duffy, P; Sully, M; Levitt, D; Black, P; Neptune and Company, Inc.; *rlee@neptuneinc.org*

Implications of Anthropogenic Climate Change on Radioactive Waste Disposal in the United States

Radioactive waste disposal in the US occurs in a regulatory framework that requires risk assessment of potential disposal sites. The main concern is radionuclide transport out of the disposal site into the nearby environment. Future environmental radionuclide concentrations, resultant risks, and associated uncertainties are quantified in "performance assessments" (PAs), which are probabilistic radionuclide transport/risk models specific to each disposal site. Past PAs have assumed that large-scale future climate changes will follow glacial cycles of approximately the past 1 million years, and have ignored anthropogenic "greenhouse gas" emissions. Considering near universal consensus on anthropogenic climate influences, it is now prudent to address these in PAs and associated decision analyses (DAs). Important aspects for PAs/DAs include influences of climate change on overall temperature/precipitation (affecting water infiltration), frequency of maximum precipitation events (affecting erosion), likelihood of human habitation, and delay of the next glacial period. Examples of PAs at different US sites are presented, in which projections of anthropogenic climate influences over the next millennia are being incorporated. A New Mexico site could experience lower precipitation/higher temperatures, lowering infiltration and reducing habitation; but increases in extreme monsoon events, hastening erosion. A West Texas site could experience desertification, and thus less infiltration and habitation. A New York site could experience greater precipitation and more extreme events, thus increasing runoff and erosion. A Utah site is less likely to be inundated by the return of Lake Bonneville, due to delay of the next glacial period. The economic implications of these climate influences on radioactive waste disposal are likely in the trillions of dollars over multiple sites and waste types, as disposal decisions are associated with large costs and substantial risk implications.

P.100 Lemay, JC*; Peterson, MK; Pacheco Shubin, SE; Prueitt, RL; Gradient; *jlemay@gradientcorp.com*

Comprehensive Multipathway Risk Assessment of Chemicals Associated with Recycled (

Thousands of synthetic turf fields in the US are regularly used by millions of individuals (particularly children and adolescents). Although many risk assessments have concluded that there are low or negligible risks related to exposure to chemicals found in the recycled rubber used to make turf fields, concerns remain about the safety of this product. In response to these concerns, some federal and state agencies have initiated long-term studies of recycled rubber infill. In general, criticisms of existing studies focus on their limitations, which include low sample sizes and limited evaluation of relevant exposure pathways and scenarios. To address such concerns, we conducted a multipathway human health risk assessment (HHRA) of exposures to chemicals in recycled rubber. We compiled all the available chemical composition data on recycled rubber from the literature as well as all the available data related to chemical concentrations in the air above synthetic turf fields made with recycled rubber. We limited the relevant data to over 100 recycled rubber samples (including virgin samples) from more than 50 North American fields and nearly 100 air samples from indoor and outdoor artificial turf fields. We also assessed background data on exposure to chemicals in natural soil and air to provide context for the HHRA's results. We evaluated ingestion, dermal absorption, and inhalation pathways according to US EPA guidance, and considered multiple exposure scenarios (e.g., youths playing on indoor and outdoor fields, spectators). The results showed that, even using 95% upper confidence limit concentrations, the estimated non-cancer hazards and cancer risks for all evaluated scenarios were below levels that US EPA considers acceptable. In addition, we found that risk levels for athletes playing on synthetic turf fields were lower than those associated with playing on natural turf fields with background levels of heavy metals and polycyclic aromatic hydrocarbons.

P.1 Leung, ACW*; Minnery, JG; Chung, R; Public Health Ontario; *alvin.leung@oahpp.ca*

Identification of potential biological hazards in groundwater underlying cemeteries and graveyards

Growing interest in natural or green burials is not only challenging traditional cemetery practice but also how they are assessed and managed. In Ontario, new cemetery site applications are reviewed by local municipalities, the Ministry of Environment and Climate Change and local public health authorities with limited guidance available to inform decision making and risk management. Public Health Ontario was approached to assist a local health unit in the review of a cemetery site application that would include several burial types including traditional (e.g., embalmment and coffin) and natural (e.g., shroud without embalmment). There was concern that microbiological constituents could leach during decomposition at burial sites and migrate into the groundwater that supplies residential drinking water wells adjacent to the proposed site. Existing guidance recommends a minimum distance of 0.5 m between the grave and water table without supporting rationale. Public Health Ontario reviewed existing guidance and conducted a targeted literature search related to assessing and managing potential impacts from cemeteries on groundwater quality. Overall, it was found that proper cemetery construction and design is important in reducing potential impacts to groundwater. Combining knowledge of pathogen survival times and existing hydrogeological conditions at a proposed site can help characterize the risk of contaminating a secure drinking water source. Finally, monitoring standard microbial indicators (including heterotrophic plate count, total coliform and E. coli.) in the vicinity of a cemetery could be conducted to observe for changes to potable groundwater quality. Advances in forensic science illuminate both limitations in our reliance on indicator organisms as well as opportunities to improve our metrics of groundwater quality.

M2-I.3 Lewis, RJ*; Freeman, J; ExxonMobil Biomedical Sciences; *r.jeffrey.lewis@exxonmobil.com*

Application of Systematic Review: An Industry Perspective

Systematic review has gained considerable interest in both the regulatory and regulated scientific communities. Adoption of systematic review methods by both regulatory and regulated entities could significantly enhance transparency and reproducibility as well as quality of chemical health risk assessments. However, conducting systematic review is difficult, time consuming and potentially costly. Also, a number of approaches and frameworks have been proposed. Collectively, these issues can confound appropriate use of systematic review. Herein, we will attempt to address some of these issues. This presentation will describe an industry perspective regarding potential benefits and challenges in applying systematic review to chemical health risk evaluation. Examples related to reviews of human studies for environmental exposure to hydrogen sulfide and cancer mortality among refinery workers will be described to illustrate efforts to advance application of systematic review methods in an industrial setting. Challenges in applying systematic review methods will also be described, along with potential research needs to further enhance adoption and use of these methods by the scientific community.

W1-A.4 Li, Y*; Ren, T; Zhang, W; Chen, K; East Tennessee State University; *liy005@etsu.edu*

Projecting future climate change impacts on heat-related mortality in large urban areas in China

Global climate change is anticipated to raise overall temperatures and is likely to increase future mortality attributable to heat. Urban areas are particularly vulnerable to heat because of high concentrations of susceptible people. As the world's largest developing country, China has experienced noticeable changes in climate, partially evidenced by frequent occurrence of extreme heat in urban areas, which could expose millions of residents to summer heat stress that may result in increased health risk, including mortality. While there is a growing literature on future impacts of extreme temperatures on public health, projecting changes in future health outcomes associated with climate warming remains challenging and largely unexplored, particularly in developing countries. This is an exploratory study aimed at projecting future heat-related mortality risk in major metropolitan areas in China. This study focuses on 51 largest Chinese cities that cover about one third of the total population in China, and projects the potential changes in heat-related mortality based on 19 different global-scale climate models and three Representative Concentration Pathways (RCPs). Using city-specific risk estimates for the 51 largest urban areas in China, we estimated that for the 20-year period in Mid-21 century (2041-2060) relative to 1970-2000, incidence of excess heat-related mortality in the 51 cities to be approximately 37,800 (95% CI: 31,300-43,500), 31,700 (95% CI: 26,200-36,600) and 25,800 (95%CI: 21,300-29,800) deaths per year under RCP8.5, RCP4.5 and RCP2.6, respectively. Slowing climate change through the most stringent emission control scenario RCP2.6, relative to RCP8.5 was estimated to avoid 12,900 (95% CI: 10,800-14,800) deaths per year in the 51 cities in the 2050s. Findings from this study provides valuable information to support climate policy decision making and heat-related risk management in China.

W4-D.1 Li, Huanhong*; Xu, J; Department of Environmental management, College of Environmental Sciences and Engineering, Peking University; *lihh0012@pku.edu.cn*

Comparing environmental risk regulations in China and the United states

The relative stringency of environmental risk regulations between countries has great implications on foreign investment and international trade. The entrenched idea is that developed countries have more stringent environmental risk regulations than developing countries. However, there is no study validating this. Previous studies did find a different pattern in the relative stringency of risk regulations between EU and the United States than previously thought. This leads us to study the relative stringency of environmental risk regulations between China and the United States over the past 40 years. We intend to identify how and why the relative stringency of environmental risk regulations between China and the United States differ. By using a case-oriented quantitative approach, we compare the relative stringency of regulations on a broad range of environmental risks. These environmental risks include but not limited to climate change, air pollution, and toxic substances. We use a fuzzy set approach to code the value of relative stringency of specific risks in China and the United States. These values are then used as the outcome variable for our further explanation analysis. A preliminary explanation would be conducted to look inside political factors influencing the relative precautionary. Those factors are: pressure from the public, influence from interest groups, policy learning and international pressure, and characteristics of the risk, such as severity of outcome, controllability.

P.150 Li, N; Powers, R*; Texas Tech University; *nan.li@ttu.edu*
The Role of Science News Sources in Shaping Risk Perceptions of Agricultural Use of Pesticides
Pesticides have been extensively used in agriculture and urban settings to control weeds, insects and other pests. The use of pesticides has resulted in a range of benefits, including increased crop production and decreased insect-borne diseases. Nonetheless, the agricultural use of pesticides has also raised persistent concerns about possible adverse effects on human health and the environment. As most people lack direct experiences with and/or scientific knowledge of pesticides, they will have to rely on external information sources, such as mass media, to judge the safety of pesticide use in farming. This study conducts a secondary analysis of the 2016 General Social Survey Ballot 2 data (Sample N=859) to investigate how the US public form their risk perceptions of agricultural use of pesticides. Results show that females, those who are pessimistic about scientific advances and concerned about environmental quality tend to perceive pesticides to be more hazardous. In addition, people who rely on television as primary sources of science news are less likely to think pesticide is dangerous compared with those who primarily use online-only news. What's more, although the Internet allows its users to selectively expose to information that aligns with their generally optimistic attitudes toward science and hence attenuates their risk perceptions, the same function does not apply to printed media and television. These findings have furthered our understanding of the different roles of printed, broadcast and online-only media in communicating about chronic environmental risks. Although previous studies have characterized mass media as an amplifier of environmental risk, this function might be varying as the whole media landscape has become increasingly fragmented. Future studies should develop a more coherent framework explaining the role of mass media in communicating risks under different circumstances and develop risk communication strategies that tailor to individuals' news use behaviors.

W4-G.2 Linkov, I*; Madchese, D; Fox-Lent, C; Trump, B; US Army Engineer Research and Development Center; *ilinkov@yahoo.com*
Risk and resilience in complex systems: review of concepts and assessment methods
Risk-based approaches have been used to assess threats and mitigate consequences associated with their impact. Risk assessment requires quantifying the risk of failure for each component of a system and associated uncertainties, with the goal of identifying each component's contribution to the overall risk and ascertaining if one component poses substantially more risk than the others. These components become the basis of quantitative benchmarks for the system, and becomes the de facto standard for system improvements designed to buy down risk. Rapid technological evolution, combined with the unprecedented nature and extent of emerging threats defy us to enumerate all potential hazards, much less estimate reliable probabilities of occurrence and the magnitude of consequences. A comprehensive approach to protecting the nation's critical infrastructure, economy, and well-being must be risk based—not risk exclusive—and must provide a way for decision makers to make their organizational systems resilient to a range of threats within specific cost and time restraints. In contrast to the definition of risk, resilience is focused on the ability to prepare and recover quickly from threats which may be known or unknown. Resilience is a property of the system itself and can be measured without identification and assessment of threats which act on or within a system. Managing for resilience requires ensuring a system's ability to plan and prepare for a threat, and then absorb, recover, and adapt. Coupled with a systems view that decomposes components across physical, information, cognitive, and social environments in which the system exists, is the basis of an approach to quantifying resilience with decision analytical tools and network science approaches.

P.81 Lipscomb, JC*; Willison, S; Parry, E; Chattopadhyay, S; Snyder, E; US EPA National Homeland Security Research Center; *lipscomb.john@epa.gov*
Determining the health protective capability of analytical detection methods for short duration exposures
Emergency response decisions require integrating exposure and risk information. Optimal guideline values for acute or short-term exposures are based on dose-response data for the relevant duration and address multiple levels of severity. U.S. EPA's National Homeland Security Research Center (NHSRC) has tools to characterize exposures and risk during temporary reutilization of previously contaminated infrastructure: The Provisional Advisory Levels (PALs) and Selected Analytical Methods for Environmental Remediation and Recovery (SAM). Oral and inhalation PALs cover three tiers of severity (minimal, reversible; more severe, irreversible or escape-impairing; and lethal) for up to 24 hours, 30 days, 90 days and 2 years. PALs decrease with time and increase with effect severity. SAM recommends optimal analytical methods for a matrix-analyte pair and describes performance. Using SAM, the sufficiency of analytical capability for acrylonitrile (ACN), a widely used industrial chemical, relative to the PALs values was evaluated. Oral PALs (as drinking water equivalents for children) ranged as low as 0.064 mg/L. SAM identified EPA Method 524.2 (run time ~ 30 minutes) as the optimal method for drinking water (GC/MS). This method provides a detection limit of 0.00022 mg/L and a limit of quantitation of 0.0009 mg/L, sufficient to detect ACN concentrations associated with even minimal, reversible effects. Inhalation PALs ranged as low as 0.030 mg/m3. From SAM, OSHA Method PV2004 for acrylamide (HPLC/UV) may be applicable, with a possible detection limit of 0.001 mg/m3. Confidence will be increased when this method can be verified for ACN and a limit of quantitation established. For some acute exposures, the logistical constraints for sample collection, transport and analysis serve to emphasize the value of enhanced field detection capabilities. This process will be applied to other priority chemicals. This abstract may not represent the views and policies of the US EPA/ORD/NHSRC.

W4-J.2 LIU, C*; MARANO, K; RAI Services Company; *LIUS1@rjrt.com*
Characterization of Inhalation Exposure to Cigarette Smoke
Quantitative risk assessment (QRA) may inform regulatory decisions regarding tobacco products. In general, QRA is a five-step process that includes problem formulation, hazard identification, dose-response assessment, exposure assessment, and risk characterization. Evaluation of human health risks from cigarette smoking requires an adequate assessment of the exposure, which is a challenging task in part because the concentration of chemicals in the respiratory tract and exposure duration are not constant. No regulatory guidance currently exists for exposure assessment of tobacco products, although examples exist in the peer-reviewed literature. The U.S. Environmental Protection Agency (EPA) provides guidance that addresses methods for quantitative evaluation of exposure and risk, which is useful and can be applied to tobacco products. Two different methods were developed to quantify inhalation exposure with machine-generated smoke yields from a market survey of U.S. cigarettes. The first method treats exposure to a chemical in smoke as a continuous process and estimates an exposure concentration by averaging the yields of the chemical from cigarettes consumed over the average daily volume of air inhaled by a user. The second method treats exposure to the chemical as discrete smoking sessions and estimates a respiratory concentration of the chemical via summation of discrete smoking sessions over the course of a day. Both methods incorporate standard exposure parameters to derive an upper-bound lifetime average exposure to the chemical. For simplicity and conservatism, both methods assume 100% retention of the chemical in the smoker's body. The two methods provide risk estimates with relative percent differences within 30%; the first method was more conservative (i.e., risk-maximizing). Exposure assessment of tobacco products should be consistent with available evidence, guidance, and state of the science for risk assessment. These findings indicate that incremental modifications to exposure input assumptions do not materially affect the QRA results.

P.153 Liu, X; Mumpower, JL*; Portney, KE; Vedlitz, A; Texas A&M University; *jmumpower@tamu.edu*

Risk Perceptions of Lone-Wolf Terrorist Threats and Policy Preferences for Government Counterterrorism Spending: Evidence from a U.S. National Panel Survey

Using data from a two-wave U.S. national survey (May and November 2016), we replicated and extended past research. First, we investigated the ability of sociodemographic variables and other individual-level characteristics to predict public risk perceptions about lone-wolf terrorist threats. Second, we compared the ability of psychometric variables (severity of consequences, levels of public and scientific understanding, number affected, and likelihood) and sociodemographic ones to predict public risk perceptions. The results supported previous research that found both psychometric and sociodemographic variables were significant predictors of perceived risk, but that psychometric variables were generally stronger. Third, we assessed how well perceived risk, sociodemographic variables, and other individual-level characteristics can predict preferences for national and local government spending levels for counterterrorism. We replicated previous research which found that perceived risk was a significant predictor of preferred spending levels and that adding sociodemographic variables somewhat improved the ability to make such predictions. Fourth, we tested models to predict changes in public risk perceptions of terrorist threats between Wave 1 and Wave 2. We found that no sociodemographic variables were significant predictors, but that changes over time in several of the psychometric variables significantly predicted changes in perceived risk levels. Fifth, we found that change in levels of perceived risk over time was a significant predictor of change over time in preferred levels of government counterterrorism spending, and that predictive ability was somewhat enhanced by adding certain individual-level characteristic variables to the model, particularly change in perceptions of governmental competence.

P.155 Liu, S.*; Yang, J.; University at Buffalo, State University of New York; *sixiaoli@buffalo.edu*

Perception and acceptance of HPV vaccination: Evaluating the impacts of message framing, motivation, cultural cognition and gender in a cross-country context

Human papillomavirus (HPV) is the most common sexually transmitted virus worldwide, and the prevention of HPV transmission is an important public health issue. It has been widely accepted that HPV vaccination holds a great promise to prevent the infection of HPV, which in turn reduces the contraction rates of HPV-induced diseases (e.g., genital warts, cervical cancers). This research aims to examine the influence of message framing (gain vs. loss), motivation orientation (approach vs. avoidance), cultural cognition, and gender on young adults' perceptions of risks associated with HPV and HPV vaccines, as well as their intentions to get vaccinated. Also, given the newly approved HPV vaccines in mainland China, this research will compare the framing effects in a cross-cultural setting, based on undergraduates participants recruited from both the U.S. and China.

P.25 Liu, W*; Schick, A; Kazemi, R; US Food and Drug Administration (FDA); *reza.kazemi-tabriz@fda.hhs.gov*

Inspections outcomes and their association with contract manufacturing and drug application submissions

Abstract Regulatory agencies around the world conduct careful inspections of regulated drug manufacturing facilities to determine whether the firm is compliant with regulations and good manufacturing practices (GMPs) to mitigate risk to public health. Although many hypotheses and questions have been raised in forums and conferences about the relationship between GMP inspections and the state of quality in manufacturing facilities, or the effect that potential "risky behaviors" of facilities have on phenomenon like shortages, few analytical and data driven studies have actually been conducted to evaluate these hypotheses. In this paper we set to study two such questions. First, are pharmaceutical contract manufacturing organizations (CMOs) more susceptible to quality problems, compared to facilities that cannot be identified as contract manufacturers? And as an extension, do they experience worse inspection outcomes compared to their counter parts? This study will also take into account the uncertainties involved in identifying contract manufacturing facilities. The second question has to do with regulatory agencies' assessment of the state of quality of drug manufacturing facilities, particularly with respect to the quantity/characteristics of products with which manufacturers are involved. For instance, is there a trend where facilities with a favorable inspection outcome, subsequently submit or are named in an increasing number of applications? This change in the variety or volume of products being manufactured affects the risk profile of the facility, and can dramatically impact regulators' facility risk assessment. Since regulatory agencies have limited resources in conducting inspections, this study may be particularly important in helping them develop optimal-risk based inspection schedules, allowing them to re-direct their inspectional resources in order to more efficiently advance their mission in protecting public health.

M2-F.3 Logan, TM*; Bricker, JD; Guikema, SD; University of Michigan and TU Delft; *tomlogan@umich.edu*

Tsunamis, sea walls, and memory - vulnerability in coastal communities

Our coastal communities are increasingly vulnerable due to global environmental change. Tsunamis are one example of a coastal hazard, and the north-east coast of Japan has been struck by four in the past 110 years. Seawalls are commonly used to defend against tsunamis, making it is essential we understand whether they truly mitigate damage. A model combining a cellular automaton and hydrodynamic models simulates possible land change development over time and under different scenarios. These scenarios include different seawall heights, aversion to developing in inundation prone areas, and coastal living preferences. The results include development patterns, frequency-number curves, and damage over time. We examine how the development changes the vulnerability of the community, and find evidence that high sea walls fail the inhabitants when black swan events arise. These insights further our understanding of suitable strategies to reduce risk of coastal communities.

W1-A.3 Long, Chen*; Haoran, Zhang; Wei, Zhang; Xuejun, Wang; East China Normal University; *chenlong@geo.ecnu.edu.cn*

Trade-induced atmospheric mercury deposition over China and implications for demand-side controls

The Minamata Convention was launched to inhibit mercury (Hg) risks on humans and the environment. Demand-side Hg controls are required to help implement the convention in China. Here, we combine emission inventory, multiregional input-output analysis and atmospheric transport model to investigate the effect of China's interregional trade on atmospheric Hg deposition over China, allocate the consumer responsibilities for the deposition and assess the potential approach and benefits of proposing demand-side measures for China. Results show total atmospheric Hg deposition over China is 408.8 Mg/yr in 2010, and 32% is embodied in China's interregional trade with the deposited hotspot over Gansu, Henan, Hebei and Yunnan province. Interprovincial trade considerably redistributes atmospheric Hg deposition over China with the variation range of -104%~+28% for deposition flux. Large imports of the developed regions, such as the Yangtze River Delta (Shanghai, Jiangsu, Zhejiang) and Guangdong, could avoid much Hg deposition over their geographic boundaries but cause much additional Hg deposition over other developing provinces. Due to close relationships on interprovincial trade and atmospheric transport, the bilateral influence is considerably high within northern provinces and eastern provinces, such as the Jing-Jin-Ji region (Beijing, Tianjin, Hebei) and the Yangtze River Delta, which could be the joint-control area. Transferring advanced technology from developed regions to their trade partners would be an effective measure to mitigate China's Hg pollution. The measure implemented by different developed regions would result in different effects. Our findings are relevant to interprovincial efforts to reduce trans-boundary Hg pollution in China.

P.84 Lopez, TK; Tetra Tech; *theresa.lopez@tetratech.com*
Senior Toxicologist, Human Health Risk Assessment

In assessing human exposure to or establishing risk-based values for a surface water body, it can be necessary to account for exposures through fish ingestion as well as water ingestion. To do so, a bioaccumulation factor (BAF) that estimates tissue concentrations in fish from water is needed for each chemical evaluated. BAFs are available in the literature, but site-specific BAFs are not typically developed during site investigations. In practice, published BAF values for each species or trophic level are relied upon to estimate human exposures from fish ingestion. These BAFs assume a fixed linear relationship between a chemical's concentration in water and the concentration in fish. However, this assumption does not hold for metals since the rate of bioaccumulation decreases as the concentration in water increases; thus the BAFs overestimate exposure with increasing concentrations in the water column. Establishing or selecting BAF for metals for fish of any trophic level is complicated by other factors as well: the natural presence of metals is to be expected in ambient water and fish tissue, as opposed to organic chemicals; ionic form, temperature, and pH are complicating factors in determining uptake and availability of metals; and some metals are essential nutrients to aquatic life. Rather than using a fixed BAF for each metal to estimate fish tissue concentration, it is proposed that BAFs be calculated from the slope of the line characterizing tissue concentration versus water concentration. Information establishing tissue concentration at various water concentrations, available from many sources and for many trophic levels, can be used to quantify the relationship between water and fish tissue concentration. Using the slope of that line allows for calculation of metal BAFs that should more accurately predict fish tissue concentrations relative to water conditions, providing a more accurate estimate of human exposure for a specific water body.

T3-K.4 Lord, JJ*; Whitmarsh, L; Poortinga, W; Cardiff University; *lordjj@cardiff.ac.uk*

Development and validation of novel scales to measures cultural worldviews in the UK

Cultural worldviews refer to preferences for social organisations or "ways of life" often conceptualised according to two orthogonal dimensions of grid (hierarchism vs egalitarianism) and group (individualism vs communitarianism), and have been linked to perceptions of various hazards. Several scales are available to measure worldviews. However, most of these have been developed within the US context, and exhibit poorer psychometric and predictive performance in other cultural contexts. This paper presents the development of the United Kingdom Worldview Scales (UKWS). An initial item-pool was developed with reference to existing worldview measures and socio-political attitudes in the UK. Following initial cognitive interviewing, items were revised and administered in a pilot survey (n = 190). Psychometric analyses identified poorly performing items. The remaining items were then administered in a nationally representative survey (n = 1,533). Following further psychometric analyses, a 9-item hierarchy and a 6-item individualism scale were rendered. Correlations with related constructs confirmed the convergent validity of the two scales, and regression models revealed that they relate to risk perceptions as predicted. The causality of these relationships was subsequently tested in a survey experiment (n = 594). In the experimental condition, participants completed a task designed to increase their egalitarianism, using mortality salience and an egalitarianism prime. All participants completed the UKWS and risk perception measures. Relationships found between worldviews and risk perceptions confirmed the predictive validity of the UKWS. Neither hierarchy nor individualism scores differed between the experimental and control condition, however, suggesting that the manipulation did not influence worldviews. MANOVA revealed that risk perceptions did not differ across conditions. Implications for the use of value primes in risk research and communication are discussed.

M2-J.3 Lu, H*; Schuldt, JP; Niederdeppe, J; Cornell University; *hanglu1028@gmail.com*

Examining Cognitive and Affective Factors Associated with Support for Pollution Policies in the Chesapeake Bay Watershed: Identifying Promising Messaging Strategies

Over the past few decades, scientists have documented the changing chemistry (eutrophication) of the Chesapeake Bay in response to increased input of nitrogen and phosphorus from human sources. In particular, attention has focused on the negative environmental impacts of agricultural runoff from production facilities in the Chesapeake Bay watershed. Amid ongoing policy discussions, environmental NGOs and advocacy groups have expressed a need for public opinion data that speak to the links between sustainability, agricultural practices, and support for pollution policies in the state of Maryland. We conducted a survey of a representative sample of 1,230 adult Maryland residents to better understand cognitive and emotional factors that shape public opinion toward agricultural pollution and sustainability issues and to offer evidence-based suggestions about ways that environmental advocates could improve their messaging efforts to build support for policies that aim to improve the environmental quality of the Chesapeake Bay. Our results show that several factors including beliefs about causes, attribution of responsibility, concerns about consequences and emotional responses are significantly associated with support for pollution mitigation policies. Promising message targets to promote various policy solutions to address pollution in the Bay include (1) emphasizing that manure runoff from large poultry companies on the Eastern Shore is a major cause of increased pollution in the Bay, (2) emphasizing that pesticide is a major cause of increased pollution in the Bay, (3) deemphasizing that too many boats and ships in the water are a major cause of increased pollution in the Bay, (4) communicating that failed oversight by local government is to blame for increased pollution, (5) increasing concern about damaging the natural beauty of the Bay, (6) increasing concern about death of fish and other aquatic species, (7) reducing guilt, and (8) increasing sadness.

M2-K.2 Lull, RB*; Hallman, WK; Brossard, D; Jamieson, KH; California State University, Fresno; Rutgers University; University of Wisconsin-Madison; University of Pennsylvania; *lull@mail.fresnostate.edu*

US public opinion about insecticide spraying in the context of Zika virus

The 2015-16 Zika virus outbreak in the Americas emphasized the importance of suppressing the primary Zika vector, Aedes aegypti mosquitoes. In the US, suppression campaigns largely rely on spraying insecticides from the ground and air. Yet, few studies have examined public opinion regarding these vector suppression methods within the context of preventing Zika infections. To do so, we conducted a nationally representative survey of the US population in November 2016. We used structural equation modeling to examine approval of ground spraying and aerial spraying, respectively, as functions of risk and benefit perceptions of each method, concerns about Zika, and engagement with the Zika issue. For ground spraying, the model fit the data well, 2(128)=214.91, CFI=.96, TLI=.95, SRMR=.06, RMSEA=.04. As predicted, risk perceptions (=-0.23, p

P.54 Lynch, MT*; Chiger, A; Houlihan, J; Abt Associates (1&2) and Healthy Babies Bright Futures (3); *mtklynch@gmail.com*

Estimate of IQ loss in infants due to exposure to arsenic in infant cereals

Children in the United States may be exposed to inorganic arsenic via food and drinking water. Our goal is to quantify the risks of IQ loss in children from arsenic in infant rice cereal. We will present the results of a literature review for dose-response functions linking inorganic arsenic exposures to IQ loss in children, and for reference doses based on these effects. We will use our arsenic exposure estimates (presented in a companion poster titled “Inorganic Arsenic Exposures Associated with Consumption of Infant Rice Cereal” by Andrea Chiger, Jane Houlihan and Meghan Lynch) and used these estimates in our quantitative dose-response analysis. We will present estimates of avoided IQ losses in children from reduced consumption of infant rice cereal (due to a switch to other cereals with lower arsenic content such as oatmeal, or from consumption of theoretical decreased arsenic concentrations in infant rice cereal). Our analyses indicate that inorganic arsenic exposures from infant rice cereal consumption may be associated with adverse neurodevelopmental effects, specifically IQ loss, in U.S. children.

M3-D.3 Maberti, S; ExxonMobil Biomedical Sciences Inc.; *silvia.i.maberti@exxonmobil.com*

Practical considerations for the assessment and control of exposures to engineered nanomaterials in the secondary industry

Neat engineered nanomaterials (ENM) are used in production processes for the formulation of intermediate and finished products (i.e. additives, composites, coatings, building materials). Handling and use of these products in the secondary industry entails manipulation, mixing, spraying, abrading, cutting, etc., which can yield occupational exposures that have not yet been well characterized, as they consist of materials different from the bulk ENMs. Studies evaluating releases from nanoenabled products show three release scenarios: particles of the carrier matrix, particles with carrier matrix and ENM, or ENM alone. Released particles may be agglomerated or severed from the bulk. Given the relative small percentage of ENM in the product, safety information might not report the potential for exposure to ENM released during the handling or use of these products. However, use in the industrial scale may lead to chronic exposures to low-levels of neat, agglomerated, or severed ENMs. Industrial hygienists must rely not only is SDS information, but on understanding of the processes that give rise to the exposure to propose appropriate controls. A practical screening approach is proposed to assess the potential release during use of nanoenabled materials and determine if additional controls are required for different stages of use.

W3-H.4 Macal, CM*; MacDonell, MM; Mishra, SK; Trail, JB; Chang, YS; Cooke, RM; Authors 1-5: Argonne National Laboratory; Author 6; Resources for the Future; *macdonell@anl.gov*

Toward preventing a doomsday pandemic

Naturally occurring pandemics pose a growing concern for global security due to a combination of factors. These factors include increasing densities of human and animal populations; expanding human mobility with increasing trade, transport, and migration; changing reservoirs and vector patterns related to climate change; and continued emergence of new pathogens and antimicrobial resistance. At the same time, advances in synthetic biology ranging from gene editing to designer microbes have broadened this concern to engineered bio-threats, whether inadvertently or intentionally released. The impact of pandemics on health, welfare, and social and economic stability is substantial, with recent estimates of economic losses alone exceeding $6 trillion over the next century. Evolving approaches and tools can be applied to help predict pandemics and highlight key intervention needs. Agent-based modeling (ABM) and high-performance computing are being harnessed to simulate infectious disease transmission in synthetic populations, as illustrated by a disease scenario (as well as a zombie apocalypse) for a U.S. city with nearly three million people, involving several trillion individual contacts over the representative activities, locations, and time frame evaluated. The paper will illustrate an integrated assessment framework for evaluating potential pandemics and guiding intervention plans, using an approach that (1) incorporates ABM and cumulative risk concepts; (2) explores what combination of conditions might lead to a serious pandemic that could cause millions of fatalities; and (3) links outputs to an economic assessment of intervention costs and benefits, with an emphasis on health care infrastructure. The ultimate aim is to strengthen risk analysis tools to help understand the potential for pandemics and guide the development of priority interventions, toward ultimately avoiding a doomsday scenario.

T2-I.3 MacDonald-Gibson, J*; Zabinski, J; University of North Carolina at Chapel Hill; *jackie.macdonald@unc.edu*

Dose-Response Assessment of Arsenic in Drinking Water: A Bayesian Network Model of Diabetes Risks

Regulatory risk assessment requires dose-response models that accurately link exposure to toxicants to the probability of adverse health outcomes. In current U.S. practice for regulating contaminants in drinking water, dose-response models are binary: they assume a threshold (the reference dose) above which risk is presumed present and below which it is presumed absent. This approach does not allow for the computation of a quantitative risk measure that can be used in comparing health benefits of programs to reduce toxicant exposure. In this research, we demonstrate the use of an alternative dose-response assessment approach based on Bayesian belief networks for quantifying noncancer risks from arsenic in drinking water. Using a data set of 1,050 individuals from an arsenic-endemic region of Chihuahua, Mexico, we fit a Bayesian belief network model to estimate the risks of pre-diabetes and diabetes from arsenic exposure, biomarkers of arsenic metabolism, and demographic characteristics. Using a training-testing approach, we compare the predictive ability of the Bayesian network model to that of a reference dose model and to a logistic regression model. We find that the Bayesian network model achieves a higher sum of sensitivity and specificity than the reference dose and logistic regression models. The results could inform the development of improved approaches for dose-response assessment of chemicals in drinking water.

W3-H.2 MacDonald-Gibson, J*; George, A; University of North Carolina at Chapel Hill; *jackie.macdonald@unc.edu*

Antibiotic-Resistant Staphylococcus Aureus Transmission from Hog Farms to Humans: Bayesian Network Risk Assessment Models

Since the first documented transmission of methicillin-resistant Staphylococcus aureus (MRSA) from livestock to humans was documented in the Netherlands in 2004, concern about the contribution of antibiotic use in livestock to the development of resistant human pathogens has increased. This study quantifies the contribution of antibiotic use in industrial hog farms in North Carolina—the second-largest hog producer among U.S. states—to carriage of MRSA and multi-drug-resistant Staphylococcus auerus (MDRSA) among humans. We will compare two different Bayesian belief network models for estimating the risk of MRSA and MDRSA transmission from industrial hog farms to humans. The first model is machine-learned from a study of 400 adult-child pairs in areas of intensive hog farming in North Carolina, with half of the pairs representing households of hog farm workers and the others representing control households. Human samples were taken from each pair, and questionnaires concerning household behaviors and occupational activities were administered. A Bayesian network model predicting MRSA and MDRSA carriage in children as a function of parent's occupation (hog farm worker or other), hog farm operational characteristics, individual behavioral variables, and demographic characteristics was learned from the data set. The second model was built from an expert-informed influence diagram parameterized with conditional probability tables derived from a systematic review of previous relevant studies. This presentation will report on hog farm operational practices and community factors contributing to MRSA and MDRSA risk and will compare and contrast the predictions of the two models.

M3-E.2 MacKenzie, CA*; Regnier, E; Hetherington, S; Prisacari, A; Iowa State University; *camacken@iastate.edu*

The Hurricane Decision Simulator and Its Impact on Decision Making

The Hurricane Decision Simulator is a web-based simulation program to help personnel at the U.S. Marine Reserve Forces in New Orleans gain experience with hurricane-preparation decisions given forecast uncertainty. It provides simulated hurricanes with probabilities of whether a hurricane will strike New Orleans. The user is provided with forecasted probabilities of hurricane-force winds and decides whether or not to take preparatory actions. The simulation ends when a hurricane either hits or misses New Orleans. A study was conducted to assess how training on the simulation impacts people's decisions. The study suggests that people training on the simulation are more likely to wait to evacuate.

T4-F.2 MacKenzie, CA*; Zobel, CW; Iowa State University; *camacken@iastate.edu*

Allocating Resources to Enhance Resilience, with Application to Superstorm Sandy and an Electric Utility

This talk presents a framework to help a decision maker allocate resources to increase his or her organization's resilience to a system disruption, where resilience is measured as a function of the average loss per unit time and the time needed to recover full functionality. Enhancing resilience prior to a disruption involves allocating resources from a fixed budget to reduce the value of one or both of these characteristics. The optimization model is applied to an example of increasing the resilience of an electric power network following Superstorm Sandy.

T2-F.2 MacKenzie, CA; Iowa State University;
camacken@iastate.edu
Metrics for Resilience: What Are We Really Measuring?
Resilience has become quite the buzzword in the risk analysis and disaster management communities. Consequently, many different metrics and ways to measure resilience has been proposed in a wide variety of fields. This talk will focus on some of the more popular metrics for resilience and explore what these metrics mean for decision making. Ultimately, we want to ensure that metrics for resilience align with a decision maker's fundamental objectives and do not reflect means objectives or even inputs.

M3-E.3 Madasseri Payyappalli, V*; Behrendt, A; Zhuang, J;
University at Buffalo, The State University of New York;
vineetma@buffalo.edu
Estimating effectiveness of investment, optimal resource allocation, and predictive risk analytics for fire protection
Fire-related hazards and incidents are an everyday phenomenon, and the estimated total cost of fire was $329 billion in 2011. We leverage the large amount of data available from sources such as National Fire Protection Association (NFPA) and National Fire Incident Response System (NFIRS), to create data-driven empirical and theoretical models for estimating the effectiveness of investment, for formulating optimal resource allocation strategies, and for efficiently assessing and mitigating risk in the context of fire protection. Our results show that fire losses have decreased exponentially in investment with high R2 values (~0.8), and also show potential under- and overspending in fire protection. We provide analytical closed-form solutions for effectiveness of investment as well as initial vulnerability, and derive insights. The results from the optimal resource allocation problem emphasize the need for considering the trade-off between equity and efficiency in resource allocation at state, county, and fire-district levels. In addition, a case study of federal fire grant allocation is used to validate and show the utility of the optimal resource allocation model. We use advanced data analytics and machine learning techniques, to work with data on fire incidents, fire department resources, socio-economic factors, and weather conditions, for dynamic fire risk assessment and resource scheduling. The core component of the analytics model is a generalized hazard function represented as a function of threat, vulnerability, and consequence. Finally, this work describes how the optimal resource allocation can be merged with advanced data analytics model to create a decision support system for real-time fire risk visualization as well as dynamic decision. The research will be of use to policymakers and analysts in fire protection and safety, and will ultimately help in mitigating economic costs and saving civilian and firefighter lives.

P.34 Maeda, Y*; Masuda, R; Shizuoka University;
maeda.yasunobu@shizuoka.ac.jp
Simulation of reconstruction of the affected area of 2011 Great East Earthquake
The Great East Japan Earthquake of March 11, 2011 caused serious damages. Especially this disaster was not only earthquake, but multiple hazards including tsunami and radiation contamination due to the accident of TEPCO Fukushima Daiichi NPS. Although the affected area is currently recovering from the damages, there are regional differences in reconstruction due to differences in magnitude and types of the damages. This research created a system dynamics model of three prefectures in the affected area, Iwate, Miyagi, and Fukushima, and performed simulations to estimate future trends of gross production and population in the three prefectures. The model was made by using Vensim simulation language. This model deals with the relationship between the economy and population, as well as impacts of the disaster and the reconstruction. It simulates the period from 2000 to 2040, including conditions before the disaster, during the disaster, and after the disaster. Based on the simulation results, we estimated the future of the three prefectures, what factors will influence the reconstruction from the Great East Japan Earthquake, and what factors are required for further development of the Northeast three prefectures. As the results, the followings are found. Firstly, the three prefectures tended to decrease in the prefecture's gross production before the earthquake, and the trend of the model also showed a trend along that. Secondly, even with the addition of the reconstruction factors, the prefecture's gross production will return to a decreasing trend when the reconstruction period expires, so it was not possible to grow only with the reconstruction. Thirdly, even if the labor input changes from minus to zero, it is possible to maintain the prefectural gross production at the level of reconstruction in Miyagi prefecture and Iwate prefecture. And fourthly, regarding Fukushima prefecture, recovery is delayed due to the influence of radiation compared with Miyagi and Iwate.

W4-H.3 Maeda, Y; Shizuoka University;
maeda.yasunobu@shizuoka.ac.jp
Resilience, population, and economy: findings from a simulation of reconstruction from 2011 Great East Japan Earthquake
This research discusses relationship between disaster recovery and population and economy. The Great East Japan Earthquake of March 11, 2011 caused serious damages in Japan. This research created a system dynamics model of three prefectures in the affected area, Iwate, Miyagi, and Fukushima, and performed simulations to estimate trends of gross production and population in the three prefectures in the recovery process. As the results, the followings are found. Firstly, the three prefectures tended to decrease in the prefecture's gross production before the earthquake, and the trend of the model also showed a trend along that. Secondly, even with the addition of the reconstruction factors to the local economy, the prefecture's gross production will return to a decreasing trend when the reconstruction period expires, so it was not possible to grow only with the reconstruction. And thirdly, even if the labor input changes from minus to zero, it is possible to maintain the prefectural gross production at the level of reconstruction period in Miyagi prefecture and Iwate prefecture. It suggests that in these are, especially in Iwate and Miyagi where radioactive contamination has been not severe, input of labor force is more effective than that of investments for the recovery. This result is related to the production structure in this area. Statistical data in these areas suggest that the industry in this area is dependent on human resources. For example, agriculture, fishery, and tourism industry. If this production structure is maintained as it is, how to attract people will be the key to activation of the area in the future.

P.10 Mangalam, S; Pham, P; Castellino, A*; Salamati, F; PRISM Institute; *Paul.Pham@rhra.ca*

Understanding the causes and consequences of harms to residents of retirement homes in Ontario, Canada

Retirement (seniors) homes in modern jurisdictions are regulated and typically require to be operated so that it is a place where residents live with dignity, respect, privacy and autonomy, in security, safety and comfort and can make informed choices about their care options. An evidence based harm-reduction and quality of life improvement hybrid framework is recognized as the most effective and efficient approach to regulatory oversight. This paper describes a hypothetical integrated decision support framework that is based on a combination of a risk based harm reduction model and resident-reporting quality of life survey methodology. Evidence on harms are used to build a cause-consequence model and quantify risk. Quality of life focused surveys of Retirement Home residents help establish a quality score. A resulting risk-quality index helps monitor, measure and prioritize regulatory actions.

W1-G.1 Mangalam, S*; Lal Das, P; PRISM Institute; *srikanth@prism.institute*

Real-Time Monitoring Tools and Risk Based Regulatory Oversight - The Internet of Things Case Study

Risk based inspections have proven to be an effective regulatory oversight tool particularly when regulators are facing complex and changing risks, limited resources and budgets and increased public scrutiny and expectations. Such approaches also have their limitations; they are typically based on historical inspection observations which are just a snapshot in time, there are uncertainties associated with the data and the mathematical models, and are typically overlaid with judgments that reflect political and/or public perceptions. The emergence of smart solutions such as Internet of Things (IoT) sensor technologies provide access to real-time data, significantly reduce uncertainties in model predictions and allow for creative use of resources. This paper describes a conceptual approach of the use of IoT solutions by regulators for the purposes of identifying and proactively managing risks, policy implications and value propositions. The paper also demonstrates actual case studies of such applications including those documented in a global study undertaken by the World Bank. The World Bank study examined the regulatory applications of IoT, policy implications, data privacy/ownership issues, benefits and limitations.

P.78 Marafi , N*; Berman, J; Eberhard, M; University of Washington; *abostrom@uw.edu*

Impact of Large-Magnitude Earthquakes on Structures in Deep Sedimentary Basins

The Cascadia Subduction Zone (CSZ) is capable of producing long-duration, large-magnitude earthquakes that could severely affect buildings and infrastructure in the Pacific Northwest (PNW). In addition, deep sedimentary basins are expected to amplify ground-motion intensity which underlie several cities in the Puget Sound region. The effects of long-duration and basins are poorly understood for the CSZ, because no ground-motion recordings are available for large-magnitude earthquakes in this region. To compensate for the paucity of recorded subduction events in the PNW, suites of simulated M9, CSZ ground motions are used to study their effects on archetypical structures in the PNW region. The severity of these ground motions is quantified in terms of several intensity measures that quantify ground-motion duration and frequency content known to affect structures. Finally, the performance of these archetypes is evaluated in terms of collapse risk, and appropriate design recommendations are proposed to compensate for these effects.

