**Risk Analysis**

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**1. Title: Recommended Reference Values for Risk Assessment of Oral Exposure to Copper**

**Authors: Alicia A. Taylor, Joyce S. Tsuji, Margaret E. McArdle, William J. Adams, William L. Goodfellow Jr.**

**Abstract:** The U.S. Environmental Protection Agency's (EPA) Integrated Risk Information System (IRIS) database, the authoritative source of U.S. risk assessment toxicity factors, currently lacks an oral reference dose (RfD) for copper. In the absence of such a value, various health-based reference values for copper are available for use in risk assessment. We summarize the scientific bases and differences in assumptions among key reference values for ingested copper to guide selection of appropriate values for risk assessment. A comprehensive review of the scientific literature best supports the oral RfD of 0.04 mg/kg body weight/day derived by EPA from their Drinking Water Action Level. This value is based on acute gastrointestinal effects but is further supported by broader analysis of copper deficiency and toxicity.

**2. Title:** **The ethical dilemmas of risky decisions**

**Authors: Ben J.M. Ale, David H. Slater, Des N.D. Hartford**

**Abstract:** Even in a pandemic there seem to be inherent conflicts of interest between the individual and societal consequences of remedial actions and strategies. Actions taken in the sole interests of patients, as required by the Hippocratic oath, can have broadly inconvenient economic implications for the State. (“Average” benefits for a population can impose individual inconveniences for the vulnerable.). Understandably these decisions are not normally made explicitly and transparently by governments. This leads to seemingly illogical and inhumane strategies which are not understood and hence mistrusted and often ignored by the public. Vaccination sentiments on social media are often an unwanted symptom of this dilemma. This article outlines and discusses a number of examples of such situations with a focus on ethical aspects. It concludes that each case must be considered individually as to the issues that need to be weighed in these difficult decisions; and that there are no clear and universally acceptable ethical solutions. What can be learned from the COVID-19 crisis is that short term utilitarianism has consequences that in the eyes of the population are unacceptable. This lesson seems equally valid for cost benefit evaluations regarding other risks, such as from hazardous industries, flood defenses, and air transport. Decisionmakers and politicians can learn that persuasion only goes so far. In the end the people appear to prioritize in terms of deontology.

**3.** **Title: Complex challenges should be approached by a multitude of theories and models**

**Authors: Geir Sverre Braut**

**Abstract:** The ongoing pandemic may be regarded as a wicked problem. Therefore, it should be analyzed by a multitude of theories and models. Approaching the complex set of challenges posed to individuals and society by singular methods, can lead to suboptimal decisions. Good decisions must take into account the large set of uncertainties we are facing, by using well established procedures, as for example health technology assessment (HTA) and a nuanced ethical framework.

**4. Title: Moral philosophy has much more to offer**

**Authors: Sven Ove Hansson**

**Abstract:** Moral philosophy is a rich tradition that contains many alternative approaches to determining what is right and wrong. A limited account that only considers (hedonistic) utilitarianism and deontology cannot do justice to moral philosophy. It is necessary to also consider the many other general-purpose moral theories that have been proposed, as well as the approaches developed in various branches of applied ethics, such as healthcare ethics, the ethics of technology, and the ethics of risk.

**5. Title: Distributed sensemaking in network risk analysis**

**Authors: Jacob Taarup-Esbensen**

**Abstract:** This article responds to the call advancing risk science as an independent research field, by introducing a conceptual model for risk analysis based on distributed sensemaking. Significant advances in recent decades have expanded the use of risk analysis to almost every organization globally. Continued improvements have been made to our understanding of risk, placing a wide range of contexts under organizational control. This article argues that four dimensions are central in how organizations make sense of uncertainty in their context and hence do risk analysis: the activities the organization engages in, their sensory systems, the role and competence of individuals, and the ability to coordinate information through organizational structures. The structure enables insight into the decision-making process and the dimensions contributing to how organizations perceive risks and uncertainty in a given context. Three examples from the Arctic context illustrate the network risk analysis model's practical application and how it will expose weaknesses in these organizations’ risk analysis and decision-making processes. Finally, the article discusses sensemaking in network risk analysis and how such an approach supports organizations’ ability to perceive, collect, process, and decide on changes in context.