W1-C.1 Marasteanu, IJ*; Liggans, G; Otto, J; Lasher, A; FDA; *Ioana.Marasteanu@fda.hhs.gov*

Estimating the Risk of Foodborne Illness Attributed to Food Handling Behaviors in Retail Food Establishments and Households

The prevention of foodborne illness remains a significant priority to public health agencies in the United States. Given the prevalence of multiple contributing factors that can lead to foodborne illness at both the retail and household levels, it is important to understand how individual food handling practices combine to impact the incidence of foodborne illness. This study discusses the components, assumptions, and applications of the Food Handling Practices Model (FHPM), developed as part of a collaboration between the Food and Drug Administration (FDA) and the Research Triangle Institute (RTI) International. The FHPM is a quantitative model that tracks servings of food (1,127,245,021,184 annually) as they go through various stages leading to noticeable foodborne illness. The model consists of 1,546 parameters and assumes interlinked binomial random variables. It runs Monte Carlo simulations based on inputted parameters, and estimates the number foodborne illnesses, hospitalizations, and deaths associated with the specified parameters. Baseline and change scenarios are compared to assess the change in risk due to changes in food handling practices. Among many change scenarios presented, the top 5 contributing factors leading to foodborne illness at the retail level (household level) are found to be: inappropriate behavior related to cooling (room temperature holding), thawing (thawing), cold holding (raw or lightly cooked food), advance preparation (cooking), and hot holding (cooling). Change scenario results can be inferred from each other because the model is linear and the results of most change scenarios are independent. The FHPM is an important tool in analyzing risk associated with food handling practices at the retail and household level, and can inform policy makers' decisions relating to food safety interventions.

W3-K.4 Marchant , GE; Hartley, KT*; Stevens, YA; LSP Group LLC; *khartley@lspgrp.com*

Towards best practices governing use of "genomics" in civil litigation

The use of DNA and other "genomic" evidence revolutionized identification practices in criminal law, and the uses are increasingly sophisticated. Today, the use of genomic evidence is increasing in civil litigation regarding the "why and how" of the occurrence of diseases, injuries or conditions. Over the past three years, judges and jurors received increasing submissions of genomic analyses in civil lawsuits involving, for example, drugs, vaccines, benzene, and asbestos. Similar submissions are expected in litigation regarding access to medical care. Therefore, multidisciplinary collaborations and other efforts are needed to accelerate development of best practices and standards related to use of genomics in litigation. At a minimum, three broad needs are evident. For one, best practices are needed to ensure the legitimacy of the science when presented and applied in cases. A second need is to create best practices so that information collected in litigation is preserved for and ultimately shared with scientists for research purposes. A third need is for best practices related to translating genomic information into thoughtful legal rules and principles, including a subfocus on increasing multidisciplinary participation in the framing of pertinent medical-legal discussions.

W3-K.2 Marchant, GE; Arizona State University; *gary.marchant@asu.edu*

Codes of Conduct and Private Standards for Governing Autonomous Systems

The rapid growth of artificial intelligence is spawning a rapid increase of autonomous systems. These include highly publicized cases such as driverless cars and autonomous weapon systems, but which are also expanding to include industrial robots, technology control systems, financial and legal services programs, personal assistants, medical robotics, and home and care robots. These autonomous systems can present a variety of risks including accident and safety hazards, privacy invasions, fraudulent or unethical business practices, financial disruption, technological unemployment, and social dislocation. With limited exceptions, few of these autonomous systems are directly governed by regulatory agencies, and as a result a plethora of "soft law" initiatives and private standards have been adopted and proposed. This presentation reviews these alternative risk management tools and their effectiveness for governing the risks from autonomous systems.

M4-C.2 Marchese, DC*; Linkov, I; U.S. Army Engineer Research and Development Center; *Dayton.C.Marchese@usace.army.mil*

Can You Be Smart and Resilient at the Same Time?

In response to the recent eruption of advanced technologies such as the internet of things, autonomous vehicles and intelligent personal assistants, there is a growing effort to integrate systems in a way that promotes sustainability and enhances quality of life. Smart systems, which collect, analyze and utilize data in real time are a result of this effort. Unsurprisingly, smart systems have advanced faster than the ability of developers to evaluate the response of these systems to disruptive events. This presentation serves to discuss the difference in disruption response that exists between independent traditional systems and connected smart systems. Systems of interest include water/wastewater/stormwater, energy, transportation, agriculture and telecommunication systems. Disruption response is evaluated as resilience, defined as the ability of a system to plan for, absorb, recover from, and adapt to disturbances. This discussion highlights how smart systems, which connect the multilayer physical, social and information networks, are more resilient to random disruptions (e.g. natural disasters) that often impact trivial parts of the network, but less resilient to targeted attacks (e.g. cyberattacks) on critical information systems. This disruption response is important to the long-term success of smart systems. Moreover, this investigation into the relationship between resilience and sustainability is critical for developing an efficient and reliable future.

W2-K.5 Marti, M*; Stauffacher, M; ETH Zurich; *michele.marti@sed.ethz.ch*

Communicating earthquake hazard

Earthquakes are among the most destructive natural hazards on earth and cannot be predicted nor prevented. Worldwide seismological services model, analyze and provide seismic hazard values. These are essential to implement an earthquake resistant building design, the most efficient measure to reduce potential damage. A common means to communicate results and raise awareness for seismic hazard are maps. Up to now, seismic hazard maps were mainly tailored to the needs of primary users like civil engineers, but they are used likewise to communicate with the public. Even though, maps are an established way to illustrate hazards, there is evidence that they are often misconceived. For example, same hazard levels were interpreted differently, depending on the color hues chosen to illustrate them. Besides color settings, textual characteristics, the conceptualization of legends as well as the manner of presentation are influencing how maps are understood. Accordingly, the Swiss Seismological Service at ETH Zurich revised its hazard maps and information material in line with current best practices in map design and text conceptualization. This study analyses, how experts from the building sector and the general public read and understand maps and information provided in this new format. Two workshops with engineers and architects not specialized in seismic retrofitting (N = 26) and a representative online survey with the Swiss population were conducted. Preliminary results show that understanding seismic hazard remains challenging for experts and non-experts. Especially, understanding more detailed results and navigating within the web pages has shown to be very demanding. Despite its interactive map setting, the platform of the Swiss Seismological Service cannot respond to the users' expectations with respect to the web design known from frequently used applications like for example Google maps.

P.136 Marti, M*; Stauffacher, M; Matthes, J; Wiemer, S; ETH Zurich; *michele.marti@sed.ethz.ch*

Communicating earthquake preparedness

Despite global efforts to reduce seismic risk, actual preparedness levels remain universally low. Although, earthquake- resistant building design is the most efficient way to decrease potential losses, its application is not a legal requirement across all earthquake-prone countries and even if, often not strictly enforced. Risk communication encouraging homeowners to take precautionary measures is therefore an important means to enhance a country's earthquake resilience. Our study illustrates that specific interactions of mood, perceived risk and frame type significantly affect homeowners' attitudes towards general precautionary measures for earthquakes. The interdependencies of the variables mood, risk information and frame type were tested in an experimental 2 x 2 x 2 design (N = 156). Only in combination and not on their own, these variables effectively influence attitudes towards general precautionary measures for earthquakes. The control variables gender, "trait anxiety" index and alteration of perceived risk adjust the effect. Overall, the group with the strongest attitudes towards general precautionary actions for earthquakes are homeowners with induced negative mood, who process high risk information and gain-framed messages. However, the conditions comprising induced negative mood, low risk information and loss-frame and induced positive mood, low risk information and gain-framed messages both also significantly influence homeowners' attitudes towards general precautionary measures for earthquakes. These results mostly confirm previous findings in the field of health communication. For practitioners, our study emphasizes that carefully compiled communication measures are a powerful means to encourage precautionary attitudes among homeowners, especially for those with an elevated perceived risk.

P.83 Mattuck, R*; Dubé, EM; Liu, X; Greenberg, GI; Gradient; *rmattuck@gradientcorp.com*

Exposures to Styrene from Food Packaging under CA Proposition 65

Polystyrene food containers may contain small amounts of residual styrene monomer that could potentially migrate into food. The State of California listed styrene as a human carcinogen under Proposition 65, and in 2017 established a no significant risk level (NSRL) of 27 ug/day. Although the US Food and Drug Administration (FDA) has previously determined that polystyrene is safe for use in food packaging, the NSRL is significantly lower than the acceptable daily intake (ADI) previously estimated for styrene. FDA is concerned with estimating cumulative exposure to a food contact substance (e.g., styrene) in the total diet, and their method employs a Consumption Factor (CF), which represents the fraction of the daily diet expected to contact a specific type of packaging material. However, under Proposition 65, a manufacturer must demonstrate that their specific product will not result in exposures above the NSRL, thus the use of the CF may not be appropriate. We used FDA's method only to calculate the amount of styrene that could potentially migrate into food, for several combinations of polystyrene containers and foods. We then obtained data on the amounts consumed and the frequency of consumption for these foods from the National Health and Nutrition Examination Survey (NHANES). Combining migration concentrations and consumption data, we derived estimated daily intakes (EDI) for styrene from specific foods, and compared the EDI to the NSRL. Overall, we concluded that consumption of food in contact with polystyrene food packaging is unlikely to result in exposures to styrene above the NSRL.

T3-F.1 Masten, SJ*; McElmurry, S; Davies, SH; Michigan State University, Wayne State University; *masten@egr.msu.edu*

Lessons Learned from Flint about the Operation and Resilience of Water Treatment Infrastructure

The elevated levels of lead found in the drinking water of residences in Flint, MI that began in 2014 have had a profound effect on the level of trust within the community and the State, the economy of the region, and the health and well-being of the residents of Flint and the surrounding communities. The chemistry and engineering behind what happened to Flint's water, why the distributed water was so corrosive, and the extent to which the system appears to be recovering have been investigated. This analysis is based on an extensive review of the Monthly Operating Reports (MORs) and other reported documents from the water treatment facilities, and through personal communication with plant operators and managers. In this talk we will explore the complexities of water treatment and distribution systems, the importance of water chemistry on water treatment, and the ethics of proper water treatment operations

T4-C.5 Mayo, MJ*; Ikeda, S; Briggs, NL; Petito Boyce, C; Mayfield, DB; Gradient; *mmayo@gradientcorp.com*

Using GIS data and tools to assess the vulnerability of industrial facilities and natural resources to flooding events

Because of changes in the Earth's climate, the number and intensity of flooding events is predicted to be greater in the future. A higher frequency of major flooding events could increase risks to human activities and structures (e.g., industrial facilities) as well as natural resource areas located near water bodies. Vulnerability assessments are a common first step in risk mitigation planning, and can help identify potential flooding impacts on infrastructure, human health, and the environment. We present a screening-level approach using publicly available geospatial data and Geographic Information System (GIS)-based tools for assessing industrial facility vulnerability and potential damages to natural resources due to flooding. Our approach demonstrates that key information – such as Toxics Release Inventory data, US Environmental Protection Agency hazardous waste site and Discharge Monitoring Report facility data, the National Wetlands Inventory, the National Land Cover Database, FEMA floodplain data, NOAA hurricane storm surge hazard data, and geospatial information for recent flood events – can be combined within a GIS database to yield a robust dataset for conducting a screening-level vulnerability assessment. We illustrate this approach for two US case study areas, located along the central Mississippi River and the southeast US coast. Our discussion focuses on the potential for direct flooding damage to infrastructure and natural resource areas, and the potential impacts associated with pollutant mobilization, both of which could result in regulatory action or litigation. We show that performing GIS-based flood vulnerability assessments can identify facilities and areas at risk, delineate pre-event baseline conditions, and inform risk mitigation planning.

P.179 McClaran, N; Michigan State University; *mcclaran@msu.edu*
Science in the news: the politicization of fracking
Prior research has shown that if an agent (political or non-political) questions the inherent uncertainty of scientific findings, people are more inclined to be anxious about a scientific technology, consider it to have higher risk, and be less supportive of its adoption overall. This effect has been labeled the politicization of science. Although prior research has explored the politicization of science through one-paragraph summaries, no known research has tested whether this effect occurs within news articles- a common way to disseminate scientific information to the public. This study thus seeks to fill this gap in literature. By manipulating news articles to (a) be framed as a conflict between either political ideologies or interest groups, or have no conflict frame at all, and (b) either include or exclude a commonly found politicizing statement, this study tests the effects of politicization on perceived risk and support of a controversial scientific technology (i.e., hydraulic fracking). More so, this study will be among the first to test whether politicization can occur implicitly through conflict frames. That is, does presenting fracking as an issue between two sides inherently cause people to be less likely to support fracking regulations due to increased skepticism of the science behind the issue? The results of this study have implications into how science technologies are often portrayed in news coverage and provides further insight into why public support for pro-environmental issues continue to fluctuate despite accumulating scientific consensus.

T2-H.2 McClellan, GE*; Coleman, ME; Applied Research Associates, Inc.; *gmcclellan@ara.com*
A Performance-Based Method for Microbial Risk Assessment for Organizations
Health risk assessment for biological pathogens differs substantially from health risk assessment for chemical agents (and biological toxins). For chemical agents, the health effects of exposure progress from mild to moderate to severe as the dose increases. Mortality rates are usually low for doses causing mild or moderate effects but can increase rapidly for doses causing severe effects. Thus, exposure guidelines can be determined for mild (or threshold) effects to individuals with minimal consequences for the functioning of an organization. On the other hand, for biological pathogens, infection can progress through mild, moderate, and severe stages, sometimes leading to death with only weak dependence on the initiating dose. Due to potential for exponential growth of pathogens, outcomes of illness may be less tied to the initial pathogen dose than is the outcome of injury due to a chemical agent. Consequently, setting exposure guidelines for pathogens requires different considerations than for chemicals. A framework for assessing organizational risk was built based on a legacy model for the time-phased health effects of pneumonic tularemia in 112 human volunteers administered known doses of the bacterial pathogen Francisella tularensis. This legacy model provides well-founded statistical distributions of individual fever profiles as a function of inhaled pathogen dose. Parameterizations are available for length of incubation period, the rise-time of fever, and the peak fever for early-phase illness. The resulting fever profile of each individual then determines the performance capability of each individual as a function of time-after-exposure. The distribution of personnel performance capabilities within an organization (the personnel status) is then connected to a hazard severity measure according to the functional needs of the organization. Thus, extension of the legacy model permits generation of time-and dose-dependent exposure guidelines and characterization of organizational risk for biological pathogens.

W4-I.1 McClellan, RO*; Chang, ET; Lau, EC; Van Landingham, C; Crump, KS; Moolgavkar, SH; Toxicology and Human Health Risk Analysis; *roger.o.mcclellan@att.net*
Case Study in Data Access and Reanalysis: Diesel Engine Exhaust and Lung Cancer Mortality in the Diesel Exhaust in Miners Study (DEMS) Cohort Using Alternative Exposure Estimates and Radon Adjustment
The Diesel Exhaust in Miners Study (DEMS), conducted by NIOSH and NCI, included 12,315 workers with 200 observed lung cancers from 8 U.S. non-metal mines (3 trona, 3 potash, 1 salt and 1 limestone). Retrospective cohort and case-control analyses yielded a positive association between diesel exhaust exposure (DEE), represented by a respirable elemental carbon (REC) metric estimated retrospectively from carbon monoxide measurements, and lung cancer mortality. This finding was a major factor in the IARCresearch on classification of DEE as a human carcinogen. Our team was given access to the DEMS data and conducted analyses to first replicate the original analyses and then conduct extended re-analyses. Our re-analyses focused on (a) use of an alternative exposure metric developed using historical data on diesel equipment, engine horse power and ventilation rates without dependence on use of carbon monoxide as a surrogate for REC, (b) inclusion of radon as a covariate in statistical models, and (c) subgroup heterogeneity. Associations with cumulative REC and average REC intensity using the alternative REC estimates were generally attenuated compared with those found using the original DEMS REC estimate. Most findings were statistically nonsignificant, especially after control for radon exposure, which substantially weakened associations with the original and alternative REC estimates. No significant findings were detected among all miners who worked exclusively underground. However, associations were anomalously strong among limestone miners; no association with REC or radon was found among workers at the other seven mines. The large differences in results based on alternative exposure estimates, control for radon, and stratification by worker location or mine type highlight areas of uncertainty and the limited robustness of the DEMS data. These limitations must be considered in any extrapolation of the DEMS findings to other populations, and especially in using them for quantitative risk assessment.

M4-E.4 Menzie, C*; Kashuba, R; Society of Environmental Toxicology and Chemistry (SETAC); *charlie.menzie@setac.org*
• The development and application of weight-of-evidence methodologies for human and ecological risk assessment: common pathways over uneven terrain
Human health and ecological risk assessments have evolved in tandem and they share common concepts and frameworks. However, the evolution of methods have journeyed uneven terrain and there exist notable differences. The variances reflects, in part, the backgrounds of the scientists and policy makers involved in these endeavors as well as the purposes of the assessments. We discuss the commonalities and differences and show that they reflect variations in perspectives and language rather than scientific underpinnings. Recent efforts within the United States and elsewhere have focused on how to integrate the disciplines and even how to conduct integrated cumulative risk assessments. While there are many dimensions for exploration of similarities and differences, the concept of "weight of evidence" is commonly evoked as a central tenet. But, this phrase has somewhat different meanings to toxicologists, health risk assessors, and ecological risk assessors. Despite the differences in usage of the term, these groups of scientists share common ideas about evidence and its attendant weight. That offers a means of bridging across and integrating disciplines. EPA has recently put forward guidance on conducting weight of evidence assessments. This echoes concepts that have been developed over the past few decades. We use the draft guidance as a starting point and show how the concepts may be employed in toxicological assessments, health assessments, and ecological risk assessments.

P.110 Merad, MMe; CNRS; *myriam.merad@unice.fr*
Risk denial: societal, organizational and cultural perspectives
Asbestos, pesticides, endocrine disruptors, ..., the long list of scandals has since then appeared in the head page of newspapers. These emblematic cases are obviously symptomatic of systems' and organizations' refusal to recognize the high amplitude of their potential consequences on health and environment. This blindness or even risks denial, whose ramifications are cognitively, organizationally and culturally framed, is often analyzed from the point of view of the conscious and voluntary strategy of stakeholders or shareholders to deny the evidences (willful blindness). It is also frequently considered from a societal point of view as being symptomatic of the rise of cynicism within certain areas of activity, or even more widely within the society. The Seventh Art has also echoed it with such iconic films such as Jeffrey C. Chandor's Margin Call (2011), The Steps of Power by George Clooney (2011), ..., and more recently "La fille de Brest" by Emmanuelle Bercot (2016), Miss Sloane by John Madden (2016). While this may cover some of the explanation of risk denial mechanisms, it remains necessary to recognize the existence of several other explanatory mechanisms. The "fabric of" (with respect to N. Chomsky contribution) "weight of evidences" and "turning points" model (Baxter and Bullis contribution), risk perception biases, the balance between risk-taking and innovation, self-censorship, etc., are all aspects to be considered in the analysis of the deep branching of individual or/and collective framing of risk denial. On behalf of the scientific program committee of the meeting, this paper will share the conclusions of IMdR "Franch Risk Management Institute" Paris 2017 meeting on "Risk denial". Based on a multi-sectorial and multi-disciplinary approach, these conclusions will contribute to clarify individual and collective risk denial mechanisms in extreme situations or even in innovation contexts.

T4-G.3 Merad, MMe; CNRS; *myriam.merad@unice.fr*
The rise of resilience: Inside the strange world of risk and sustainability governance
These last years, many scholars have point out the limits of risk based approaches and highlight the contribution of resilience based approaches. Definitions and methods were proposed and "practical applications" were published. However, looking back to practitioners' areal-life application, it seems that the switch in practice that scholars call for is still difficult to implement. In this paper, we will discuss about some missing in the conceptual and methodological arsenal in the way resilience is conceived and govern and will share some practical analysis of some risk prevention and energy transition policies and strategies with that respect.

W3-J.4 Meredith, C*; Fiebelkorn, SA; British American Tobacco; *clive_meredith@bat.com*
Quantitative risk assessment of tobacco related toxicants: comparisons between combusted and heated tobacco products.
Over 6500 components have been identified in the smoke from combusted cigarettes, many of which have established toxicological properties and may be important drivers of tobacco-related disease. We have reported previously on the use of risk prioritization tools such as Margins of Exposure (MoE) and risk assessment tools such as Incremental Lifetime Cancer Risk (ILCR) to assess the contribution of individual smoke toxicants to tobacco-related disease. Next generation products such as those that heat tobacco (to a maximum of 240°C) show levels of key toxicants in their emissions that are substantially reduced relative to the emissions from combusted products. Applying similar principles of MOE/ILCR analysis to individual toxicants in the emissions from a heated tobacco product reveals that the margins of exposure are increased substantially relative to the emissions from a combusted 3R4F reference product. Similarly, the ILCR calculated for the levels of the tobacco-specific nitrosamine NNK in the emissions from a heated tobacco product decreases substantially when compared to the levels in the emissions from the combusted 3R4F reference product. For groups of toxicants with similar modes of action (MOA), cumulative risk assessments can be considered. Overall these quantitative risk assessments on key tobacco related toxicants add to increasing evidence of the efficacy of heated tobacco products as a potential reduced exposure product.

W3-A.3 Minor, T; Parrett, M*; U.S. Department of Agriculture; U.S. Food and Drug Administration; *matthew.parrett@fda.hhs.gov*
The Economic Impact of the United States Department of Agriculture's Environmental Testing Requirements to Reduce the Incidence of Listeria monocytogenes in Ready-to-Eat Meat and Poultry Products
The United States Department of Agriculture (USDA) published a proposed rule in February 2001 titled "Performance Standards for the Production of Processed Meat and Poultry Products". Among other things, this rule proposed environmental testing requirements aimed at reducing the occurrence of Listeria monocytogenes in ready-to-eat meat and poultry products. In June 2003, in the wake of recent outbreaks of foodborne listeriosis (the infection caused by eating food contaminated with the pathogen Listeria monocytogenes), combined with recent recalls of meat and poultry products adulterated by Listeria monocytogenes, the USDA issued an interim final rule (effective October 2003) finalizing the previously proposed Listeria monocytogenes environmental testing requirements. In this paper, we test using a difference-in-differences approach whether the proposed and final Listeria monocytogenes environmental testing requirements decreased the number of meat-related listeriosis illnesses. To do this, we use novel 1998-2008 data on foodborne illnesses and outbreaks by commodity and pathogen collected by the Centers for Disease Control and Prevention (CDC) and compiled by Painter et al. (Emerging Infectious Diseases, 2013). Our results tentatively reveal no effect of the final requirements, but that the proposed requirements reduced the number of meat-related listeriosis illnesses by roughly 10 per year. This finding is consistent with existing evidence which suggests that the public responds to proposed rules (e.g., Strom, The New York Times, 2012; Thrasher, Business Insider, 2013; Minor and Parrett, Agricultural Economics, 2016).

T4-E.3 Mishra, S*; Ayyub, B; University of Maryland College Park and International Finance Corporation; *saurabhthemishra@gmail.com*

Country-based Assessment of Global Risk Profiles using Ensemble Deep Learning

There are both systemic and idiosyncratic rare events that constitute the risk profile of a country. Complexities in knowledge fusion, computational limits and interdependency among domains including economic, environmental, political, cultural or behavioral fluctuations pose a challenge for current models to inform the source of risk. Accommodating this multidimensionality constitutes the image of global risk profiles. However, earlier work has not approached country and location risk from the perspective of probabilistic reasoning. This paper provides an intelligent system architecture for tracking the current state and predictions for location risk monitoring. Using a newly constructed 3-dimensional multi-hazard risk space of high-dimension real-time data, we employ Dynamic time warping (DTW) to perform risk ontology classification. We compare results across various machine learning models and propose an ensemble deep neural network for global risk profiling using multivariate panel-time series classification. The results illustrate that the proposed ensemble deep learning model yields enhanced sense-making capabilities for executive decision making. Results show prospects for deep resource optimization given the portfolio mix of corporate investors and policymakers.

P.23 Mishra, S*; Ayyub, B; Zhang, Y; University of Maryland College Park and International Finance Corporation; *saurabhthemishra@gmail.com*

Entropy for Quantifying Uncertainty and Risk in Economic Disparity

The rise in economic disparity presents significant risks to global social order and the resilience of local communities. However, existing measurement science for economic disparity (e.g. Gini coefficient) and risk metrics do not explicitly consider the information, deficiencies and uncertainties associated with the underlying income distribution. This paper introduces probabilistic principles of Shannon Entropy to quantity uncertainty and risk in economic disparity with theoretic and empirical evidence for global, national and city level data. Entropy and conflict rise as incomes converge, whereas low entropy signal high-risk tipping points for anomaly and conflict detection. Happy societies tend to have high entropy, but a public discourse is required for entropy optimization with significance for the economies productive structure and social order. Experiments for Washington, D.C., San Francisco, Baltimore, and Detroit are used to assess risk profiles within and between cities. Entropy produces reliable results with significantly reduced computational costs than Gini coefficient.

M4-I.1 Mitchell, JM; Dean, KJ*; Tamrakar, SB; Huang , Y; Rose, J; Michigan State University; *deankara@msu.edu*

Opportunistic pathogen dose-response models

Opportunistic pathogens are ubiquitous in well-operated water distribution systems. Specifically, concerns about exposure to P. aeruginosa, L. pneumophila, M. avium, and N. fowleri through the water distribution and premise plumbing systems are of primary interests. These pathogens can grow in plumbing fixtures - shower heads and faucets - along pipe walls, and in water heaters. They are known to reside in biofilms and variations in usage or plumbing materials can lead to greater proliferation in the piping systems. In order to quantify the risk posed in these environments using Quantitative Microbial Risk Assessment (QMRA), a dose-response model for each pathogen is required to establish the risk of a health endpoint per given exposure dose. In terms of opportunistic pathogens in premise plumbing, the exposure dose could be reached by ingesting, inhaling, or being dermally exposed. Dose-response models for L. pneumophila and M. avium have previously been fit, but models need to be determined for other opportunistic pathogens. A literature review of dose-response studies for the opportunistic pathogens of interest was conducted and models were fit to selected data sets using the maximum likelihood estimation (MLE) with the "R" statistical programming package. Results showed that models for certain opportunistic pathogens were dependent on the route of exposure. For example, H. castellani having a beta-Poisson or exponential best fit depended on rather the data was fit to data from intranasal or intracardial exposures, respectively, as expected. For other pathogens, we assessed the variability in the degree of virulence across routes of exposure like for N. fowleri exposed via intranasal inoculation or through swimming. Because the overall risks for such pathogens is activity dependent it is important to evaluate these differences. This study produced new models for three pathogens emphasizing the importance of exposure route in the risk of an adverse response.

P.57 Mohammadabbasi, M*; Sheikh Hassani, N; Tehran University; *borninfarvardin@gmail.com*

Environmental risk assessment in e-SCM

Electronic supply chain management involves using internet mostly in manufacturing industry in order to management the whole supply chain. An effective e-SCM solution allows companies to produce products that meet clients' needs and result in appropriate return on investment. As companies get increasingly concerned with their environmental responsibility, there is a notable tendency to integrate environmental issues into supply chain management system. Introducing environmental dimension into supply chain would bring out new trade-offs into supply chain decisions. Addressing these trade-offs require use of specific tools and models such as Multi-Criteria Decision Making methods. In this paper, we outline the similarities and differences of risk assessment in e-SCM and traditional supply chains. We will illustrate methods that help companies using e-SCM to reach a better environmental risk assessment performance. Results from empirical research is reported to further show the application of MCDM such as TOPSIS and AHP in successfully assessing environmental risks of e-SCM.

T4-H.3 Mokhtari, A*; Oryang, D; Chen, Y; Van Doren, J; FDA-CFSAN; *amir.mokhtari@fda.hhs.gov*

A novel approach for modeling microbial cross-contamination dynamics inside food manufacturing facilities

The entry and/or persistence of microbial pathogens in a food manufacturing facility can lead to food becoming contaminated by microbial pathogens during food manufacturing. Factors contributing to microbial cross-contamination within such facilities have been identified but the detailed dynamics of cross-contamination are not well understood. Mathematical models of environmental cross-contamination offer a valuable alternative to observational studies as they allow for the expeditious and cost-effective evaluation of cross-contamination risks and enable exploration of the effects of different risk management strategies. We developed an agent-based model that simulates the cross-contamination and spread of microbial contamination in a food manufacturing facility. The model simulates the interactions between food handlers, food, and objects present in different areas within a facility (e.g., slicer and food contact surfaces in the kitchen), as well as the cross-contamination caused by food workers under different behavioral assumptions and activities. The model serves as a virtual laboratory to investigate the interactions among multiple risk factors (e.g., poor personal hygiene, contaminated objects in different area). To demonstrate the utility of the model in a decision-making context, a hypothetical case study was created and used to compare different intervention strategies for reducing contamination and spread of Listeria monocytogenes in a facility preparing ready-to-eat (RTE) foods. Notional results from the case study indicate that areas within the facility with no direct contact with food products (e.g., loading dock, storage area, and restroom) can serve as contamination niches resulting in re-contamination of areas that have direct contact with food products. Further, food handler activities including, for example, personal hygiene practices, can impact the spread of microbial contamination within the facility and in the final RTE products.

M3-C.3 Montibeller, G*; Del Rio Vilas, V; Carreras, A; Franco, LA; Loughborough University; *g.montibeller@lboro.ac.uk*

Evaluating the capability of health systems with multi-criteria decision analysis

The design of robust health systems against disease outbreaks is crucial for the management of population health but challenging for policy makers. It encompasses a wide provision of services and goods, from vaccines and doctors to educational and preventive campaigns, among many others. The evaluation of capabilities of such systems nowadays is typically based on checklists, but this prevents an overall quantitative assessment of the health system as a whole and provides very limited guidance for the efficient allocation of resources for capability building (or for the management of capability reduction when budgets shrink). In this paper we suggest that multi-criteria analysis can provide a useful framework for the quantitative and comprehensive evaluation of capabilities and support policy makers in an efficient allocation of scarce resources. We illustrate this framework for the assessment of capabilities against rabies, a neglected and deadly disease, which we conducted recently for the Pan-American Health Organization.

M4-I.4 Mraz, AL*; Weir, MH; The Ohio State Universtiy; *alexis.l.mraz@gmail.com*

Meta-Analysis of Legionella Interactions with Protozoa and Human Macrophage

Legionella pneumophila (L. pneumophila) is the most common etiologic agent of Pontiac Fever and Legionnaires' disease, respiratory diseases transmitted via waterborne aerosol inhalation. Legionellosis, a term incorporating both Legionnaires' Disease, a severe pneumonia, and Pontiac Fever, a self-limiting flu-like illness, is the most common waterborne disease in the US, and its incidence is steadily increasing. L. pneumophila grows well in warm, stagnant, water (20-50°C), particularly in large distribution systems, such as those in hospitals or hotels. L. pneumophila thrives in biofilms, where it establishes and endosymbiotic relationship with protozoa, allowing the bacteria protection from disinfectants, such as residual chlorine. While there is a plethora of information regarding how L. pneumophila interacts with protozoa and human macrophages, this information has yet to be used for a comprehensive quantitative microbial risk assessment (QMRA) model for L. pneumophila in drinking water systems. This meta-analysis seeks to combine available data regarding the uptake of Legionella by protozoa and macrophages, the replication of Legionella in the host cell, the rates of exit from the host cell, and the rates of infectivity after leaving the initial host. We will be evaluating these rates in normal conditions, under particular genetic manipulations (e.g. dot/icm gene knockdowns), and under environmental stressors (e.g. chlorine treatment). In order to glean all applicable data available a critical literature review was performed. Data was selected from the literature based on if it would be appropriate to use in a mechanistic model (e.g. there are sufficient data points, the data is validated, the data informs Legionella's ability to survive and thrive, etc.). The data will be used to build a QMRA model allowing scientists and engineers to further understand how environmental conditions effect Legionella's virulence. This is an initial step in improved exposure control and therefore prevention of legionellosis outbreaks.

W3-D.1 Mundt, KA; Dell, L; Crawford, L; Sax, S*; Boffetta, P; Ramboll Environ; *ssax@ramboll.com*

Cancer Risk Associated with Exposure to Bitumen and Bitumen Fumes: An Updated Systematic Review and Meta-Analysis

Studies of bitumen (or asphalt) workers have reported increased risks of lung cancer and inconsistent increases in risk of other cancers. We conducted a systematic review and meta-analysis of epidemiological studies of bitumen exposure and cancers of the lung, upper aerodigestive tract (UADT), esophagus, stomach, bladder, kidney, and skin. We evaluated the quality of the individual studies and used the GRADE criteria (risk of bias, inconsistency, indirectness, imprecision, and publication bias) to rate evidence for each cancer. Lung cancer risks were increased for all bitumen-exposed workers (meta-RR 1.33, 95% CI 1.20-1.47, 43 results) and roofers (meta-RR 1.79, 95% CI 1.46-2.19, 19 results) and pavers (meta-RR 1.12, 95% CI 1.04-1.21, 21 results). Certainty in these estimates was rated low: risk of bias was judged serious (potential uncontrolled confounding), indirectness was judged important (poor exposure characterization), and there was substantial heterogeneity (I2=84.1%). After excluding lower quality studies, lung cancer risks were not increased (meta-RR 0.94, 95% CI 0.74-1.20, 8 studies), and heterogeneity was not observed. For other cancers, the meta-RR was increased for UADT tract cancers overall (meta-RR 1.48, 95% CI 1.22-1.81, 19 studies) and by job: roofers meta-RR 1.32 (95% CI 1.17-1.49, 5 studies) and pavers meta-RR 1.21 (95% CI 1.00-1.47, 11 studies). After excluding lower quality studies, risks of UADT cancers remained increased (meta-RR 1.31, 95% CI 1.03-1.67, 9 studies). Increased stomach cancer risks were also observed after excluding lower quality studies (meta-RR=1.29, 95% CI 1.03-1 .62, 7 studies). Risks for other cancers were unremarkable; however, the evidence was based on studies of limited quality. Our certainty for a conclusion that bitumen exposure causes UADT and stomach cancers was rated low after applying the GRADE criteria. Indirectness was rated serious because of lack of bitumen exposure measurements, and information on tobacco smoking, alcohol consumption, and occupational co-exposures.

P.160 Murayama, TM*; Imanaka, IA; Nishikizawa, NS; Nagaoka, NA; Tokyo Institute of Technology; *murayama.t.ac@m.titech.ac.jp*
Current situation of emergency and long-term responses on community risks by chemical accidents
Emergency responses as well as long-term mitigation for environmental and social impacts induced by chemical accidents is one of important issues for industrial society. In the case of Japan, there are approximately 200 accidents annually in last ten years. Japanese national government has published a guideline on impact assessment for chemical accident, and local governments where chemical complex are located are required to comprise manuals on emergency response for chemical accidents. While those activities would be partially effective for managing some impacts by the accidents, less attention would be paid for community risks surrounding chemical complex. Conducting a questionnaire survey for local governments, we make clear about emergency and long-term responses on community risks as well as overall procedures and organizational structure for managing risks induced by chemical accidents.

P.22 Nagaraju, V*; Fiondella, L; Wandji, T; University of Massachusetts Dartmouth; *vnagaraju@umassd.edu*
A Single Changepoint Software Reliability Growth Model with Heterogeneous Fault Detection Processes
Non-homogeneous Poisson process software reliability growth models enable several quantitative decisions about the software testing process such as reliability, optimal release time, and mean time to failure. Most of these software reliability growth models are characterized by a single continuous curve. However, during the software testing process, the failure data is affected by additional factors such as testing strategy, environment, integration testing, and resource allocation. These factors can introduce one or more changepoint into the fault detection process. Recently, several researchers have proposed non-homogeneous Poisson process software reliability models with one or more changepoints to characterize the failure data more precisely. However, one of the limitations of previous research is that only homogeneous combinations of the failure distribution before and after changepoints are considered. This simplifying assumption may not necessarily be true in all cases because even simple visual inspection suggests that the failure data could follow different distributions at various stages. Therefore, it is possible to observe different combinations of failure distribution before and after changepoints. This paper develops heterogeneous single changepoint models possessing different failure distributions before and after the changepoint. The heterogeneous models are compared with existing homogeneous models using goodness-of- fit measures such as the Akaike Information Criterion and Predictive Sum of Squares Error. Experimental results suggest that heterogeneous changepoint models better characterize 60% of failure data sets considered. Optimal release policies are discussed and a general procedure is presented based on the goodness-of-fit measures to identify the best model to predict the optimal release time that considers the subset of the data available.

P.76 Murphy, SJ*; Apt, J; Sowell, F; Carnegie Mellon University; *apt@cmu.edu*
Resource adequacy risks to the bulk power system in North America
Approximately 5% of all electric generating units in the USA and Canada have unscheduled outages at any given time. To prevent a shortage of power when these unscheduled outages happen, the industry procures reserve generation that runs at idle until needed. But at times the outages can exceed 15 or even 20% of all capacity. Current practice treats all outages as independent. Using a database that covers ~85% of all generators in the USA and Canada, we show that correlated failures occur in nearly every region. We test whether the observed increases in outages may be due to random coincidence of independent failures in two ways: block subsampling and modeling outage events occurrences as binomial random variables, finding that almost all regions show correlated failures with a 99% confidence level. Since hurricane Sandy and the very cold month of January 2014 occurred during the four years we examined, we remove those events from the data set and still find with high confidence that electric generators exhibit significant correlated outages. We test whether these correlated outages occur at a particular time of the year, that might be different in different regions (winter in the northeast or summer in the south, for example). Even with just four years of data we see evidence of correlated failures in all seasons. Further, we see no recurrent seasonal patterns in the average unscheduled unavailable capacity, nor in its variance. In order to characterize the generator outage data in a way that can be used in reliability analysis, we present the results of four analyses. These are: Weibull and lognormal fits to each region's series of unscheduled unavailable capacity; fits to each unit type's distribution of normalized derating magnitudes; summaries of the mean time between failure and mean time to recovery by region and unit type, along with Weibull and gamma distributions fits to each; and time series of unavailable capacity from maintenance and scheduled events.

T4-K.2 Nako, S*; Sarkar, B; U.S. Environmental Protection Agency; *nako.steve@epa.gov*
Trends in Toxicity Adjusted Dietary Exposure to Organophosphorous and N-Methyl Carbamate Pesticides
This presentation (poster) highlights two measures will be introduced in the U.S. Environmental Protection Agency's Report on the Environment. These measures depict the effects of pesticide regulatory actions upon residues and resulting dietary exposures since the passage of the Food Quality and Protection Act of 1996. The trends indicate that high-end dietary exposures to OPs and NMCs have steadily declined over the time period, 1998-2015, mirroring declines in total agricultural usage (lbs ai) for these two class of pesticides. These measures are based on the same population-based statistic, toxicity adjusted exposures to OPs and NMCs at the Per capita 99.9th percentile, that the Agency use to assess acute dietary risks to pesticides. The downward trends reflect direct and indirect effects of regulatory actions, including both use restrictions on older chemicals and registration of new pesticides. Such measures may help provide a basis for depicting economic benefits and costs of alternative risk management options.

M4-E.5 Nance, P; University of Cincinnati; *patricia.nance@uc.edu*
Communicating risk sciences related to human and ecological risks
The key principles in risk communication do not change whether you are talking about human health risk assessment or ecological risk assessment issues. Communicating science involves the interaction between environmental risk assessment scientists, risk managers, policy makers, media and the general public. The media play the role of "mediators" between scientists and the public. We have to ensure the information we present to media is clear, concise and transparent. The information that needs communicated depends on the decisions that people face, so understanding the key motivations are critical to communicating the science appropriately. One must also consider the perceptions the intended audience of the message have regarding the situation, as this plays a role on how the information is presented. The key principles of communicating science have not changed for many years, however the method in which information is now communicated changes every year. We will discuss the various tools for communicating science to the various audiences. Come share your personal experiences communicating science!

T4-F.4 Nateghi, R; Purdue University; *rnateghi@purdue.edu*
Electric Power System Inadequacy Risk in the Residential Sector
The U.S. electric power system is increasingly vulnerable to climate variability and change. Supply inadequacies can result from unanticipated climate-induced shifts in electricity demand due to non-stationary climatic conditions. In this talk, we will present an approach to assess the risks associated with shifts in residential demand due to climate variability. A place-based, data-driven approach is leveraged to identify and assess the risk factors which render the residential electricity sector vulnerable in face of future climate variability and change. The proposed quantitative decision-making tool, can be used by the utilities, energy professionals, policy makers, and regulators to design effective strategies to minimize supply inadequacy risks in face of climate variability and change.

M3-F.4 Nelson, KS; Camp, JS*; Vanderbilt University; *janey.camp@vanderbilt.edu*
Converting Vulnerable Landscapes to Resilient Community Assets
Following the 2010 flood in Nashville, Tennessee, the City of Nashville implemented several recovery, mitigation, and adaptation strategies that propelled the community and economy to a speedy recovery. However, Nashville didn't just return to its former pre-disaster state. Instead, it took measures to ensure that it would be less vulnerable to flood events by reducing exposures through purchase of flood-damaged properties in high-risk flood areas and conversion of these developed urban landscapes to greenspace. These activities were undertaken in the hopes of making Nashville more resilient by simultaneously adding shared community value while decreasing future flood losses. This strategic land-use conversion from high-loss and liability, individually owned properties to enhanced value, public spaces can be seen as a resilience-building model for urban centers. While the community may recognize the inherent benefit of these activities, quantification of their benefits has not yet been fully realized. In this presentation we outline a proposed method for evaluation of the relationships between the provision of green spaces in flood-prone areas and community well-being outcomes and present preliminary results of an assessment of the value of avoided damage and losses and potential secondary benefits resulting from this strategic land-use conversion for the Nashville case study. In addition, methodological challenges and opportunities for further application of the method for cost-benefit analyses of similar resilience-building strategies in other communities will be discussed.

M3-D.2 Nelson, K; American Process; *knelson@americanprocess.com*
An EH&S Approach for Commercialization of Novel Forms of Nanocellulose
American Process Inc. (API) is the world's first company to produce and market five different varieties of nanocellulose products with tailored morphologies and surface properties to enhance the performance of a wide variety of materials across various industries. API's BioPlus™ nanocellulose products are manufactured using a low cost, patented process that is demonstrated at their fully-integrated Thomaston Biorefinery plant along with lignocellulosic sugars, fuels and chemicals co-products. This presentation will discuss our EH&S approach, including toxicity testing and partnership with NIOSH, for commercialization of a variety of novel forms of nanocellulose. Nanocellulose is a versatile material with a vast array of commercial applications including composites and foams for automotive, aerospace, and building construction, viscosity modifiers for cosmetics and oil drilling fluids, and high performance fillers for paper, packaging, paints, and plastics. Nanocellulose is renewable, biodegradable, biocompatible and as strong as Kevlar™. Reuter's recently named nanocellulose as one of ten innovations that will transform the world by 2025. The US USDA estimates that global production of nanocellulose could reach 34 million tons per year in the coming decades. API has been granted 8 patents and over 250 patents pending in the nanocellulose field encompassing production methods, composition, drying, redispersion, composition, and end-use applications.

P.124 Nguyen, JD*; John, RJ; University of Southern California; *hoangdun@usc.edu*

Comparing Verbal and Numeric Forecasts New Findings and Implications

Whereas the process of risk assessment requires probability estimates in their numerical forms, many organizations prefer to use verbal measures of uncertainties. This research compares the accuracies of verbal predictions and numeric forecasts. A sample of 118 NFL football experts was recruited from Turk Prime. The experts were randomized into one of the two experimental conditions. Experts in the NUMBER condition were asked to make predictions of various possible outcomes in the NFL 2016-2017 regular season by using a numerical scale. On the other hand, experts in the VERBAL condition were asked to make the same predictions by using a verbal scale that includes 11 different probability words. The experts in the VERBAL condition were later invited to participate in a separate study about "preference for gambles". The experts were presented with series of binary gambles and they were asked to choose their preferred options. The payoffs of the binary gambles were identical, but the first gamble describes the chance of winning by using a numeric value whereas the second describes the chance of winning by using a verbal expression of uncertainty. Using an iterative procedure, we were able to quantify the numeric values corresponding to the verbal expressions in the verbal response scale in the main study. These quantified values were then used to transform the verbal responses into numeric values for the VERBAL experts. Results from the main experiment showed that verbal forecasts were not statistically significant from numerical predictions in terms of the overall accuracy—quantified by the Brier score. However, numerical judgments were more resolute or discriminatory than verbal judgments. Yet, the degree of underconfidence was much less extreme among VERBAL experts. These results contradict findings in previous studies, and call more for attention to evaluate the application of verbal measures of uncertainty.

T3-C.2 Nguyen, KD*; John, RJ; University of Southern California; *hoangdun@usc.edu*

Comparing Verbal and Numeric Forecasts New Findings and Implications

While the process of risk assessment requires probability estimates in their numerical forms, many organizations prefer to use verbal measures of uncertainties to characterize and quantify potential risks. This research proposes a measure from Signal Detection Theory for such evaluation purpose and demonstrates a method based on Savage's conceptualization of subjective probabilities to quantify verbal expressions of uncertainty. A sample of 118 NFL football experts was recruited to participate in the study. The experts were randomized into one of the two experimental conditions that differ in the response scale. Experts in the NUMBER condition were asked to make predictions of various possible outcomes in the NFL 2016-2017 regular season by using a numerical scale. On the other hand, experts in the VERBAL condition were asked to make the same predictions by using a verbal scale that includes 11 different probability words. The experts in the VERBAL condition were later invited to participate in a separate study about "preference for gambles". Using an iterative procedure, we were able to quantify the numeric values corresponding to the verbal expressions in the verbal response scale in the main study. These quantified values were then used to transform the verbal responses into numeric values for the VERBAL experts Results from the follow up study showed that numeric values of positive expressions such as probable varied a lot more than the values of negative expressions such as improbable. Results from the main experiment showed that verbal forecasts were not statistically significant from numerical predictions in terms of the Brier score. However, numerical judgments were more resolute or discriminatory than verbal judgments. Experts in both conditions showed an overall tendency of underconfidence although the degree of underconfidence was much less extreme among VERBAL experts.

T4-D.4 Nichols, GP; Homeland Defense and Security Information Analysis Center (HDIAC); *gnichols@hdiac.org*

Assessing the global risk of nanotechnology-enabled weapons proliferation

Nanoscale research and engineering, spurred by robust funding programs in the United States and other nations, has risen over the past 17 years, making nanotechnology pervasive throughout society. The advent of nanotechnology brings concerns that its applications could be used for nefarious purposes, either in small-scale attacks or potentially to create weapons of mass destruction. A large portion of global nanotechnology research already occurs under the auspices of military guidance, and for obvious reasons, most weapons development happens in classified space and is not available to the general public. Increasingly challenging is that civilian and military research on nanotechnology overlap, which leads many to fear a further reduction in transparency. Because of breakthroughs in technology, increased availability of information on the internet, and substantial reductions in the cost of equipment, new fears revolve around non-state actors acquiring the necessary materials and personnel to develop new weapon types without the need for traditional research programs. Since weaponization of nanotechnology is most likely in its infancy, early stages of development would first use nanotechnology to enhance current weapon types rather than create new classes of weapons. Reports of individual events utilizing weapons based on nanotechnology or claims of engineered nanomaterials being used as weapons have already occurred. HDIAC is currently conducting an assessment of existing global capabilities (military and civilian) that could be related to nanotechnology weapons research and development and is evaluating the likelihood of use regarding these technologies. Information from this assessment will support planning efforts of federal agencies involved in protecting against attacks, enhance the response of first responders and emergency managers who respond to events, and provide necessary information for successful diplomacy related to combatting proliferation.

M4-H.3 Nicol, AM; Simon Fraser University; *anicol@sfu.ca*

Reducing early life exposure to radon: a challenge for childcare facilities

Radon gas is well-established carcinogen and the second leading cause of lung cancer in Canada. Reducing radon exposure is key to preventing cancer. Taking steps to lower radon levels in children's environments in particular can go a long way to reducing lifetime exposure to radiation. Many young children spend considerable amounts of time indoors in childcare care settings. These facilities are often situated on the ground or basement levels of buildings, where radon levels can be higher than on floors above. As such, childcare facilities are places where testing and remediation could make a considerable difference to exposure during childhood. A review was undertaken across Canada to determine policy and practices around radon exposure in these settings. The results found that as of May 2017, only one jurisdiction had a policy specific to radon in stand-alone childcare facilities. In many provinces, childcare programs in public schools were often tested as part of larger school testing programs. A number of ethical issues were raised during this review, particularly the need for legislated rather than optional testing requirements across the country. Mandatory testing in childcare facilities would ensure that all children are protected and that childcare operators are not unfairly stigmatised for their own testing efforts. Risk communication was identified as a key component of radon testing in childcare facilities, including communication between building owners and facility operators as well as between operators, staff and clients/parents. Many people are unaware of the hazard presented by radon gas and discussing the issue of chronic, lose-dose radiation exposure in the context of a childcare setting presents a number of technical and risk perception related challenges.

T4-E.1 Novikova, TS; Novosibirsk State University, Department of Economics; *tsnovikova@mail.ru*

Government support of investment projects as an instrument of risk management

Stimulation of investments with different types and levels of risk requires using of different institutional instruments and methods of evaluation. Government support for separate investment projects may reduce their risks and facilitate the implementation of projects with high economic but low financial efficiency. This paper proposes a methodology of risk management based on risk redistribution as a result of government support in terms of financial and economic efficiency. Two interrelated project models (financial and economic) with extended blocks of risk analysis were developed. To determine financial effects of the government support, indicators of net present value were used. The empirical part of the research is based on the analysis of real innovation projects in Novosibirsk region of Russia: 3 mega-projects of different catalysts, 18 micro-innovative projects of the Siberian Branch of the Russian Academy of Science, and a project of nanoceramic materials. For mega-projects, an extreme degree of support was used in the form of the direct investment financing, related to R&D with the highest level of risk. For other projects different versions of risk redistribution were analyzed under the appropriate forms of the government support and the corresponding change in the institutional framework of projects. For the project of nanoceramic materials, redistribution effects were estimated taking into account different ways a company uses R&D benefits, as well as various options for contractual relations between project participants and the corresponding change in its institutional framework. This was done on the example of investment in human capital. It demonstrates that government support has a positive effect only within the well-proven institutional design that profoundly balances the set of measures of risk management. It reduces their risks, improves the efficiency and promotes interest for private participants in the implementation of the PPP projects.

P.82 Nyambok, EO*; Hoffman-Pennesi, D; Gavelek, A; Briguglio, S; Spungen, J; Wirtz, MS; Oak Ridge Institute for Science and Education; *Edward.Nyambok@fda.hhs.gov*

Concentration of Cadmium in Spinach in U.S. Monitoring Data

In 2015 the California Department of Public Health recalled spinach due to elevated levels of cadmium. Cadmium is a toxic element widely distributed in the environment and therefore maybe found in food. Soil concentration of cadmium varies by different regions, resulting in a variation in cadmium levels in plants. Plants also differ in their rate of cadmium uptake and accumulation; some plants such as spinach tend to accumulate cadmium more readily. The U.S. produces roughly 200 million pounds of spinach and imports about 28 million pounds annually. Many countries monitor contaminants in food over time as part of market basket surveys referred to as Total Diet Study (TDS) programs. Our study reviewed cadmium data specific to spinach from TDS conducted in the United States (U.S.), Canada, and France. We reviewed spinach data from U.S. (2003-2012), Canada (2005-2012), and France (2007-2009) to see how U.S. compares to Canada and France. Among the TDS foods analyzed for cadmium, spinach is in the top five. The poster will also present trends of the cadmium levels in spinach over time for each of the three countries in the study.

M4-J.9 O'Blenis, PA*; Stefanison, I; Evidence Partners Inc; *poblenis@evidencepartners.com*

Systematic Review Automation Technologies: Available Tools and Best Practices

The field of systematic review automation is evolving rapidly and is bringing with it the ability to produce and maintain higher volumes of evidence without increasing research workloads. These tools are also dramatically improving the auditability, reproducibility and transparency of work being produced, enabling more reliable evidence-based decision making. This poster will provide a snapshot of the current state-of-the-art in systematic review automation and will be presented through practical examples of how diverse organizations are leveraging these tools today. The poster will also review emerging innovations, such as natural language processing and AI, that are expected to further impact the way in which evidence-based research is conducted and managed. Finally, the poster will provide an overview of generally applicable best practices gleaned through work with a diverse community of approximate 250 different organizations conducting reviews across a broad spectrum of domains. The information will be presented in a practical format, with examples, to present the audience with a set of tools that may assist them in the conduct of their systematic reviews.

M2-D.2 O'Reilly, MV; ARLS Consultants and State University of New York; *ARLS.OReilly@gmail.com*

Manufacturing Novelty for a Purpose: the Neuroscience Basis for Continual Review and Improvement

Neuroscience has illuminated the role of the limbic system and sub-cortical pathways in risk perception and decision making. The limbic system is closely aligned with emotion. Many decisions are made at the emotional level before cortical rationalizations are formulated. The system of emotional thought is often called a mental model. Mental models often determine choice before cortical thought kicks in. The Deming cycle of continuous improvement implemented in several management system standards, such as ISO 9000, 14000 and the proposed ISO 45000 as well as the ANSI Z10, incorporates systems thinking. Daniel Kim of MIT describes five levels of systems thinking one of which is mental models. Mental models provide one of the links between systems thinking and human cognition. The benefits of mainstreaming occupational health into management systems depends on the mental models of employers, employees, consumers and rule makers. The mental models employed by small business and large corporations are quite different. One mental model really does not fit all situations. In addition, mental models vary based on what is valued and what is continuously improved. Emphasis on production, quality and/or safety results in different outcomes. When capital is valued more than workers the outcome of continuous production improvement typically does not improve worker health and/or well-being. When return on investment from capital is greater than return on investment from productivity, those with capital get richer and workers typically do not flourish. Continuous improvement works best when all involved share similar mental models.

P.140 Ohkubo, C; Japan EMF Information Center; *ohkubo@jeic-emf.jp*

Comparison of risk perception among thirty risk factors in Japan

Risk perception of wen (n=1506) and women (n=1495) on 30 risk factors was surveyed by internet in 2016. The questionnaires include degree of risk perception on 30 factors in daily life including outdoor air pollution, indoor air pollution, diesel emissions, chemical substances in general, dioxins, pesticides, food additives, industrial wastes, nuclear power plants, ionizing radiation, X rays, radon, UV radiation, solar radiation, electromagnetic fields radiation, high-voltage power lines, cellar phones, base stations, microwave ovens, induction hobs, home electric appliances, motor vehicles, air crafts, daily foods, red meat, processed meat, genetically modified food, passive smoking, smoking and alcohol drinking. Respondents were asked for their risk perception for each risk factor. For comparison, risk perception is categorized into 3 levels, i.e., “danger”, “neither danger nor safe” and “safe”. By the gender a whole, to the 10th describing in descending order of risk perception who answered as “danger” , it was passive smoking, smoking, ionizing radiation, pesticides, outdoor air pollution, dioxins, nuclear power plants, UV radiation, diesel emissions and food additives. In wen, it was smoking, passive smoking, outdoor air pollution, ionizing radiation, dioxins, nuclear power plants, pesticides, outdoor air pollution, dioxins, UV radiation, diesel emissions and industrial wastes. In women, it was passive smoking, smoking, outdoor air pollution, UV radiation, dioxins, pesticides, ionizing radiation, nuclear power plant, food additives and diesel emissions. Risk perception on electromagnetic fields related risk factors, to the 5th describing in descending order of risk perception who answered as “danger”, it was high-voltage power lines, cellar phones, microwave ovens, base stations and home electric appliances by the gender a whole. The proportion of women who answered “danger” was higher than men in all the risk factors.

M3-K.2 Oiso, S; Institute of Nuclear Safety System; *ooiso@inss.co.jp*

A study of Japanese people’s awareness about radiation after the Fukushima Daiichi Nuclear Power Plant accident

This study used a survey to examine public awareness about radiation in light of the continuing public interest and concern over radiation since the Fukushima Daiichi Nuclear Power Plant accident in Japan. The survey was conducted in 2015 among 1,000 randomly selected adult participants. In 2012 and 2014, similar surveys which had several of the same questions were conducted, so trends in awareness related to some questions was also analyzed. The percentage of persons who felt anxious about radiation was about 70%. A higher percentage of women, 77%, felt anxious about radiation than men (64%). A higher percentage of elderly persons had anxiousness compared to younger participants. The percentage of persons who knew that natural radiation exists was a little more than 60%, but the percentage was a little less than 50% for younger participants (persons less than 30 years old). In the case of analyzing the results by gender, a higher percentage of men displayed some knowledge about radiation than women did. Among the persons who answered that they knew natural radiation existed, they were additionally asked its amount. The percentages of persons who knew exposure to natural radiation for Japanese was about 2 millisieverts a year were 17% for men and 10% for women. There was also some questions for which knowledge about radiation fell in the 2015 survey compared with the 2012 survey just after the Fukushima accident. The percentage of persons who had knowledge about external exposure and internal exposure in particular fell. The percentage of persons who knew ways to protect themselves against radiation in the event of a nuclear power plant accident also fell. The passage of time since the Fukushima accident was considered as the reason for this drop. Finally, the percentage of persons who had knowledge about taking refuge indoors was less than the percentage of persons who had knowledge about evacuation to protect themselves against radiation.

P.175 Ollison, WM*; Leston, AR; American Petroleum Institute and AirQuality Research & Logistics, LLC; *ollisonw@api.org*

Field Evaluations of Newly Available “Interference-free” O3 Monitors and 2-10 meter near-ground O3 gradients

Metal oxide scrubbers ideally remove only ozone (O3) from scrubbed reference streams of conventional O3 photometers deployed in the U.S. O3 standard compliance network; however, in reality they change ambient vapor levels of water, mercury, and 254 nm-absorbing aromatic species, ultimately enhancing reported O3 levels when subtracted from the un-scrubbed sample stream. Recent comparisons of Federal Equivalent Method (FEM) conventional photometers (doi: org/10.1080/10962247.2017.1339645) to newer FEM photometers equipped with post-scrubber Nafion™ humidity equilibration (e.g., 2B Technologies 202/205) or gas-phase nitric oxide scrubbers (e.g., 2B 211) to also eliminate Hg and UV-active aromatic compound interference, improve air quality standard compliance. Newer 2B heated graphite-scrubbed photometers (doi: org/10.5194/amt-10-2253-2017) also reduce photometer artifacts many-fold and avoid the gas handling burdens of NO-based scrubbers. Currently allowed U.S. O3 compliance monitor inlet heights range from 2 to 15 meters (m) above ground level (AGL), averaging 5.4 m in urban and 10 m in rural compliance locations. Previous near-ground O3 gradient studies (Atm. Environ. 32: 1317-1322, 1998) report 20% O3 drops over a 4 m to 0.5 m inlet height range under stable conditions and up to 7% decreases under well-mixed conditions. Human nose heights are typically 1-2 m AGL so 2 m inlets best approximate outdoor population exposures. The use of newer FEM O3 photometers with 2 m inlets provides both improved air quality compliance and more realistic health risk assessments.

P.68 Ono, K*; Tsunemi, K; AIST; *kyoko.ono@aist.go.jp*

Risk perception on hydrogen fueling stations for Japanese public with risk and benefit information

Hydrogen storage facilities, such as hydrogen fueling stations (H2 station), are inevitable infrastructure for the utility of fuel cell vehicles. We are interested in the public acceptance of H2stations and how the installation of these H2 stations is perceived by the public. Aims of this study are to describe the characteristics of public perception of H2 station in Japan using risk perception and acceptance scales and to analyze differences of people’s acceptance on H2 station with risk or benefit information on a H2 station. We conducted an online survey asking respondents to rate their acceptance of having an H2 station constructed in the gas station nearest their home. Respondents were divided into 18 groups by providing with or without risk and/or benefit information. At the same time, we asked the respondents on their risk perception, scale of risk acceptance, and risk-avoiding tendencies. Factor analysis was conducted to extract factors to characteristics of public acceptance by each group. We found the following to be explanatory factors for acceptance: gender, degree, vehicle use, knowledge about hydrogen, risk perception of H2 station, and inherent risk acceptance and avoidance. Binominal regression analysis and a structural equation modelling were conducted to construct an acceptance model, and the risk perception factor “Dread” was dominant among the effective independent variables. We also discussed the difference of acceptance rates among groups which were provided or not provided with risk or benefit information. This work was supported by Japan Science and Technology Agency (JST), Cross-ministerial Strategic Innovation Promotion Program (SIP).

P.143 Opperhuizen, Erasmus University Rotterdam, AE*; Schouten, Erasmus University Rotterdam, KIM; Klijn, EH; Erasmus University Rotterdam; *opperhuizen@fsw.eur.nl*

Up and down in the cycle: the effects of media attention on the political debate and policy on the public risk of Earthquakes

Media functions as amplification station by transmitting information about a risk event towards the general public. Media are an important source of information which influences the public and political perception of a risk. In the framework of social amplification of risk the media is often mentioned as an institutions with its own rules. While political scholars focus on media function as agenda-setter for political (risk) debate, there is limited research on the role of media on the ripple effect they create in the policy sphere. In this study we focus on the agenda-setter role of the media on both the political sphere as well as the policy sphere. We do this in case of increasing earthquakes risk caused by gas drilling in The Netherlands. The risk of earthquakes offer the opportunity to study media attention over a long period (25 years) and at the same time provides in-depth knowledge about media attention on political risk debate and risk policy. In this a Supervised Machine Learning (SML) techniques is applied to conduct a content analyses of media articles (N= 2265) from 5 different newspapers, political documents reporting about debates in the Parliament (N= 124) and policy documents. We expect that the frequency of media attention influence how often the earthquakes risk are subject of policies debate. It is also expected, in line with the symbolic agenda setting theory, that the content of topics mentioned by media is reflected in the political sphere. We expect further, in line with the substantive agenda setting, risk control reflex and ripple effects theory also influence the policy sphere.

T2-H.1 Oryang, DO*; Fanaselle, W; Van Doren, J; Dennis, S; CFSAN, FDA; *david.oryang@fda.hhs.gov*

Developing and Using Decision Analysis Tools for the FDA Foods Program – A Decade of Continual Improvement

Decision analysis evaluates the complex alternatives surrounding a decision, in terms of values and uncertainty, and is the systematic process of unraveling, explaining, and documenting the key components and implications of a decision. It is among the evidence-driven, risk-based approaches FDA uses to target, evaluate, and prioritize a multitude of food-safety issues. Using a case-study approach, this presentation will review the general process we use to develop evidence-driven, risk-based decision-analysis tools, with a focus on multi-criteria decision analysis methodology that utilizes risk-modeler and decision-maker (risk-manager) teams; i.e., the two primary teams involved in the decision-making process. We will discuss several key lessons learned from our experience, including the need for the modeling team to engage decision-makers early in the process, to ensure a good understanding of the decision to be made, the alternatives to be considered, and any constraints that may impact the modeling. Discussion of the need for the modeling team to undertake some data collection and exploration of the issues in this often-iterative process will be included. We will also discuss the importance of identifying the appropriate public-health criteria and collecting data that inform the tool as to the criteria to be established, to ensure that the decision model is appropriately risk-based. Other decision criteria, such as feasibility or socio-economic factors, also may be considerations in a given decision, and we will discuss how these are included. The case studies we present will include tools designed to prioritize animal-drug residues, for milk-testing programs; firms, for inspection planning; and research projects, for resource allocation.

M4-K.1 Osberghaus, D; Demski, C*; Centre for European Economic Research and Cardiff University; *DemskiCC@cardiff.ac.uk*

The causal effect of flood experience on climate engagement: evidence from search requests for green electricity in Germany

Personal experience of climate change-related weather events has the potential to reduce the psychological distance of climate change and to trigger engagement in climate protection measures. We use a novel longitudinal dataset on revealed household behaviour and insured damage data to re-examine this relationship, which has mostly been studied by cross-sectional and self-reported data. Using a difference-in-differences estimator, we quantify the causal effect of experiencing financial damage from the 2013 floods in Germany on the interest for renewable energy tariffs in online power portals, which we take as a proxy for engagement in climate protection. The results broadly confirm the expected positive effect of flood experience on climate engagement, but there are important non-linear effects. Most notably, the effect drops to zero if damages are very high meaning the causal effect of flood experience on interest in green energy holds only for moderately affected regions. One explanation for this inverted U-shaped effect is that high flood damages may constrain the available budget for costly climate protection, due to high recovery and reconstruction costs. This interpretation is supported by further analyses regarding various economic indicators and flood insurance coverage. Another explanation refers to non-protective responses such as feelings of helplessness and resignation if damages are relatively high. When supporting private climate engagement, policymakers should not rely on a motivating effect of damage experience, but should acknowledge the economic and psychological limitations of severely flood-affected households. Moreover, the analysis shows that high flood insurance penetration is not only beneficial in terms of flood resilience, but also increases the probability that households engage in climate protection in the aftermath of an event.

T3-H.1 Otten, A*; Ernst, N; Ng, V; Smith, B.A; Fazil, A; Public Health Agency of Canada; *ainsley.otten@phac-aspc.gc.ca*

Cross-contamination of Broiler Chickens with Campylobacter During Transport

Campylobacter frequently colonizes the intestines of broiler chickens on farm. Cross-contamination to the exterior of birds creates risk to consumers, as the cells of Campylobacter can persist through processing and are routinely present on retail products. Ingestion of Campylobacter by consumers can cause gastroenteritis and potentially serious sequelae. The role of cross-contamination during broiler transport has not been extensively modelled, and due to complexities of the system is often not included in QMRAs concerning Campylobacter on poultry. An agent-based model was developed with AnyLogic software to study how broiler chicken Campylobacter contamination may change during transport from farm to slaughterhouse. Contamination may be present or introduced in the truck from: a) transport crates which were not properly sanitized prior to loading; b) the exterior of incoming birds; and c) colonized birds who defecate during transport. Each bird is represented as an individual agent within the model and the colonization status and exterior contamination level is simulated and recorded. Contamination may be passed within and among crates through bird and fomite contact. Additionally, colonized chickens may soil broilers below or beside them with fecal material. Outputs include the final number of birds with exterior contamination and the respective concentration of Campylobacter. Scenario analysis allows transport interventions such as limited inter-crate transfer, logistic loading and reduced transport time to be evaluated. Results will be implemented in a Canadian farm-to-fork QMRA of Campylobacter in chicken products sold at retail to examine mitigation strategies that can be employed to reduce the risk of campylobacteriosis in Canada.

P.182 Outkin, A.V.*; Eames, B.K.; Jones, S.T.; Vugrin, E.D.; Walsh, S.; Phillips, C.A.; Hobbs, J.A.; Galiardi, M.; Wyss, G.D.; Sandia National Laboratories; *avoutki@sandia.gov*

A Game-Theoretic Approach to Attacker-Defender Interaction in Cyber Systems

Modern society relies extremely heavily on cyber-intermediated systems that affect nearly all aspects of modern life including communications, energy, transportation, social networking, news provision, and other systems. Disruptions to those systems can be impactful, hard to detect as well as to respond. We present a game-theoretic approach to attacker-defender interaction in a resource contention game, called PLADD (probabilistic, learning attacker and dynamic defender). We provide a comprehensive mathematical framework for analysis of the dynamic attacker-defender interaction with incomplete information that can be used to create simple, analytically tractable yet practically insightful models for understanding cyber disruptions to these systems and their security. We build upon an existing model called FlipIt, extending it into a scenario involving a probabilistic attacker and defender playing for control over a resource. Using the martingale-based approach, we solve analytically for defender strategies and show how defender strategies affect the attacker payoffs. We compare the analytical solution to a simulation and show how the simulation can be extended into analytically intractable scenarios. Finally, we discuss how PLADD can be extended into domain of multi-resource games to represent more realistic attack scenarios.

P.123 Pace, ND*; Poole, C; University of North Carolina at Chapel Hill; *nelsonpace@gmail.com*

A risk by any other name would not smell as sweet

Risk and odds are two methods of reporting disease frequency. Odds ratios can approximate risk ratios when the underlying risk of disease is rare. That approximation improves with greater rarity of disease. When the approximation is the same to several decimal places, we suggest that odds ratios be referred to a risk ratios because (1) risk ratios are easily understood in comparison to odds ratios which will facilitate improved scientific communication, (2) the numeric difference between risk ratios and odds ratios for very rare diseases is unobservable in published literature due to factors such as rounding, and (3) the decimal places needed to portray these minute differences are often beyond the level of precision of most measured variables. For these reasons, we advise that calculated odds ratios in very rare disease research be referred to as risk ratios.

W4-I.2 Pagone, F*; Persky, J; RHP Risk Management Inc.; *fpagone@rhprisk.com*

What does the current unit risk estimate used for diesel particulate matter cancer risk calculations indicate for worker and environmental health?

In 2012, the IARC classified diesel engine exhaust as carcinogenic to humans (Group 1). Since this classification, there has been limited research on Diesel Particulate Matter (DPM) excess lifetime inhalation cancer risks (ELCR). DPM potentially effects workers (e.g. truck drivers, construction) as well as non-workers (e.g. general population); therefore, the need for classification, characterization, and communication of actual and perceived DPM risk is timely. This study calculated the DPM ECR using the Unit Risk Estimate (URE) developed by the California ARB/OEHHA (CARB) and compared DPM risks with other pollutants. The individual ELCR associated with exposure to DPM were calculated by multiplying the 1998 CARB DPM URE of 3E-4 (µg/m3)-1 by the estimated dose modeled by the USEPA as part of the 2011 National Air Toxics Assessment (NATA). NATA DPM emissions were based on the EPA 2011 National Emissions Inventory (NEI) measurements of mobile source PM10. The maximum ELCR due to modeled and estimated DPM dose in Cook County was 1.1E-3 (i.e., 1 in 1,000) with a census tract mean of 3.4E-4. All census tract level DPM risks were above the upper bound USEPA's ELCR of 1 in 10,000. The maximum NATA ELCR from all other NATA carcinogens combined, excluding DPM, was 1 in 10,000. During the period of 2009-2013 in Cook County, IL, there were reported 16,799 cases of Lung and Bronchus Cancer, with cigarette smoke and radon being the leading causes. Whether a meaningful reduction in actual lung and bronchus cancer rates would have been realized because of DPM dose reduction is difficult to express with the current approach utilizing theoretical DPM modeled concentrations and the 1998 DPM URE. Perhaps these results indicate that a more specific way to express DPM cancer risk needs to be developed for purposes of decision-making alternatives as well as for communicating the extent and practical significance of DMP dose reduction.

T4-C.4 Pagsuyoin, SA*; Santos, JR; Salcedo, G; Yip, C; University of Massachusetts Lowell; *Sheree_Pagsuyoin@uml.edu*

Spatio-Temporal Drought Risk Analysis Using GIS-based Input Output Modeling

A significant number of studies on climate change have predicted an increase in the frequency and severity of droughts across the globe. Some of these predictions are already felt; for example, northeastern United States has recently experienced record rainfall deficits, triggering government agencies to issue warning-level to emergency-level drought advisories in the region. Since water is an essential resource in producing goods and services, droughts lead to economic losses that propagate through the interconnected sectors of an economy. Further, these sectors exhibit varying resilience to drought severity and duration depending on their reliance on water availability. In the present work, we develop a spatial and dynamic input-output (IO) modeling framework to examine the adverse effects of drought events on interdependent economic sectors. A decision support system utilizing geographic information systems (GIS) was created to: (1) model the progression of drought intensity, (2) simulate the dynamic behavior of economic sectors during the drought timeline and throughout the various phases of recovery, and (3) assess the regional impacts of these behaviors on the regional economy. The resulting integrated IO-GIS model was applied to the State of Massachusetts, which experienced historic widespread drought conditions in 2016.

M4-C.5 Palma-Oliveira, J; University of Lisbon;
jpalma-oliveira@psicologia.ulisboa.pt
Perspectives on resilience scholarship and research
Concepts are often prone to ambiguities driven by a metaphorical usage that undermine science endeavors. Resilience, sustainability, risk, and risk communication are prime examples of this, where practitioners within these fields frequently contend with inaccurate or imprecise disciplinary definitions that ultimately lead to logic faults or unclear guidance for customers and stakeholders. To address such concerns, this talk delves into the core meaning behind the disciplinary use of 'resilience' to advocate for a more operationalized usage of the term in our daily lexicon. Specifically, this talk will discuss resilience components such as (i) its normatively neutral (rather than inherently positive) framing, (ii) its inherent focus upon systemic and multi-temporal risk events, and the occasionally paradoxical relationship between resilience and sustainability in applied resilience scholarship and research. In this vein, this talk will raise a brief overview of the human – environment interaction in order to highlight the systematic entropic action that can simultaneously generate system resilience in some cases while increase system brittleness to the effects of others.

M3-H.1 Pang, H*; Pradhan, AK; University of Maryland;
panghhao@gmail.com
Risk of Pre-Harvest Microbiological Contamination in Tomatoes: Effects of Meteorological, Farm Management, and Environmental Factors
Tomatoes have been linked to several foodborne disease outbreaks in recent years and the source of contamination has been traced back to tomato farms. This study sought to identify and evaluate meteorological, environmental, and farm management factors affecting microbial contamination risk in tomato fruits and in tomato production environments at the pre-harvest level. Tomato (n = 259), irrigation water (n = 72), and field soil (n = 45) samples were collected from 24 farms located in Maryland, Delaware, and New Jersey. Local meteorological information (temperature and precipitation) during the study period were collected from National Climatic Data Center. Farm level environmental factors and management practices were acquired through questionnaires answered by farmers. These factors were evaluated for their association with aerobic plate count (APC), total coliform (TC) count, and presence of generic E. coli in tomato, irrigation water, and field soil samples. For tomato samples, prevalence of E. coli was significantly reduced by the use of potable water for cleaning, chemical application, and hand washing; however, prevalence of E. coli increased with increasing of precipitation on sampling day. In addition, higher TC counts occurred in tomatoes from farms exposed to higher average temperature and higher average precipitation over the previous 10 days before sampling. In irrigation water samples, presence of E. coli increased with increasing average temperature over the previous 25 days before sampling day. In addition, increasing precipitation over the previous 30 days before sampling increased the count of APC and TC in irrigation water samples. These results indicate that microbial contamination at tomato pre-harvest level can be influenced by certain meteorological conditions, environmental factors, and farm management practices. Our study provides information that will assist growers in evaluating farm management and preventive measures to reduce the risk of pre-harvest contamination in tomatoes.

T4-H.5 Paoli, G*; Hartnett, E; Risk Sciences International;
ehartnett@risksciences.com
Exploring Efficient Simulation Techniques in Quantitative Microbial Risk Assessment (QMRA)
Food production, preparation, and consumption is a complex and varied process. When developing quantitative microbial risk assessment (QMRA) models, quantifying the response of pathogens to the vast spectrum of conditions posed by food production processes can lead to simulation components that are widely variable, sometimes spanning several orders of magnitude. Impose upon that quantification of the inherent uncertainty, and simulation rapidly becomes cumbersome, and prone to stability issues leading to poor quality, and even inaccurate, results. Methods are available to assist in producing efficient simulation in the face of poorly behaved models, for example sample re-weighting, and importance sampling, and these techniques have been applied in other fields yet their use in microbial risk assessment is not common-place. These techniques can provide significant benefits in the development of robust and efficient simulation models designed to explore microbial food safety risk. We will demonstrate the benefits by example with real-world food safety issues (for example food contamination with Listeria spp.).

P.97 Patterson, J*; Chaisson, C; Diskin, K; Parker, A; Babich, M; Biggs, MB; 1University of Cincinnati, formally Toxicology Excellence for Risk Assessment, 2The LifeLine Group, 3U.S. Consumer Product Safety Commission;
patteji@ucmail.uc.edu
Human exposure to nine flame retardants in indoor environments
Flame retardants (FRs) are chemicals added to materials to improve their resistance to fire. FRs have been detected in indoor environments, particularly in air, household dust, and consumer products. Incidental ingestion of household dust is believed to be a major source of human exposure. Toxicity observed in animals includes reproductive and developmental toxicity, organ toxicity, and cancer. Human exposure was estimated for 9 FRs (TDCPP, TCPP, TCEP, TEP, TPP, TBB, TBPH, TBBPA, antimony trioxide) from indoor air and household dust in 4 environments (home, office, child care, and car) for which published data were available. Data from the most competent and relevant publications were used to represent concentrations for each FR and relevant media scenario. Dust and air particulate measurements were used as indicators of the overall contaminant levels of FRs indoors. Using probabilistic exposure assessment methods (LifeLine™ software) a range of aggregate exposures from oral, dermal, and inhalation routes for several age groupings were estimated. The highest exposures for all FRs except TEP (at the 50th percentile of the population's exposure) were for children ages 1 to <3 years). For over half of the FRs, the home environment contributed the most to the combined daily exposure for infants and children ages 1 to <3. TCPP levels in the home environment generated the highest estimates of exposure for infants and children 1 to <3 years. For adults, exposure from air and dust TCEP concentrations in the office environment was the highest exposure. The many FR studies presented substantial information on exposure concentrations but the reliability of the assessments' conclusions is limited by the frequent lack of information on experimental design, collection methodologies, description of environments, and FR sources. These comments are those of the CPSC staff and have not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

T2-D.2 Paul, R; Minda de Gunzburg Center for European Studies Harvard/Law and Society Unit Bielefeld University; *regine.paul@uni-bielefeld.de*

Frontex risk analysis: a tool for integrated border management in Europe?

Scholars have recently highlighted the importance of Frontex risk analysis in the harmonization of border control - usually a stronghold of member state competency. This paper argues that, beyond securitizing migration and migrants (as argued in critical security studies), Frontex risk analysis can also be interpreted as an internally-oriented governance tool which helps the EU manage the institutional (rather than merely societal) risks associated with supranational border control decisions. We use empirical examples from Eurosur impact level assessment and resource allocation through the Internal Security Fund to illustrate (a) the extent to which border control in Europe is actually risk-based and (b) how a focus on risk-based differentiation in supranational decision-making might contribute to a more harmonized border risk assessment and management in Europe.

T3-E.2 Pinelis, J; Scouras, J; Slavinsky, I*; Johns Hopkins University Applied Physics Laboratory; *jane.pinelis@jhuapl.edu*

Does the Nuclear Balance Matter?

The importance of the nuclear balance vis-a-vis our principal adversary has been the subject of intense but unresolved debate in the international security community since the Soviet Union acquired nuclear weapons almost seven decades ago. Perspectives on this question underlie national security policies regarding potential unilateral reductions in strategic nuclear forces, the imbalance of nonstrategic nuclear weapons in Europe, nuclear crisis management, missile defenses, nuclear proliferation, and cross-domain and extended deterrence. The overwhelming majority of past studies of the role of the nuclear balance in nuclear crisis evolution and outcome have been qualitative and have focused on the relative importance of the nuclear balance and national resolve. Some recent analyses have invoked statistical methods, however, these quantitative studies have generated intense controversy because of concerns with analytic rigor. We apply a multi-disciplinary approach that combines historical case study, international relations theory, and appropriate statistical analysis. This approach results in defensible findings that describe the relationship between nuclear balance and nuclear crisis resolution.

M4-K.3 Pidgeon, NF*; Spence, E; Understanding Risk Research Group, Cardiff University; *pidgeonn@cardiff.ac.uk*

Risk Perceptions of Enhanced Weathering as a Biological Negative Emissions Option

This paper addresses risk perceptions and the social acceptability of enhanced weathering, a carbon dioxide reduction technology which would involve spreading silicate particles over terrestrial surfaces in order to boost the biological processes which currently sequester CO2 as part of the earth's natural carbon cycle. Carbon reduction technologies have gained in prominence following the Paris International Climate Agreement in 2015, which aspires to a global "balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases" (i.e. net-zero emissions) sometime between 2050 and 2100. The implication of this is that by then all remaining 'positive' fossil fuel emissions (e.g. from aviation, shipping, and other hard to decarbonise sectors) must be fully offset by operation of an equivalent set of 'negative' emission processes. We present the first exploration of British attitudes towards enhanced weathering as a biological negative emission option, using an online survey (n=935) of a representative quota sample of the public. Not surprisingly, baseline awareness of weathering was extremely low. When presented with a description many respondents remained undecided or neutral about risks, although more people support than oppose weathering. Factors predicting support for weathering and its research included feelings about the technology (affect) and trust in scientists. Over half of the sample agree that scientists should be able to conduct research into effectiveness and risks, but with conditions also placed upon how research is conducted; including the need for scientific independence, small-scale trials, strict monitoring, risk minimisation, and transparency of results. Public engagement is needed to explore in more detail risk and benefit perceptions for biological and other types of negative emissions technologies.

W1-G.2 Pinkston, KE; Ridge, AC*; US Nuclear Regulatory Commission; *karen.pinkston@nrc.gov*

Development and Implementation of a Risk-Informed Monitoring Program for the Saltstone Disposal Facility

The National Defense Authorization Act for 2005 (NDAA) requires the U.S. Nuclear Regulatory Commission (NRC) to monitor disposal of certain reprocessing waste that the U.S. Department of Energy (DOE) determines not to be high level waste (HLW). As part of this responsibility, the NRC staff monitors the disposal of salt waste at the Saltstone Disposal Facility (SDF) at the Savannah River Site (SRS). Salt waste at SRS is generated primarily from cleaning tanks used to store HLW from reprocessing spent nuclear fuel. The low-activity fraction removed from the tanks, called salt waste, is treated to reduce the concentrations of certain radionuclides and then solidified with dry grout to form saltstone. DOE evaluated the potential dose from the SDF by performing a performance assessment (PA) in 2005, a PA revision in 2009, and special analyses in 2013, 2014, and 2016. The NRC bases its monitoring plans on technical reviews of these DOE analyses, supporting documents, and other relevant literature on the risk significant processes. The NRC's monitoring strategy prioritizes specific targeted technical areas called monitoring factors based on risk significance. Because the risks are expected to occur many years (e.g., hundreds to thousands) in the future, monitoring is based on model projections and indirect evidence of system performance. Model projections are used to evaluate what parameters are driving the system and to focus monitoring on the most risk significant parameters. However, a change in the model design can result in a change to which parameters appear to drive system performance. Similarly, when the parameter values used in the models change, the amount of justification required for a given parameter might also change. This work describes the regulatory process of balancing monitoring resources based on the level of uncertainty in a parameter and its projected effect on system performance.

M2-C.1 Pluchinotta, I*; Giordano, R; Pagano, A; Tsoukias, A; University Paris Dauphine; *irene.pluchinotta@gmail.com*

An integrated approach for aiding collaborative decision-making: the flash flood emergency management in Lorca (Spain)

Over the last few years, a number of natural disasters have demonstrated the need for quick and effective responses, to minimize the number of deaths and injuries, as well as the financial cost associated with damage and losses. Response needs to be provided under the severe stress of crisis conditions, and requires effective coordination among several institutional and non-institutional actors. Enhancing the coordination effectiveness of different responders has been considered from multiple perspectives. Most of these studies suggested that involved agencies claimed for a fast though-smooth and well-structured distributed and collaborative decision-making process. Nevertheless, the implementation of collaborative decision-making approaches has received limited attention. This is mainly due to the existing gaps between the traditional emergency management methods characterized by centralization and hierarchy-based structures and the actual collaborative management process, characterized by non-hierarchical structure and flexibility. In order to address the above mentioned issues, a methodology based on the integration among the Storytelling approach (SA), Problem Structuring Methods (PSM) and Social Network Analysis (SNA) has been adopted. On one hand, this work aims at demonstrating that the integration between SA and PSM allows integrating the macro- and the micro-level in analysing and unravelling the complexity of the emergency management. On the other hand, this work evaluates the suitability of the PSM-SNA integrated modelling approach to create significant knowledge system to stakeholders, and support decision-making. The potential of the integrated approach has been investigated in the Lorca (Spain) flood risk management case study.

M2-H.2 Pohl, AM*; Gaveleck, AY; Spungen, JH; Pouillot, R; Van Doren, JM; US Food and Drug Administration; *aurelie.pohl@fda.hhs.gov*

Listeria incidence and exposure: Assessing the impacts of changing US population demographics and differing consumption patterns among groups at higher risk for listeriosis

Listeriosis is an important foodborne illness with incidence rates that vary significantly among US population subgroups with pregnant women, older adults, and the Hispanic population having increased relative risks. Using FoodNet data, we evaluated the predicted number of cases and incidence rates of listeriosis over time, as the proportions of elderly and Hispanic individuals increase. If the incidence rate per subpopulation is held constant, the overall US population listeriosis incidence rate would increase from 0.25 per 100,000 (95%CI: 0.19-0.34) in 2010, to 0.28 (95%CI: 0.22-0.38) in 2020 and 0.32 (95%CI: 0.25-0.43) in 2030, because of the expected changes in the population structure. Likewise, the pregnancy-associated incidence rate would increase from 4.0 per 100,000 pregnant women (95%CI: 2.5-6.5) in 2010, to 4.1 (95%CI: 2.6-6.7) in 2020 and 4.4 (95%CI: 2.7-7.2) in 2030 as the proportion of Hispanic pregnant women increases. An important question is why incidence rates differ between the Hispanic and non-Hispanic populations. One possible explanation is differing exposure due to consumption patterns among these groups. Data on consumption patterns among the higher and lower risk sub-populations was obtained from the National Health and Nutrition Examination Survey (NHANES) for the years 2003-2014 and compared for selected food categories that have been associated with listeriosis. Comparisons were made among the Hispanic and non-Hispanic subpopulations including pregnant and non-pregnant women of childbearing age (20-44 years). Consumption by older adults (60-69, 70-79 and 80+ years) was also compared with that of younger adults. A number of significant differences (p-value

M2-J.2 Poinsatte-Jones, K*; Trump, B; U.S. Army Corps of Engineers, Risk and Decision Sciences Focus Area; *kpoinsatte@gmail.com*

Overcoming Local Resistance to Proposed US Government Projects: A case study in dredging harbors

Industrial and government projects often generate negative feedback and potential resistance from local communities due to perceptions that such communities will experience negative side effects and externalities from the development and implementation of a proposed project. One example of this includes dredging and sediment management and disposal in US waterways for the benefit of shipping and water-based travel. However, such actions increase the potential for risk to affect humans and the local environment – something that many local communities perceive as an unnecessary and unacceptable risk that could be distributed elsewhere. In his plenary talk at the Society for Risk Analysis World Congress, Dr. José Palma-Oliveira attributed such public resistance to project development, and the potential for projects to slow in development and potentially even halt altogether, to failures in risk communication. This talk adapts Palma-Oliveira's perspective to the case of dredging and sediment management in the United States, and provides insight regarding (a) why failures in risk communication contribute to public distrust and resistance to sediment disposal on local lands, and (b) an understanding of how such risk communication efforts may be improved through direct engagement with local publics.