**6. Title: Trade-offs and the precautionary principle: A lexicographic utility approach**

**Authors:** **Daniel Steel, Paul Bartha**

**Abstract:** The precautionary principle is often argued to be irrational because it cannot adequately explain how resources should be distributed across multiple possible catastrophes or between catastrophic and noncatastrophic risks. We address this problem of trade-offs by extending a recently proposed formal interpretation of the precautionary principle (PP) within a lexical utility framework and using it to prove results about which distribution of resources maximizes lexical utility when several catastrophic risks exist, given different assumptions. We also explain how our lexical utility interpretation of PP can recommend balanced distributions of resources between disaster prevention and other concerns.

**7. Title: Establishment of risk acceptance criteria using Life Quality Index: Application to the Indian context**

**Authors: Sandip Roy**

**Abstract:** The formulation of risk acceptance criteria may be coupled gainfully with a prediction of the of investment required to comply with it, an exercise which can benefit from the application of socioeconomic indicators. The Life Quality Index (LQI) is one such indicator which amalgamates human mortality and wealth creation and places an implicit economic value on reduction of life risk. While there have been a number of studies to demonstrate the application of LQI pertaining to various technological systems, the present work extends it to estimate the sectoral level investment needed to reduce public risks to within the As Low As Reasonably Predictable region for the chemical industry, with specific illustration of the methodology for India. The potential reduction in public individual risk is computed as a function of percentage increase in safety investment expressed as a fraction of the industry's contribution to the nation's GDP. In addition, using a new, more accurate expression, estimates of a related parameter, the implied cost of averting a fatality (ICAF), are obtained for a number of developed economies and India. The ICAF estimates show reasonable agreement with the value of statistical life (VSL), a parameter which is integral to cost-benefit analysis of safety and environmental regulations.

**8. Title:** **Leader–follower equilibria to examine investment decisions in grid resilience-enhancing measures**

**Authors: Chiara Lo Prete, Ashish Radhakrishnan**

**Abstract:** Large-area, long-duration power outages are increasingly common in the United States, and cost the economy billions of dollars each year. Building a strategy to enhance grid resilience requires an understanding of the optimal mix of preventive and corrective actions, the inefficiencies that arise when self-interested parties make resilience investment decisions, and the conditions under which regulators may facilitate the realization of efficient market outcomes. We develop a bi-level model to examine the mix of preventive and corrective measures that enhances grid resilience to a severe storm. The model represents a Stackelberg game between a regulated utility (leader) that may harden distribution feeders before a long-duration outage and/or deploy restoration crews after the disruption, and utility customers with varying preferences for reliable power (followers) who may invest in backup generators. We show that the regulator's denial of cost recovery for the utility's preventive expenditures, coupled with the misalignment between private objectives and social welfare maximization, yields significant inefficiencies in the resilience investment mix. Allowing cost recovery for a higher share of the utility's capital expenditures in preventive measures, extending the time horizon associated with damage cost recovery, and adopting a storm restoration compensation mechanism shift the realized market outcome toward the efficient solution. If about one-fifth of preventive resilience investments is approved by regulators, requiring utilities to pay a compensation of $365 per customer for a 3-day outage (about seven times the level of compensation currently offered by US utilities) provides significant incentives toward more efficient preventive resilience investments.

**9. Title: Risk ranking of food categories associated with Salmonella enterica contamination in the central region of Mexico**

**Authors: Angélica Godínez-Oviedo, Fernando Sampedro, John P. Bowman, Francisco J. Garcés-Vega, Montserrat Hernández-Iturriaga**

**Abstract:** To prevent and control foodborne diseases, there is a fundamental need to identify the foods that are most likely to cause illness. The goal of this study was to rank 25 commonly consumed food products associated with Salmonella enterica contamination in the Central Region of Mexico. A multicriteria decision analysis (MCDA) framework was developed to obtain an S. enterica risk score for each food product based on four criteria: probability of exposure to S. enterica through domestic food consumption (Se); S. enterica growth potential during home storage (Sg); per capita consumption (Pcc); and food attribution of S. enterica outbreak (So). Risk scores were calculated by the equation Se\*W1+Sg\*W2+Pcc\*W3+So\*W4, where each criterion was assigned a normalized value (1–5) and the relative weights (W) were defined by 22 experts’ opinion. Se had the largest effect on the risk score being the criterion with the highest weight (35%; IC95% 20%–60%), followed by So (24%; 5%–50%), Sg (23%; 10%–40%), and Pcc (18%; 10%–35%). The results identified chicken (4.4 ± 0.6), pork (4.2 ± 0.6), and beef (4.2 ± 0.5) as the highest risk foods, followed by seed fruits (3.6 ± 0.5), tropical fruits (3.4 ± 0.4), and dried fruits and nuts (3.4 ± 0.5), while the food products with the lowest risk were yogurt (2.1 ± 0.3), chorizo (2.1 ± 0.4), and cream (2.0 ± 0.3). Approaches with expert-based weighting and equal weighting showed good correlation (R2 = 0.96) and did not show significant differences among the ranking order in the top 20 tier. This study can help risk managers select interventions and develop targeted surveillance programs against S. enterica in high-risk food products.

**10. Title: Leveraging risk assessment for foodborne outbreak investigations: The Quantitative Risk Assessment-Epidemic Curve Prediction Model**

**Authors: Amir Mokhtari, Hao Pang, Sofia Santillana Farakos, Crystal McKenna, Cecilia Crowley, Vanessa Cranford, April Bowen, Sheena Phillips, Asma Madad, Donald Obenhuber, Jane M. Van Doren**

**Abstract:** Root cause analysis can be used in foodborne illness outbreak investigations to determine the underlying causes of an outbreak and to help identify actions that could be taken to prevent future outbreaks. We developed a new tool, the Quantitative Risk Assessment-Epidemic Curve Prediction Model (QRA-EC), to assist with these goals and applied it to a case study to investigate and illustrate the utility of leveraging quantitative risk assessment to provide unique insights for foodborne illness outbreak root cause analysis. We used a 2019 Salmonella outbreak linked to melons as a case study to demonstrate the utility of this model (Centers for Disease Control and Prevention [CDC], 2019). The model was used to evaluate the impact of various root cause hypotheses (representing different contamination sources and food safety system failures in the melon supply chain) on the predicted number and timeline of illnesses. The predicted number of illnesses varied by contamination source and was strongly impacted by the prevalence and level of Salmonella contamination on the surface/inside of whole melons and inside contamination niches on equipment surfaces. The timeline of illnesses was most strongly impacted by equipment sanitation efficacy for contamination niches. Evaluations of a wide range of scenarios representing various potential root causes enabled us to identify which hypotheses, were likely to result in an outbreak of similar size and illness timeline to the 2019 Salmonella melon outbreak. The QRA-EC framework can be adapted to accommodate any food–pathogen pairs to provide insights for foodborne outbreak investigations.

**11. Title: State estimation for nonlinear state-space transmission models of tuberculosis**

**Authors: Duayne Strydom, Johan Derik le Roux, Ian Keith Craig**

**Abstract:** Given the high prevalence of tuberculosis (TB) and the mortality rate associated with the disease, numerous models, such as the Gammaitoni and Nucci (GN) model, were developed to model the risk of transmission. These models typically rely on a quanta generation rate as a measurement of infectivity. Since the quanta generation rate cannot be measured directly, the unique contribution of this work is to develop state estimators to estimate the quanta generation rate from available measurements. To estimate the quanta generation rate, the GN model is adapted into an augmented single-room GN model and a simplified two-room GN model. Both models are shown to be observable, i.e., it is theoretically possible to estimate the quanta generation rate given available measurements. Kalman filters are used to estimate the quanta generation rate. First, a continuous-time extended Kalman filter is used for both adapted models using a simulation and measurement sampling rate of 60 s. Accurate quanta generate rate estimates are achieved in both cases. A more realistic scenario is also considered with a measurement sampling rate of one day. For these estimates, a hybrid extended Kalman filter (HEKF) is used. Accurate quanta generation rate estimates are achieved for the more realistic scenario. Future work could potentially use the HEKFs, the adapted models, and real-time measurements in a control system feedback loop to reduce the transmission of TB in confined spaces such as hospitals.