W3-I.1 Pouzou, JG*; Costard, S; Zagmutt, FJ; EpiX Analytics; *jpouzou@epixanalytics.com*

Comparative dietary exposure assessment of selected heterocyclic amines and polycyclic aromatic hydrocarbons through meat and bread consumption in the United States

Dietary exposure to two compound classes proposed as a link between meat consumption and colorectal cancer (CRC), polycyclic aromatic hydrocarbons (PAH) and heterocyclic amines (HCA), was quantified from average US meat and bread consumption. Studies reporting PAH or HCA content of cooked meats were identified via literature review. Results were pooled using linear mixed models/meta-regression to predict the concentration of two HCAs (PhIP,MeIQx), and PAH8 based on cooking methods, time, temperature, and other factors, whereas bread PAH8 was estimated empirically. Concentration models/predictors were selected using likelihood ratio tests ($p<0.05$). Concentrations were combined via Monte Carlo simulation with meat (beef, poultry, pork, seafood) or wheat bread consumption estimated from a US dietary survey (NHANES) to compare the mean daily consumption of PAH and HCA. Statistical significance of PAH or HCA consumption was considered when confidence in the PAH/HCA consumption being highest (PrHighest) was >95%. PAH8 concentration was not different among meats ($p=0.861$, beef: 3.7 ng/g, poultry: 1.1 ng/g, pork: 0.6 ng/g, and seafood: 0.4 ng/g), but was significantly impacted by cooking method ($p<0.001$), using open flame ($p<0.001$), and cooking time ($p<0.001$). Meat type and cooking method were significant to HCA concentration ($p<0.001$, pork: 4.6 ng/g, poultry: 4.3 ng/g, beef: 0.5 ng/g, and seafood: 0.02 ng/g). HCA or PAH dietary exposure was not significantly different among meats or bread. Within meat categories, only pan-frying significantly increased exposure to MeIQx in beef (6.5 ng/day, PrHighest: 99%) and poultry (12.7 ng/day, 97%). Although cooking methods affect PAH and HCA concentration, dietary exposure did not differ across meat or bread categories because of differences in consumption and cooking practices in the US. Our findings can be combined with epidemiological data to assess the consistency of evidence and comparative diet-associated risks of CRC.

P.61 Poyraz, OI; Keskin, OK*; Pinto, CA; Old Dominion University; *okesk001@odu.edu*

Annualized Loss of Revenue Caused by Cyber-attacks for Power Generation in Virginia Using Agent-Based Modeling

In 2016, the highest annualized cost of cyber-crime to a commercial company was $74M, and the average annualized cost of cyber attacks to utilities and energy industry was $14.80M. The cost of cyber-crime has been increasing as frequency and sophistication of cyber-attacks increase. On the other hand, organizations invest more in cyber security and cyber insurance to prevent from loss of confidential information, business disruption, loss of revenue, and even loss of hardware. If state sponsored or non-state sponsored attackers decide to infiltrate an organization network to make an impact, with enough resources and dedication, they can eventually accomplish this malicious goal through different intrusion methods such as social engineering and Trojan. If these compromises occur in the critical infrastructure sector, this may lead the nation into chaos for a while. Some examples of this are the attacks in Estonia (2007), Georgia (2008), and Ukraine (2015). The motivation of this study is to illustrate the potential cost of cyber-crime and give a ballpark idea to evaluate the risk. Critical infrastructure decision-makers need to gauge whether the cyber investment or insurance is a necessity for the organization. In this study, we conducted a Monte Carlo Simulation and computed the average annual loss of revenue using Agent Based Modeling. In the model, we included current power generation entities of the Commonwealth of Virginia and represented the model on a map using Geographical Information Systems. We also included the loss caused by business disruption, hardware-software, and cyber-security monitoring cost in order to calculate the total annualized average loss from cyber incidents. The input parameters of the simulation are detection time, recovery time, and unit price of the electricity. We conducted the simulation by utilizing the real data from Energy Information Administration and industry surveys of Ponemon Institute.

T4-H.1 Pradhan, AK; University of Maryland, College Park; *akp@umd.edu*

Innovative supply chain and system modeling approaches for pathogenic bacteria in leafy greens

Leafy greens are highly susceptible to microbial contamination as they are minimally processed. In addition to the microbial safety concern from pathogenic bacteria such as Escherichia coli O157:H7, Salmonella spp., and Listeria monocytogenes, leafy greens have quality issues as those are of highly perishable commodity. By using a nonlinear programming (NLP) approach, a model was developed to optimize the maximum temperature for leafy greens during the supply chain. Furthermore, to understand the pathway of E. coli O157:H7 in leafy greens production, an innovative system model simulating a hypothetical farm was developed. The model for quality and microbial safety includes the cost of refrigeration, sensory quality parameters (i.e., fresh appearance, wilting, browning, and off-odor), and microbial safety. For this modeling effort, an interactive graphical user interface was developed. The system model consists of subsystems (soil and plant), inputs to the system model that affect the subsystems (irrigation, cattle, wild pig, and rainfall), harvested crop as the output of the system, and contamination in the soil at the time of harvest as the feedback, i.e., it would affect the soil conditions for the next crop. Results indicate that pathogen growth is of more concern than loss of sensory quality in fresh-cut Iceberg lettuce when considering a shelf-life of up to two days. Results from the system model indicate that the seasonality of E. coli O157:H7 associated leafy greens outbreaks was in good agreement with the prevalence of this pathogen in cattle and wild pig feces. The developed models have their significance in predicting the optimized storage temperature in the supply chain of leafy greens and in providing a better understanding of the seasonality in E. coli O157:H7 outbreaks associated with leafy greens.

T3-I.1 Price, PS*; Glen, WG; Hubbard, HF; Isaacs, KK; Dionisio, KL; US Environmental Protection Agency; *Price.PaulS@EPA.gov*

Developing a rich definition of the person/residence to support person-oriented models of consumer product usage

Person Oriented Models (POMs) provide a basis for simulating aggregate chemical exposures in a population over time (Price and Chaisson, 2005). POMs assign characteristics to simulated individuals that are used to determine the individual's probability of interacting with each of multiple sources of exposure and their resulting doses. The characteristics need to be internally consistent (e.g., physiology and exposure-related behaviors are consistent with the age and gender of the individual). We have developed software, the Residence Person Generator (RPGen), to create populations of simulated individuals with 90 characteristics. The interindividual variation in these characteristics are consistent with interindividual variation in the general U.S. population. Individuals are created by sampling data from four national surveys: Public Use Microdata Survey, National Health and Nutrition Examination Survey, American Housing Survey, and the Residential Energy Consumption Survey. The characteristics include: demographic information (e.g., age, gender, and ethnicity); physiology (e.g., weight, height, surface area, blood flows, and tissue compartment volumes); family structure (e.g., ages and genders of others living in the residence); and residential characteristics (e.g., household income, type and size of residence, and presence of a garden, lawn, or pool). RPGen is part of the Human Exposure Model, a POM to characterize aggregate chemical exposures from the use of consumer products. The characteristics are used to determine the likelihood that a person will use a product (e.g., only adults with a young child use a baby shampoo to wash the baby, and only individuals in homes with yards use a lawn fertilizer) and as inputs to exposure scenarios (e.g. body weight, breathing rates, and skin surface areas). Price, P. S. and Chaisson, C. F. 2005. A conceptual framework for modeling aggregate and cumulative exposures to chemicals. JESEE, 15(6), 473-481.

W4-F.5 Rachunok, BA*; Nateghi, R; Purdue University; *brachuno@purdue.edu*

Homogeneous-Use Infrastructure Modeling

We rely increasingly on infrastructure to improve and advance our society. This reliance becomes no more apparent than when infrastructure is exposed to catastrophe and fails. The inability to mitigate extreme events which threaten our infrastructure emphasizes the need to develop infrastructure models and methods of analysis which can support decision making in the planning, development, and maintenance of infrastructure systems. Additionally, infrastructure systems are becoming interdependent, ie power infrastructure relies heavily on internet connectivity. This interdependence increases the complexity of infrastructure analysis and is a key field of study. In this work, we introduce a novel framework for the modeling of infrastructure in which use-case is considered and isolated. Homogeneous-use infrastructure modeling is described as a conceptual framework and its performance relative to other infrastructure modeling approaches is reviewed.

M2-J.1 Raimi, KT; Wolske, KS; Hart, PS; Campbell-Arvai, V*; University of Michigan and University of Chicago; *kraimi@umich.edu*

Who is Afraid of Tampering with Nature? Individual Differences in (Dis)comfort with Altering the Natural World

People differ in their comfort with tampering with the natural world. While some see alterations to the natural environment as a sign of human ingenuity and progress, others see them as dangerous and even a sign of hubris. This can sometimes lead to puzzling situations in which people who are concerned about environmental risks (such as those caused by climate change) are also resistant to approaches that might ameliorate those risks (such as carbon dioxide removal technologies). To explore this phenomenon, we developed the Tampering with Nature (TWN) Scale to measure individual differences in people's discomfort with tampering with nature. Across four samples of American adults, we demonstrate that fear about tampering with nature is a distinct construct, but one that is related to moral and religious values, environmental concern, and trust in technology and science. Unlike most measures of environmental concern, the TWN is only weakly related (if at all) to political ideology. Furthermore, the TWN predicts opposition to a wide range of nature-altering activities in the environmental and medical domains—from GMOs to gene therapy—including actual donations to anti-tampering causes. By shedding light on who is afraid of tampering with nature and the beliefs that correspond with this discomfort, the TWN provides opportunities for researchers and practitioners to better understand public opposition to technological innovations, predict consumer preferences for "natural" products, and refine strategies for science communication.

T4-H.4 Rainwater, CR*; Pohl, EP; Enayaty, FE; University of Arkansas; *cer@uark.edu*

Risk-Driven Decision-Making Towards Food Protection in China: Quantitative Tools and Analysis

This work offers insights into the application of quantitative risk methods towards the poultry supply chain in China. An overview of the features and considerations unique to poultry production in China is discussed. Using data collected from multiple companies and academic institutions throughout China, risk analysis associated with Salmonella contamination is presented. Insights into opportunities for Salmonella reduction are discussed and a framework for a dynamic risk assessment approach is offered.

P.166 Rak, A*; Vogel, CM; Bandolin, N; Noblis and US Army Public Health Center; *andrew.rak@noblis.org*

Hazard Assessment of Ethylbenzene for Potential Impacts to National Defense

The Department of Defense's (DoD's) Chemical and Material Risk Management (CMRM) Program has a well-established three-tiered process for over-the-horizon scanning for Emerging Contaminants, conducting qualitative and quantitative impact assessments in critical functional areas, and developing sound risk management options. This "Scan-Watch-Action" process was used to examine potentials risks from potential increased regulation of ethylbenzene under the Toxic Substances Control Act (TSCA), the Environmental Protection Agency's Integrated Risk Information (IRIS) Program, and the European Union Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) regulation. Subject matter experts (SMEs) from throughout the DoD used the Emerging Contaminants Assessment System (ECAS) tool to evaluate the potential risks to DoD associated with these two mission critical chemicals. Members of the CMRM Program team used the Impact Assessment Criteria Assessment Tool (ICAT) to analyze SME input. Together, these two groups developed a set of initial risk management options (RMOs) to be considered within the DoD. The risks identified by the SMEs and the potential RMOs for each chemical are presented for each of five different functional areas. The uncertainties in the SME's risk estimates are also discussed and recommendations for further analysis are presented. The assessment concluded that increased regulation of ethylbenzene poses moderate or high risk to three DoD functional areas: Acquisition/Research, Development, Testing, and Evaluation; Site Cleanup; and Environment, Safety, and Health. Risk management actions are required to develop safer alternatives that meet military performance requirements. The CMRM Program will continue monitoring of regulatory and scientific development with a specific focus on potential changes under TSCA Section 6 and the IRIS Program.

T4-D.1 Rak, A*; Underwood, PM; Shatkin, JA; Ede, J; Noblis and Office of the Assistant Secretary of Defense (Energy, Installations, and Environment); *andrew.rak@noblis.org*

A DOD Framework for Examining Possible Health and Environmental Impacts Of Nanomaterials for Use in Weapon Systems

Emerging applications of nanotechnology in the DoD are leading to improved technologies that bring significant advances in capability to the warfighter. However, the improved properties introduced by engineered nanomaterials (ENMs) are not without caveat and risks associated with human and environmental exposure that should be considered during development of technologies enabled by ENMs. This presentation will discuss recent organizational guidance that encourages identification and collection of information needed to understand the environmental and human-health hazards of ENMs. The guidance describes a four step approach to collecting data that is tied to the existing DoD System Acquisition Process. Collection of chemical, physical, and toxicological data occurs in parallel with DoD's overall systems' performance evaluation process. The objective for collecting these data is to inform tradeoff, design, supportability, and sustainability decisions to improve overall environmental safety and occupational health aspects of weapons system throughout the system's lifecycle. Collection of chemical, physical, and toxicological data on ENMs will enable Program Managers to make informed programmatic decisions regarding risk management measures for handling, use, maintenance, repair, update and disposal throughout a system's life cycle while ensuring the health of the warfighter, minimizing costs, and maintaining system schedules.

P.64 Ramchandran, V*; Gernand, JM; Penn State University; *vzr124@psu.edu*

A Novel Clustering Analysis for the Examination of Metal Oxide Pulmonary Toxicity in Rodents

A quantitative, analytical relationship between the characteristics of emerging nanomaterials and related toxicity is desired to better assist in the subsequent mitigation of toxicity by design. Experimental toxicology studies are accompanied by drawbacks relating to time and cost which can be overcome or limited by the development of computational approaches. Quantitative structure activity relationships (QSAR's) and meta-analyses are popular methods used to develop predictive toxicity models. A meta-analysis for investigating the dose-response and recovery relationship in metal oxide (MO) pulmonary toxicity studies on rodents was performed using a novel clustering approach. The primary objective of the clustering is to categorize groups of similarly behaving MOs (similar dose-response-recovery relationship) leading to the identification of any physicochemical differences between the various clusters and evaluate their contributions to toxicity. The studies are grouped together based on their similarity of dose-response-recovery, the algorithm uses a combination of genetic algorithms and robust hierarchical clustering to categorize the different MO particles. The algorithm uses the Akaike information criterion (AIC) as the performance metric to ensure there is no overfitting. Differences in the toxicity of the clusters can be explained by their respective potency and correlated to variations between the attributes of the clusters. The results from the clustering analysis of MO particles (for 5 response variables) revealed that there are at least 6 toxicologically distinct groups present among the MOs on the basis of similarity of dose-response. Analysis of the attributes of the clusters reveals that they also differ on the basis of their length, diameter and chemical composition. The MO particles with short lengths and small diameters were found to be more potent than the other MO's analyzed.

T3-G.2 Ramsey, BA*; Wilson, JM; Smith, KL; Norton, RA; Desert Research Institute, UNR and Auburn University; *beverly.ramsey@dri.edu*

An Argument and Methods for Integrated Risk Assessment for Decision Support

A continuing problem in assessing risk and providing decision support to policy makers and to preparedness managers is the historical stove piping of risk analysis. For example, in developing the guidelines for ecological risk assessment, EPA has focused on indicator species or population effects of a chemical or contaminants. However, research has consistently demonstrated that environmental risk is best assessed by addressing the hierarchical levels of ecosystem organization, providing estimate/predictions of risk to ecosystems, to ecological communities as well as specific populations/species. We believe it is essential to provide a non-partisan dialogue of scientists and evidenced based methodology in order to improve our estimation of risk to water and to food from Anthropocene events. Examples include the increased stress on public health in Haiti following the recent natural disaster by introduction of relief workers carrying disease. The global community has struggled with infectious disease crisis warning and associated risk assessments- particularly those associated with health security implications. Uncertainty in the global enterprise to provide effective early warning and assess risk has resulted in imbalanced communication to funders and most importantly, the public. This inability to place risk in context and apply balance in communication with stakeholders has challenged the credibility of the entire global public health and biodefense enterprise. This, in turn, has contributed to shortfalls in sponsor support of public health, as evidenced in the recent West Africa Ebola and Zika response efforts. In this paper, we present approaches for better estimation of risks from multiple sources and from cascading natural and man-induced events which would result in better forecasting and therefore meaningful interventions in infectious disease and agroterrorism risks.

P.113 Rani, S*; Dubey, JP; Pradhan, AK; University of Maryland and USDA Animal Research Services; *sur1404rani@gmail.com*

Assessing food safety risk of Toxoplasma gondii in muscle tissues of naturally infected meat animals in the United States.

Toxoplasma gondii is a protozoan parasite that infects virtually all warm-blooded animals including humans, livestock and marine mammals. Various surveys have found that 10–50% of the adult population has been exposed to this parasite. T. gondii infection causes mental retardation, loss of vision and other congenital health problems in human infants. Toxoplasmosis is an important cause of morbidity and mortality in immunosuppressed individuals and can cause serious health problems in healthy adults. Annually, approximately 1 million people in the USA are infected with T. gondii, and over 4,800 people develop symptomatic ocular disease. There are no quantitative data pertaining to concentration of viable T. gondii in naturally infected meat animals. The goal of this study is to quantify T. gondii concentration in muscle tissues of naturally infected lambs and goats. The muscle tissues of 4 lamb and 4 goat legs along with their hearts were serologically tested for T. gondii antibodies and then bio-assayed in mice in different amounts, 5 g, 10 g and 50 g to observe its infection rate. Results suggested that T. gondii DNA was detected by PCR more consistently, but not correlated with the presence of viable T. gondii in muscle tissues. This study indicated that the parasite can be present in naturally infected meat animals and could pose threat of foodborne illness to consumers.

P.28 Rao, V*; Francis, R; Tanir, J; The George Washington University, Human and Environmental Sciences Institute; *vrao81@gwu.edu*

Assessing consumer product manufacturers' tradeoffs among design criteria in chemical substitution decisions

Many chemical manufacturers are embracing alternatives assessment to identify alternative chemicals in consumer and/or specialty products that are safer and more environmentally friendly than chemicals of concern identified in emerging regulations. For example, California has established a Green Chemistry Initiative and has enacted regulation to improve evaluation of chemicals, raise transparency to end users, and require substitution of priority chemicals of concern. Thus, it is important to understand tradeoffs made by chemical and product manufacturers and designers with regards to final product design and re-design decisions. The objective of this research is to characterize tradeoffs among six factors affecting product design: Business Strategy, Economic Considerations, Functionality and Performance, Health and Environmental Endpoints, Public Perception, and Regulatory Factors. These factors were further disaggregated into 33 attributes distributed across the six factors. We assessed tradeoff weights for each factor and the degree of influence of the specified attributes on a recent product design or re-design by administering a survey to consumer or specialty product manufacturers. Our results indicate the most highly weighted factors are Economic Considerations, Functionality and Performance, and Health/Environmental Endpoints. The most important attributes are Product Price, Product Performance, Meets Desired Specifications, Company Reputation, and Meets Regulatory Standards. Although health/environmental endpoints are one of the three most important decision factors, our results suggest consideration of this decision factor must be situated in the broader economic context faced by product manufacturers.

T2-D.3 Rath, B*; Myles, P; The Vienna Vaccine Safety initiative and The University of Nottingham; *barbara.rath@vi-vi.org*

Evacuation following a natural disaster versus migration to escape armed conflict - what may be the impact on children and young adults?

Background Displacement and migration of children and young adults (CYA) have been on the rise. Migration and displacement may be triggered by war and civil unrest or natural disasters. Little is known about the psychosocial impact of different types of migration from the viewpoint of the CYA and their families. Methods We accessed data from two cross-sectional surveys: the first was administered to a convenience sample of 1,133 children and young adults (CYA) aged 0-24 years and/or their parents/guardians, attending healthcare facilities post Hurricane Katrina in the metropolitan New Orleans area from 1 October to 31 December 2005. The second was administered to a convenience sample of 405 CYA (0-24 years) and/or their parents/guardians, seeking asylum in Germany while they waited for registration at the Regional Office for Health and Social Welfare (LaGeSo) in Berlin, Germany between 7 October 2015 and 15 March 2016. Both surveys used an identical survey instrument and included questions on general health as well as questions from a validated psychological questionnaire adapted from the National Child Traumatic Stress Network (NCTSN). Results CYA arriving in Berlin as refugees were significantly more likely to have experienced traumatic injury (unadjusted OR 50.01 (95% CI) 21.68- 115.35); p

M2-D.3 Redinger, CF; The Institute for Advanced Risk Management; *cfr@redinger360.com*

Manifesting Quality Management and CQI in Environmental, Health and Safety: ISO's Approach

Quality management (QM) has a rich and important history. It has made significant impacts in improving organizational performance. Continuous quality improvement (CQI) is an approach to QM that has evolved from traditional quality assurance methods. The International Organization for Standardization (ISO) jumped into this arena in 1987 with a quality assurance standard called ISO 9001; this standard reflects traditional QM and CQI principles. In the 1990s there was a proliferation of ISO-based standards related to environmental, and occupational health and safety (OHS) management. This presentation will provide a brief historical background, and then focus on: how ISO processes currently (2017) manifest and are executed in organizations, related to environmental and OHS management; and, how ISO frameworks integrate with regulatory requirements. Topics addressed include: the effectiveness of ISO/CQI approaches; temporality and double-loop learning, ISO/CQI's impact on mental models and culture; and, ISO's approach as a robust risk management platform.

P.6 Redinger, CF; The Institute for Advanced Risk Management; *cfr@redinger360.com*

Awareness-Based Risk Management: Seeing, Transforming, and Unleashing Organizational Capacity

Risk management is a lens through which organizational values and culture lay bare, and through which they can be transformed. Awareness-Based Risk Management (ABRM) provides a way to transform an organization's risk management function – it generates a shift in context from compliance and status quo – whereby risk awareness increases, along with organizational energy, vitality, creativity, and resilience. The risk function is not only stronger, but also impacts the culture – where there is a higher sense of purpose and alignment with organizational vision and mission. ABRM is not value-neutral. It advocates a view that – the aspiration to improve human, community, environmental and global health and well-being is universal, and the capacity to do so is latent in most systems. ABRM suggests a way to unleash this latent capacity. A key component of ABRM is reframing the "objectives" and "uncertainty" concepts stated in ISO's definition of risk – in terms of "what matters and is important" and "paradox". This reframing and shift-in-thinking increases engagement – it fundamentally shifts the relationship to risk, for individuals and teams. This poster presents: a risk management maturity continuum; ABRM's seven dimensions; an organizational risk-awareness measurement scheme; and several case examples.

M3-F.3 Reilly, AR*; Tonn, G; Ghaedi, H; Guikema, SD; University of Maryland; *areilly2@umd.edu*

Seismic Changes for Financing the FEMA Public Assistance Program but Seismic Changes for Regional Risk?

FEMA recently proposed deductible-based approach for its Public Assistance (PA) Program, which could produce a seismic shift in how disaster recovery is financed and in the risk landscape for many communities. The PA Program is responsible for financing debris removal and repair of critical public infrastructure following presidentially-declared disasters. The new rule would shift away from a 25% cost-share for states to a system whereby states must first contribute a level of funding equal to that of their deductible. States would be encouraged to engage in pre-disaster planning and mitigation by targeted deductible reductions. This talk will review the proposed rule, and its implications for FEMA, states, and the hazard environment.

T2-I.1 Reiss, R*; Loccisano, A; Whatling, P; Wang, W; Exponent (1,2), FMC Corporation (3,4); *rreiss@exponent.com*

Rat and human PBPK model for malathion: application for risk assessment

Malathion is an effective organophosphorus insecticides and has been used on the market for decades. one of the most widely used insecticides in the United States and-It is currently under reregistration review at the U.S. Environmental Protection Agency (EPA). In recent years, physiologically based pharmacokinetic/pharmacodynamic (PBPK/PD) modeling has been established as a scientifically sound tool for predicting internal exposure and the new approach has been well-received by EPA for estimating the uncertainty in human health risk assessment. The PBPK/PD models have been used to develop chemical-specific uncertainty factors for interspecies extrapolation and intraspecies variability. This paper describes the development of rat and human PBPK/PD models for malathion for acetylcholinesterase inhibition, the most sensitive toxicological endpoint for malathion. Data of the chemical, physiological and biochemical properties are available for developing the models. In addition, anAn in vitro testing program was has been undertaken to develop kinetic constants for malathion activation to its active toxicity moiety malaoxon, detoxication of malathion and malaoxon, and inhibition of acetylcholinesterase. The detailed architecture of the PBPK/PD model will be described, including the malathion/malaoxon metabolism scheme, principally through carboxylesterase, and inhibition, reactivation, and aging of acetylcholinesterase and butrylcholinesterase. The model can estimate acetylcholinesterase inhibition for oral and dermal exposures for malathion and oral exposures for malaoxon. The presentation will describe the use of the PBPK/PD models to estimate chemical specific uncertainty factors for pharmacokinetics and pharmacodynamics between rats and humans and within the human population.

W4-G.5 Renn, O.R.*; Jaeger, C.; Lucas, K.; Institute for Advanced Sustainability Studies (IASS); *ortwin.renn@iass-potsdam.de*

Dealing with complexity and connectivity: the challenge of systemix risks

ABSTRACT The history of the last four decades has been a success story in terms of conventional risk management. All data show that life expectancy is increasing, accidents become less frequent and habitual risks less severe. The picture becomes, however, less favorable if we look at globally interconnected, non-linear risks such as those posed, for example, by climate change or the global financial system and the closely related growing inequality between rich and poor. Systemic risks can be characterized by four major properties: they are (1) global in nature, (2) highly interconnected and intertwined leading to complex causal structures, (3) non-linear in the cause-effect relationships and (4) stochastic in their effect structure. The main features of systemic risks include ripple effects beyond the domain in which the risks originally appear and the threat of a multiple breakdown of important or critical services to society. The main problem is that it is often difficult to predict when a system will suffer a breakdown or collapse. Governance of systemic risks require strategies that address the complexity, scientific uncertainty and socio-political ambiguity of its underlying relationships. However, national as well as international attempts to address systemic risks have decoupled risk anticipation from sustainable and resilient risk management processes and structures. Public participation has proven to be an important part and often key driver for successful and legitimate risk governance for advancing effective policies to curb systemic risks. In the end risk management and communication needs to address the four characteristics of systemic risks and develop the appropriate instruments to deal with global, interconnected, stochastic and non-linear risks.

M3-A.1 Rennert, KJ*; Wichman, C; Resources for the Future; *rennert@rff.org*

An assessment of opportunities to improve the climate damage functions in the DICE, FUND, and PAGE integrated assessment models.

Resources for the Future is leading a multi-institution initiative to address the full set of near-term recommendations of the National Academies of Sciences (NAS) and provide a comprehensive update of the social cost of carbon estimation process. This broad effort will incorporate advances throughout the components of the social cost of carbon estimation process -- socioeconomic projections, climate system modeling, climate damage estimation, and discounting – and generate an updated estimate of the social cost of carbon along with associated uncertainty. A key aspect of the comprehensive update will be the evaluation of the existing set of model damage components, removal those components without clear empirical basis or articulated expert rationale, and the updating of the remaining set of damage components to be consistent with the current state of the peer-reviewed literature on climate damages. In this presentation we highlight results from a detailed review of the existing set of damage functions employed by the integrated assessment models employed by the Interagency Working Group on the Social Cost of Carbon (DICE, FUND, PAGE), focused on the underlying studies, calibration protocols, and uncertainty quantification, and discuss the development of scientific and transparency criteria for evaluating damage functions and their underlying studies that are consistent with the recommendations from the NAS report. We provide specific focus on three sectors for which the current state of the literature offers clear opportunities for updating the existing set of damage functions – energy usage, human health, and agriculture.

W3-C.2 Resurreccion, JZ*; Blanco, AB; Santos, JR; Bangate, JM; University of the Philippines-Diliman; The George Washington University; *joannazr@gwu.edu*

Integrating Geospatial Information in Network Modeling for Prepositioning Supplies under Extreme-event Conditions

In the most disaster-prone countries such as the Philippines, extreme-weather events including typhoons bring devastation to infrastructure and disruption to various industrial, agricultural and service sectors of an economic region. Moreover, these events place the health and safety of affected communities, particularly in rural areas, at greater risk. With intensified threats of climate change, there is a rising complexity in mitigating this risk. Furthermore, stringent response time requirements become primarily inherent in the early stages of today's disaster relief operations. Consequently, pre-positioning of supplies has been found to largely contribute in the mitigation of disaster consequences by reducing response time, casualties and operational costs. In this regard, this research explores the utilization of flood hazard map information in network analysis for pre-positioning relief supplies under potential destruction of pre-positioned supplies and capacitated-supply points. A model is developed to integrate the spatial dimension in evaluating the associated vulnerability of supply point based on local path flood susceptibility. The research will demonstrate the method through an adaptation of the Light Detection and Ranging or LIDAR-based 3D flood hazard map data developed by the Philippine government agencies in collaboration with various research institutions to derive path flood susceptibility. Start times of pre-positioning activities and restocking requirements are derived based on the typhoon return period classification and size of exposed population. The model determines the supply points to preposition supply to, preposition quantity and corresponding path options. The resulting model will have flexibility and scalability over flood hazard maps of different return periods and different regions.

P.149 Rickard, LN; Kumara, SMSP*; University of Maine; *laura.rickard@maine.edu*

The effect of gain vs. loss message framing and spatial distance on influencing support for aquaculture among U.S. seafood consumers

In response to declining wild fisheries and increasing global seafood demand, aquaculture – the breeding, rearing, and harvesting of animals or plants in water environments – has emerged as one of the fastest growing food production sectors, currently contributing over 50% of the world's seafood. Yet, farming seafood is not without drawbacks, and attention to possible environmental and human health risks has amplified risk perceptions, especially among U.S. and European audiences, and rendered some policies controversial. In this study, we examine whether support for aquaculture may be influenced by communication about its benefits, including environmental sustainability and job creation. Specifically, we investigate the impact of gain versus loss framing (i.e., highlighting the advantages of adopting or disadvantages of not adopting) and spatial distance (i.e., the location in which aquaculture occurs, from the perspective of the message recipient) as two variables that may influence support for aquaculture policies and products. Using a nationally representative sample of U.S. residents collected by GfK in January 2017 (N = 1210), we report on a messaging experiment utilizing a 2 (gain vs. loss) x 2 (near – U.S. vs. far – China) between-subjects, experimental design, with a no-message control group designed to explore the main and interactional effects of message treatment on support for aquaculture. Four simulated newspaper messages are used to highlight the gains of implementing or losses of failing to implement aquaculture, in the context of the U.S. or China. We explore the possible mediating effect of perceived benefit (versus risk) of aquaculture, as well as the potential moderating variables of source credibility, political ideology, subjective and objective (i.e., fact-based) knowledge about aquaculture, and level of seafood consumption. Theoretical implications for strategic risk communication messaging, as well as applied insights for aquaculture industry and government stakeholders, will be presented.

M2-J.5 Rickard, LN*; Noblet, CL; University of Maine; *laura.rickard@maine.edu*

Frankenfood or farm fresh? Measuring support for aquaculture among U.S. consumers

More than 50% of seafood produced globally for human consumption comes from aquaculture – the breeding, rearing, and harvesting of animals or plants in water environments – and this percentage is rising. Aquaculture supporters point to many potential benefits of this production technology, including reducing pressure on wild fisheries, enabling more efficient production, and creating jobs. In the U.S., advocates promote aquaculture expansion as a way to reduce the seafood trade deficit. Yet, in recent years, aquaculture has lacked widespread support, and even generated amplified risk perceptions in some U.S. communities for various reasons, which might include:(1) highly publicized environmental and human-health related risk events, such as contaminated products; (2) generally low levels of knowledge about products or processes; (3) uncertainty about regulation and lack of trust in officials; and (4) the use of "dreaded" technologies, such as genetic modification (GM). In this study – the first of our knowledge to examine a representative U.S. sample on this issue – we explore the factors leading individuals to view aquaculture as "frankenfood" or "farm fresh" – that is, what predicts acceptance of aquaculture, and how might these variables differ from those previously shown to influence acceptance of other "novel" food technologies, such as GM food? We report on the results of an online survey administered by GfK in January 2017 (N = 1210). Using hierarchical regression, we explore the relative contribution of variables previously shown in the risk perception and communication literatures to predict support for food technologies, including: perceived risk and benefit; source credibility; awareness and knowledge; attributes of the technology (e.g., perceived controllability); trust in science; and demographic and sociocultural variables (e.g., age, sex, U.S. region, environmental values). Implications for risk communication theory and practice – specifically, with respect to the U.S. aquaculture industry – will be presented.

P.94 Ries, D*; Durant, K; Sorrentino, C; Interstate Technology and Regulatory Council, ; state government; *riesd@michigan.gov*

State-of-the Art Consensus on how to Evaluate Bioavailability in Contaminated Soil: Guidance from ITRC

State-of-the Art Consensus on how to Evaluate Bioavailability in Contaminated Soil: Guidance from ITRC Divinia Ries (Michigan Department of Environmental Quality), Kathryn Durant (Department of Natural Resources & Environmental Control, New Castle, DE), Claudio Sorrentino (Department of Toxic Substances Control, Sacramento, CA), and Interstate Technology and Regulatory Council (ITRC) The Bioavailability in Contaminated Soil (BCS) guidance from the Interstate Technology and Regulatory Council focuses on lead, arsenic, and polycyclic aromatic hydrocarbons (PAHs). It is a consensus-based, easy-to-read, web-based document that represents the shared knowledge of representatives from state and federal regulatory agencies, the private sector, academia, and tribal and public stakeholders. It aims to provide detailed information on available bioavailability and bioaccessibility methods, including what the risk assessment practitioner should consider to make informed decisions for a specific site. The BCS guidance includes case studies that present how bioavailability of lead, arsenic and PAHs have been evaluated at sites. It also discusses the challenges, how these challenges were overcome, and the lessons learned. In vivo bioavailability methods provide insights into site-specific bioavailability; however, the high cost and duration of in vivo studies severely limit their applicability to a small number of large contamination sites, and requires considerable resources and long timeline. In the past few years, various groups have developed in vitro methods to measure bioaccessibility as a surrogate for bioavailability. These in vitro methods are available for arsenic (As) and lead (Pb) and their relatively low cost and short turnaround time allow for the inclusion of site-specific bioavailability considerations for many small or low contamination sites. This new guidance will provide regulators, stakeholders, and practitioners with the tools they need to make informed decisions.

T2-E.2 Ripberger, JT*; Gupta, K; Jenkins-Smith, H; Silva , C; University of Oklahoma; *kuhikagupta@ou.edu*

Emotion and Individual Reasoning About Exclusively Negative Risks: Public Responses to a Military Crisis between the U.S. and North Korea

A considerable body of scholarship shows that individuals rely on the affect heuristic (positive/negative feelings) when formulating perceptions and making decisions that involve risk. This is especially true when risks involve a combination of positive attributes that evoke "good" feelings, and negative attributes that evoke "bad" feelings. In these situations, positive and negative "gut" reactions provide discriminant information about the risk. The affect heuristic is less discriminate when risks are exclusively negative (all feelings are bad). Here, a small but growing body of scholarship indicates that people draw on more specific types of negative emotion, such as fear, anger, and/or sadness when formulating perceptions and making decisions about risk. We contribute to this growth by addressing three questions: (1) Do people experience different negative emotions in response to the same situations? (2) If so, why? What factors orient the negative emotions that people experience? (3) What are the policy consequences of these differences? Do different emotions promote different opinions about how the government should address/respond to a given risk? We address these questions by analyzing responses to an experiment on a recent survey of U.S. adults (n = 3,000) that involves a military crisis between the United States and North Korea. Results indicate (1) significant variation in the negative emotions that respondents experience; (2) that factors such as gender, culture, and ideology systematically orient the negative emotions that people experience; and (3) that emotions strongly influence respondent opinions about how the U.S. government should act in response to the military crisis.

M4-D.4 Ritterson, R; Gryphon Scientific, LLC;
rritterson@gryphonscientific.com
Communicating Risk Assessments for Policymaking
Communicating the results of risk assessments requires care and consideration of the audience, and risk assessment for policymaking is no exception. For example, the statutes from which oversight and policymaking authority is granted often require tailoring the results of risk assessments to specific policy questions, or a focus on specific risks, to ensure actionable polices can be developed from an assessment. How the results are conveyed is also key, as for example, the comparison of the risk of everyday activities to increased risks of cancer due to radiological threats may inadvertently cause the audience to focus on the perceived danger of the everyday activity, instead of the risk of the threat. Drawing from Gryphon Scientific's more than a decade of experience conducting risk assessments for policymaking in areas such as chemical, biological, radiological and nuclear (CBRN) defense, pandemic preparedness, emerging technologies, and other global catastrophic risks, we'll present stories of lessons learned from conducting risk assessments for policymaking.

P.108 Rosenstein, AB*; French-McCay, D; Rowe, J; Author 1: Lexington Environmental Risk Group, LLC, Lexington, MA. Authors 2 and 3: RPS/ASA, South Kingstown, RI;
envriskexpabr@aol.com
Air Quality Concerns Following Ocean Oil Spills
Decision-making during oil spill emergency responses should take into account all exposure pathways for workers and communities, in particular, air exposures. Workers can be exposed to contaminated air following a spill while working on oil rigs, boats, or during beach cleanups. Communities have the potential for air exposures, especially if the spill occurs close to shore. However, air quality data following oil spills are often lacking. In addition, although there are some published guidelines for "air events" such as wildfires, there are no published guidelines specifically for practitioners who need to make quick decisions on worker or community health related to air exposures following an ocean oil spill. Oil spills emit volatile organic compounds (VOCs), including highly volatile, intermediate volatile and semi volatile organic compounds, which result in increased oxidant (e.g. organic hydrogen radicals and ozone) and secondary organic aerosol production from oxidation products. Since air exposures will vary considerably by spill location and oil type, oil spills may be categorized to predict the levels and composition of atmospheric exposures. We will present our proposed "decision tool," based on (1) modeling of air emissions following oil spills, and (2) available air quality guidelines, including a discussion of petroleum-related compounds without published guidelines. Variables that may be components of the air exposure decision tool include: location of spill (e.g. shallow or deep water, distance from shore); size of the spill (e.g. large, medium, small); and type of oil spilled (e.g. crude oil, condensate, diesel, heavy fuel oil). Risk analysts have an important role in the emergency response decision-making context; this proposed decision tool, based on air emissions modeling and a thorough review of air quality guidelines, will be a proactive, health-protective step that practitioners could use in the immediate aftermath of an oil spill.

P.133 Rose, KM*; Scheufele, DA; Brossard, D; Xenos, MA; University of Wisconsin-Madison; *kmrose@wisc.edu*
Engaging with human gene editing: public views toward decision-making about controversial scientific issues
The rise of low cost, efficient gene editing technologies (e.g., CRISPR/Cas9) has given new urgency to calls for public dialogue about the potential technical and societal risks surrounding human gene editing. In fact, many issues raised by such technologies do not have exclusively scientific answers but require broader societal debates about the moral, political, and societal complexities. This was echoed by the 2017 National Academy of Sciences and National Academy of Medicine report on human genome editing which brought attention to both the potential implications and calls from the scientific community for public engagement in policy decisions related to the technology. While many in the scientific community recognize the need for public involvement in decisions concerning controversial technologies with far reaching risks and benefits, public attitudes toward engagement in these decisions have yet to be determined. In this study, we examine public attitudes toward involvement in regulatory and scientific decisions related to human gene editing. Specifically, we analyze attitudes toward public engagement and the capabilities of the scientific community to responsibly develop the technology using data gathered from a nationally representative survey of U.S. adults (N=1,600; RR1=35.9%) from December 2016 to January 2017. We find sharp divides across ideological and religious groups in attitudes toward the technology and in views of the abilities of scientists to appropriately regulate themselves with respect to future development of the technology, however, the same groups which differ in their attitudes are united in their support for public engagement. Implications for public engagement in policy making on this emerging technology are discussed.

T2-E.4 Rouse, JR; Arete Associates and The Joint Staff;
jrouse@arete.com
Inconvenient Truths: When Risks Aren't as Severe as You Would Like
Over the past 15 years, Pentagon leaders and analysts have worked diligently to more closely tie risk analysis to resource priorities after years of doing them independently. Unfortunately they have done their work too well, and in the battle for resources stakeholders either ignore or inflate standard risk metrics to support their claims. How Joint Staff leaders and staffers have addressed this challenge provides significant insights to analysts and leaders in government and other budget-driven organizations. Attendees will benefit from a discussion of techniques to most accurately bound the type and degree of risk associated with resource decisions; techniques transferable to the private sector as well. The endstate is a risk-informed decision-making process that clarifies rather than obscures choices.

W4-C.5 Royal, A; Resources for the Future; *aroyal641@gmail.com*
Understanding Attitudes Towards Flood Risk with Prospect Theory
In the decades since its inception, Kahneman and Tversky's Prospect Theory (PT) has continued to receive substantial empirical support as the leading quantitative theory of decision-making under risk. This study explores whether PT can deliver insights in the domain of flood risk by testing whether insurance decisions made by homeowners located in the floodplain are predicted by individual differences in loss-aversion, decision-weighting and diminishing sensitivity. A survey of homeowners obtained information on self-reported insurance status and homeowner attitudes towards flood risks and insurance. Each survey participant also encountered a series of real monetary decisions designed to elicit individual risk attitudes and risk perceptions modeled by PT. Participant responses from the survey are paired monetary decisions and used to evaluate how well PT explains decisions in response to flood risk.

W4-K.2 Ryan, C; Monsanto Company;
camille.d.ryan@monsanto.com
Monsanto's Evolving Communication Strategy in the Age of Mass Information
We live in world where people are geographically and generationally removed from food and agriculture production; one where science and technology outpaces society's capacity to keep up. This creates uncertainties for the public. This broad uncertainty has only been exacerbated in delays by science and industry to educate and engage with skeptical public about modern ag technologies such as genetically engineered crops. We at Monsanto have discovered that traditional communication strategies no longer work in an increasingly complex environment of mass information, 'fake news', and false experts. Humanizing science and mobilizing key narratives have now become key ways in which to reach skeptical audiences in meaningful ways. In the age of mass information, the information is less important that how it is delivered. In this presentation, we will provide an overview of Monsanto's beleaguered reputational history, and how the company has made concerted efforts to engage with the public in recent years. Monsanto has and continues to show up differently in unexpected places: IQ2 debates, online blogs, and by empowering its employees to engage in social media, etc. But is it enough? What can we anticipate in terms of follow-on innovations moving forward? How can we work to further reduce public skepticism about key technologies that show so much promise from a socioeconomic perspective?

W1-G.4 Røvang, LB*; Gravdal, T; Bersaas, J; Gassco AS;
lbr@gassco.no
Updating the tool-box for risk management - a practical case study
Risk matrices is a common tool in risk manage-ment within the oil and gas industry. It is simple and its broad prevalence makes it attractive from a practi-cal point of view. Risk matrices have been extensive-ly used in Gassco, first in the project department and later in all its organizational units. However, it is well known that risk matrices have limitations and many weaknesses in characterizing risk, and in this paper we will report on and discuss the experiences from the recent change made in Gassco to replace risk ma-trices with a more informative risk approach and de-scription. The change coincides with a new way of defining risk in the petroleum industry in Norway, in-troduced by the Norwegian Petroleum Safety Au-thority (PSA-N) January 2015. According to this def-inition risk is understood as the consequences of the activities with associated uncertainty. A main chal-lenge of the work has been to express the uncertainty associated with each risk event. A key motivation of the work has been to reduce the focus from where to put the risk event in the matrix towards a better un-derstanding of the risk and its underlying risk factors (risk sources, risk drivers), and thereby increase the ability to identify appropriate mitigating actions. The plan is to develop a new software supporting this change, making the organization with hands-on train-ing facilities for both methodology and practical use.

P.42 Sager, SL*; Forsberg, ND; Prucha, C; Bull, L; ARCADIS U.S., Inc., (Sager & Forsberg) Waste Management (Prucha & Bull);
shawn.sager@arcadis.com
Implications of Recent Changes to the Toxicity of 1,4-Dioxane on the Derivation of Regulatory Criteria
1,4-Dioxane is emerging as a water resource contaminant of interest because of its presence in many industrial and commercial products as well as its historical use as a solvent and as a stabilizer for solvents (e.g., 1,1,1- trichloroethane). Due to its high solubility, 1,4-dioxane is frequently detected in groundwater at low part per billion levels. The United States Environmental Protection Agency (USEPA) has not established a drinking water standard for 1,4-dioxane although several states have set groundwater or drinking water standards for this constituent. The USEPA revised its cancer evaluation for liver tumors in rodents in 2010, concluding that 1,4-dioxane is likely to be carcinogenic to humans. USEPA justified developing a cancer risk assessment approach by also concluding that the available toxicological data were insufficient to adequately support a non-linearized cancer mode of action (MOA) for 1,4-dioxane. Applying these conclusions to the derivation of ground water quality criteria yields sub-part-per-billion levels. Scientific investigations by Dourson et al. (2014) and the Alliance for Risk Assessment in 2017 to resolve MOA data gaps concluded that 1,4-dioxane causes liver tumors in rodents through a regenerative cell proliferation MOA. This cancer MOA shows a threshold of exposure below which tumors do not form and supports the use of a non-linear low-dose extrapolation procedure for estimating risks with the most-sensitive, tumor endpoint. Using these results, alternative risk-based drinking water criteria can be derived. Using these toxicity values, a drinking water quality criterion that is over 1,000 times greater than that derived using USEPA's current toxicity values can be derived. This presentation will summarize recent advances in the understanding of 1,4-dioxane's cancer MOA and discuss the impact of the new information on establishing risk-based drinking water quality criteria utilizing methodologies established by several states.

M2-H.1 Sanaa, M; Anses; *moez.sanaa@anses.fr*
Listeria monocytogenes in ready-to-eat (RTE) foods and the risk for human health in the European Union (EU)
In order to address the identified factors/hypothesis explaining the increase of human listeriosis incidence in the EU/EEA a quantitative risk assessment model was developed based on the available data in EU. The model predicts consumer exposure based on the initial contamination level at retail of a variety of RTE foods, and the potential growth before consumption. The consumer probability of being infected and getting listeriosis is then predicted by applying a dose-response (DR) relation model. Fourteen subpopulations defined by age and gender were considered when assessing exposure and DR models. A suitable model structure integrating exposure and DR models were applied in order to assess the impact of different factors on the public health risks from consumption of various RTE food categories contaminated with L. monocytogenes. The model include variability and uncertainty. It was built in such a way that it avoids the recurring problem of convergence when Monte Carlo techniques are used.

P.69 Santana, S.P.B.*; Pessoa, R.W.S.; Oliveira-Esquerre, K.P.; Federal University of Bahia; *karlaesquerre@ufba.br*
Reliability analysis of a containment system, transport and segregation of effluents
Water pollution is a major global concern and every effort to avoid it must be carried out. In an effluent treatment plant the reliability of the effluent is a matter of great importance when the effluent is reused or mainly discharged into the water receiving body. Data analysis becomes challenging when you want to find information that measures the probability of an overflow (failure) in a containment system, transport and segregation of effluents. Reliability analysis was used is this work as a tool to investigate the probability of occurrence of some event (problem) that compromise the safety, operation of the system or process for subsequent decision making of the considered system. The presence of rain was taken into account as an accelerating factor of overflow which can directly influence the station's operation. The probabilities of overflow from each basin to another one or to the water body (sea or river) were estimated. Among others, the results show that under rainfall the probability of failure is higher than during dry seasons. The developed tool can help in making decisions in the operation of the system in order to better manage its risks.

M3-H.2 Santillana Farakos, SM*; Pouillot , R; Davidson, GR; Johnson, R; Spungen, J; Son, I; Anderson, NA; Van Doren, J; Food and Drug Administration; *sofia.santillanafarakos@fda.hhs.gov*
The impact of a microbial reduction treatment on the risk of human salmonellosis from the consumption of almonds and pecans in the United States: A comparison
We developed quantitative risk assessments to assess the risk of human salmonellosis arising from the consumption of almonds and, separately, pecans, after the application of a microbial reduction treatment level (1-5 log CFU). These include exposure models evaluating contamination at harvest and including various steps in tree nut processing such as pre-treatment storage, post-treatment partitioning, and post-treatment and retail storage. Steps specific to each tree nut, such as pecan processing immersion in water, drying, conditioning, and cracking were included. U.S. consumption data and the WHO/FAO Salmonella dose-response model were used to assess the risk per serving and per year, quantifying variability and uncertainty separately. The model predicted a mean risk of salmonellosis from consumption of almonds and almond products (>80% almond) in the U.S. with no microbial reduction treatment and no further cooking by the consumer as 1,697 cases/year (95% CI: 1,162– 3,501 cases). For pecans and pecan products (>80% pecan), the mean estimated number of cases/year under a cold conditioning process with no microbial reduction treatment and no further consumer cooking was estimated as 529 cases (95%CI: 213 – 2,295 cases). Assuming 77% of shelled pecans sold at retail receive hot conditioning (industry estimate), the mean estimated cases/year from consumption of in-shell and shelled pecans uncooked at home combined is 203 cases (95%CI: 81 - 882 cases) when no additional microbial reduction treatment is applied. In spite of differences in initial contamination, survival, processing steps, and consumption, the models for both almonds and pecans estimate that a minimum 4 log reduction treatment results in a mean risk of illness below one case/year in the U.S., including uncertainty, assuming typical conditions. Atypical situations that may occur post-treatment (e.g., cross contamination) could result in higher risk estimates that are not impacted by treatment level.

T4-C.1 Santos, JR*; Yip, C; Pagsuyoin, S; Thekdi, S; George Washington University; *joost@gwu.edu*
Workforce, Economy, Infrastructure, Geography, Hierarchy, and Time (WEIGHT): Reflections on the Plural Dimensions of Disaster Resilience
The concept of resilience and its relevance to disaster risk management has increasingly gained attention in recent years. Indeed, efforts to enhance the resilience of vulnerable systems against disruptive events have been shown to generate significant benefits in terms of reducing the associated losses and expediting the recovery timeline. In this paper, we explore the complexity and plurality of disaster resilience. In particular, we propose a conceptual framework that decomposes resilience into six primary dimensions: workforce, economy, infrastructure, geography, hierarchy, and time (WEIGHT). These dimensions are not addressed holistically in the literature; often they are either modeled independently or in piecemeal combinations. This paper provides a review of each dimension and provides insights for enhancing disaster risk management through the recognition and coordination of the multiple dimensions of resilience. Through this paper, we also aim to spark discussions among researchers and policymakers to develop an integrated framework for evaluating the efficacy of resilience strategies; for example, the proposed dimensions can be treated as multiple objectives in the context of disaster risk management and decisionmaking. Furthermore, the WEIGHT dimensions may also be used in developing a structured approach that can potentially generate new approaches for data analytics of resilience-related information and knowledge bases.

P.3 Sato, N*; Kojima, N; Tokai, A; Osaka University; *satou@em.see.eng.osaka-u.ac.jp*

Development of methodology for finding underestimated chemical substances for health risk based on human kinetic adjustment factor analyzed by QPPR-PBPK model

To address interspecies differences and human variability in sensitivity concerning chemical risk assessment, the Uncertainty Factor (UF) of 10 is commonly used. However, because it has been reported that the use of UF can lead to underestimation of risks to high susceptible populations, the World Health Organization, proposed a chemical-specific adjustment factor (CSAF). CSAF stems from the results of quantitative evaluations of substances sets, based on the test animals and human toxicokinetics (TK) and toxicodynamics (TD) datasets. The focus of this study is on the Human Kinetic Adjustment Factor (HKAF), a sub-factor of CSAF (√10 3.16). The objective is to extract priority evaluation substances, whose HKAF exceeds 3.16.The HKAF was calculated using the Quantitative Property-Property Relationship Physiological Based Pharmacokinetic (QPPR-PBPK) model, applying the average value for the physiological parameters of adults and infants, for 14 substances. The biochemical parameters of substances were estimated from physical property data, using QPPR. It was found that one substance, Glycol, exceeded the default value with 3.35, and three substances presented values higher than 2.7, (Bisphenol A:2.97, NMP:2.72, and Butoxyethanol:2.70).And also, these substances presented high blood air partition coefficients that exceeded 10,000(-). Furthermore, by using QPPR method, it was suggested that the fact the molecular weight × water vapor pressure / water solubility is low lead to high blood air partition coefficients. Especially for these substances, the values were lower than 0.1.In the future, using these parameters, extraction of priority assessment substances is carried out for 149 substances that satisfy the data for QPPR. Extending this studies for the reaming substances will allow for the identification of substances exceeding the default value of the UF and will prevent the underestimation of risk, by replacing with the CSAF. This work is supported by Japanese METI.

P.9 Savidge, MJ*; Hsu, LC; Smegal, DC; U.S. Food and Drug Administration; *matthew.savidge@fda.hhs.gov*

State of knowledge and data gaps regarding the potential for cyanide poisoning from consumption of apricot kernels in the United States

Apricot kernels are one of several different foods that contain the cyanogenic glycoside amygdalin. Once ingested, amygdalin is metabolized to hydrogen cyanide, a known toxin. In recent decades, amygdalin, and consequently, amygdalin-rich foods such as apricot kernels, have become a popular “natural” alternative to traditional cancer treatment therapies. Despite little evidence backing these claims, the popularity of apricot kernels continues to grow within the United States and abroad, which has resulted in numerous cases of cyanide poisonings around the world. Following the increase in poisoning cases in their countries, agencies in Australia (FSANZ) and the EU (EFSA) completed assessments on the likelihood of cyanide poisoning from consumption of apricot kernels available to consumers in their respective countries. Both agencies concluded that the consumption of apricot kernels poses a likely health concern for all populations, and FSANZ issued a ban on apricot kernels in 2016. Here, we discuss the approaches taken by FSANZ and EFSA and the data gaps currently limiting FDA’s ability to evaluate the potential for cyanide poisoning from apricot kernel consumption in the United States. The two primary data gaps identified by FDA are 1) lack of quality data on levels of amygdalin in apricot kernels and 2) lack of reliable information on consumption patterns in the U.S. Addressing these data gaps would provide valuable insight on the magnitude of exposure to amygdalin from apricot kernel consumption in the U.S relative to other countries, and could potentially inform policy decisions regarding the sale of apricot kernels in the U.S.

W4-K.4 Schachtman, N; Schachtman Law; *nathan@schachtmanlaw.com*

The Language of Law: When Risk is Tried in the Court of Public Perception

Two issues in the field of statistics and probability plague judicial and jury decisions and fact finding in the United States. The first is use of risk ratios from clinical trials or epidemiologic studies to determine the probability of causation of a given claimant’s injury or disease from a putative cause. The use of attributable risk and the probability of attribution has been widely criticized, but many of the criticisms are overstated, and result in untoward outcomes when adopted. The second issue arises from the careless use of statistical significance testing and the misinterpretation of p-values and confidence intervals in judicial proceedings. Although both issues have been widely discussed in the statistical and legal literature, the problems persist to undermine the integrity of judicial judgments in a wide range of cases, especially in health effects litigation, but in other cases as well. Both issues obscure risk communications in the courts. Examples from recent cases are used to illustrate how these issues continue without resolution in the United States, and some suggestions will be considered for improving current practice in the courts.

P.77 Schell, K*; Guikema, SD; Pinson, P; University of Michigan; *krschell@umich.edu*

Assessing the Risk of Wind Drought for Wind Farms

There are over 10,000 individual wind turbines currently operating in the state of Texas. Tax credits have helped spur past and future investment in the Texas wind industry, which anticipates a further 11 GW of new capacity additions in the near future. While this increase in wind capacity, at times, provides a remarkable percentage of load with renewable generation, variable wind power output is not often synchronous with peak demand, which raises the issue of its contribution to overall resource adequacy. We propose a new method for assessing wind resource adequacy in the planning phase, utilizing cross-spectra analysis of wind speed and system load time series. The results indicate which geographic locations in an electricity system have wind resource potential that is most able to contribute to meeting system load, across time. This metric gives wind farm planners information on where to site wind farms that reduce reliability risk and increase supply adequacy. This knowledge is particularly important as electricity systems move toward maximum levels of variable renewable power penetration.

T2-G.1 Schell, MC*; Schell, KR; Abdulla, A; University of Rochester, University of Michigan, Ann Arbor and University of California, San Diego; *m.c.schell@rochester.edu*
Investigating the evolution of risk culture in disparate fields
All organizations seek to minimize the risks that their operations pose to public safety. For some, this task takes on particular significance because they deal with complex and hazardous technologies. Five decades of research in the field of quantitative risk analysis have generated a set of overall risk management frameworks and best practices that extend across a range of such domains. Diagnoses and prescriptions for improving risk assessment and management rhyme regardless of domain, but treatment of risk generates di erent results. Here, we investigate the risk analysis and management ethos (we collectively term this the "risk culture") in three di erent enterprises that require exceedingly high standards of execution: nuclear power, aviation, and medical physics. While the scope and class of risk in each domain is di erent, each has existed long enough for an evidence-based risk culture to develop, and the evolution of this culture is traceable in publications seminal to each. Among these three fields, the risk culture is oldest in aviation, and newest in medical physics. We conduct a textual analysis of the seminal risk documents in each of these three fields, and a citation network analysis to assess how siloed they have been, historically. We discover that nuclear power and aviation have synthesized risk cultures that borrow best practices from a wide range of disciplines, and especially from each other. There appears to be a distinct di erence in medical physics' engagement with the risk community: it is more isolated, and its best practices lag behind other fields'. We outline how this state of a airs may prove harmful, and provide recommendations for improving the risk culture in medical physics.

T3-E.3 Schweizer, VJ*; Mitchell, RE; University of Waterloo; *vanessa.schweizer@uwaterloo.ca*
Socio-economic challenges and conflict for climate scenarios for Sub-Saharan Africa
Climate change is a global catastrophic risk with potential to be a "threat multiplier," as changes in precipitation patterns and more extreme weather events can disrupt water availability as well as agricultural productivity, damage infrastructure, and exacerbate conflicts over resources and refugees. Using a system-theoretic approach, we consider how the interplay of demographic and economic development factors for low-income and lower-middle-income nations in Sub-Saharan Africa can influence regional socio-economic challenges in the face of climate change.

W2-J.4 Schweizer, PJ; Institute for Advanced Sustainability Studies Potsdam; *pia-johanna.schweizer@iass-potsdam.de*
Governance of Renewable Energy Infrastructure Planning. Potentials for Public Participation
The German energy transition implies the restructuring of the German energy sector. By 2050, at least 80% of Germany's electricity is to be derived from renewable energy sources. This includes the comprehensive and accelerated extension of the electricity grid. As a frontrunner in the transformation of its electricity system, Germany represents a learning ground in the search for sustainable models of energy production and consumption. The transformation of the German energy infrastructure poses major challenges to all parties involved. Not only involves the energy transition substantial financial risks but also social risks and benefits need to be fairly balanced. As a result, many infrastructure planning projects lead to opposition from stakeholders and parts of the public. Governance of infrastructural planning therefore has to reconcile public opposition and robust planning. Facilitating the energy transition in Germany poses serious governance challenges thereby demanding balanced decision-making that incorporates science and values in judgmental risk governance. The presentation will investigate these challenges for decision-making by drawing on empirical evidence from Germany, focusing on the potential of public participation and stakeholder involvement for discursive governance, especially with regard to the prospects and limits of deliberative, group-based approaches in online and offline formats.

W4-G.1 Schweizer, PJ; Institute for Advanced Sustainability Studies Potsdam; *pia-johanna.schweizer@iass-potsdam.de*
Governance of Systemic Risks: Challenges and Potential Solutions
Systemic risks, such as climate change, financial crises, and epidemics, can be characterized by four major properties. First, systemic risks are characterized by scientific complexity and epistemological uncertainty. Science cannot identify exact hazard probabilities. Instead, science utilizes models of scenario building to sketch out the stochastic nature of systemic risks. Second, systemic risks are transboundary and global in nature. They transgress nation states and call for international cooperation. Third, although systemic risks originate in one subsystem of society or the environment, the ripple effects of these risks affect all social subsystems, such as the economy, politics, and civil society. Fourth, future technological and societal developments are non-linear. Science struggles to identify tipping points of technological and social trends. Nevertheless, political decision makers call for scientific advice to govern our emergent future. Effective, inclusive governance strategies are necessary to pursue the goals of resilience and sustainable development. Systemic risks governance demands cooperative management efforts of experts, corporate sector, civil society and regulators. Effective risk management must strike a balance between efficiency and resilience, and the solutions devised must be fair to all people affected. The presentation will pay special attention to the ways in which complexity, uncertainty and ambiguity pose challenges to governance of systemic risks. The meta-theoretical concept of inclusive governance serves as a guiding framework. The challenges posed by systemic risks call for the balanced integration of all kinds of knowledge (factual, experimental, local, anecdotal, etc.) in risk governance. By the same token, values and societal preferences need to be taken into account in order to reach socially acceptable decisions. Consequentially, the demand for the inclusion of various stakeholders at an early stage in the governance process poses new challenges to institutionalized routines of decision making.

T4-J.3 Scott, RP; Colorado State University; *ryscott5@uw.edu*
Local management and effects on citizen reporting risks and externalities of oil and gas drilling
Given limited monitoring resources, environmental management agencies often rely upon citizen feedback mechanisms to assess compliance and select targets for inspection and enforcement. This strategy is particularly common for regulating unconventional oil and gas extraction;however, public complaints, though a measure of dissatisfaction and potential harm, are also are a potential indicator of involvement in the civic process. Citizens who file a complaint and are unsatisfied with the process may be less likely to again engage in complaint behavior and may seek an alternative venue for addressing concerns about oil and gas. Public managers can play a pivotal role in these governance arrangements. Accordingly, this paper tests how increased participation of government actors at the state and local level is associated with changes in citizens continuing to engage in the complaint forum. I use statistical network analysis to evaluate how interactions between local government managers, state government managers, and citizens are associated with changes in the likelihood of citizens filing a second oil and gas complaint on a separate issue. Controlling for whether a corrective action is taken as a result of the complaint, the involvement of local government officials as opposed to state officials within a complaint process both increases the likelihood of a complaint being resolved rather than administratively closed and also increases the chance of the citizen again choosing to participate in the complaint process. Coupling these quantitative results with supplementary evidence from semi-structured interviews with complainants, this paper demonstrates that public managers play an important role in shaping citizen satisfaction with complaint processes, but that involvement of local managers within the resolution process has an ability to confer legitimacy and competence to a process that may be missing when only a single state agency is involved.

M4-F.1 Seager, TP; Arizona State University; *thomas.seager@asu.edu*
Redesigning Resilient Infrastructure Research
Despite federal policy directives to strengthen the resilience of critical infrastructure systems to extreme weather and other adverse events, several knowledge and governance barriers currently frustrate progress towards policy goals, namely: 1) a lack of awareness of what constitutes resilience, 2) a lack of judgement about how to create resilience, 3) a lack of incentives that motivate resilience, and 4) obstacles that prevent action. I describe each of these barriers in greater detail and provide a catalog of theories for overcoming them. Regarding awareness, I present four different characterizations of resilience as robustness, recovery, graceful extensibility, and sustained adaptability. Integral Theory demonstrates the necessity of integrating multiple investigative perspectives. Resilience is presented as a set of processes, in addition to resources and outcomes. Regarding judgement, theories of human development identify the most critical infrastructure in terms of the services they provide to end users. Regarding incentives, the modes and tools of financial analysis by which investments in resilience infrastructure may be prioritized find two failings: the difficulty of estimating the monetary value of optionality, and the problem of exponential discounting of future cash flows. Regarding obstacles to action, a hierarchy of adaptive actions applicable to physical infrastructure and the essential dimensions of organizational maturity determine how adaptive actions might be initiated. Finally, I discuss the difficulty of education and training for resilient infrastructure systems and propose simulation gaming as an integrative research and education approach for capturing lessons learned from historical catastrophes, play-testing scenarios, sharing knowledge, and training a workforce prepared for the challenges of the post-industrial infrastructure age.

W1-D.1 Sellke, P*; Porcari, A; Borsella, E; Benighaus, C; Mehmood, A; Kelly, S; Renn, O; Rodrigures, I; Dialogik; *sellke@dialogik-expert.de*
Risk Governance in caLIBRAte: The Integration of Analysis, Perception and Participation
CaLIBRAte - a nano risk governance project - uses an integrated analytic framework which provides guidance for the development of comprehensive assessment and management strategies to cope with risks. The new framework integrates scientific, economic, social and cultural aspects and includes the effective engagement of stakeholders. The framework was oroginally developed as part of the research activities of the International Risk Governance Council in Geneva (IRGC: White Paper on Risk Governance. Towards an Integrative Framework. Geneva 2005).The concept of risk governance comprises a broad picture of risk: not only does it include what has been termed ‘risk management’ or ‘risk analysis’, it also looks at how risk-related decision-making unfolds when a range of actors is involved, requiring co-ordination and possibly reconciliation between a profusion of roles, perspectives, goals and activities. The framework offers two major innovations to the risk field: the inclusion of the societal context and a new categorisation of risk-related knowledge. As part of the project caliBRATe engaged different types of stakeholders to analyses needs, priorities and views on managing risks in the innovation, launch and post marketing process. The stakeholders proposed many aspects. The framework’s risk process, or risk handling chain breaks down into three main phases: ‘pre-assessment’, ‘appraisal’, and ‘management’. A further phase, comprising the ‘characterisation’ and ‘evaluation’ of risk, is placed between the appraisal and management phases. The risk process has ‘communication’ as a companion to all phases of addressing and handling risk and is itself of a cyclical nature.

T4-G.1 Selvik, JT*; Signoret, J-P; Author 1: University of Stavanger and IRIS (International Research Institute of Stavanger), Norway; Author 2: France: Project leader of ISO/TR 12489 ; *jon.t.selvik@uis.no*
A safety perspective on systemic risk
‘Systemic risk’ is a common term used in finance to describe events that could threaten the stability of a whole system or a financial market, i.e. where a combination of events is causing adverse consequences on a system level. Within the oil and gas industry, the term is also used in a safety context where it is linked to safety-critical failures of safety instrumented systems (SIS). The paper studies the definition and the use of this term in such a context, showing that it strongly relates to the interdependencies between the components of the system. These dependencies are a key for understanding the risk of ‘systemic failures’ as the system failure cannot be simply described from the individual component failures of the system. This is a straight outcome of the Aristotle principle explaining that the whole is greater than the sum of its parts. Hence a holistic picture is needed when assessing the risk of such failures. Some relevant examples are used in this paper to clarify the meaning of this term and to show how different systemic dependencies can influence risk.

W3-A.2 Sertkaya, A; Ackerley, N; Ertis, D*; Grayson, P; Vardon, P; Sassi, A; Eastern Research Group, Inc.; Eastern Research Group, Inc.; Eastern Research Group, Inc.; Eastern Research Group, Inc.; U.S. Food and Drug Administration; U.S. Food and Drug Administration ; *Daniel.Ertis@erg.com*

Delivery of Safe Food to Rural and Frontier Areas: Examination of Gaps and Constraints

The Food Safety Modernization Act of 2011 (FSMA) required a study of the transportation of food for human consumption in the United States, including transportation by air, that includes an examination of the unique needs of rural and frontier (R/F) areas with regard to the delivery of safe food. For that purpose, we designed and implemented an expert elicitation to assess gaps and constraints of the transportation distribution logistics that may limit certain food types from being delivered to R/F communities, or that may affect the ability of the system to deliver safe food to these areas. On the one hand, we found that lack of or poor infrastructure (e.g., poor roads, no airport, no cellular/GPS network, etc.) and insufficient employee training appear most likely to have the greatest impact on the safe delivery of foods to R/F areas. On the other hand, the failure to achieve sanitary food transportation is most often the result of poor planning, training, follow-through, and/or carrier selection, regardless of shipping destination. Although it might be more expensive to transport foods into smaller market areas, it is possible to do so safely with the proper equipment.

T4-A.5 Sertkaya, A*; Wong, H; Jessup, A; Ertis, D; Eastern Research Group, Inc.; *aylin.sertkaya@erg.com*

Burden of Disease for CDC-recognized Urgent Threats: Clostridium difficile, Carbapenem-resistant Enterobacteriaceae, and Drug-resistant Neisseria Gonorrheae Infections

According to a 2013 report published by the Centers for Disease Control and Prevention (CDC), Clostridium difficile (CDI), carbapenem-resistant Enterobacteriaceae (CRE), and drug-resistant Neisseria gonorrheae (NG) infections are considered high-consequence antibiotic resistant threats that require urgent attention. Here, we examine the mortality and morbidity burden of these infections in the United States. In 2016, we estimate that there were 16,500 and 1,100 deaths attributable to CDI and CRE, respectively. Using a value of a statistical life (VSL) of $9.7 million, the monetized burden of mortality from CDI and CRE exceeds $170 billion per year in the United States alone. Moreover, these infections also result in significant morbidity measured in lost quality of life years (QALYs); approximately 8,700 lost QALYs for CDI, 20 for CRE, and around 2,600 for NG. The total monetized morbidity burden of these infections is subsequently estimated around $4 billion annually using a value of a statistical life year (VSLY) of $350,000. Of these three CDC-recognized urgent threats, CDI has the most substantial societal burden of disease.

T2-I.4 Shao, K; Indiana University; *kshao@indiana.edu*

Impact of Generalized Informative Prior on BMD Estimation using Dichotomous Data

Historical toxicological data can provide risk assessors invaluable information regarding the shape of dose-response curves, which is especially useful when the data being analyzed have limited dose-response information. The Bayesian dose-response modeling framework is an important tool for combining prior information from historical studies with the information from the specific dataset being considered. In this study, we employ the recently developed Bayesian benchmark dose (BBMD) estimation system to examine how generalized informative prior distributions can impact BMD estimates. We first use 518 toxicological data sets (mainly from the IRIS database, including cancer and noncancer) to identify an appropriate distribution for each parameter in commonly used dichotomous dose-response models. Then, to mitigate the estimation error and sensitivity to potential data errors in specific data sets included in the analysis, a Bayesian hierarchical model is applied to estimate the distribution of the parameters in these dose-response models. These resulting distributions of model parameters are used as generalized informative prior for further analyses. Both real data analyses and simulation studies are employed to examine how significantly the informative priors can impact BMD estimates individually. Preliminary results show that the background and potency parameters can usually be adequately informed by the data being analyzed (i.e., informative priors generally have limited impact on these two parameters). On the other hand, an informative prior for the shape parameter can be greatly beneficial for the precision of the estimated BMD.

W4-C.1 Shao, W; Gardezi, M*; Xian, S; Auburn University at Montgomery; *wshao@aum.edu*

Examining the Effects of Objective Risks and Community Resilience on Risk Perceptions at the County Level in the U.S. Gulf Coast: An Innovative Approach

The coupling effects of changing climate and rising concentration of population in the coastal region pose serious challenges to coastal communities. Communities' risk perceptions can influence their abilities to cope with coastal hazards. Our study presents a pioneering effort to examine environmental risk perceptions at the county level. In this study, we first apply a spatial statistical model to construct county-level risk perception indicators based on survey responses. Next, we employ Bayesian inference to reveal the relationship between contextual risks and community resilience, on the one hand, and county-level perceptions of coastal risks, on the other. Results of this study are directly applicable in the policy-making domain as many hazard mitigation plans and policies are designed and implemented at the county level. Specifically, two major findings stand out. First, two indicators of the contextual risks positively affect county-level risk perceptions. Second, higher levels of economic resilience and community capital are found to lead to heightened risk perceptions, which suggests that concerted efforts are needed to raise awareness of coastal risks among counties with less economic and community capitals. We end this study by proposing a theoretical framework laying out hypothetical links among contextual risks, community resilience, and risk perceptions.

P.47 Shao, K*; Shapiro, A; Indiana University; *kshao@indiana.edu*
A Web-based Bayesian Dose-Response Assessment System
Since the introduction of the benchmark dose (BMD) methodology, the traditional BMD modeling tools (e.g., EPA's BMDS and RIVM's PROAST) have played a key role in facilitating and promoting the BMD approach. These tools employ the maximum likelihood estimation methods to fit dose-response models and produce mainly point estimates for model parameters, benchmark dose values, and other quantities of interest. As the mainstream regulatory risk assessment community is moving towards a probabilistic assessment framework, more robust methods are needed to provide quantitative estimates (such as distributional estimation) to support risk assessment and enable benefit-risk analysis. To address these needs and further the state of the science, a new system that is fully based on Bayesian statistics has been developed. This software application utilizes the Stan probabilistic programming language for model fitting using MCMC sampling for Bayesian inference. Modeling outputs include distributions of model-fit parameters, distributions of BMD estimates, and risk/response calculations for user-specified dose levels. Posterior model weights are used to not only evaluate model fitting performance but also to calculate model-weight averaged BMDs. New module is added to utilize the posterior sample of BMD estimates from the dose-response modeling step to do the probabilistic low-dose extrapolation as introduced in Chiu and Wout 2015. Here we present the new software system and the web-based interface which has been developed to enable users to conduct their own analyses.

P.46 Shapiro, AJ; US National Toxicology Program; *andy.shapiro@nih.gov*
High-throughput benchmark dose modeling using a web-application and Python interface library for US EPA Benchmark Dose Modeling Software (BMDS)
The US EPA benchmark dose modeling software (BMDS) is a widely-used application in dose-response modeling, and has been extensively applied in regulatory decision making. However, the software is designed as a desktop application, and the dose-response models are written using a performant low-level programming language with fixed-text input and output files, making it difficult to interface with modern software. Because of these implementation limitations, the BMDS software has generally been applied to lower-throughput modeling applications, or highly customized software packages to solve a specific scientific problem (e.g., BMD Express for microarray data). Rewriting the application in a different language which would allow for easier integration into model pipelines would present a challenge in acceptance of outputs from a new application without a large burden of software equality tests. Instead, we present a Python-based interface for easy and efficient execution of the BMDS software, https://pypi.python.org/pypi/bmds. This flexible, open-source, python interface allows for integration of the BMDS modeling software into other systems. The interface allows for automatic creation of model input files, model execution, parsing of output files, figure creation, and model-recommendation logic. Input and settings are fully customizable. Further, a web-application has also been created with a REST API for job submission, allowing for seamless integration in other applications requiring no installation of BMDS on the target machine. Performance on a standard desktop computer allows for dose-response throughput of up to one dataset/second, allowing for BMDS to be used in new scientific realms such as high-throughput assays or microarrays. Further, the application has been designed to be agnostic to model input setting and recommendation methods, allowing for maximum flexibility and adaptability. All software presented is currently available, open-source, and free.

M4-J.3 Shapiro, AJ*; Addington, JA; Rooney, AA; Boyd, WA; US National Toxicology Program ; *andy.shapiro@nih.gov*
HAWC (Health assessment workspace collaborative): A modular, web-based interface to facilitate development of human health assessments of chemicals
Regulatory and scientific research institutions frequently conduct literature-based assessments of the potential for chemicals to pose a threat to human health. Such assessments typically consist of a critical review of a literature corpus to identify adverse health effects, and to characterize exposure-response relationships from literature. In addition to extraction of exposure-response data, systematic review of potential bias in literature, as well as documentation of the literature search strategy, are important steps in these reviews. A clear and detailed presentation of analysis and outputs, as well as intermediate decisions, are critical to ensure transparency of the process. We address these challenges by creating a modular, web-based content-management system to synthesize multiple data sources into overall human health assessments of chemicals. This free, open-source web-application, HAWC (Health Assessment Workspace Collaborative, https://hawcproject.org/), integrates and documents the overall workflow from literature search and review, to data extraction, dose-response analysis using benchmark dose modeling software (BMDS), customizable visualizations of evidence and risk of bias, and data exports. User access is assessment-specific; project-managers can create public or private assessments, and can share with their team during development and ultimately release publicly as supplemental information to final reports (e.g., the US National Toxicology Program (NTP) monograph of immunotoxicity associated with PFOA/PFOS exposure, or NTP's systematic evidence mapping of paraquat and Parkinson's disease). Crucial benefits of such a system include improved integrity of the data and analysis results, greater transparency, standardization and consistency in data collection and presentation. To date, nearly 400 assessments have been created by users, and has been adopted for use by groups such as the NTP, the US EPA NCEA, and the WHO IARC monographs program.

W4-F.1 Shashaani, S*; Guikema, SD; Umiversity of Michigan; *sshashaa@umich.edu*
Hurricane Power Outage Prediction with Feature Selection Approaches
Hurricanes are a prominent natural hazard that affects a large portion of the U.S. population. One of their major impacts is power outages. Hurricane-induced power outages can be widespread and prolonged. They both pose substantial inconvenience and exposure the population to other secondary risks. Predicting hurricane power outages facilitates disaster response decision-making by electric power utilities as well as other organizations of critical importance to society such as water systems and emergency response agencies. However since spatial hurricane outage data is largely zero-inflated with a sizable number of explanatory variables, finding statistical models that can provide reliable predictions remains a challenge. We develop a new model that leverages variable selection techniques by using out of bag performance of the predictors for such datasets to guide the search process. We found promising results experimenting on central gulf coast outage data.

M3-D.4 Shatkin, JA*; Foster, EJ; Peters, TF; Vireo Advisors, LLC; *jashatkin@gmail.com*

Method Development for Measuring and Assessing Exposure to Nanomaterials in the Workplace

This talk will present a collaboration formed to develop methods for assessing workplace exposure to nanocellulose, to allow commercial entities to ensure they are addressing worker exposure while manufacturing nanocellulose and downstream products. Significant efforts are underway to develop nanocellulose materials with a wide range of applications including paper and packaging, coatings, absorbents, viscosity modifiers, and a diversity of composite materials. However, conventional forms of cellulose are known irritants when inhaled by workers. While the data are thin regarding health effects associated with exposure to the nano-forms of cellulose, we do know that, for a given mass concentration exposure to many other materials, adverse health effects can be greater when the material occurs as nanoparticles rather than larger ones because of the increased surface area and ability to penetrate deeper into the lung. To adequately assess and manage risk in this nascent industry, we need validated methods to detect whether, and to what extent, nanocellulose exposures may occur in the workplace. Such methods are not available because the novel detection methods that have emerged for quantitative analysis of other nanoscale materials are not suited for nanocellulose, which occurs as small organic particles with high aspect ratio (length / diameter) and at low concentrations. This presentation will discuss the process of developing the methods, present current data, and describe how the work will be developed into a standard measurement method.

W1-G.3 Sheikh Hassani, N; Akdeniz University; *sheikhhassani.n@gmail.com*

Risk evaluation in industrial property insurance based on fuzzy ANP and fuzzy TOPSIS

Industrial units rely on industrial property insurance for safeguarding themselves against various risks such as a fire breaking out in production facilities, theft, destruction and etc. Insurance schemes are usually a major expense to industrial units, however, this expense could be compensated in two main ways: Firstly, through protection of properties and equipment which worth millions of dollars against losses and damages. Secondly, through protecting business against loss of sales and income which arises from damages to properties. This research introduces a risk evaluation method which can be utilized by either industrial property owners or insurance companies when partnering. Industrial property owners need to compare different insurance policies offered by different companies to make an optimal choice. Similarly, insure companies need an efficient tool to help them evaluate risks related to each industrial property before concluding an insurance agreement. This method uses a fuzzy Analytic Network Process (ANP) combined with fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to rank: alternatives risk policies for industrial property owners and risks of industrial properties for insurance companies. In this hybrid method, the suggested hierarchical structure allows for identifying inter-dependent criteria and ANP is used for calculating weightings of criteria. The output of ANP is then used by TOPSIS method to evaluate and rank risks/alternatives. A case study is presented to illustrate the capability and effectiveness of the model in assisting industrial property owners and insurance companies to assess risks properly and significantly improve decision making.

P.18 Sheikh Hassani, N; Akdeniz University; *sheikhhassani.n@gmail.com*

A TOPSIS-based model for performance appraisal of risk management system

Risk management systems have become an essential component of management system in many firms. Therefore, having useful tools and methods to appraise the performance of these risk management systems is critical. A performance appraisal in place helps firms to ensure that risk management system is fulfilling the pre-defined targets properly. It also provides the opportunity for further improvements and setting up more rigorous targets. In order to evaluate performance of risk management systems, various performance indicators are introduced by researchers. These indicators reflect on a wide range of organizational, development, capacity and institutional aspects in risk management system. This research utilizes The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) to get a performance measure index and rank the risk management system along different performance indicators. TOPSIS method has been widely used before in risk assessment phase for evaluating risks of different alternatives. However, this research expands its application into monitoring phase of risk management system and tries to provide an effective measure for performance appraisal of risk management system itself.

W2-F.2 Shekar, V*; Fiondella, L; Halappanavar, M; Chatterjee, S; University of Massachusetts Dartmouth and Pacific Northwest National Laboratory; *vshekar@umassd.edu*

Transportation Network Vulnerability Assessment using Dynamic Traffic Simulation

Transportation networks are critical to the social and economic function of nations. Given the continuing increase in the populations of cities throughout the world, the criticality of transportation infrastructure is expected to increase. Thus, it is ever more important to mitigate congestion as well as to assess the impact disruptions would have on individuals who depend on transportation for their work and livelihood. Moreover, several government organizations are responsible for ensuring transportation networks are available despite the constant threat of natural disasters and terrorist activities. Most of the previous transportation network vulnerability research has been performed in the context of static traffic models, many of which are formulated as traditional optimization problems. However, transportation networks are dynamic because their usage varies over time. Thus, more appropriate methods to characterize the vulnerability of transportation networks should consider their dynamic properties. This paper presents a quantitative approach to assess the vulnerability of a transportation network to disruptions with methods from traffic simulation. Our approach can prioritize the critical links over time and is generalizable to the case where both link and node disruptions are of concern. We illustrate the approach through a series of examples. Our results demonstrate that the approach provides quantitative insight into the time varying criticality of links. Such an approach could be used as the objective function of less traditional optimization methods that use simulation and other techniques to evaluate the relative utility of a particular network defense to reduce vulnerability and increase resilience.

M4-F.4 Shortridge, JE*; Zaitchik, BF; Virginia Tech; *jshortridge@vt.edu*

Infrastructure planning under climate change – bridging robustness and probabilistic approaches

Climate change has the potential to dramatically impact many of our infrastructure systems. Avoiding these impacts will require that infrastructure is built and upgraded with future climate change in mind, particularly in systems with long lifespans that will be operating decades into the future. However, one challenge in incorporating climate change into infrastructure planning is the uncertainty surrounding climate change projections generated by climate models. This uncertainty has been addressed in different ways. For example, some researchers use ensembles of climate models to generate probabilistic climate change projections, but these projections can be highly sensitive to assumptions about model independence and weighting schemes. Because of these issues, other argue that robustness-based approaches to climate adaptation are more appropriate, since they don't rely on precise probabilistic representation of uncertainty. In this research, we present an alternative approach to infrastructure planning under climate change that leverages methods from both robust decision frameworks and probabilistic climate model ensembles. The Scenario Discovery process is used to search across a multi-dimensional space and identify the climate scenarios most associated with system failure, and a Bayesian statistical model informed by climate model projections is then developed to estimate the probability of those scenarios. This provides an important advancement in that it can incorporate many climate variables instead of just mean temperature and precipitation, and multiple statistical model formulations can be used to account for uncertainty in probabilistic estimates. We demonstrate the methodology using proposed water resources infrastructure in Lake Tana, Ethiopia, where climate model disagreement on changes in future rainfall presents a major challenge for reservoir planning.

W1-H.5 Siegrist, M*; Hübner, P; Hartmann, C; ETH Zurich; *msiegrist@ethz.ch*

Differences between experts and laypeople: Risk prioritization in the food domain using deliberative and survey methods

One aim of the study was to examine differences between experts and laypeople in risk prioritization in the food and everyday items domain. The second aim was to examine whether a deliberative method results in a different ranking compared with a survey method. We examined how laypeople (N = 92) and experts (N = 14) prioritized 28 hazards related to food and everyday items. Participants received detailed descriptions of the hazards, enabling the participants to make deliberative decisions. The participants prioritized the hazards before and after a group discussion (approximately 15 persons per group), in which the group's average prioritization was discussed. The rankings of the hazards before and after the group discussion were highly correlated. However, laypeople and experts differed significantly in their rankings for 18 of the 28 hazards. To test the influence of the deliberative method (e.g., providing detailed information about each hazard), data from a second group of laypeople were collected with a no-information survey (N = 118). This group did not receive specific information about the hazards. The risk rankings of the laypeople who received information were highly correlated with the risk rankings of laypeople who did not receive information. Overall, the results suggest that deliberative methods of risk ranking or no-information survey methods with no information about hazards provide similar results among laypeople. The conclusion is that government agencies should not only base their risk prioritization on evidence from risk assessments but also need to consider laypeople's hazard rankings. This procedure may result in an efficient and publicly accepted risk management strategy.

T2-J.1 Slovic, P; Decision Research and University of Oregon; *pslovic@uoregon.edu*

Confronting the Collapse of Humanitarian Values in Foreign Policy Decision Making

Decisions to save civilian lives by intervening in foreign countries are some of the most difficult and controversial choices facing national decision makers. Although each situation is unique, decisions involving tradeoffs that pit the value of human lives against other important objectives are quite common. Furthermore, there is often a striking disconnect between the high value placed on saving human lives expressed by top government officials and the apparent low value revealed by government decisions not to intervene. Specifically, when multiple objectives are in play, highly regarded humanitarian values appear to collapse in the competition with national security and economic security objectives, no matter how many thousands or millions of lives are at stake. I shall discuss the implications of this bias that demotivates efforts to intervene in massive humanitarian crises within the evolving discipline known as Behavioral Public Choice. Within this framework, officials have the opportunity to face tradeoffs between security and humanitarian objectives with improved laws and decision making procedures less susceptible to cognitive and behavioral shortcomings.

W4-K.1 Slovic, P; University of Oregon; *pslovic@uoregon.edu*

The Complexity of Risk: Implications for Communication

Psychological research has aimed to aid risk analysis by (i) providing a basis for understanding and anticipating public responses to hazards and (ii) improving the communication of risk information among lay people, technical experts, and decision-makers. Among the questions I shall address are: How do people think about risk? What psychological, social, cultural, and political factors determine the perception of risk and the acceptance of risk? What role do emotion and reason play in risk perception? What are some of the social, economic and political implications of risk perceptions in today's global world?

W2-E.2 Smith, MD; Pate-Cornell, ME*; Stanford University; *msmith7@stanford.edu*

Cyber Risk Analysis for a Smart Grid: How Smart is Smart Enough? A Multi-Armed Bandit Approach to Cyber Security Investment

As electric sector stakeholders make the decision to upgrade traditional power grid architectures by incorporating smart grid technologies and new intelligent components, the benefits of added connectivity must be weighed against the risk of increased exposure to cyberattacks. Therefore, decision makers must ask: how smart is smart enough? This dissertation presents a probabilistic risk analysis (PRA) framework to this problem, involving systems analysis, stochastic modeling, economic analysis, and decision analysis to quantify the overall benefit and risk facing the network and ultimately help decision makers formally assess tradeoffs and set priorities given limited resources. Central to this approach is a new Bayes-adaptive network security model based on a reformulation of the classic "multi-armed bandits" problem, where instead of projects with uncertain probabilities of success, a network defender faces network nodes that can be attacked at uncertain Poisson-distributed rates. This new technique, which by similarity we call "multi-node bandits," takes a dynamic approach to cybersecurity investment, exploring how network defenders can optimally allocate cyber defense teams among nodes in their network, in effect taking teams that traditionally respond to cyber breaches after they occur, and instead employing them in a proactive manner for defensive and information gathering purposes. We apply this model to a case study of an electric utility considering the degree to which to integrate demand response technology into their smart grid network, jointly identifying both the optimal level of connectivity and the optimal strategy for the sequential allocation of cybersecurity resources.

M2-G.4 Snell, S; Smithsonian Institution; *snells@si.edu*

Preparedness and Response in Collections Emergencies (PRICE) – The Smithsonian's Collections Emergency Team

The Smithsonian recognizes the need for a collections emergency management plan integrated into the Smithsonian's existing Emergency Management Program that focuses on the safety and security of staff and visitors. A robust program that includes collections emergency training, preparedness, mitigation, and response capability at a centralized level has been deficient in recent years. To foster best practices, the Smithsonian Collections Emergency Management Working Group was established in 2012 to study and make recommendations for improving collections emergency management, planning, preparedness, and response. This interdisciplinary group jointly co-chaired by the National Collections Program (NCP) and the Office of Protection Services developed Preparedness and Response in Collections Emergencies (PRICE). The purpose of PRICE is: • To strengthen and support museum-level and pan-Institutional collections emergency mitigation, preparedness, response, and recovery capabilities, including policy, procedures, training, and logistics; • When activated, to provide collections support, response, and recovery as requested by the NCP and/or by individual museum Emergency Command Centers (ECCs); • To promote and foster improved communication and collaboration among Smithsonian museums and with first-responders, sister cultural institutions, and professional organizations. The PRICE team is part of the Smithsonian Emergency Operations Center and is generally available for advice, consultation, and assistance related to collection emergencies. In its first nine months, PRICE has developed multiple initiatives to revitalize collections emergency management at the Smithsonian.

M2-J.4 Song, H*; McComas, KA; Schuler, KL; Cornell Uniiversity; *hs672@cornell.edu*

The role of trust and perceived similarity in psychological reactance against regulatory wildlife policy

Policymakers often choose to introduce enforceable regulations to achieve tighter control on human behavior for important risk-related issues. However, according to research on psychological reactance, regulations threatening people with punishments can cause unintended adverse effects because people tend to react against controlling stimuli perceived as threatening their sense of freedom or choice. The current study investigated how trust in and perceived similarity to a message source could help mitigate such reactance effects in the context of preventing the spread of chronic wasting disease (CWD) in deer. In particular, this study examined how risk messages intended to decrease the use of an item that could potentially spread CWD might interact with the sources and influence the messages' effectiveness. Members of a national deer hunting organization participated in an online survey experiment where they read a press release describing a new ban on natural scent-based attractants. They were randomly assigned to one of three conditions where the source of the press release was indicated as the state government, state wildlife agency, or their own deer hunting organization. Measurements included responses related to reactance processes such as source derogation, message derogation, anger, and counterarguing, as well as various individual differences. Results show that the deer hunting organization was the most trusted source of information followed by the state wildlife agency, and state government. Similarity accounted for these differences in trust, but only to a limited extent. Confirming their reactance-mitigating effects, trust and similarity played unique parallel mediating roles in the effect of source types on reactance variables. Discussion covers theoretical implications for trust in risk communication literature, as well as practical implications for the communication of regulatory policies.

T4-F.3 Staid, A*; Watson, JP; Bynum, ML; Arguello, B; Sandia National Labs; *astaid@sandia.gov*

Quantifying power system resilience to support decisions in the face of adverse weather events

There is increasing interest in designing more resilient infrastructure systems. The ability to better withstand and recover from adverse events will result in fewer service disruptions and lower costs over the long run. In order to improve system resilience, we must first understand the critical threats and resulting consequences. From there, we can work to mitigate these consequences through better planning and operational decision-making. Here, we focus on the electric power transmission system of one electric utility company. We use historical outage data to develop realistic scenarios that can be used for planning in a stochastic optimization context to increase resilience both now and in the near future. Stochastic optimization seeks to find the best solution to an operational problem given that uncertainty exists about the future. We use real data to assess the range of potential consequences given weather threats, and we generate scenarios to represent plausible future outcomes based on adverse events experienced by the system. We use these outage scenarios to evaluate the optimal decisions and potential actions that can be taken to minimize loss of load in the face of uncertain, future threats. Short-term decisions take the form of re-dispatching generators in advance of a storm, and long-term decisions encompass investments in hardening transmission lines to prevent future damage. Both sets of decisions rely on the identification of critical components and likely failures due to adverse weather. We demonstrate the potential increase in resilience from using stochastic optimization with real system data. We also highlight the many challenges of data availability and of working with historical power system data.

T2-J.4 Stearns, M; University of Maryland Carey School of Law; *MStearns@law.umaryland.edu*
A Public Choice Perspective on Behavioral Approaches to National Security Decision Making
Max Stearns will offer commentary on the paper informed by the perspective of public choice broadly defined, and more conventional law and economics analysis, based on which tools he concludes are most relevant in assessing its implications for law and public policy. The relevant tools will combine neoclassical economics, interest group theory, social choice, and game theory, as these tools relate to the underlying project.

P.135 Steinhardt, JS; Michigan State University; *jsteinh@gmail.com*
What's Numbers Got To Do With It?: The Role of Statistical Content in Risk Perception About Road Saftey
Numbers saturate news coverage and health and risk messaging. But as our expertise in the creation of statistical information increases, the ability to use those statistics in decision making remains frustratingly inadequate. There has been a wealth of research related to how to train people to better use the numbers they interact with on a daily basis. Far less research however explores the appropriate way to use numbers in communication. Three experiments explored the role of numbers in risk perception related to road safety while driving. Experiment 1 found that the presence of numbers influence risk perception, but whether those numbers reflect accurate statistics or random numbers does not change their influence. Experiment 2 found that removing all statistics entirely from infographics and replacing them with linguistic gist representations of the numbers (i.e. words like “some,” “many,” “none”) increased risk perception even though people found the infographics to be less informative than the ones containing numbers. Experiment 3 found that the effects described in the first two experiments pertain not just to infographics but also to bite sized text-based risk communication. The results suggest that the gist representations of the numbers in the context of the infographics are equivalent regardless of their value, such that the very presence of statistics influences judgment and risk perception but not their meaning. They also suggest that people do not always realize how they are using statistical information in their judgement and decision making process.

P.162 Stenhouse, N*; Vraga, E; Myers, T; Kotcher, J; Beall, L; Maibach, E; University of Wisconsin-Madison; *stenhouse@wisc.edu*
The impact of advocacy by scientists on credibility and citizens' deference on specific issues
Scientists wishing to lend their voice to policy debates often worry that advocating positions on polarized issues may reduce the credibility of scientists in the eyes of the public. As well as fearing credibility loss, scientists fear that citizens or policymakers will be less likely to defer to them – to take their advice on specific scientific issues seriously – if they are seen as advocates. The present study (data collected, but not yet analyzed) measures the impact of advocacy messages by scientists on these two outcomes – deference and credibility. A previous study has shown that some forms of advocacy by scientists on social media do not substantially harm credibility. However, it might be the case that advocacy harms deference but not credibility – perhaps citizens perceive scientists who advocate as just as credible, per se, as those who do not, but still become less willing to defer to their expertise. Without measuring both these effects, we cannot be certain of what impact advocacy has on both these important outcomes. We look at the impact of scientists’ advocacy messages on credibility and deference on a large quota sample (N=2451) of US adults. The advocacy messages related to four issues – climate change, severe weather, influenza, and marijuana use. In addition to testing the impact of these messages on citizens’ willingness to defer to scientists on these specific issues, we measure the “spillover” impact on deference for other issues such as biotech crops and nuclear power.

P.122. Stifelman, M; Brown, J; Lowney, Y; Follansbee, M*; Diamond, G; Burgess, M; SRC, Inc.; *follansbee@srcinc.com*
Recommendations for sieving soil and dust samples at Superfund sites for assessment of incidental ingestion via dermal adherence
Incidental ingestion is the primary pathway for exposure to lead, and other contaminants, in soil and dust and is dependent on dermal adherence. Hence, site-specific risk assessment requires that soil and dust samples be sieved to accurately represent incidentally ingested material that adheres to skin. Soil and dust particle size, an important determinant of dermal adherence, is generally inversely associated with lead concentration, mobility, and bioavailability. Reliable data on the particle size fraction that is most likely to adhere to hands and on the lead concentration found in that particle size can improve the accuracy of exposure and risk calculations in lead risk assessments. We reviewed literature for relevant data on the relationship between particle size and dermal adherence, and between particle size and lead enrichment. The review revealed that growing body of evidence showing that dermally-adhered soil and dust is dominated (>90%) by particles

T4-K.4 Stillo, F*; MacDonald-Gibson, J; University of North Carolina at Chapel Hill; *jackie.macdonald@unc.edu*

Racial Disparities in Access to Municipal Water Supplies in the American South: Impacts on Lead Exposure and Children's Health

Throughout the American South, African American neighborhoods on the fringes of cities and towns were systematically excluded from municipal services, including water and sewer service, paved roads, and police and fire protection. More than five decades after the Civil Rights Act, many such neighborhoods still lack municipal services, even as those services have been extended to newer, majority white neighborhoods. Yet, little is known about the health impacts of these exclusionary zoning practices. This paper will assess risks of exposure to lead in drinking water in peri-urban African American neighborhoods of Wake County, NC, excluded from municipal water service and will assess associated health risks. We will report on results of water tests for lead in 60 households. We will quantify effects of lead exposure on children's IQ in affected households using a combination of blood lead data and physiologically based pharmacokinetic modeling. While the recent Flint, Michigan, water crisis renewed attention to disparities in the quality of municipally supplied drinking water, this study is the first to assess lead exposure disparities arising from exclusion from municipal services—the reverse of the situation that occurred in Flint.

W1-E.4 Streetman, SS; Data Architecture Solutions, Inc.; *stevestreetman@gmail.com*

Degree of Difficulty for Terrorist Attacks: an approach to improving likelihood assessment and evaluation of alternatives for decision making

Assessing the likelihood of terrorist attacks, especially potential attacks using weapons of mass destruction (WMD), poses substantial challenges for risk assessors attempting to prioritize defensive measures. One often overlooked component of the likelihood of an attack is its feasibility. Attacks that are substantially more difficult to successfully complete may be avoided in favor of attacks more likely to succeed. Even within the rarified area of WMD terrorism attacks, the difficulty of carrying out an attack varies widely among targets, material (chemical, biological, radiological, nuclear, explosives CBRNE) and dissemination approaches. It is relatively common to assess the vulnerability of a target to attack (and, essentially, the likelihood an attack will be defeated), but the difficulty of accomplishing the attack apart from defeating defensive measures is largely ignored even though the attack logistics may be as influential or more influential on selection than the vulnerability of the target to the attack. Assessing the relative degree of difficulty of a terrorist attack may, therefore, be a useful proxy for likelihood of selection and/or likelihood of a successful attack. Combining the degree of difficulty with an assessment of adversary capabilities may provide even better resolution of potential likelihood of attack. This presentation will propose a framework for estimating terrorism degree of difficulty and show how it can be incorporated into terrorism risk assessment and into evaluation of alternatives - including how the degree of difficulty may change based on changes in defensive measures.

P.132 Sutton, J*; Resnick, S; Vos, SC; Yu, Y; Olson, M; Butts, SC; University of Kentucky; *jeannette.sutton@uky.edu*

Modeling social media engagement across the disaster continuum

Existing research on social media and risk communication in the context of disaster focuses on the threat and response phases, with little attention to the communication strategies implemented during nonthreat periods. Furthermore, much of the research in this area remains descriptive and provides limited guidance on effective messaging strategies for engagement. In this paper, we add to the scholarship by examining social media use across the disaster continuum in order to identify message strategies that enhance engagement during threat and nonthreat periods. To date, social media "engagement" has been conceptualized primarily as dialogic communication, displayed through symmetrical or asymmetrical posts and directed messages that are aimed at building an online participatory community. This strategy imagines communication on social media as interpersonal conversation; as a result it fails to capitalize on all of the strengths of this channel, including network features and the ability to reach mass audiences. In this paper we propose a model of social media risk communication that builds on the current literature to inform an ongoing strategy of engagement across the threat-nonthreat time continuum. We draw from our previous findings to code, analyse, and model the message design and network features of a systematic, proportional, stratified random sample of 6,000 Tweets distributed by the census of National Weather Service accounts from 2014-2016. We conduct a thematic content analysis of three primary engagement strategies, informing, instructing, and dialogue across two time periods, threat and nonthreat, to develop a classifier system. We then use automated coding to identify microstructure features (#, @, RT, and url). We build models to identify the message design and network features that affect engagement, in the form of message sharing. The results identify strategies that increase engagement during threat and nonthreat periods.

M2-G.3 Swiatkowska, B*; Czop, J; Jedrychowski, M; Klosowska, A; Okragla, D; Skoczen-Rapala, £; Bratasz, £; National Museum in Krakow and Yale University; *bswiatkowska@mnk.pl*

Chemical deterioration and physical failure – risk-informed archive facility planning

The National Museum in Krakow, Poland holds one of the leading national collections of works on paper for which the museum is planning a new storage facility. Since 2015, the museum has been carrying out a collection risk assessment to inform facility planning. To assess value of objects, the collection was stratified into groups homogeneous in terms of type of object, theme or technique. Examples include drawings, watercolors, works of important artists and large groupings of documentary prints - portraits, religious, military or costume prints. Relative values of the selected groups were estimated based on their market values. More focused risk analysis is concentrating on two key hazards – chemical deterioration and physical failure upon handling. Scenarios were developed based on variable susceptibility of groups of objects to those two hazards. Criteria considered included: paper brittleness, paper pH, vulnerability of the technique in which the work was executed, and degree of protection of objects against physical forces. Next, the accumulation of damage from the deterioration processes or multiple events for each group within the specific risk scenario was estimated. For chemical degradation, damage accumulation was expressed as expected "lifetime" of objects, calculated from the available expressions for the rate of paper degradation. For the physical failure from handling, the parameter was expressed as damage accumulation predictions for a selected time horizon of 50 years derived by museum conservators from long-term collection observations. Loss of value corresponding to predicted damage accumulation was estimated by museum staff by considering how the predicted changes affect the artistic value of the work, its documentary information, and/or the display potential. The information collected at all stages was introduced into a specifically developed software tool which calculated and presented magnitudes of risks across the entire collection.

M3-K.7 Sütterlin, B*; Siegrist, M; ETH Zurich; *bsuetterlin@ethz.ch*
Symbolic information on naturalness and its biasing effect on the evaluation of energy technologies and environmental hazards: the case of fracking
Recent research has shown that people base their evaluations of outcomes or consequences of a hazard on the symbolic meaning that relates to the naturalness of the cause of the hazard (human- vs. nature-caused), and this may result in biased judgments. The biasing effect of symbolic information has also been demonstrated in risk assessments of solar and nuclear power generation technologies. The present study provides evidence for this bias for an energy technology that has become a critical focus in several countries' energy debates—namely, hydraulic fracturing. In an experiment, we provided participants with a text describing how several hundred animals died due to toxic chemicals that were released into the soil and entered the water of a nature reserve. The participants were told either that 1) the chemicals had originated from the burst pipe of a fracking installation ("man-made" chemicals, human cause); 2) the chemicals were naturally occurring but were released due to vibrations caused by a nearby fracking installation (natural chemicals, human cause); or 3) the chemicals were naturally occurring and were released because of an earthquake (natural chemicals, natural cause). The analysis revealed that the identical outcome (i.e., the death of several hundred animals) was perceived as being more severe when the hazard was human-caused (i.e., fracking) than when it was nature-caused (i.e., earthquake). Furthermore, animal suffering was perceived to be lower when the animals died because of naturally occurring chemicals released by an earthquake compared to chemicals released due to the burst pipe of a fracking installation. The present study provides further evidence for the biasing effect of symbolic information on naturalness on the evaluation of energy technologies and environmental hazards. Further, the findings suggest that this bias is driven by the cause of a hazard rather than the naturalness of the "direct cause" of a negative effect (i.e., chemicals).

P.165 Taber, DL*; King, ZM; Cains, MG; Henshel, DS; Indiana University; *mgcains@indiana.edu*
Thematic Mapping of Cyber Security and Cyber Security Risk: Expert Elicitation of Researchers and Practitioners
The National Initiative for Cybersecurity Careers and Studies defines cyber security as an activity or process that protects and/or defends information and systems against damage, unauthorized use or modification, or exploitation. Given the interdisciplinary nature of cyber security research, it is important that researchers from disparate disciplines share a common understanding of what is meant by cyber security and cyber security risk. Common definitions of cyber security and cyber security risk are imperative when conducting research across disciplinary and sectoral (i.e. academia, government) boundaries. In an attempt to identify this common understanding, researchers in the Cyber Security Collaborative Research Alliance (CSec CRA) conducted interviews on these topics with experts in academia and the U.S. Army. The common understandings were determined through thematic analysis of the interview corpus. Thematic analysis is commonly used in qualitative research to identify overarching patterns, or themes, that are expressed both implicitly and explicitly across datasets. This method draws on the practice of developing theory from trends via systematic investigation of qualitative data (standardized in the social sciences as Grounded Theory). The results of refined thematic analysis can be visually summarized in thematic "maps" which are useful in distilling and relating commonly-held perceptions of cyber security and cyber security risk across diverse issues and stakeholder groups. The coding process represented in thematic mapping illustrates the analytical consolidation of similar ideas into representative themes. The research presented here provides a comparison of thematic maps of both cyber security and cyber security risk that were generated from interviews across the disciplines of academic research and Army practice.

W4-H.2 Tai-Yi, LIU; Ming-Che, HU*; Hwa-Lung, YU; National Taiwan University; *mchu@ntu.edu.tw*
Spatial-temporal-frequency manifold analysis of multipollutant emission variation and sampling
This research proposes an innovative spatial-temporal-spectrum manifold model to investigate multipollutant emission variation and sampling. The model establishes a coordinate system with spatial relation, temporal correlation, and frequency spectrum of multipollutant emission. The Euclidean distances near data points are estimated. Accordingly, the Euclidean distance of emission data are reconstructed in a nonlinear manifold space. The newly developed manifold is used to analyze nonlinear spatial, correlation, and frequency emission relation. Furthermore, a manifold-based multi-objective monitoring optimization model is formulated. Then, the tradeoff between monitoring coverage and accuracy is examined.

W2-K.1 Tanner, A*; Arvai, J; University of British Columbia, University of Michigan; *alexa.tanner@ires.ubc.ca*
Perceptions of risk and vulnerability following exposure to a major natural disaster: The 2013 Calgary flood
Many studies have examined the general public's flood risk perceptions in the aftermath of local and regional flooding. However, relatively few studies have focused their attention on large-scale events that affect tens of thousands of people within an urban center, and that garner significant local and international media attention. Likewise, in spite of previous research on flood risks, unresolved debates persist regarding the variables that might influence perceptions of risk and vulnerability, along with management preferences. In light of the opportunities presented by these knowledge gaps, the research reported here examined public perceptions of flood risk and vulnerability, and management preferences within the City of Calgary in the aftermath of extensive and high-profile flooding in 2013. Our findings, which come from an online survey of residents, reveal that direct experience with flooding is not a differentiating factor for risk perceptions when comparing evacuees with non-evacuees who might all experience future risks. However, we do find that judgments about vulnerability—as a function of how people perceive physical distance—does differ according to one's evacuation experience. Our results also indicate that concern about climate change is an important predictor of flood risk perceptions, as is trust in government risk managers. In terms of mitigation preferences, our results reveal differences in support for large infrastructure projects based on whether respondents feel they might actually benefit from them.

M3-G.4 Tatar, U*; Keskin, OF; Poyraz, OI; Pinto, CA; Kucukkaya, G; Old Dominion University; *utatar@odu.edu*

Multidisciplinary Risk Management in Cybersecurity: Course Development

Cybersecurity is an ever increasingly critical issue for all states and a skilled and knowledgeable workforce is vital to the continued security of the nations, across social, economic and political domains. The National Security Agency funded several curriculum development projects on cybersecurity to meet the future workforce demands of the U.S. Federal Government. We will share the findings from requirements analysis of a funded project, "Multidisciplinary Risk Management in Cybersecurity". The aim of the project is to develop a modular course in Multidisciplinary Risk Management in Cybersecurity, and to create a common understanding of risk for a diverse set of experts which are coming from different disciplines such as technical, social, economics, law, politics, etc. In the first step of the project, the requirements analysis, we aimed to identify which topics should be covered to what extent and what soft and hard skills are required to be qualified in cybersecurity risk management. To answer these questions, we (1) analyzed federal job postings related with cybersecurity risk management, (2) examined the syllabi of previously taught courses in other institutions, and (3) organized a focus group meeting which is composed of a diverse set of professionals, academics, and students to elicit information and validate our findings from job posting and syllabi analysis. Results showed that current cyber risk management courses do not provide enough knowledge and skills to satisfy the need of the job market. The detailed results will be delivered in the presentation.

P.80 TEIMOURI, MABOOBEH, MT*; RA, KYUNGYEON, KR; CONKLING, EMILY, EC; BOOR, BRANDON, BB; HOWARTER, JOHN A, JA; WHELTON, ANDREW J, AJW; Purdue University; *awhelton@purdue.edu*

Understanding Chemical Emission from In-Situ Water Pipe Repairs

Water pipe repairs are increasingly being completed with polymer coatings and cured in place pipes (CIPP). These technologies enable pipe owners to avoid costly pipe replacement activities (i.e., road closures, building repairs) by installing a barrier between the corroded pipe and water that it conveys. CIPP pipes are new pipes chemically manufactured inside an existing damaged pipe in-situ. Today, 50% of all water pipes are repaired by CIPP technology. At present, little information is available about chemical emission into air and water by CIPP installation activities. Results of two ongoing CIPP chemical emission studies will be presented. In 2016, the US National Science Foundation funded a rapid response study to investigate chemical air emissions caused by the CIPP installation processes. In 2016, six US state transportation agencies also funded a project to investigate how to better understand and limit emissions into waterways when CIPP technology is used for storm water culvert repairs. Results showed that chemical air emissions can be high, transient, and contain more than styrene. Results are being further analyzed and prepared for release. Characterization of installed CIPP materials also has indicated a variety of organic compounds can be released from the CIPP once the contractors leave the worksite. Results in this presentation will be described in the context of workplace safety and environmental toxicity thresholds.

W4-J.3 Teuschler, LK; LK Teuschler & Associates; *lindateuschler@gmail.com*

Chemical mixture human health risk assessment methods applicable to the evaluation of complex mixtures of tobacco smoke

Tobacco smoke is composed of thousands of components; 93 are named by the Food and Drug Administration as Harmful and Potentially Harmful Constituents and designated as causing carcinogenic, repro/developmental, cardiovascular, respiratory and/or addictive effects. Different effects may be caused by typically high dose exposure pathways/routes to chemicals and particles, e.g., inhalation (direct, side stream, second hand), oral smokeless tobacco. Sensitive populations (e.g., asthmatics, those with genetic susceptibility to cancer) need to be considered in quantitative risk assessment. Chemical mixture risk assessment approaches are historically divided into whole mixture and component-based methods. Whole mixture methods are more appropriate for evaluating complex tobacco smoke exposures, for which toxicology and epidemiologic data are available, but sufficient similarity procedures are needed to extrapolate results to other exposures or products. Component methods, based on additivity assumptions, generally use toxicology data on single chemicals. These may be unrepresentative of the whole mixture risk, but are useful, e.g., to make comparisons across product formulations. This presentation details the scientific principles that underpin the methods, describes applied approaches and discusses similarity of toxic action assumptions. Methods to be discussed include: whole mixture evaluation and sufficient similarity; response-addition, based on independent action, generally used for mixtures of carcinogens; dose-addition, based on similar action, typically used for noncancer endpoints (hazard index [HI], margin of exposure, relative potency factors); and methods to incorporate toxicological interactions (interaction-based HI, weight-of-evidence interaction profiles). Uncertainty in chemical mixtures risk assessments will be considered.

T4-C.2 Thekdi, S*; Aros-Vera, F; University of Richmond; *sthekdi@richmond.edu*

Risk-based decisions and strategies for geospatial multi-network resilience

Recent high-profile disasters have caused catastrophic disruptions to networks responsible for efficient movement of people, goods, services, and information. Deficiencies in coordination among regions and unbalanced resilience characteristics have exacerbated these disruptions. We address these issues by creating models for: 1) Developing a geospatial data-informed multi-network resilience model that expands beyond traditional boundaries, 2) Assessing the most critical nodes of the multi-network using a variety of network uses, such as highway freight movement, mixed-use commuting, waterway freight movement, and others, 3) Developing a simulation and decision-support model to understand priorities for disruptive scenarios that are considered to be of low-probability and high consequence, such as environmental disasters, cyber-terrorism, and energy grid failures. This paper is the first to support decision-making for data-informed risk mitigation strategies for multi-networks with unbalanced resilience characteristics. The methodology will be applied to a case study for the Great Lakes mega-region, consisting of 38 cities, with maritime uses responsible for over 200 million tons of cargo annually, local economies critical for large-scale manufacturing and agricultural uses, and with a population of over 60 million.

W4-C.4 Thomas, M; Pidgeon, N*; Partridge, T; Harthorn , BH; Cardiff University and University of California Santa Barbara ; *ThomasMJ6@Cardiff.ac.uk*

Using role-play to explore energy perceptions in the US and UK

We present the results of a novel role play game, which explored the perceived risks and benefits associated with different energy options in in the US and UK. Six day-long workshops focussing on public perceptions of shale gas and oil development were held in four urban locations (Los Angeles and Santa Barbara in the US; London and Cardiff in the UK) and two rural locations (Hirwaun and Winford in the UK). In small groups, participants assumed the role of town councillors and were asked to rank six energy proposals in order of preference: shale gas, shale oil, onshore wind, solar, coal and nuclear; a task that stimulated energetic, in-depth discussions around preferences, conditions and trade-offs. We find that while preferences were in part driven by site-specific familiarity with particular energy sources -especially coal and nuclear- broad themes emerged relating to participants' decision-making criteria and their conditions for shale exploitation. Particularly important were siting preferences, job provision, safety considerations, justice issues, and export limits. We draw upon our results to discuss the importance of debating energy developments in relation to other options, as well as the significance of local contexts. We also consider the implications for future deep shale fracking in the US and the UK, and elucidate the merits –and limitations- of using role play as a method to engage the public with complex risk decisions.

W2-F.1 Thorisson, H*; Lambert, JH; University of Virginia; *ht3jt@virginia.edu*

Disruptions of Emergent and Future Conditions in Advanced Logistics Systems

Supply chains and logistics systems are dependent on efficient flow of commodities. Port operations involve multiple stakeholders as cargo is moved between several modes: vessels, trucks, and rail. Balancing priorities of the various stakeholders is necessary to ensure successful long-term operations. This paper studies the influence of emergent and future conditions of commerce, environment, politics, and others on performance of terminal operations to assure resilience and profitability. Vessel berthing, that is allocating space and time slots to ships calling at a terminal, has been addressed in literature using operations research and optimization. However, vessel arrivals are highly uncertain and less attention has been given to the effect of disruptive scenarios on berth plans. In this paper, the disruptiveness of several scenarios is quantified in terms of cost, delays, and diverting vessels to other terminals. The scenarios include both short and long term conditions with potentially severe consequences. Examples are the proliferation of larger container vessels bringing higher cargo volumes, construction activities temporarily closing parts of terminals, and extreme weather events slowing down operations. Layers of uncertainty in the modeling process pertaining to external data quality, internal data quality, and insight quality are characterized. The methods presented can enhance the resilience of logistics systems by identifying disruptive scenarios and evaluating recovery profiles of several different response strategies. The approach can be extended to air traffic control, public transportation scheduling, and resource allocation for other logistics sectors.

P.2 Thorne, ST*; Kovacs, DK; Austin, LA; Qiu, X; Horb, E; Martyn, N; Hay, A; Decision â'¢ Partners, Inc., Novus Environmental, RiskLogik, Southern Harbour; *dkovacs@decisionpartners.com*

Climate Change Vulnerability, Risk Assessment and Adaptation Scenario Development for Municipalities

For many urban centers climate change will have an increasing impact on development, economy and vitality. This demands efforts to reduce and stabilize levels of greenhouse gasses emitted (i.e., mitigation) and to increase community and municipal sustainability and resilience (i.e., adaptation). These impacts, manifested, for example, as the increasing severity of extreme weather events and decreased lifecycle for critical infrastructure, fundamentally alter the relationship between the civil society, the economy and the environment that supports them both. Many cities have wisely embarked on a program of risk characterization and response in order to mitigate and adapt to as many of the potential impacts as possible in advance of extreme events, and avoid their potentially crippling costs. But even in affluent cities, there are not enough resources to mitigate or adapt to every risk. The deployment of limited resources must be made on the basis of the greatest benefit to the greatest number of citizens or the protection of the most critical infrastructure assets. Until now, it has been extremely difficult and time consuming, to define with any degree of empirical accuracy, repeatability or auditability, what is critical and must be protected under changing circumstances. Further, even when critical risks have been identified, it is difficult to address them in a holistic fashion in a way that takes advantage of opportunities for synergies across multiple projects and, at the same time, prioritizes efforts based on the values, interests and priorities of those who have a stake in the process or the outcome. Our Team applies a multidisciplinary approach of risk assessment, risk management, resilience and stakeholder engagement to develop a holistic, strategic climate change mitigation and adaptation solution.

W3-E.1 Tonn, BE; Stiefel, D*; University of Tennessee; *dstiefel@utk.edu*

Anticipating the Unintended Consequences of Science and Technology

Society's technological choices generate unintended consequences that may include global catastrophic risks, within which the existential risks of human extinction are of most interest. This presentation investigates society's opportunity to improve its ability to anticipate the unintended consequences of science and technology by applying a theoretical framework of unintended consequences to emerging technologies. Emerging technologies create unintended consequences such as invasive species from Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR)-created species, or uncontrollable artificial intelligence from autonomous vehicles, or stressors on watersheds from environmental remediation technologies. This presentation applies Tonn and Stiefel's (2015) theoretical framework of unintended consequences, which links causes (X) and effects (Y) via waypoint(s) (W). The causes are discoveries, products, and processes, and behaviors resulting from science and technology research and development. A series of waypoints such as events, trends, or forecasted patterns lead to the effects, the unintended consequences. The theoretical framework then explains (Y) as a function of (X) and (W), where (Y) is defined abstractly along these types of metrics: magnitude of the consequence (e.g., high, medium, low); direction of the consequences (e.g., positive, negative, both); timing of the consequences (e.g., near-term, mid-term, long-term); and general aspects of the consequences (economic, political, environmental, technological, social, human health). In the context of these findings, this presentation considers the psychological, practical (institutional), and worldly approaches to taking action or inaction. It concludes with the key limitations and opportunities for future research.

M3-F.2 Tonn, GL*; Czajkowski, JR; Kunreuther, HC; Wharton Risk Management Center; *gtonn@wharton.upenn.edu*

Strengthening Infrastructure Resilience through Insurance and Economic Incentives

In the US, infrastructure is generally becoming less resilient due to insufficient investment in maintenance and replacement. A gap exists between the preparedness of critical infrastructure and the actual risk. A large proportion of federal disaster funding is spent on repair of public infrastructure, and disruptions to infrastructure systems cause significant economic losses and increase recovery time. Through interviews with insurers and infrastructure managers, we identify barriers and opportunities for strengthening infrastructure resilience to natural and man-made disasters. We evaluate how disaster insurance and other financial tools can enhance resilience and recovery and we present recommendations on ways to incentivize resilience. Our focus is on critical transportation infrastructure, but the findings are applicable to a wide range of infrastructure systems.

T3-E.4 Toton, E; Scouras, J; Ice, L*; Johns Hopkins University; *james.scouras@jhuapl.edu*

Has the Advent of Nuclear Weapons Saved Lives?

Senior leaders in the United States Department of Defense and scholars have argued that the advent of nuclear weapons has saved lives. This assessment has often been based on a particular study of the statistics of wartime fatalities from the year 1600 to 2000 that shows a marked drop subsequent to 1945. A graphical representation of these data has been developed and continues to be used to convincingly convey this conclusion. Our work is motivated by the significance of this conclusion coupled with the absence of critiques of the underlying study. This presentation will first provide a critique both the original statistical analysis and its graphical representation, then conduct a more rigorous analysis using the same data and conclude with suggestions of alternative interpretations of the results. We find that, while the original analysis has been persuasive in making the case that nuclear weapons have saved lives, it is irreproducible and that there are numerous biases in its graphical representation. Further, a more rigorous analysis, more objectively presented, brings the claim that nuclear weapons have saved lives—and, by implication, will continue to do so—into question. This doesn't mean that nuclear weapons have not saved lives. But, to make the case that they have requires a multidisciplinary analysis that makes a causal, not merely statistical, argument. Moreover, even if nuclear weapons have saved lives, this doesn't mean that they will continue to do so; we need to acknowledge the risks associated with the strategy of nuclear deterrence.

M2-C.4 Treuer, G*; Bolson, J; University of Miami and Florida International University; *gtreuer@gmail.com*

Accelerating adaptation: Urgency, barriers, and constructed risk in Miami Beach's pivot to sea level rise adaptive stormwater management

Climate change induced sea level rise threatens coastal communities with increased flooding, displaced populations, and degraded infrastructure. Cities are already experiencing increased flooding during high tides and impacts are projected to be exponentially worse by 2050. The potential losses can be reduced through adaptation, however the ahistorical nature of climate change requires new solutions. To find effective, efficient, and equitable adaptation solutions local governments must take the risk of experimenting with untested approaches. Adaptation experiments are often disrupted or blocked by a variety of barriers, however lessons from early actors can help. The city of Miami Beach's rapid pivot towards sea level rise adaptive stormwater management, beginning in 2013, provides a useful case to observe how barriers arise despite political and financial support. This study extends the Relational Theory of Risk by defining three aspects of the risk relationship in climate change risks, and uses it to identify mechanisms present in the dynamic, interdependent relationship between urgency as a driver of policy change and barriers to climate adaptation in Miami Beach. We find that barriers arose only after the city set its agenda and began implementing adaptation actions, attracting new stakeholders into the process. Also, adaptation actions that address risks at multiple timescales, e.g. raising streets, were the most successful. Finally, facilitation coordinated within the Mayor's Blue Ribbon Panel on Flooding and Sea Level Rise was essential for capitalizing on urgency, creating legitimacy for action, and overcoming barriers as they emerged during the initial period of accelerated change.

T2-C.1 Trump, BD*; Cegan, J; Poinsatte-Jones, K; Wells, E; Wood, M; Rycroft, T; Warner, C; Linkov, I; US Army Corps of Engineers; *benjamin.d.trump@usace.army.mil*

Published Literature and Communities of Practice for Synthetic Biology

Synthetic biology is a technology with growing applications in various veins of research. Likewise, it is being increasingly discussed within scholarly literature based upon emerging research trends, potential risks, and concerns pertaining to the governance of this emerging technology. However, no articles to date have sought to iteratively review such literature based upon trends in research and ongoing discussion by developers, policymakers, and academics across the world. This talk will introduce ongoing efforts to conduct such a bibliometric review of synthetic biology literature from 2000 through 2016, with specific discussion centered around synthetic biology research practice, product development, risk science, and concerns of domestic and international governance. Output from this review is twofold, including (i) descriptive statistics based upon research trends over this period, as well as (ii) leading veins of discussion within each of the four areas of inquiry noted above by leading experts in academia, government, industry, and non-governmental organizations.

M4-K.2 TSAI, J*; Cheng, C; Esselman, R; Northern Arizona University; *jiun-yi.tsai@nau.edu*

Integrating the Socio-Ecological Perspective in Predicting Willingness to Take Actions to Mitigate Climate Change Impacts: A case for Michigan's Huron River watershed

As climate change adaptation becomes an integral part of urban planning for coping with climate change, communicating climate change risks and adaptation strategies plays a critical role in engaging the public to progress towards a sustainable future. Despite an increase in research investigating the individual-level factors influencing policy support and behavioral decisions, the interactions between intrapersonal, interpersonal, and community-level factors remain scarce. This study integrates the socio-ecological perspective in public health intervention to delineate the mechanism through which lay people decide to take actions and install green infrastructure to mitigate climate change impacts. The socio-ecological approach highlights the multiple-levels of contextual influences on human behavior. Thus we ask: 1) How do intrapersonal, interpersonal and community-level factors predict lay public's behavioral intentions? 2) How do intrapersonal, interpersonal and community-level factors predict lay public's willingness to install green infrastructure? In collaboration with The Huron River Watershed Council, we recruited Michigan residents (N =149) to participate in an online survey using a convenience sample. The survey was uploaded and collected from November 2016 to January 2017. Intrapersonal-level factors include risk perception, anger, worry, issue importance, self-efficacy and perceived certainty of climate impacts. Interpersonal-level factors capture people's social connections. Community-level factors are measured by indicators of social vulnerability (Cutter et al., 2003) and perceived community vulnerability. We found that perceived community vulnerability, feeling angry about the lack of urgent policy responses, issue importance, and self-efficacy positively predict local residents' intention to take actions and willingness to install green infrastructure. Findings highlight the importance of developing a multi-level intervention to promote individual behavioral change for developing resilience.

M2-I.1 Tsaioun, K; Johns Hopkins Bloomberg School of Public Health; *ktsaiou1@jhu.edu*

Introduction to systematic reviews: methods and concepts developed in clinical medicine and their applicability to other domains

Systematic reviews help clinicians keep abreast of the medical literature by summarizing large bodies of evidence and helping to explain differences among studies on the same question. Used to inform medical decision making, plan future research agendas, and establish policy, systematic review methods are ready to be adopted in risk assessment. We will provide a primer on key elements such as review registration, protocol development, systematic databases searches, and meta-analysis. In addition, the concepts of internal validity (i.e. 'risk of bias') and external validity (i.e. generalizability of results) will be discussed. The presentation will conclude with an introduction to a case study on the application of these principles to Tox21 test methods comparison to traditional toxicological methods.

P.39 Tsunemi, K*; Kawamoto, A; Ono, K; National Institute of Advanced Industrial Science and Technology; *k-tsunemi@aist.go.jp*

Analysis of Consumers' Preference to Accidental and Chemical Risk in a Purchase of a Domestic Appliance

The aim of this study is to construct a framework of qualitative and quantitative evaluation of various effects including consumers' preference contributed to establish safety target of domestic appliances. Questionnaire survey was conducted on consumers' preference to accidental risk and chemical risk focused on flame retardants used in plastic parts of electric and electronic home appliances. First, we classified effects of flame retardants into four groups, such as health, environment, safety and economy, and we also identified four alternatives, such as products including brominated flame retardant, phosphorus flame retardant, inorganic flame retardant and with no flame retardant. Next, we evaluated the effects of health, environment, safety and economy of four alternatives qualitatively. Then, we conducted a questionnaire survey to consumers in the purchase of a domestic appliance and analyzed the consumers' preference by analytic hierarchy process (AHP). As the result, the degree of each consumer's preference to health, environment, safety and economy was quantified as 24%, 18%, 32% and 25%, respectively. It revealed that consumers had consciousness to avoid accidental risk in preference to avoid chemical risk. While, the alternative product including inorganic flame retardant which has low level of safety had the largest degree of consumer's preference, which was inconsistent with the former result.

M4-K.6 Vaishnav, P*; Abdulla, A; Carnegie Mellon University; *parthv@cmu.edu*

Decomposing the public's fear of nuclear power

There is a substantial literature that examines public attitudes to technologies that are considered particularly controversial. Of these findings, perhaps the most replicated and undisputed is nuclear power's unique status as a technology that engenders "dread." In this paper, we recruit respondents and randomly assign them to one of two groups. The first of these groups is given information about the risk profile of each of the clean technology options available for mass deployment. The second group is given the same risk profile information, although the names of the options are withheld. In each case, we task respondents with creating an energy portfolio to meet U.S. electricity demand in 2030 under a carbon dioxide emissions constraint. Our results show that stripping nuclear power of its label—but not its risks—results in a large (7%) and statistically significant ($p = 0.01$) increase in support for the technology. This translates to an additional 350TWh of nuclear generation in the US. In our second study, we created three vignettes, each of which asked respondents the extent (on a scale of 1-6) to which they supported a proposed energy infrastructure project. These three vignettes were identical in their discussion of accident risk, but one proposed building a hydroelectric power plant, the second a hydroelectric dam, and the third a nuclear power plant. Despite communicating identical risks across all three treatments, respondents expressed an unambiguous preference for hydroelectric power plants over nuclear power plants ($p=0.002$). Our work implies that seeking to develop an accident-proof reactor will not enable nuclear power to gain the level of acceptability required for substantially increased deployment. More generally, developers of new technologies must not only make them actuarially safe, but also be extraordinarily careful to shape the public's perception of them.

W1-K.2 Vink, D*; Good, M.D.; Crossroad Communications Inc.; *dvink@cognitivesciencesystems.com*
New Mental Modeling TechnologyTM Adds Capability to Risk Reducing and Life Saving Risk Communication
When risk reduction requires a change in behaviour, mental modeling techniques are the tools of choice. That's what the Technical Standards and Safety Authority (TSSA) of Ontario decided when they needed an effective risk communication strategy to address homeowners' information needs to reduce the risk of carbon monoxide (CO) in the home. They needed a risk communications strategy that reinforced what homeowners already knew to be correct, informed what they didn't currently know or misunderstood, and emphasized what they needed to know. The strategy needed to be driven by insight into homeowners' values, priorities, and information needs, rather than by guesswork or unilateral decision-making. The mental modeling approach provided the TSSA with a research-based risk communication strategy that could be used to improve homeowner awareness of CO safety in the home in order to save lives from a silent killer. While this case study had good impact, and improved on the risk communications that had been planned before adopting the mental modeling approach, if we could repeat the project today using the new Mental Modeling TechnologyTM & Platform, we could have improved: • Precise and common understanding of the problems and the value of solving them • Data collection and analysis using the CASS software • Literature reviews using cost-effective cCASS text recognition • Expert modeling made more efficient and dynamic • Analysis and recommendations for risk communications customized for each of the stakeholders, not just TSSA. Using a two-track visualization, this case study reviews the approach originally taken, and compares how the new technology can improve the process and increase the value of the outcomes.

W4-E.2 von Stackelberg, KE*; Chu, V; Mitchell, C; Wallis, L; Stark, J; Landis, W; Harvard Center for Health and the Global Environment; *kvon@hsph.harvard.edu*
Quantitative Tools for Linking Adverse Outcome Pathways with Process Models: Bayesian Relative Risk Networks
In a complex and changing environment (e.g., in the face of climate change) and with an increasing emphasis on sustainability of coupled human-natural systems, reductionist approaches to environmental management that fail to consider interactions, multiple stressors, and spatial and temporal characteristics of exposures and populations no longer suffice. Chemical risks and effects research has traditionally focused on adverse biological effects of chemical exposure to individuals. A more comprehensive assessment of ecological risk links chemical effects on individuals to those at increasing levels of biological complexity and to evaluate the spatial and temporal context in which chemical exposures occur. An integrated understanding of species activities (e.g., migration), physical stressors (e.g., habitat, climate, etc.) and biological factors (e.g., trophic interactions) is required to link individual-level exposures to population-, community- and ecosystem-level consequences. Adverse outcome pathways (AOPs) consider the continuum from molecular initiating events through a series of key events to adverse outcomes of regulatory interest. Here we demonstrate how existing data and models can be integrated through a Bayesian Relative Risk (BN-RRM) framework that explicitly links molecular initiating events to regulatory outcomes of interest and incorporates the influences of multiple stressors. The flexible approach allows multiple stressors linked to multiple outcomes based on integrating existing data and underlying process models. We provide several examples of ongoing case studies – one for chlorpyrifos exposures and an existing AOP based on acetylcholinesterase inhibition in fish in the Pacific Northwest, and another with a less well understood AOP based on immunotoxic effects of pefluorinated compounds.

P.38 Vogel, C*; Rak, A; Underwood, P; Scanlon, K; Bandolin, N; Esola, S; (1,2) Noblis, Inc.; (3,4) Office of the Assistant Secretary of Defense for Energy, Installations, and Environment; (5) U.S. Army Public Health Command; (6) DoD Defense Contract Management Agency Industrial Analysis Group ; *catherine.vogel@noblis.org*
Evaluating impacts to the DoD mission and the defense industrial base from chemical regulation under the amended Toxic Substances Control Act
The Toxic Substances Control Act (TSCA), amended in June 2016, provides the Environmental Protection Agency (EPA) with new authority to evaluate and address risks to human health and the environment from chemical substances and mixtures. The EPA identified an initial list of 15 chemicals for which risk evaluations and risk management actions will be developed through TSCA Sections 6(b) and 6(h) rule makings. TSCA-driven risk management actions can range from use restrictions and implementation of additional industrial hygiene control measures to full manufacturing bans. Many of the chemicals identified by EPA are used in Department of Defense (DoD) sustainment activities or in the manufacturing of components for weapon systems and platforms. The Deputy Assistant Secretary of Defense Environment, Safety and Occupational Health (ESOH) staff, the Military Departments, and the Defense Contract Management Agency Industrial Analysis Group are using a collaborative, multi-pronged approach to identify and evaluate potential DoD mission impacts from the TSCA rule makings. The approach includes (1) identifying the conditions and usage amount of each chemical through database research; (2) engaging subject matter experts to identify the mission criticality of these chemicals; (3) assessing industrial base impacts; and (3) engaging with EPA to inform the TSCA rule makings. A pilot assessment of two chemicals with proposed TSCA Section 6(b) rule makings is underway to identify supporting industrial base suppliers, explore the availability of potential chemical substitutes, and project the associated industrial base impact of the regulations. The pilot effort will aid in proactively identifying and addressing DoD mission risk from future TSCA rule makings. The poster describes the collaborative risk evaluation approach, summarizes supporting data, and presents key pilot assessment results.

M2-G.1 Waller, RR; Protect Heritage; *rw@protectheritage.com*
Risk analysis targeted to each and every manager's perspective
Museums, libraries, and archives use limited resources to preserve collections, ideally in perpetuity. These collections comprise a wide range of object and material types, embody many social values, and are subject to damage or loss from diverse hazards ranging from catastrophic fire to gradual light fading. The preservation system has been represented in a Cultural Property Risk Analysis Model (CPRAM). This model is hierarchical in the sense of Haimes' Hierarchical Holographic Modelling (HHM) and is kept as simple as possible at every level. It is intended for initial risk ranking and screening. As such, it serves as a guide to further, targeted risk analysis but can also identify egregious risks to be treated immediately. Medium to large museums, like any organization, are subject to silo effects. Taking advantage of preservation being a high-level institutional goal, together with the simple, hierarchical structure of the CPRAM, permits custom interpretations and representations of each manager's ability to influence risk to collections based on the scope of control enabled by their responsibilities. Due to a combination of simple and complex attributes, cultural property risk analysis general, and CPRAM in particular, are potential hotbeds of innovation in organization-wide risk analysis and management.

T3-K.3 Walpole, HW*; Wilson, RS; The Ohio State University; *walpole.23@osu.edu*

Fighting risk with risk: An exploration of attitudes towards inter-domain risk tradeoffs

Considerable research in psychology and economics has examined people's willingness to undertake risk, generally known as risk attitude. While early research defined a person's attitude towards risk as a single trait, more recent work suggests a more nuanced process where people may underweight some kinds of risks while they overweight others. This domain-specific account has many advantages but is not without its limits. Many decisions involve tradeoffs in risks and/or rewards across domains, for instance, gambling carries financial risks and rewards as well as social risks (being labeled a degenerate gambler). Our current understanding of domain specific risk-taking does not take into account the potential for domain specific risk attitudes to scale differently from one another. As such, our current instruments may not be able to accurately predict what a person would do when forced to trade-off two risk domains. It is critical in these situations to understand not only how important each risk is to a person but also how important they are relative to one another. Our research aims to aid understanding of people's risk-taking behaviors by measuring attitudes toward inter-domain risk tradeoffs and identifying whether these decisions can be predicted by differences in standard domain specific risk attitude measures. Participants will be presented with a version of the DoSpeRT scale and a series of choices between paired gambles that require tradeoffs between risk in two domains (e.g., finance vs. safety). Identifying how much risk results in a preference reversal between gambles will allow us to dial in how much risk a person will accept in one domain to avoid risk in the other and whether these tradeoffs can be explained with individual domain risk attitudes. We believe that this approach will produce stable attitudes towards risk tradeoffs that may be helpful for predicting and understanding engagement in behaviors that involve risk tradeoffs between domains.

T3-K.5 Walpole, EH*; Wilson, RS; Toman, E; The Ohio State University; *walpole.31@osu.edu*

The effects of construal level on perceptions of climate-exacerbated hazards

It is well understood that climate change will result in more intense and damaging natural hazards in many areas. Studies have also established that concrete construal of hazards often increase perceptions of risk and likelihood, while attributions of extreme weather events to climate change among those impacted by such events, and the public at large, have been increasing. We are interested in exploring the underlying mechanisms of these relationships and how they may be connected. Specifically, our research questions are how construal manipulations affect perceptions of natural hazards and how climate change associations may alter these effects. We conducted an experiment where we manipulated participants' mental construal level, and whether a hazard is associated with climate change or not in an informational message. We hypothesized that concrete construals will be more effective at increasing risk perceptions and mitigation intentions for a hazard in the absence of climate change associations. However, because matching construal levels (between objects and mindsets) reduces the effort required to traverse mental distances, we hypothesized that associating a hazard with climate change (in itself an abstract concept) will have a moderating effect on that relationship, resulting in abstract construals being more effective at increasing risk perception and mitigation intentions when the hazard is believed to be associated with climate change. The results can contribute to our understanding of both Construal Level Theory and how to best engage the public about protecting themselves from climate change related hazards and extreme weather events.

M3-E.4 Wang, B*; Zhuang, J; University at Buffalo, SUNY; *bairongw@buffalo.edu*

Rumor Response, Debunking Response, and Decision Makings of Misinformed Twitter Users during Disasters

The rapid spread of rumors occurring on social media is a critical problem that poses a great risk to emergency situation navigation, especially during disasters. Many research questions, such as how misinformed users judge potential rumors or how they respond to them are crucial issues for crisis communication, but have not been extensively studied. This paper fills this gap by originally documenting and studying Twitter users' rumor and debunking response behaviors during disasters, such as during Hurricane Sandy in 2012 and the Boston Marathon bombings in 2013. To this end, two rumors from each disaster and their related tweets are documented for analysis. Users who were misinformed and involved in the rumor topic by posting tweet(s), respond to a rumor by: (1) spreading (≥ 86%); (2) confirming (≤ 9%); and (3) doubting (≤ 10%). For confirmation-seeking (confirming) tweets, results show that not all of these tweets will get accurate replies. There were some confirming tweets from three cases were replied with rumor descendant tweets. Fortunately, more than 50% of these confirming tweets with rumor replies were also replied with accurate rumor debunking information at the same time. Confirming tweets are replied significantly more frequently than those non-confirming tweets from three rumor cases (P≤ 0.1). Rumor debunking analysis results indicate that if the given rumor spreading users were debunked, they would respond by: (1) deleting rumor tweet(s) (≤ 10%); (2) clarifying rumor information with a new tweet (≤ 19%); or (3) neither deleting nor clarifying (≥ 78%). We conclude that Twitter users would perform poorly in rumor detection and rush to spread rumors. The majority of users who spread rumors would not take further action on their Twitter accounts to fix their rumor spreading behaviors. Twitter users who post new tweets for rumor confirmation will face the risk of being rumored. But fortunately, more than half of them will eventually be debunked with accurate replies.

W3-F.1 Wartman, JB; Berman, J*; Olsen, M; Miles, S; Irish, J; Gurley, K; Bostrom, A; Lowes, L; University of Washington; *abostrom@uw.edu*

Enabling integrated disaster risk research with the RAPID facility

The NHERI post-disaster, rapid response research (or "RAPID") facility, at the University of Washington (UW) will enable natural hazard researchers to conduct next-generation quick response research through reliable acquisition and community sharing of high-quality, post-disaster data sets that will enable characterization of civil infrastructure performance under natural hazard loads, evaluation of the effectiveness of current and previous design methodologies, understanding of socio-economic dynamics, calibration of computational models used to predict civil infrastructure component and system response, and development of solutions for resilient communities. The facility will provide investigators with the hardware, software and support services needed to collect, process and as-sess perishable interdisciplinary data following extreme natural hazard events. Support to the natural hazards research community will be provided through training and educational activities, field deployment services, and by promoting public engagement with science and engineering. Specifically, the RAPID facility is undertaking the following strategic activities: (1) acquiring, maintaining, and operating state-of-the-art data collection equipment; (2) developing and sup-porting mobile applications to support interdisciplinary field reconnaissance; (3) providing advisory services and basic logistics support for research missions; (4) facilitating the systematic archiving, processing and visualization of acquired data in DesignSafe-CI; (5) training a broad user base through workshops and other activities; and (6) engaging the public through citizen science, as well as through community outreach and education. The presentation will provide an overview of the vision for the RAPID facility, the plans for operations and user training, and an overview of the schedule for facility development.

T4-J.5 Weber, RF; Georgia State University; *rweber@gsu.edu*
The Risk Regulation Turn in Financial Regulation
Risk regulation literature has undertaken a rich discussion of how risk is conceived as a legal-regulatory object, particularly with respect to increased political demands of governments to control and manage danger and catastrophe. It might seem natural for scholars of financial regulation to utilize a risk regulation lens to better understand decisionmaking in supervisory agencies. After all, many financial regulatory programs are set up for the express purpose of regulating systemic risk and supervising the organizations designed to create, take, and profit from financial risks. And yet that has not happened. First, this essay will explore why the risk regulatory model has historically not taken hold in financial regulatory arena. The overarching theme of modern administrative law is accountability. With financial regulation, concern for accountability has often been countermanded, and at times even overwhelmed, by a concern for independence. So while environmental regulation and health and safety regulation, aided by Congress and the courts, have developed elaborate statutory and administrative architectures for how to integrate scientific and technological uncertainty into their respective regulatory fields, financial regulation is comparatively underdeveloped on this score. The second part of the essay will identify respects in which the legal-regulatory regime of bank supervision has, in ways that have largely gone unnoticed, already migrated toward a risk regulatory model. For instance, one of the key distinctive attributes of risk regulation regimes is that the legality of a regulatory intervention depends on the regulator making a threshold determination about the existence or likelihood of an uncertain harm. Two regulatory initiatives stand out on this score: the Financial Stability Oversight Council (FSOC)'s designation of nonbank systemically important financial institutions (SIFIs) and the Federal Reserve Board of Governors (FRB)'s Comprehensive Capital Analysis and Review program.

M2-G.5 Wegener, CA; Smithsonian Institution; *wegenerc@si.edu*
Analyzing Risk for Cultural Property during Armed Conflict
Cultural heritage sites and collections around the world are currently at risk from one of the oldest and most damaging of man-made hazards – armed conflict. From the looting of the Iraq National Museum in 2003 to the intentional destruction of multiple archaeological and religious sites by religious extremist groups like ISIS in the past few years, cultural heritage professionals in several countries now face the potential for collateral and intentional damage from armed conflict at a rate not seen since World War II. While many may lament that there is little that can be done, colleagues working in today's war zones have had significant success in protecting collections and sites using the same basic methods developed during World War II. These include coordination and negotiation with armed groups, in situ stabilization and security, and in the worst-case scenario, evacuation of collections to more secure locations.

W3-A.4 Weinberg , J*; Lappin, B; U.S. Food and Drug Administration; *Jessica.Weinberg@fda.hhs.gov*
FDA's Internal Message Testing Network: An Innovative Approach to Risk Communication
Federal health agencies have an ongoing need to communicate clear messages to healthcare professionals and the public, but there are often no resources and insufficient time for formal message testing. The Paperwork Reduction Act (PRA) required approval to conduct testing with more than nine members of the public is lengthy, which is problematic when needing to rapidly communicate about emerging risks. The PRA, however, does not apply to collecting information from Federal employees when it applies to the context of their work. To conduct message testing without the need for additional financial resources and within tight timelines, we created an internal message testing network at the Food and Drug Administration (FDA). This network helps connect FDA's communicators with over 800 employee volunteers who are willing to test messages and serve as a proxy for target audiences. Our network is comprised of a diverse array of staff, including healthcare professionals. We conduct cognitive interviews with network members to understand their comprehension of messages. We then qualitatively analyze the interview data and provide FDA communicators with recommendations on how to improve their messages. FDA's internal message testing network has enabled the agency to improve its messages in a timely manner. Although testing with employees is no substitute for more rigorous testing, it successfully uncovers basic flaws in messages. Internal testing has increased the clarity and visual appeal of FDA messages. Internal testing results have led to the agency's use of enhanced graphics, more user-friendly web pages, and improved labeling of regulated products.

M3-H.3 Weir, MH*; Mraz, AL; Mitchell, J; The Ohio State University; *weirmarkh@gmail.com*
An Advanced Legionellosis Risk Model Incorporating Epidemiological Evidence of Disease Burden
The overall disease burden of Legionellosis in the United States has been increasing in the past decade. This increase in national disease burden has made Legionella pneumophila (L. pneumophila) the leading waterborne etiological agent in the United States. Legionellosis is a disease outcome that incorporates two specific diseases, first is Pontiac Fever, a self-limiting febrile illness, and Legionnaire's Disease, a potential lethal pulmonary disease. This research desired to account for more realistic water use patterns in showering, effects of flow rate on aerosol size, breathing rates of the population, and rates of disease incidence in the United States. The incorporation of these factors has developed a microbial risk model with the potential for higher accuracy and resolution to the population. Additionally, as the disease burden data were reported using age, sex and racial demographics, these demographics were modeled as well. The risks were modeled as daily risk of infection and illness, annual risk of infection and illness, moderate illness DALY, severe illness DALY and post-acute illness DALY. This research postulates three methods. First, that the method of incorporating incidence rate to model probability of illness given infection allows for a means of modeling this probability of illness given infection for specific populations. Second, that higher disease risk estimate resolution can be provided to use moderate DALY for Pontiac Fever, severe DALY for Legionnaire's Disease and post-acute DALY for consequences of illness later in life. Third, a more accurate model of L. pneumophila exposure and pathogenesis develops a more accurate risk model. This model allows for the first steps in a deeper understanding of the population level risk of Legionellosis in the United States' drinking water systems.

T4-E.4 Welburn, JW*; Hausken, KH; RAND Corporation; *jwwelburn@gmail.com*

The Saga Continues: Insight Into The Greek Debt Crisis Through a Repeated Game

The Greek debt crisis began in 2010 and has continued through three rounds of bailout programs sponsored by the European Union, the European Commission, and the International Monetary Fund (the so-called troika). The crisis highlights several economic policy problems including commitment and moral hazard. That is, approving one bailout may provide temporary relief but risks committing the troika to future bailouts and creating a moral hazard which encourages excessive fiscal risk taking. We characterize the repeated negotiations between Greece and the troika as a two-player repeated game between a country and a financial authority. In each period the country faces the decision to repay debt, borrow, default, or seek a bailout. If a bailout is sought, a negotiation ensues where failed negotiations leave the country with the choice of either borrowing from credit markets or default. Players make decisions using beliefs formalized as probability distributions over uncertain characteristics of the opposing player and the world using the Harsanyi doctrine. Using the two-player repeated game, we explore how approving one bailout commits a financial authority to future bailouts and how repeated bailouts affect the probability of default. We use solutions to this game to shed light on the likelihood of a fourth bailout program in the Greek debt crisis and whether or not the bailouts contribute to eventual recovery or default. Our findings produce new insights for economic policy and managing default crises.

T2-C.3 Wells, E*; Trump, BD; Linkov, I; US Army Corps of Engineers - Risk and Decision Science Team; *emilyw.usace@gmail.com*

Comparative Review of the Environmental Effects of Biofuels

Synthetic biology has the potential to revolutionize how science, technology, and product development benefit society. One notable instance of this includes biofuel research and development, where researchers are exploring how engineered algae can serve as a source of biofuel production in controlled settings. Despite the benefits that may be raised through the development of a potentially more efficient and reliable fuel source, engineered algae may also incur novel environmental risks. These risks are driven by the potential for novel genetic information to break containment and interact with the natural environment or proliferate in an unintentional and harmful manner. Therefore, future proposals for risk assessment of engineered algae should consider a variety of conventional and novel risk considerations, such as with horizontal gene transfer or the potential for engineered algae to proliferate in the environment alongside benefits such as with energy availability/efficacy improvements, as well as a reduction in land-use requirements for traditional feedstock options. This talk serves as one exploration of biofuel risk considerations, where engineered algal biofuel production will be comparatively reviewed against conventional options of corn and sugarcane feedstock, respectively. Ultimately, this talk will discuss how such a comparative approach can help elucidate areas of novel risk concern and help to qualitatively characterize such risks and benefits that algal biofuels may incur if such research is able to commercialize in the near future.

P.49 Wheeler, MW*; Bailer, JB; Whittaker, C; National Institute for occupational safety and health; *mwheeler@cdc.gov*

Applying in vitro toxicity data to inform chemical risk assessment

Various in vitro toxicity assays, including those in the USEPA ToxCast high throughput toxicity testing database, have been developed in an effort to better inform chemical risk assessments; however, few modeling methodologies have been created to fully use this information. For example, whole dose response curves for a collection of responses are typically not considered, and more complex models that involve multiple structurally-similar chemicals are frequently not used. This presentation investigates applying machine learning approaches including Gaussian processes, functional data models, and clustering techniques to databases created from the National Toxicology Program's databases as well as the US EPA's ToxCast high throughput toxicity testing platform to better classify risk. The results are presented to explore potential advantages of using this information to augment a standard quantitative risk assessment based on the analysis of the results from a single long-term bioassay study. We look at the potentiality of combining this information to develop models that will augment traditional quantitative risk assessment.

M4-I.5 WHELTON, ANDREW J, AJW*; SALEHI, MARYAM, MS; ABOUALI, MOHAMMAD, MA; WANG, MIAN, MW; ZHOU, ZHI, ZZ; NEJADHASHEMI, AMIR POUYAN, APN; MITCHELL, JADE, JM; CASKEY, STEPHEN, SC; Purdue University; *awhelton@purdue.edu*

Water Chemistry and Micriology Changes as Plumbing Ages

Drinking water chemistry and microbiology inside buildings is a field of much needed scrutiny. Coupled with new innovative plumbing designs, low water use fixtures are increasing water age in buildings. Consequences of increased water age have shown to be related to off-tastes and -odors, reduced disinfectant residuals, production of disinfectant byproducts, and greater microbial levels, among others. A field study was conducted from September 2015 through December 2015 to understand the link between fixture water use and drinking water quality in a newly plumbed residential green building. Water use and quality were monitored at four in-building locations. Once the home was fully inhabited, the maximum water stagnation time found was 72 hr. Bacteria and organic carbon levels increased inside the plumbing system compared to the chlorinated municipal tap water entering the building. A positive correlation between organic carbon and bacterial concentration at select locations was observed. A greater number of bacteria was detected in hot water samples compared to cold water. This suggested that hot water plumbing promoted greater microbial growth. At some fixtures, metal plumbing components caused Zn, Cu and Pb levels to increase above the levels measured at the water treatment plant. At the basement fixture, where the least amount of water use events occurred, greater organic carbon, bacteria, and heavy metal concentration were detected. Different fixture use patterns resulted in disparate drinking water quality within the same residential building. Additional research will be described pertaining to organics release from plastic pipes, heavy metal fate in drinking water plumbing, along with other building plumbing research topics.

W1-I.2 Whittaker, MH; ToxServices LLC;
mwhittaker@toxservices.com

Chemical hazard assessment tools for identification of chemicals of concern.

Chemical hazard assessment (CHA) is a systematic process of assessing and classifying hazards across a spectrum of physical, health, and/or environmental endpoints. CHA is used by industry, government and NGOs to support product design and development, materials procurement, and as part of alternatives assessment to meet regulatory requirements. Eliminating or substituting a chemical of concern in a product and throughout a supply chain can be an expensive proposition. When faced with a chemical restriction, the least proactive position a company can take is to eliminate the restricted chemical of concern and replace it with a structurally similar chemical that is currently unrestricted. This approach can be risky because it is possible that the substitute will have the same (or worse) hazard characteristics as the original chemical of concern. In order to conduct a chemical hazard assessment, it is critical to understand the Globally Harmonized System of Classification and Labelling of Chemicals ("GHS"). GHS is a system for harmonizing hazard classification criteria and chemical hazard communication elements worldwide, and includes consideration of mixtures toxicity. In addition to GHS, there are publicly accessible, transparent, non-regulatory, stand-alone chemical hazard assessment schemes that build on GHS. Best known systems in the United States include U.S. EPA's Design for the Environment (DfE) Alternatives Assessment Criteria for Hazard Evaluation, Clean Production Action's GreenScreen® for Safer Chemicals, and the Cradle to Cradle Products Innovation Institute's Material Health hazard assessment protocol. Examples of these CHA methods including case report examples showing how these tools by industry will be presented, including discussion of how and when exposure considerations can be incorporated into the assessment process.

W1-I.4 Wiener, JB; Duke University; *wiener@law.duke.edu*

Risk, Hazard, Precaution, and Adaptive Policy Learning

The Precautionary Principle (PP) espouses regulation of uncertain risks, sometimes based on hazard alone, without consideration of exposure, risk, or policy impacts. (1) Priority selection. The PP offers little guidance on which risks or hazards deserve priority. Because all risks pose uncertainty, the application of the PP may be overbroad or arbitrary. Some hazards with low exposure may be selected while other hazards with high exposure may not. A common claim is that Europe has become more precautionary than the US, but the reality has been selective application of precaution to particular risks on both sides of the Atlantic. (2) Perverse outcomes. Invoking the PP may impede innovation and induce risk-risk tradeoffs. We need attention not only to exposure to the hazard, but also to exposure to the policy. The solution is to broaden beyond the target hazard, ensuring full portfolio impact assessment toward reducing overall risk. (3) Permanence vs. learning. Uncertainty warrants not permanent precaution but rather investment in learning. Precaution should be "provisional" or "adaptive" to ensure review and updating over time. Retrospective review is needed to assess policy performance, not just to reduce costs but to compare policy designs and to improve the accuracy of prospective impact assessments. International regulatory cooperation should not simply harmonize standards, but should learn from observed policy variation. Crisis events can be opportunities for learning if institutions are designed in advance to "prepare to learn." The strongest case for true precaution is not uncertainty, but rather the obstacles to learning from extreme catastrophic risks. Learning can be pursued through a menu of instrument choices for adaptive regulation. Improved versions of precaution should go beyond hazard to assess risks (including exposure), benefits, costs, and risk tradeoffs, and to foster adaptive learning over time.

W3-K.1 Wiener, JB*; Bennear, LS; Duke University;
wiener@law.duke.edu

Instrument Choice for Adaptive Regulation of Emerging Technologies

Regulation is often viewed as a one-time, go/no-go decision, attempting to balance prospective benefits, costs and risks; such decisions could be optimal, but they could also yield suboptimal errors by either overregulating a net beneficial technology or underregulating a net harmful technology. Emerging technologies imply that understanding of benefits, costs and risks will improve over time. A better approach may therefore be "adaptive regulation" that replaces the one-time yes/no decision with a series of multiple partial sequential decisions informed by monitoring and review – i.e., designing regulation to incorporate learning over time. Meanwhile, regulation does not come in just one type, but actually offers a variety of instrument choices. This presentation identifies and compares instruments for adaptive regulation of emerging technologies, including: retrospective review; prospective-retrospective review; adaptive RIA; periodic reviews (e.g. every X years); sunset and reauthorization clauses; monitoring indicators with triggers for automatic policy adjustment; discretionary policy adjustment by an oversight body; accident investigation bodies; ex post liability; experimental deployments; adaptive licensing to targeted subpopulations; and others. Comparing and choosing instruments for planned adaptive regulatory learning will be crucial to sound regulation of emerging technologies.

T2-G.4 Wiersma, RP; Technical Standards and Safety Authority;
rwiersma@tssa.org

On the relation between safety outcomes and regulatory compliance

Regulations exist worldwide for the purpose of protecting the public good. A building code, for instance, may ensure that buildings are constructed to be fire resistant. Regulatory bodies often perform inspections to measure compliance and enforce adherence to the applicable regulations and codes. In the case of public safety, it is expected that complete compliance is necessary. An underlying assumption in this activity is that safety is related to the level of compliance. We compare different levels of measuring compliance with the aim of exploring the relation between observed safety and compliance. How do safety and compliance relate? How do risk and compliance relate? Is it possible to invoke cost-benefit analysis to determine the value of encouraging/enforcing compliance? If there are diminishing returns for compliance enforcement, is it possible to predict a point of 'over-compliance'? We find that traditional ways of measuring compliance prove to be unsatisfactory and more novel approaches are proposed.

M3-C.2 Wikoff, DW*; Welsh, BT; Henderson, R; Brorby, G; Britt, J; Myers, E; Goldberger, J; Lieberman, HR; O'Brien, C; Doepker , C; ToxStrategies; *dwikoff@toxstrategies.com*

Application of Systematic Review in the Evaluation of Caffeine Safety: Potential Adverse Effects of Caffeine Consumption in Healthy Adults, Pregnant Women, Adolescents, and Children

As an update to a foundational publication issued by Health Canada in 2003, a systematic review of data on potential adverse effects of caffeine was conducted according to the IOM standard. Five PECO (population, exposure, comparator, and outcome) questions to address five types of outcomes (acute toxicity, cardiovascular toxicity, bone and calcium effects, behavior, and development and reproduction) in four healthy populations (adults, pregnant women, adolescents, and children) relative to comparators: 400 mg/day for adults [10 g for lethality], 300 mg/day for pregnant women, and 2.5 mg/kg/day for children and adolescents (established by Health Canada) were developed. Data was extracted and risk of bias assessments conducted for the 381 articles meeting inclusion/exclusion criteria. Conclusions were drawn for the body of evidence for each outcome using a weight of evidence approach based on that developed by OHAT with slight modifications. When the total body of evidence was evaluated, and when study quality, indirectness, consistency, risk of bias, level of adversity, and magnitude of response were considered, the evidence generally supported that conclusions reached by Health Canada over a decade prior remain acceptable for healthy individuals (400 mg/day in adults, 300 mg/day for pregnant women, and 2.5 mg/kg-day for children and adolescents) for the outcomes evaluated. The results of this systematic review support a shift in caffeine research to focus on aspects such as characterizing effects in sensitive subpopulations and establishing better quantitative characterization of interindividual variability. This review, being one of the first to apply systematic review methodologies to toxicological assessments, also highlights the need for refined guidance and frameworks unique to the conduct of systematic review (e.g., multi-endpoint reviews) in this field.

M2-I.2 Wikoff, DS*; Rager, JE; Harvey, S; Haws, L; Chappell, G; Borghoff , S; ToxStrategies; *dwikoff@toxstrategies.com*

Development and refinement of a framework for quantitative consideration of study quality and relevance in the evaluation of mechanistic data based on Key Characteristics of Carcinogens

Evaluation of mechanistic data in a systematic review is an element unique to the field of toxicology; methods established in evidence-based medicine are not sufficient to integrate this data stream. Smith et al., (2016) described an approach to organize mechanistic data via ten key characteristics of carcinogens (KCC). However, this approach does not incorporate data quality, directionality, and concordance with adverse outcomes – concepts key to use in risk assessment. Thus, a framework that integrates these elements is proposed; it has three components (reliability, strength, and activity) that are evaluated using an algorithm which provides a score for each KCC and subsequently categorization as weak/moderate/strong. Reliability scores provide a measure of study quality. Strength scores provide a measure of relevance for each model, which are used to characterize applicability to the evaluation of carcinogenicity in humans; this component considers both the number of models and assays. Activity scores account for active/inactive results. The algorithm allows for flexibility in component weighting, and the scoring approach allows for the incorporation of many study types, including high throughput screening data. Resulting data are then considered relative to animal and human evidence streams, and tumor responses. Application of this framework to multiple mechanistic datasets for chemicals associated with different types of cancers and in different models demonstrates that simple categorization of data by KCC are not alone sufficient, and that evaluation of complex and diverse data (i.e., endpoints measured at the organ, cellular, and molecular level) relative to tumors observed in other evidence streams is critical. The proposed framework provides a quantitative approach that accommodates data quality and relevance, thus increasing the utility of evaluating and integrating the identified KCC, as well as providing a transparent and reproducible process for assessment of mechanistic data in systematic reviews.

P.43 Wilkins, A*; Thayer, K; Federal Government; *wilkins.amina@epa.gov*

Use of DistillerSR to Facilitate Systematic Reviews

ABSTRACT: Use of DistillerSR to Facilitate Systematic Reviews To support the Environmental Protection Agency's (EPA) mission to protect human health and the environment, the Integrated Risk Information System (IRIS) Program evaluates studies of chemicals in the environment to identify adverse health effects and characterize exposure-response relationships. Over the last several years, the IRIS Program has been adopting systematic review methodology in the development of their assessments. As part of implementing systematic review, the IRIS program is increasingly using a variety of specialized software applications to increase efficiency of conducting the assessments. This poster describes the use of one web-based systematic review software tool, DistillerSR, commonly used in the field of systematic review to screen studies for relevance. DistillerSR facilitates group screening efforts and includes many features, including tracking of screening conflicts, creation of inclusion/exclusion reports, project management capabilities, and user-customized form creation. Key features and staff time metrics for recent screening work will be described in this presentation. The views expressed herein are those of the authors and do not necessarily reflect the views or policies of the US EPA.

P.129 Williams, PRD*; Meiro-Lorenzo, M; Puech Fernandez, MR; Kadeli, LG; E Risk Sciences, LLP and World Bank; *pwilliams@eriskciences.com*

Current and Emerging Human Health Impacts Associated with Land-Based Pollution in Low and Middle-Income Countries (LMICs): Data Gaps & Research Needs

Little is known about the health impacts from land-based pollution in low and middle income countries (LMICs), although preliminary estimates suggest that exposures and risks are significantly greater than in high income countries. Such pollution occurs from both legacy and active sites involving industries such as lead-acid battery recycling, industrial mining and ore processing, lead smelting, tanning operations, artisanal small-scale gold mining, and e-waste recycling. This presentation provides an overview of key findings from the available literature, identifies important knowledge and data gaps, and discusses research currently underway by the World Bank to better understand the health impacts from contaminated sites in LMICs. For example, although a number of studies have collected data in LMICs, different study designs and sampling methods makes it difficult to compare or generalize from these study findings. Most research has also focused on a single pollutant or category (e.g., lead, mercury, metals, pesticides) and limited number of exposure pathways and health outcomes. Additionally, non-uniform survey questionnaires has resulted in variable and incomplete information on population exposure factors, such as intake rates, time-activity patterns, behaviors, lifestyle factors, and comorbidities. Most lacking are data and analyses linking environmental concentrations, population factors, estimated or measured exposure levels, and observed or predicted health effects at the local or regional level. Few attempts have also been made to utilize, validate, or modify existing exposure and risk models for use in developing countries. To address these issues, the World Bank is supporting research to collect and analyze site-specific and population factor data from selected target countries (e.g., Nigeria, Ghana, Tanzania, Bangladesh, Pakistan) and improve the robustness of affordable tools to estimate health and economic impacts from land-based pollution in LMICs.

P.98 Williams, PRD*; Fries, M; Ovesen , J; Maier, A; E Risk Sciences, LLP and University of Cincinnati College of Medicine; *pwilliams@eriskciences.com*

VOC Exposures from Use of Aerosol Brake Cleaner

Airborne exposures were measured during the use of a common aerosol brake cleaner under varying conditions. Short-term (15 min) and task-based (≥1 hr) personal, area, and background samples were collected using charcoal tubes. Real-time monitoring of total VOCs during application of the brake cleaner was also conducted. Sampling occurred during 8 simulations in which the product composition, potential for dilution ventilation, and use of an industrial floor fan varied. Each simulation involved the disassembly, cleaning and inspection, and reassembly of brakes (disc and drum) on four passenger cars and light duty trucks. For the personal short-term samples, the average detected concentration of THC and toluene across all simulations ranged from 19.0–217.5 mg/m3 (5.5–61.5 ppm) and 10.4–162.5 mg/m3 (2.8–44.0 ppm), respectively. For the personal task-based samples, the average detected concentration of THC and toluene across all simulations ranged from 3.6–66.0 mg/m3 (1.0–18.5 ppm) and 2.4–52.0 mg/m3 (0.6–14.0 ppm), respectively. Lower airborne concentrations were measured for the area samples. The highest measured concentrations of THC and toluene occurred during the greatest use of aerosol brake cleaner, when the bay doors were closed, and when the floor fan was turned off. Benzene was not detected in any of the samples. Peak concentrations of total VOCs ranged from approximately 20–764 ppm, with no measurements exceeding 300 ppm for 10 minutes. The ambient temperature during the study was hot (82–96°F) and humid (RH 48–73%). Wind speed measurements using a hot wire anemometer only exceeded 30 ft/min when the floor fan was on. The amount of aerosol brake cleaner used in each simulation (33.4–136.6 grams) was driven by the number of parts cleaned. The scenarios evaluated in this study encompassed both typical and worst-case conditions during the use of an aerosol brake cleaner, and should be applicable to other products with similar compositions and use patterns.

M4-J.6 Williams, AJ*; Shah, I; Patlewicz, G; Wambaugh, J; Grulke, C; Edwards, J; Richard, A; Judson, R; Environmental Protection Agency; *williams.antony@epa.gov*

The EPA Comptox Chemistry Dashboard: a web-based data integration hub and its applications to supporting risk assessment

The U.S. Environmental Protection Agency (EPA) Computational Toxicology (CompTox) Program helps prioritize chemicals for research based on potential human health risks by integrating advances in biology, chemistry, and computer science. Over the past decade, EPA CompTox data have been made publically accessible through a series of software applications. Recent efforts have focused on developing a software architecture that assembles the data into a single platform. The new CompTox Chemistry Dashboard web application provides access to data associated with ~750,000 chemicals, including substances represented as chemical structures representations as well as UVCB substances (Unknown or Variable Composition, Complex Reaction Products and Biological Materials). Associated data include physicochemical properties, toxicity values, bioassay screening values, and exposure data. The dashboard provides searching based on chemical names, synonyms and CAS Registry Numbers, either as single entries or batch-based searching for multiple chemicals simultaneously. Data streams and functionality have been delivered to support risk assessment through the RapidTox application. Toxicity data is collected from multiple resources including the Integrated Risk Information System (IRIS), Provisional Peer-Reviewed Toxicity Values (PPRTV), and the European COSMOS database for cosmetics. The CompTox Chemistry Dashboard remains under constant curation and expansion with new data. This presentation will provide an overview of the dashboard, especially in regards to its use in rapid risk assessments. The presentation will highlight available data, the flexible search functionality, and the integration to other public resources. This abstract does not reflect U.S. EPA policy.

M4-A.4 Williams, RA*; Yamoun, DY; George Mason University; *rwiliav123@gmail.com*

LNT and Economic Analysis

The Linear No Threshold (LNT) model has been widely accepted for cancer risk assessments, with the assumption that a single molecule may initiate a cancer sequence. For many chemicals, and radiation, it is likely that that their are threshold's at doses that would give rise to risks that begin at around 1 in 10,000. Because of this, estimates based on LNT will exaggerate the amount of target and reduced risks. We will examine how, for radiation, use of the LNT has generated expected benefits vastly in excess of the likely benefits (for soil clean-up) and suggest an economic definition of a threshold that will avoid this problem.

T3-K.1 Wilson, RS*; Zwickle, A; The Ohio State University; *wilson.1376@osu.edu*

Measuring risk perception: Is there a right way?

Risk perception is often measured in a variety of ways, with the most popular measures being a combination of probability and consequence, or likelihood and severity. However, the measures reported in the literature also include items related to worry, concern, exposure, and vulnerability, just to name a few. A recent paper by Ferrer et al. (2016) in the Annals of Behavioral Medicine claims that there are three key dimensions to risk perception: deliberative, affective and experiential. However, this study focused solely on a disease context to assess their measure. Overall, there is no real consistency or agreement in the measures that are used, presenting a real challenge for understanding what exactly we are measuring when we measure perceived risk. To address this challenge, we conducted a review of the literature to identify the range of measures used previously, and then developed a survey instrument containing a standardized set of items capturing multiple dimensions of risk perception. The survey was deployed with a representative online panel of U.S. citizens. We tested these multi-item measures of risk perception for multiple categories of hazards ranging from those posing both environmental and human health consequences (e.g., water pollution) to those posing health consequences only (e.g., disease). We also measured individual traits of the respondents to assess how responses to particular items may vary by respondent characteristics, as well as intentions to act to reduce one's risk for a given hazard. We used psychometric techniques to identify the most valid and reliable measure of the construct from the set of possible items, exploring to what extent the best measure varied for different types of hazards. Results of the measurement study will be presented and recommendations for how to best measure risk perception for different contexts will be discussed.

T4-F.5 Winckler, V; Wollega, E; Baroud, H*; Vanderbilt University; *hiba.baroud@vanderbilt.edu*

Assessing the resilience power systems under renewable sources supply risk

Recent research has focused on the opportunities to increase the supply of renewable energy using wind, solar, hydro, biofuel, and other sources in order to gradually replace the consumption of fossil fuels. With the prediction of renewables being highly uncertain and vulnerable to external events, the increase of power supplied by renewable sources can potentially lead to a less resilient power system. For example, a particular solar energy supply on a given day is determined by the thickness of the cloud on that day, the wind energy supply is affected by wind velocity, the volume of rain affects hydroelectric power generation, among other scenarios. The forecast of the level of supply from these renewable sources under future uncertainty is non-trivial. In addition, renewables supply disruptions are not uncommon due to natural hazards such as tornadoes and hurricanes. As such, it is important to make sure that power systems in the future are resilient to disruptive events. The objective of this paper is to establish and measure resilience metrics of power systems in the future as the fossil fuel supply gradually decreases and the renewables supply increases. The power system is modeled as a stochastic network in which supply nodes represent power plants and demand nodes represent cities, counties, or states. Using stochastic network optimization tools, this work seeks to identify the most effective way to distribute power in the United States and provides the combination of renewable and non-renewable sources that minimizes the impact and maximizes recovery in the event of a major disaster.

T2-C.4 Wirz, CD*; Howell, EL; Brossard, D; Scheufele, DA; Xenos, MA; University of Wisconsin-Madison; *cwirz@wisc.edu*

High risk, high reward: the role of ambivalence in perceptions of nanotechnology and synthetic biology

Meaningful differences are lost when measures of risk and benefit perceptions for new technologies are only considered separately. For example, someone who perceives high risks and low benefits associated with synthetic biology will view the technology very differently than another individual who has the same risk perception but also sees many potential benefits. Even though these two individuals perceive the same level of risk, the second person is ambivalent when seeing both potential risks and benefits with the technology. Generally understudied, an understanding of levels of ambivalence such as the one portrayed above among the general population could, however, give a more nuanced view of how individuals perceive risk related to new technologies, and in turn, would have important implications for how risks are managed and communicated. This study aims to better understand ambivalence in risk and benefit perceptions related to new technological issues. We analyze perceived societal risk and benefit and compare them to a measure of ambivalence for two technological advancements: synthetic biology and nanotechnology. Using these topics, we explored how different factors from past risk research (e.g. gender, trust) relate to risk and benefit perceptions and to different levels of ambivalence. We analyzed data from three nationally representative surveys in the U.S. from 2011-2014 to determine the stability of perceptions over time for each topic and to see what nuances including a measure of ambivalence can add beyond the separate measures of risk and benefit. Additionally, we compared these results to the perceptions of experts in both synthetic biology and nanotechnology to better understand how professional familiarity alters the levels of ambivalence. Preliminary results show differences when risk/benefit perceptions are analyzed together, with a fair amount of the public seeing both no risks or benefits from the technologies.

M2-K.1 Wirz, CD*; Johnson, BB; University of Wisconsin-Madison; Decision Research; *cwirz@wisc.edu*

Mapping the media and risk landscape around Zika: Where do people get information about risk?

Our media environments have been rapidly evolving for several decades, especially with the advent of online platforms and tools like search engines and social media. These advances have dramatically changed the way people seek and are exposed to information about risk. This study uses the recent outbreak of the Zika virus as a case study for understanding what types of media (e.g. broadcast news, online news, social media) and specific outlets (e.g. ABC, Fox News, the New York Times) people used in the U.S. to get information about the Zika virus. This research also analyzes how media use and the specific content of different media types relate to risk perceptions surrounding to the Zika virus. This study uses a combination of survey data collected in four waves from July 2016 to April 2017 from a U.S. national online panel, and content analyses of varied sources and source types identified by respondents as sources they used for information about Zika. The content analyses were performed for the week before each wave of the survey was launched, of such content as whether risks or reassurances were emphasized, or whether management options such as travel warnings or spraying for mosquitoes were mentioned. This study advances understanding of media use and agenda-setting for risk judgments and management preferences.

W4-G.4 Wong, CML; University of Luxembourg; *catherine.wongml@gmail.com*

Risk Governance and the Crisis of Expertise

The U.S. Elections and Brexit vote of 2016 brought to light the rise in populism as a blowback effect from decades of uneven globalization. A key underpinning feature of this trend is the crisis of expertise both in terms of the legitimacy of expert knowledge as well as the ability of expert knowledge systems to forecast or anticipate future hazards and disasters, natural or otherwise. As a normative framework, the risk governance scholarship have attempted to address the legitimacy of decisions and ability to anticipate risks by providing greater clarity on the different characteristics of risk problems and uncertainties. But as a mode of practice risk governance has been less adequate in gaining traction among policy elites. This raises a number of new challenges for risk governance as a concept and in practice: 1) how to translate risk governance as a normative framework into a mode of practice; 2) how to make use of expertise in an era when expertise is suspect; 3) how to evaluate expertise in risk governance processes; and 4) how to evaluate the legitimacy of risk governance as an expert process itself. This paper approaches these challenges by exploring a range of planning tools and institutional arrangements that can help strengthen the ability of risk governance to adapt to and address the crisis of expertise and build bridges across scientific communities and between experts and publics.

W2-K.2 Wong-Parodi, G*; Fischhoff, B; Strauss, B; Carnegie Mellon University and Climate Central; *gwparodi@gmail.com*

Effect of risk and protective decision aids on flood preparation in vulnerable communities

Although the risks of flooding demand responses by communities and societies, there are also many cost-effective actions that individuals can take. We examine two potential determinants of such adoption: individual predisposition to act and the impact of decision aids that emphasize the risk, the actions, both the risks and actions, or neither (control). Respondents were a representative sample of 1,201 individuals in the areas most heavily impacted by Super Storm Sandy, in 2012. We find that individuals who report having taken action previously are more responsive to all messages except for the combined message – which had a positive effect on those who had not acted previously, but a negative effect on those who had. Finding individual differences in propensity to act supports previous results, as does finding that both stating a problem and providing solutions can motivate people who have not acted previously. Finding that a combined message can reduce reported intention for future action among people who have already taken protective measures, is a new, and potentially troubling result. One possible explanation is that the decision aids generally reduced participants' estimates of flooding risk. Although even those risks were still high enough to motivate action for many participants, those who had already acted may have felt that they had done enough, after reviewing the full picture described in the combined aid.

W1-K.4 Wong-Parodi, G*; Dias, B; Taylor, M; Carnegie Mellon University; *gwparodi@gmail.com*

Effects of using indoor air quality sensors on perceptions and behaviors: Pittsburgh empowerment lending library study

Air quality affects us all and is a rapidly growing concern in the 21st century. We spend the majority of our lives indoors, and can be exposed to a number of pollutants smaller than 2.5 microns resulting in detrimental health effects. Indoor air quality sensors have the potential to provide people with the information that they need to understand their risk, and take steps to reduce their exposure. In a two-part study, we assess baseline views and behaviors related to indoor air pollution among the general public (n=212) in Pittsburgh, PA recruited online and at local public libraries. We then evaluate the effect of using an indoor air quality sensor on people's views and behaviors (n=25) after checking out and using a sensor for up to three weeks in their homes. We find that the general public feels knowledgeable but uncertain about their indoor air pollution, want to know more, and prefer using a device that is freely available. Sensor users learned more about indoor air quality, seemingly took steps to reduce their risk from what they learned, and shared their experience with others. Thoughtfully designed and deployed personal sensing devices can help empower people to take steps to reduce their risk.

W4-E.4 Wood, AL; North Carolina State University; *alexa.l.wood@gmail.com*

Mental models of climate change and food security in northwest Ghana

Though climate change is expected to impact populations across the globe, marginalized communities will experience its most severe effects. At-risk communities are expected to face food shortages and decreased access to water. Sub-Saharan Africa is widely considered to be among the most vulnerable regions of the world, as semi-arid conditions are expected to expand southward. As temperatures increase, rainfall patterns will become less predictable, which will threaten the livelihoods of people across the region. Conditions in the Upper West region of Ghana reflect this trend; unpredictable rainfall has impacted the livelihoods of subsistence farmers. At present, there is a lack of research that focuses on the experiences and needs of individual farmers. It is thought that a more thorough understanding of the individuals' experiences can help inform policymakers and lead to more effective strategies to mitigate climate stress. This project explores the perspectives of over 70 subsistence farmers in the Lawra District, located in the Upper West region of Ghana. The interview data will be translated into mental models, which graphically represent the decision-making processes of the farmers in the study. Mental models of two contrasting scenarios will be compared: customary practices versus responses to external pressure. The two models will depict how climate change has shifted traditional farming practices along with the new behaviors farmers have developed in response to environmental stress. This work will be used as part of a larger project to understand and model the impacts of climate change upon food security on a variety of social scales across Western Africa.

M4-C.4 Wood, MD*; Blue, S; Cato, C; Wells, E; Zemba, V; Linkov, I; U.S. Army Engineer Research and Development Center & U.S. Army Institute for Behavioral and Social Sciences; *matthew.d.wood@usace.army.mil*

Integrating Resilience Across the Organization

Abstract: For organizations to be ready and resilient, they need to understand how attempts to improve the organization through training or other tools at one level of organizational structure (i.e., individuals, groups) impact other levels of the organization. An inherent assumption of individual resilience training programs is that improvement in individual resilience skills will result in units that are better equipped to address adversity. Hypothesized effects of improved unit resilience include improvements in organizational mission readiness and enhanced community resilience. Research is presented on understanding the relationships between individual and unit-level resilience via a systematic literature review and a meta-analysis. The research providing mechanistic accounts of relationships between unit resilience and organizational readiness or community resilience as it relates to large organizations like the U.S. Army is not well understood. Measurement constructs, to the extent that they exist, are needed to understand the relationship between unit resilience and both organizational readiness and community resilience.

P.52 Wu, C*; Chen, CH; Chen, HC; Liang, HJ; Chen, ST; Lin, WY; Wu, KY; Chiang, SY; Lin, CY; National Taiwan University; *d01841001@ntu.edu.tw*

NMR-and MS-based metabolomics to investigate molecular effects of repeated dose exposure of maleic acid in Spague-Dawley rats

Maleic anhydride (MAH), an organic raw material frequently used in consumer and industrial products, was intentionally adulterated in a variety of starch-based foods. We aim to elucidate possible mechanisms through which MA-toxicity occurs by 1) determining the changes of metabolic profile of Sprague-Dawley rat urine after repeated exposure using 1H NMR spectroscopy and multivariate analysis; 2) investigating whether MA induce oxidative stress using LC-MS/MS. Adult male Sprague-Dawley (SD) rats were divided into four dose groups and subjected to a 28-day repeat-dosed study (0, 6, 20 and 60 mg/kg) via oral gavage. Urine samples were collected twice a day on Day 0, 7, 14, 21, and 28; organs underwent histopathological examination. Our results demonstrated that MA exposure increases the urinary concentrations of 8-OHdG, 8-NO2Gua and 8-isoPGF2α; analysis of acetoacetate, hippurate, alanine, and acetate demonstrated time- and dose-dependent variations in the treatment groups. Changes in body weight gain and relative kidney weights in medium- and high-dose groups were significantly different compared to untreated rats ($p < 0.05$). Physio-morphological alterations were evident in the kidneys and liver. Our results suggest that MA consumption escalates oxidative damage, membrane lipid destruction, and disrupt energy metabolism. These aforementioned changes in biomarkers and metabolites can assist in characterizing the possible mechanisms by which maleic acid induces nephro- and hepatotoxicity.

T4-G.4 Wu, F; Chen, C*; Michigan State University; *fwu@msu.edu*

Antibiotic Resistance: The Need for a New Risk Assessment Framework

Increasingly, national and global health policymakers are recognizing and addressing the risk of bacteria becoming resistant to the antibiotics available in medicine. If bacteria evolve widespread resistance to common antibiotics, many of the medical procedures taken for granted today (e.g., appendectomies and Caesarian sections), and the common infections currently treated with simple antibiotic regimes (e.g., ear infections and some skin infections), will become more difficult, complicated, and risky. However, assessing the risk of antibiotic resistance is complex, because at least three different potential hazards must be considered in dose-response and exposure assessments: the antibiotics themselves, the antibiotic resistant bacteria, and the antibiotic resistance genes. Moreover, problem formulation of the risk assessments would differ for antibiotics used for human medicine vs. animal agriculture. In this manuscript, we describe how three different types of risk assessment – chemical, ecological, and microbial – provide helpful insights to all aspects of assessing antibiotic resistance risk. We focus on the use of antibiotics in animal agriculture, and discuss what gaps in knowledge must be filled.

M2-J.8 Wu, F*; Hallman, WK; Rutgers University; *fanfan31@gmail.com*

Responsibility, Recalls, and Reputations of Organizations: Theory-Based Experimental Studies to Improve Food Safety Crisis Communication

This study tests the applicability of Situational Crisis Communication Theory (SCCT) to the unique circumstances posed by food safety crises. The study uses a factorial experimental design with a representative sample of 1510 online participants. The study investigates the effects of different types of food safety crises, initial crisis communication strategies, and follow-up communication strategies on public responses as the crisis unfolds. The types of food safety crises include: accidental and omission preventable. The initial crisis communication strategies include: deny responsibility with a recall of the affected food and accept responsibility with recall. The follow-up strategies include: deny responsibility with scapegoating, diminish, rebuild with responsibility and apology, and rebuild without responsibility or apology. The unfolding of the crisis was designed to reflect: T1-breakout of crisis, T2-confirmation of the company's involvement, T3-identification of crisis cause, and T4-follow-up communication. The results confirm that the public makes a distinction between accidental and preventable crises, with an omission preventable crisis generating more negative public responses (e.g. less favorable attitudes and behavioral intentions). While our previous research showed the importance of having a recall at the early stage of a crisis, the results of this study show that "accept responsibility with recall" initial strategy generates better public responses than "deny responsibility with recall". Furthermore, the results indicate that "rebuild with responsibility and apology" follow-up strategy generates the most favorable public responses. This study extends the SCCT and highlights a crisis as an ongoing process and that companies should issue communications appropriate to each stage. This study also underlines the advantage of taking responsibility and offering an apology in restoring organizational reputation and consumers' behavioral intentions.

W4-A.3 Xian, SY*; Lin, N; Chavas, D; Oppenheimer, M; Princeton University; Princeton University; Purdue University; Princeton University; *sxian@princeton.edu*

A New Method of Modeling and Simulating Hurricane Losses

US hurricane losses are induced by wind, storm surge flooding and precipitations. A statistical model is developed, associating the US landfall hurricane loss fraction (loss/exposure) to maximum wind, peak storm surge and maximum rainfall amount of landfall hurricanes. The economic exposure ($) is calculated from: (1) the reported affected counties; (2) the wind field modeling for each historical storm (using our latest wind field modeling method). Peak storm surge height and maximum wind speed explain a higher proportion of variance in loss fraction (54%) than maximum wind speed alone (44%). Adding maximum rainfall amount can increase explanatory variance to 64%. A random forest model can explain 88% of the variance. Storm arrival and hazards are modeled as respective stochastic processes. A normal copula is then used to simulate the hazards for each simulated storm. Applying simulated hazard parameters into the statistical models, we can simulate the loss fractions for the period of observation(1900-2014) and long-term (10,000 years). The simulation for the period (1900-2014) generates very close uncertainty range with the observed data. The simulation for a long-period (10,000 years) produces a return period that is close to that estimated using observed data. We propose a new modeling and simulation approach using all relevant hazards and allows an easy way to simulate hurricane losses under changing climate at a large-scale.

M2-C.3 Xian, SY*; Lin, N; Oppenheimer, M; Feng, KR; Princeton University; *sxian@princeton.edu*

Coastal protection for megacities

Coastal flood risk increases with time owing to rapid coastal development and the effect of climate change. In response to the increasing risk in the future, many coastal megacities have constructed protection systems with very high-standards such as the Thames Barrier in London, the 'dike rings' in Amsterdam and sea wall for Shanghai. However, other important coastal megacities including NYC have low level of flood protection. Superstorm Sandy in 2012 raises up a wide discussion about how to design flood protection measures for NYC. Return level design specifies the safety standard but cannot consider the temporal variations of the hazard and vulnerability, coastal exposure development and building characteristics due to building code. Economically optimal design considers both hazard and vulnerability but is sensitive to the topography. In this study, we first provide a methodology framework to integrate the estimation of temporal flood hazards from probabilistic risk assessment of hurricanes and storm surge, the vulnerability of the urban assets at the building-level, to pursue return-level design and optimal flood adaptation strategies for local-scale coastal protection. Optimal design minimizes the combined cost of flood adaptation and future expected losses (in present value). We also explore dynamic adaptation design strategy that allows the temporal increments of the protection levels, using algorithm of dynamic programming. We apply these design strategies to lower Manhattan, NYC. The aim is to find out an integrated design strategy that takes advantage of both the standardized return-level design and optimal design and allow policy makers to make cost-effective and robust decisions. Incorporating dynamic adaptation design may be a good option especially when we are unsure about future variations in climate, sea level, building characteristics and urban environment from scientific and engineering model projections.

P.7 Yamaguchi, H*; Yamada, T; Hirose, A; National Institute of Health Sciences; *h-yamaguchi@nihs.go.jp*

Developing the probability prediction model for the carcinogenic potency by using the Bayesian method to support hazard assessment under Japan's Chemical Substances Control Law

Hazard management exposure levels in human health assessment under Chemical Substances Control Law (CSCL) in Japan are derived based on mainly the hazard assessment data of four endpoints: repeated toxicity, reproductive toxicity, genetic toxicity, and carcinogenic toxicity. About 200 chemicals have been already identified as high priority chemicals requiring risk assessment, and the carcinogenic toxicology data are not available for about half of these chemicals. Due to taking long period of time and a lot of chronic assays, conducting the chronic testing of all chemicals is impossible. The purpose of this study is to develop the probabilistic model for prediction of carcinogenic effects by using the existing short-term toxicology data, and to propose the practical scheme for priority settings of the chronic toxicity tests in risk assessment under CSCL. Taylor et al. (1993) and Yokota et al. (2004) constructed the models incorporating the Bayesian approach to predict the likelihood of the carcinogenic potency based on the information of LD50, Ames test results, and Maximum Tolerated Dose (MTD). In this study, we developed the models using the toxicity data from the 28 days or the 90 days repeated dose studies instead of MTD as input data of their model. We simulated by using substances that all data of four endpoints were available: LD50, Ames, NOAEL of sub-chronic test, and TD50. Prior distributions of the occurrence probability of carcinogenic potency were estimated by LD50 and Ames test results. Applying the Bayesian method, posterior distributions were derived by the NOAEL obtained by sub-chronic tests. These results were compared with the carcinogenic potency obtained by the long-term carcinogenicity tests. Finally, we discussed improving the tiered testing approach to support hazard risk assessment under CSCL, adding the view of the Threshold of Toxicological Concern (TTC) or the category approach based on chemical structural similarities.

P.75 Yahyazadeh, Z*; Davidson, R; Trainor, J; Kruse, J; Nozick, L; University of Maryland; *Zeinabj@udel.edu*

Modeling homeowner retrofit behavior for wind and flood

For existing homes constructed before current building codes were in place, retrofitting (i.e., strengthening) can be an effective way to reduce damage from hurricanes and other extreme events. It has not been widely implemented, however. Understanding the process by which homeowners make retrofit decisions is critical to developing programs to encourage it. This presentation provides an analysis that adds to the scant empirical literature on the subject. We combine revealed and stated preference survey data for homeowners in North Carolina to develop separate mixed logit models for homeowner decisions about retrofits aimed at addressing four different types of hurricane damage—wind damage to the roof, openings (windows, doors), and roof-to-wall connection, and flood damage. In each case, we examine the effect of three possible types of economic incentives—low-interest loan, insurance premium reduction, and grant. Combining the two data types allows us to combine the strengths of each—investigation of incentives that do not yet exist through stated preference data and take-up rates thought to be more reliable based on revealed preference data. In particular, the study aims to develop the statistical models so they can be used to: (1) predict regional take-up rates for different retrofit types under different possible incentives; (2) better understand the effects of the different incentive types; and (3) and identify characteristics of homeowners more likely to undertake retrofits. Results provide evidence that offering a grant increases the likelihood of retrofitting, but offer no such evidence for incentives in the form of low-interest loans or insurance premium reductions. The models also suggest the probability of retrofitting varies by type, with the most interest in strengthening openings, and that homeowners are more likely to retrofit when they are closer to the coast, younger, in newer homes, or within a year of a hurricane experience.

W2-F.3 YAN, JY; ETH Zurich; *jingya.yan@frs.ethz.ch*

Ontology-based approach to modeling interdependency of critical infrastructure

Critical infrastructures are providing flows of services, the disruption of which are seriously affecting society's functioning and well-being. There is an emerging trend of interdependencies within and between infrastructure systems becoming more coupled, making them prone to 'domino effects'. While interdependencies within an infrastructure system may be represented as flows of networks, the representation of interdependencies between systems has been a challenge. In general, interdependencies of different forms have been identified and categorised into two types: flow and non-flow interdependencies. A comprehensive understanding of infrastructure interdependencies is a necessary first step towards better preparedness and more effective loss mitigation measures. However, limited work can be found on this subject, especially about the non-flow interdependencies. This work aims to clearly define interdependencies of critical infrastructures and build the framework for knowledge of infrastructures and their interdependencies. Based on this framework, a tool will be developed to represent interdependencies of different systems. As a navigation approach, the ontology provides a means to navigate through specific terms and definitions linked in a network of relationships. It can be manipulated directly as a standalone tool that offers the user a view of the domain coverage and the scope of the service. Ontology-driven approaches provide formal representation tools to represent systems and system-of-systems that are close to natural language, which fosters joint understanding. Once a formal consistent representation exists, ontology-driven information systems (ODIS) provide interfaces to answer what-if questions (query languages), to automate or semi-automate inferential reasoning. This ODIS can be used to connect to the existing database and support different applications. The ontology framework of CIs interdependencies can be integrated with other approaches to support different applications, such as resilience analysis and urban infrastructure development.

P.70 Yan, J*; Tang, J; Future Resilient Systems, Singapore-ETH Centre; *junqing.tang@frs.ethz.ch*

Resilience-oriented Analysis of Risk Management and Ontology-based Categorisation of Hazards in interdependent Infrastructure Systems

A resilient and safe infrastructure network should represent high connectivity efficiency, tolerable robustness to the disturbance, and moderate service flow. The disruptions can be roughly classified as random failures and deliberate attacks from either natural hazards or technical system failures. Here either traditional risk management approach or resilience analysis of general infrastructure system all comprehensively emphasise on the critical understandings of unexpected hazards. Due to the different levels of granularity and complexity, the uncertainty and ambiguousness of a risk which could subject to infrastructure system in our city become increasingly intriguing, for it is becoming evolving and dynamic in its own nature. Therefore, a new approach, resilience-based risk management, is essentially in great demand. Yet, it is an emergent scientific approach which still lack of development in the field. We proposed these new analysis approaches could realise in the following ways: 1) Develop a framework to organise the resilience and risk analysis for general infrastructure systems. 2) By applying those new approach and frameworks, we could provide essential and inspiring aids on decision-making process during risk management and analysis. The effectiveness of approaches could be formalised in testing on real-world infrastructure systems. For example, our study could identify the weak points of transport network with respect to different disturbance. By reinforcing those weak points, the network's robustness could be improved so that the mobility of the network could also be improved simultaneously. The work is still currently under development and the future works involve applying resilience-oriented risk management approach to real-world case studies and testing the categorisation method to real infrastructure networks hazard data.

P.74 Yang, K*; Davidson, R; Nozick, L; Brian, B; Brian, C; Wachtendorf, T; Drasback, K; DeYoung, S; Kolar, R; Yi, W; University of Delaware; *kunyang@udel.edu*

Sensitivity analysis on resident evacuation behavior in the Integrated Scenario-based Evacuation (ISE) framework

Hurricane evacuation is a complicated process involving uncertainty in the evolution of the hurricane and many interactions among natural, human, and infrastructure systems, both of which change over time. The newly developed Integrated Scenario-based Evacuation (ISE) computational framework integrates dynamic hazard modeling based on an ensemble of scenarios, dynamic population evacuation behavior prediction, and dynamic traffic assignment modeling to solve for a tree of evacuation recommendations that minimize risk and travel time. Each path through the tree corresponds to a set of recommended evacuation orders at each decision time that are conditional on how the hurricane has evolved until that time. The performance of the ISE framework has been demonstrated for a full-scale case study in North Carolina for Hurricane Isabel. In this presentation, we examine the sensitivity of the framework evacuation recommendations and performance to the evacuation behavior of the population. Specifically, we conduct a series of analyses, including ones that assume nobody leaves (providing an upper bound on risk), no official evacuation orders are given (only shadow evacuation), orders are given and are more influential than currently assumed (due to an education program perhaps), and full compliance (i.e., everyone who is given an order leaves, but no one else). Results are examined in terms of false negatives (people not leaving when they should) and false positives (people leaving when it is not necessary). This sensitivity analysis is useful for helping to interpret the results, understand the role of population behavior relative to the hazard and other components of the process, and guide future model development.

P.138 Yang, J.*; Chu, H.; University at Buffalo; *zyang5@buffalo.edu*

Processing risks: What makes the U.S. public attend to information about the 2016 presidential election vs. climate change

The 2016 presidential election presented a unique case study for risk communication because the frenzied campaign unavoidably left many Americans feeling uncertain about the future, if not fearful or anxious due to elevated risk perceptions. These risk perceptions, and the strong emotional responses they generated, inevitably had an impact on U.S. electors' communication behaviors and decision-making processes. Although not a risk object in the traditional sense, the 2016 election embodied many characteristics that define risks, such as the many unknown and uncontrollable factors that influenced its outcome. Applying the risk information seeking and processing (RISP) model, this study examines the social cognitive variables that motivated the U.S. public to attend to information about the risks posed by the election. Further, the utility of the RISP model in explicating information processing in the election context is juxtaposed with an identical model specified to a dataset on climate change, a typical risk that enjoyed much less issue salience during the election cycle. To examine what made the U.S. public attend to information about the risks posed by the election vs. climate change, both datasets were collected from Oct 6 to Oct 23, 2016 using Qualtrics national panels. Results indicate that in the climate change context, risk perception had a stronger relationship with affective responses, which were significantly related to systematic processing. In contrast, affective responses were not significantly related to systematic processing in the election sample. Perceived knowledge had a stronger relationship with information insufficiency and information processing in the election context. The relationships between other RISP variables and systematic processing were consistent across both datasets, which justified the use of the RISP model in studying the presidential election as a risk issue.

W1-K.3 Yang, S; University of Wisconsin-Madison; *shiyu-yang@outlook.com*

Linking heuristic-systematic processing to adoption of behavior

This study sets out to draw connections among key components within three conceptual models: the Risk Information Seeking and Processing model, the Heuristic-Systematic Model, and the Theory of Planned Behavior. Specifically, it proposes and tests the theoretical linkages among heuristic and systematic information processing, depth of processing, attitude stability, and behavioral intention. Archival data drawn from a panel survey that concerns health risks from drinking municipal tap water are used for theory testing. Findings reveal that systematic processing is positively related to number of strongly held behavioral beliefs, strength of belief outcome evaluations, and strength of cognitive structure—all indicate depth of processing, and that heuristic processing is negatively related to all three measures. Cognitive structure and attitude toward the behavior appear to be consistent in direction and strength. Attitude toward the behavior, subjective norms, and alternative behavior are positively related to behavioral intention. An anticipated positive relationship between perceived behavioral control and behavioral intention was not found. Finally, theoretical and practical implications of the findings are discussed.

W4-J.4 Yeager, RP; US FDA ; *raymond.yeager@fda.hhs.gov*
Regulatory Perspective on the Assessment of Tobacco Product Risk
Various centers of the FDA have used diverse risk assessment methods in executing their statutory authority. While a risk assessment is not required for a toxicological evaluation of tobacco products, when appropriate, a quantitative risk assessment (QRA) may be informative. The development of a QRA for tobacco products should consider the question to be answered by the risk model, within a given statutory framework. In general, evaluation of risks in any regulated consumer product requires consideration of the chemical exposure from product use, the route by which the product is consumed, the strength of evidence for adverse effects relevant to non-cancer or cancer endpoints, and how chemicals in a mixture may combine to result in adverse health effects. Thus, an evaluation of tobacco product associated risks could potentially be conducted by using an approach similar to traditional QRA. Generally, sound scientific justification is needed to support the selection of parameters, values, and their relationship in a predictive QRA model, including justification of explicit and implicit assumptions. There are a number of challenges in developing a QRA to estimate tobacco product risk but there are also opportunities to advance the use of QRA in tobacco science.

P.99 YEN, YT*; WU, KY; National Taiwan University; *r04841015@ntu.edu.tw*
Study on risk assessment of aloe-emodin for Taiwanese population
Aloin is added to the dietary supplements sold in the market in Taiwan. In addition to the application in the dietary supplements, aloin is also applied as laxatives in medical use and bittering agents in alcohol beverage. However, it is necessary to be concerned with the impact of dietary supplements on humans, since chronic aloin consumption is associated with adverse health effects such as bowl irritation and diarrhea. In the National Toxicology Program(NTP) two-year chronic toxicity study, aloe-emodin demonstrates carcinogenicity in animals; in rats, chronic exposure to aloe-emodin result in colon adenocarcinoma and cancer. We determine residues of aloin in dietary supplements with Taiwanese consumption data from National Food Consumption Database and the proposed daily suggested amount of intake, which indicated that no more than 10 mg/day. Monitoring residues data were collected from market survey by TFDA. We calculated the following: Mean concentration(MC), Lifetime Average Daily Dose(LADD), and Margin of Exposure(MOE). We found that aloin residue was detected in a large amount in the various dietary supplements sold in the Taiwan market. The initial results shown as follows: the LADD is 4.30 x 10-3, mg/kg/day, and the MOE is 150.78. The MOE is considered to be lower than the standard which needs further health concern. Therefore, the guidelines of aloin in dietary supplements require revision. Moreover, people may expose to multiple aloin in foods simultaneously. Thus, the MOE indicates public health concern. This study established a complete health risk assessment of aloin in dietary supplements in recent year in 2015. Through this study, people will realize the importance of proper use of aloin. Further studies are needed to integrate all possible aloin residues in foods. We provided important information for risk assessment of aloin. Moreover, this study can equip risk-related managers with auxiliary scientific evidence to improve policy formation and social practice about dietary supplements in Taiwan.

T4-G.5 Ylonen, M; VTT Technical Research Centre of Finland; *marja.ylonen@vtt.fi*
Knowledge dimensions in the risk field – Ontologies and epistemologies
Knowledge dimensions play a relevant role in the risk field. Despite its relevance in the risk context the concept of knowledge often remains undefined. Talks about uncertainties related to knowledge or strength of the knowledge leave the concept untouched. This presentation will look at the different definitions of knowledge based on philosophy and social sciences. In addition, ontological and epistemological questions are dealt with. What is knowledge? How knowledge is generated? How can we get a grip on knowledge? What kind of knowledges can we talk about? In which context we can talk about knowledge-based consensus? The aim of the presentation is to provide some insights into the world of knowledge in order to better understand the challenges and possibilities related to knowledge and production of it in the risk field. At its best, understanding of knowledge dimensions will contribute to strengthening the foundation of risk field.

P.156 Young , CE *; McComas, KA ; Cornell University ; *cey26@cornell.edu*
The influence of narrative and participatory drama on social interaction and efficacy around health and environmental issues in Malawi
This project tests the role of narrative and participatory drama as creative methods of communication in response to the impacts of climate change and other environmental and social pressures in sub-Saharan Africa. Specifically, the research seeks to understand the influence that these communication methods have on increasing social interaction, engagement, attitudes, and efficacy around inter-related sustainability issues among smallholder farmers in Malawi. In order to test the role of drama, 500 farmers in two regions of the country participated in an integrated curriculum on climate change, agroecology, soil health, health and nutrition, and social equity. Half of the participants used stories and drama in their training, and the other half acted as a control group using small group discussions. This poster includes some of the key quantitative (N=500) and in-depth interview (N=47) findings. The poster focuses on those findings related to risk perceptions and increased confidence around new ideas and innovations. The research draws on theories around health, environment, science, and risk communication, and considers the complex interrelationships between multiple sustainability issues, including health & nutrition, climate change, social equality, and agroecology & soil health. It also considers the communication of sensitive social issues, such as HIV/AIDS, alcoholism, and violence in the household. This project builds on previous research by offering unique context and scale, as well as a focus on communicating the relationship among multiple health, environmental, and social issues.

P.109 Yu, J*; Hennessy, D; Wu, F; Michigan State University; *yujina@msu.edu*

Indirect Health Risk Reduction Through Transgenic Bt Corn

Risk analysis has important methodologies that can help in evaluating controversial questions of policy importance, such as the use and potential impacts of transgenic (genetically modified) crops in the United States and elsewhere. Traditional plant pathological and agronomic studies had previously reached no consensus as to whether transgenic Bt corn, the GMO planted most commonly worldwide, has resulted in significantly lower aflatoxin levels than non-GM corn. If this benefit did exist, then Bt corn could be an important strategy in reducing dietary aflatoxin exposure worldwide, with corresponding human health and economic benefits. In this study, we focus in the United States, using data from the USDA Risk Management Agency from 2001-2011; to evaluate the incidence of aflatoxin-related crop insurance claims among corn growers as a function of Bt corn planting across all US corn-planting counties. Our analysis factored in other risk factors for aflatoxin occurrence in corn, including high summer temperatures and drought (data from NOAA). We found that a significant negative correlation exists between Bt corn planting and aflatoxin-related insurance claims in the US, even when controlling for temperature and drought/humidity. In the US, this benefit primarily results in better economic returns for corn growers. Elsewhere worldwide, there could be important human health implications from the results of this risk assessment.

T2-F.3 Yu, J*; Baroud, H; Vanderbilt University; *jinzhu.yu@vanderbilt.edu*

Measuring community recovery rate with sparse data: a comparison of multiple approaches

Resilience is often referred to as the ability to recover from the occurrence of a disruptive event. Various metrics have been developed to measure resilience for different types of hazards, but a common issue in quantifying those metrics and modeling them using data-driven methods is the lack of recovery data from historical events. Sparse data result in challenges in measuring and predicting resilience metrics within an acceptable level of accuracy. In this paper, the rate of recovery to the level prior to the occurrence of a disruptive event is used as the metric for resilience. Three statistical models are considered, hierarchical Bayesian model, Bayesian kernel model, and multivariate Poisson generalized linear model, to model the recovery rate with sparse data. The three methods are compared in terms of goodness of fit and prediction accuracy. Deviance and log-likelihood are used as the metrics for the goodness of fit, and root mean square error and normalized root mean square error are used as the metrics for prediction accuracy. The accurate estimation of recovery parameters from disasters improves recovery management, such as the optimization of resource allocation. We illustrate this work using a case study of Shelby County in Tennessee.

T2-H.3 Zanabria, R*; Racicot, M; Leroux, A; Arsenault, J; Ferrouillet, C; Griffiths, M; Holley, R; Gill, T; Charlebois, S; Quessy, S; Canadian Food Inspection Agency; *alexandre.leroux@inspection.gc.ca*

Source attribution at the sub-product level for 32 pathogen-commodity combinations for the development of the Canadian Food Inspection Agency Establishment-based Risk Assessment model

The Canadian Food Inspection Agency is modernizing its risk-based approach to oversight by developing the Establishment-based Risk Assessment (ERA) model to enhance a more effective allocation of resources to highest-risk areas. In 2013/14, two expert elicitations selected the most important risk factors for the model, and assigned weights to the assessment criteria based on human health's relative risk. As the model assesses establishments' food safety risks at the sub-product level, a third expert elicitation was needed considering no studies were available on this area. The process was conducted in 2016 (January to August 2016), and the foodborne illness burden at the sub-product level for 32 pathogen-commodity combinations was estimated. Targeted pathogens and commodities included Campylobacter, Salmonella non thyphoidal, Norovirus, Shiga toxin producing E. coli, Toxoplasma gondii, Clostridium perfringens, Listeria monocytogenes and Yersinia enterocolitica in beef, pork, poultry, game, dairy, fish/seafood, produce and eggs/egg products. The number of sub-products within each commodity varied from 4 (eggs) to 13 (dairy). A snow-ball approach resulted in 119 Canadian experts being invited to participate on a web-based survey (available in English/French). Experts provided estimates for each pathogen-commodity combination and evaluated their level of certainty using a scale from 1 (low certainty) to 10 (high certainty). Forty-nine experts from industry, government and academia with over 18 years' experience (average) participated in the study. Data analysis compared 3 different approaches: (1) weight experts' estimates according to their certainty level, (2) remove estimates with a certainty level ≤2, and a combination of (1) and (2). No significant differences were found among the results obtained with the 3 methods. Thus, the first approach was chosen and the estimates for the attribution of risks at the sub-product level were included in the ERA model.

W3-J.1 Zelikoff, JT*; Lauterstein, D; Gordon, T; New York University School of Medicine ; *judith.zelikoff@nyumc.org*

Health Effects Associated with E-cigarettes in Vulnerable Populations

There is a general perception among the public that electronic (e)-cigarettes are safer than conventional cigarettes, and a growing number of pregnant women share this belief. Approximately 10% of all pregnant women who smoke in the U.S. continue conventional cigarette use during pregnancy. Up to 40% of all women who quit smoking conventional cigarettes in preparation for and/or during pregnancy resume smoking after pregnancy. These "ex" smokers are particularly vulnerable to e-cigarette use, as they perceive that e-cigarettes are a "safer" way for pregnant women to maintain their ability to "smoke". Propylene glycol and glycerol, two of the main ingredients in e-cigarette liquids, are generally regarded as safe when ingested, but information concerning effects of these agents via inhalation is severely lacking. While not currently validated or confirmed scientifically, nicotine-replacement therapy products (e.g., nicotine patches or gum) appear to be less harmful to the fetus than conventional cigarettes and based on this, e-cigarettes may eventually prove to also be a "safer" alternative. However, the safe use of these products during pregnancy remains uncertain as data are lacking regarding the safety of these constituents for pregnant women/developing fetus as well as potential for harm to children from exposure to secondhand e-cigarette aerosols. In addition, our recent data demonstrate that e-cigarette use during pregnancy poses a potential threat to the developing brain, as nicotine is a known neurotoxicant. The proposed studies will generate scientific knowledge that can be readily translated to policy and serve as a guide for regulatory decisions and actions.

M3-F.1 Zhai, C*; Guikema, SD; Reilly, AC; University of Michigan, Ann Arbor; *cwzhai@umich.edu*

Modeling Dynamic Vulnerability and Risk at the Community Level with Agent-Based Modeling

Understanding human behavior under repeated hazards is essential in reducing damage from hazards, promoting wise decisions, and providing insights into how community resilience evolves. This talk summarizes an Agent Based Model that can be applied to analyze how decision makers adapt to repeated hazards and different policies and how this influences the evolution of regional vulnerability over time. It introduces modeling different hazard scenarios, agent learning and decision making processes, collective action, and government policies. A case study using open-source data in Maryland is presented to show how this region's vulnerability evolves under repeated hazards.

W1-A.2 Zhang, W*; Zhen, G; Chen, L; Wang, H; Li, Y; Ye, X; Tong, Y; Zhu, Y; Wang, X; Renmin University of China; *zhw326@ruc.edu.cn*

Evaluation of China's mercury emission controls in the coal-fired power industry: projection for the health and welfare effects

Mercury pollution has attracted much attention around the world, especially after the 2013 adoption of the United Nations Minamata Convention on mercury. Most mercury found in the atmosphere originates from anthropogenic emissions, such as coal combustion, non-ferrous metal smelting, waste incineration and mining. Coal combustion and mercury emission are closely linked, and coal combustion is estimated to be the second largest global source of anthropogenic emissions. The relationship between coal burning and mercury pollution is particularly relevant in China. Coal accounts for 70% of the primary energy consumption in China and coal-fired power plant is a major source of atmospheric mercury emission. Therefore reduction of mercury emissions from coal combustion in China is important for mercury control in East Asia. In order to implement the Minamata Convention, various emission control policies were proposed for the coal-fired power plants in China. What will be the effect of the mercury control policies, especially on the regional atmospheric transportation and health and welfare of residents in East Asia? In this study, we target to this question and evaluate the cost-benefits of the proposed mercury emission control policies. We examine the mercury emissions from the coal-fired power plants in China in 2010 as the baseline. Four scenarios of control policies, including the baseline scenario, the coal washing scenario, the device update scenario and the new energy scenario, were selected based on the emission control policies of the energy industry for the next ten years. The atmospheric mercury concentration and deposition under different scenarios were simulated using the Geos-Chem model. The effect of the policies on the mercury transport and the associated health benefits in East Asia were discussed. Based on the cost-benefit analysis, suggestions on the atmospheric mercury emission control for the coal-fired power industry were proposed.

P.16 Zhang, Y*; Ayyub, BM; Center for Technology and Systems Management, University of Maryland, College Park; *zhyating@umd.edu*

Urban Heat Projections in a Changing Climate: Washington D.C. as a Case Study

Extreme heat events are posing a rising threat to us due to a changing climate. The Urban Heat Island (UHI) effect further amplifies heat impacts and raises heat-related risks during heat events. Therefore, it is important to characterize future trends and levels of heat events for cities to manage and reduce associated risks. However, previous predictions for local heat events were limited by its low spatial resolution and oversimplified atmospheric model. This study utilizes the improved Weather Research Forecasting (WRF) model, which dynamically downscales projection results from Community Earth System Model (CESM), to generate high-quality heat event predictions. Using this method, we predicted heat waves in the Washington metropolitan area for the next 80 years and investigated the interaction between heat events and the UHI effect. Results based on the highest concentration scenario of greenhouse gases, Representative Concentration Pathway (RCP) 8.5, indicated that the intensity, frequency, and annual duration of heat waves will increase continuously. The UHI effect and heat events strengthen each other, which can be weakened by increasing urban surface albedo or vegetation cover ratio.

W3-F.2 Zheng, Hanzhong*; Xu, Linyu; Beijing Normal University; *zhenghz_2016@163.com*

Urban Ecological Risk Assessment Based on Green Infrastructure Theory

In recent years, the conflict between rapid urbanization and ecological environment are becoming increasingly obvious, meanwhile, more and more attention has been given to the urban ecological risk and urban human settlement. It plays an important role for urban sustainable development by assessing the ecological risk induced by urbanization as well as finding out the regularity of the ecological risk. At present, scholars at home and abroad focus their studies of urban ecological risk assessment on pollutant emission, climate change and natural disaster. In this paper, a green infrastructure theory is introduced, and by selecting ecological environmental elements including greenway, forest, park, wetland and native vegetation as an evaluation object to assess urban ecological risk. It aims to propose a systematic and robust strategic approach for urban sustainable development and ecological environment protection. Green infrastructure could not only provide habitat for natural species, maintain the natural ecological process but also protect the quality of air and water. Besides, it could promote the healthy development of the community and improve the health of the residents, and so as to ensure urban ecological security.

W2-F.4 Zimmerman, R; New York University; *rae.zimmerman@nyu.edu*

Risk reduction assessment of innovative solutions to interdependent cascading infrastructure failures

The risk and consequences of cascading failures from infrastructure dependencies and interdependencies are now well known. These often span not only physical dimensions of infrastructure but also social dimensions affecting users and nearby communities and environmental impacts that can be widespread and long lasting. Innovations in the way infrastructures are deployed or used are becoming a popular way to reduce the consequences of these failures, especially in light of the increase in threats from destructive events, including extreme weather that interact with the interdependencies. Adaptations and mitigations have proliferated to reduce adverse consequences, and the next step is to identify conditions under which they are effective in confronting or counteracting negative impacts. This paper applies risk assessment research and methods to develop a strategy or concept to analyze the effect of innovations in reducing such failures. Innovations include reconfigurations, decentralization, radical changes in resource bases that provide infrastructure services, and behavioral changes in how infrastructure services are consumed. This exercise is complex since the innovations themselves have their own set of impacts. One platform that is used illustratively here is water retardation in the form of now common green infrastructures to identify how the scale or geographic size of the applications combine with the magnitude of the threat in terms of the flooding potential or amount and force of water to shape the effective design of the green infrastructure approach. Institutional arrangements and interventions in the form of infrastructure financing are introduced as risk decision-making and policy options that can alter the effectiveness of the innovations. The paper begins to fill the gap in risk science and management for assessing how infrastructure-related innovations reduce risk by taking into account a spectrum of special conditions under which they can operate.

M2-H.3 Zoellner, C*; Jennings, R; Wiedmann, M; Ivanek, R; Cornell University; *cez23@cornell.edu*

A novel agent-based model of Listeria spp. dynamics in a food processing facility for assessment of environmental monitoring programs

To reduce the risk of foodborne listeriosis, food manufacturers conduct routine sampling of equipment, personnel and facilities as part of environmental monitoring (EM) and corrective action programs. Our objective was to model the hourly dynamics of Listeria in a cold-smoked salmon slicing room as an example of a food processing facility implementing EM strategies. Using agent-based modeling, the 3D environment of the slicing room was discretized into 625-cm^2 patches with spatially explicit autonomous entities (objects, employees and equipment) defined by rules and attributes central to the behavior of Listeria. Cleanability of equipment, presence of water, traffic patterns and introduction events to the slicing room were modeled. Relationships between entities based on physical proximity or interactions created the network upon which Listeria spread. Expert elicitation and extensive literature review methods were used in parameter estimation. Preliminary modeling results illustrated that without EM, the median prevalence of Listeria on food (FCS) and non-food contact surfaces (NFCS) would be 8.9% (5th and 95th percentile: 8.5-9.5) and 3.2% (3.0-3.3), respectively, with most FCS and NFCS (98% and 99%, resp.) containing ≤ 10 CFU/cm^2. The median prevalence of Listeria on the floor was 1.9% (1.7-2.1). The median prevalence of Listeria in smoked salmon fillets entering the slicing room was 0.10% (0.09-0.11). FCS and NCFS prevalence were strongly correlated with cross-contamination events and employee contacts with FCS ($p < 0.001$). FCS prevalence was also correlated with contaminated smoked salmon fillet prevalence ($p < 0.05$). Eliminating incoming fillet contamination to the slicing room reduced FCS and NFCS median prevalence to 3.6% (2.7-4.9) and 1.8% (1.4-2.3), respectively. Methods and results presented are intended to be useful in customizing models to food production facilities for evaluation of different EM schemes and interventions on prevalence of Listeria.

P.117 Zoellner, C*; Jackson, P; Al-Mamun, MA; Grohn, YT; Worobo, R; Cornell University; *cez23@cornell.edu*

PSCMT: A supply chain model of microbial contamination risk in fresh tomatoes

According to the Centers for Disease Control and Prevention, 46% of foodborne illness each year in the United States of America is attributed to contaminated fresh produce. The source of contamination with human pathogens is often in the production and handling environments of fresh produce. But, the post-harvest supply chain also presents conditions which either encourage or discourage microbial growth and survival. The objective of this study was to develop a generic modeling tool of microbial contamination dynamics in order to identify pathogen control points in fresh produce supply chains. The postharvest supply chain is explicitly modeled, including transportation of the harvested produce to a packaging location and subsequent activities to sort, wash, cut, pack, store, distribute and sell the product in the supermarket. The model starts with introducing a microbial load at one node and a modular process risk modeling approach determines the resulting levels throughout the supply chain due to growth, survival, transfer and reduction. Each node utilizes input parameter values from published studies of microbial behavior on fresh produce to govern these modular microbial processes. Upon simulation, the microbial contamination level for each node is displayed in different scales and at discrete time points. The tool is demonstrated with Salmonella Montevideo in a fresh tomato supply chain consisting of four nodes—field, packinghouse, distribution center and supermarket—to model the impact of supply chain decisions. This detailed, mechanistic model of microbial behavior dynamics is developed to address the unique risks of fresh produce supply chains and is intended for identification of practices that may reduce contamination risks and foodborne illness.

P.130 Zwickle, A*; Cox, J; Hamm, J; Zhuang, J; Upham, B; Dearing, J; Michigan State University; *zwicklea@msu.edu*

The social and economic effects of environmental contamination and remediation

Environmental contamination can have natural, social, and economic impacts, especially when they occur in populated areas. As part of a larger effort to study Superfund sites in the United States, this research focuses on the economic effects of dioxin contamination in a mid-sized Michigan city. A person's home is usually their most valuable asset, and a drop in its value can have significant economic and social implications. In addition to the direct physical impacts, well publicized pollution events can create social forces, such as stigma and perceptions of health risks, which negatively impact home values. To study the effect that environmental contamination and remediation have had on home values over time, we collected assessed home value for nearly 800 parcels from the years 2000-2017. Homes were placed into three groups: those found to contain dioxin levels above the threshold deemed safe and were subsequently remediated, those found to contain dioxin levels below the threshold and were not remediated, and a comparison group. We then conducted a multi-level longitudinal analysis to determine if the value of homes in each group changed at different rates over time. This analysis is set against the backdrop of notable contamination related events in the community's history, such as a contentious and well reported public meeting and the highly visible cleanup and remediation phase. We conclude this presentation with a discussion of the practical implications of our findings for future remediation processes, as well as avenues for future research.

M4-C.3 Øien, K*; Jovanović, AS; EU-VRi, Germany;
jovanovic@risk-technologies.com

Practical application of the SmartResilience methodology for assessing resilience of multiple critical infrastructures

The EU research project SmartResilience is developing a resilience assessment methodology, which takes the vulnerability of SCIs into account in a holistic manner. This methodology is based on the identification of existing and new, smart indicators of resilience. The resilience attributes considered are based on the definition of resilience used in the project, corresponding to the five phases of the resilience cycle. For each of these phases, the issues that are important for them are identified, and indicators to measure those issues are developed. Thus, the three lowest levels in the SmartResilience structure are phases, issues and indicators. In addition, the overall structure consists of the area level, e.g. a city or smart city, the critical infrastructures (CIs) within that area, and finally the threats considered most relevant for each of the CIs. Any type or form of indicators are considered appropriate in the methodology, meaning that they can be yes/no questions, numbers, percentages, portions, or some other type. Their real values, of whatever type, are collected and transformed to a score obtained by interpolation between the best and worst values. The identification, collection and storage of issues and indicators in a database are performed in several stages throughout the project and they are refined through an iterative process. The collection consists of over 600 relevant issues and corresponding indicators used to measure resilience of the respective infrastructure. In this paper, a practical application of the resilience assessment methodology is demonstrated on the cases of the smart critical infrastructures in the area of production (refineries), transportation (airport) and smart cities. It emphasizes the baseline resilience assessment performed periodically for multiple critical infrastructures. However, it also considers continuous monitoring, stress testing and issues related to interactions and cascading effects.