**12. Title: Emergency risk communication and sensemaking during smoke events: A survey of practitioners**

**Authors: Madeleine Thomas, Celine Klemm, Brett Hutchins, Stefan Kaufman**

**Abstract:** Emergency risk communication (ERC) for smoke emitted from major fires continues to challenge governments. During these events, practitioners (including scientific, communication, and emergency response government staff) are tasked with quickly making sense of the public health risks and the communication options available. Practitioners’ sensemaking—the process of creating meaning from information about an unfolding emergency—is key to effective ERC. This article identifies the factors that ERC practitioners consider the most important to their sensemaking for smoke events. A survey of practitioners (n = 86) was conducted to elicit their views on the level of importance of 22 different factors (individual, organizational, and contextual) on their sensemaking. The results indicate that the majority of the factors tested are very important to practitioners. This finding likely reflects the multidimensional nature of emergency smoke events and provides evidence as to why practitioners are challenged when trying to make sense of emergency situations. Despite multiple factors being considered very important to practitioners, the time-limited nature of emergencies means that practitioners will inevitability be forced to prioritize in their sensemaking efforts. Our results also provide insight into practitioners’ prioritization of different information sources. Specifically, practitioners prioritize their own knowledge and the knowledge of other practitioners. The two most important factors were information from other incident management stakeholders and the practitioners’ past experience. Other information, including community-based and academic knowledge, appear to be of lower priority for practitioners. Based on the study results, recommendations for practice and future research are discussed.

**13. Title: Residents’ information seeking behavior and protective action for earthquake hazards in The Portland Oregon Metropolitan Area**

**Authors: Carson C. MacPherson-Krutsky, Michael K. Lindell, Brittany D. Brand**

**Abstract:** Though significant research exists on earthquake hazard adjustment adoption more generally, research focused on how information seeking influences planned or actual preparedness behavior is rare, limiting our understanding of how information seeking translates into preparedness. To address this gap, our study tests a proposed model of household seismic hazard adjustment using questionnaire responses of roughly 400 households living in the Portland, OR metropolitan region. The proposed model includes components of the Protective Action Decision Model (PADM) with specific emphasis on past information seeking behavior, preparedness behavior, intentions to seek information, and intentions to take protective action. Other components include risk perception, earthquake experience, affective response, seismic risk zone residency, and demographics. Consistent with previous research, this study finds information seeking behavior to be the strongest influence on preparedness with other important influences being risk perception, affective response, and intentions to prepare. We find weak ties between risk zone residency and earthquake risk perception, though this may be because our sample has little experience with earthquakes and the majority live in the same earthquake risk zones. Importantly, longitudinal studies are needed to determine whether information seeking and intentions to prepare eventually result in household protective action.

**14. Title:** **Psychophysiological coherence training to moderate air traffic controllers’ fatigue on rotating roster**

**Authors:** **Wen-Chin Li, Jingyi Zhang, Peter Kearney**

**Abstract:** The nature of the current rotating roster, providing 24-h air traffic services over five irregular shifts, leads to accumulated fatigue which impairs air traffic controllers’ cognitive function and task performance. It is imperative to develop an effective fatigue risk management system to improve aviation safety based upon scientific approaches. Two empirical studies were conducted to address this issue. Study 1 investigated the mixed effect of circadian rhythm disorders and resource depletion on controllers’ accumulated fatigue. Then, study 2 proposed a potential biofeedback solution of quick coherence technique which can mitigate air traffic controllers’ (ATCOs’) fatigue while on controller working position and improve ATCOs’ mental/physical health. The current two-studies demonstrated a scientific approach to fatigue analysis and fatigue risk mitigation in the air traffic services domain. This research offers insights into the fluctuation of ATCO fatigue levels and the influence of a numbers of factors related to circadian rhythm and resource depletion impact on fatigue levels on study 1; and provides psychophysiological coherence training to increase ATCOs’ fatigue resilience to mitigate negative impacts of fatigue on study 2. Based on these two studies, the authors recommended that an extra short break for air traffic controllers to permit practicing the quick coherence breathing technique for 5 min at the sixth working hour could substantially recharge cognitive resources and increase fatigue resilience. Application: Present studies highlight an effective fatigue intervention based on objective biofeedback to moderate controllers’ accumulated fatigue as a result of rotating shift work. Accordingly, air navigation services providers and regulators can develop fatigue risk management systems based on scientific approaches to improve aviation safety and air traffic controller's wellbeing.

**15.** **Title: An agent-based model for evaluating reforms of the National Flood Insurance Program: A benchmarked model applied to Jamaica Bay, NYC**

**Authors:** **Lars Tjitze de Ruig, Toon Haer, Hans de Moel, Philip Orton, W. J. Wouter Botzen, Jeroen C. J. H. Aerts**

**Abstract:** Coastal flood risk is expected to increase as a result of climate change effects, such as sea level rise, and socioeconomic growth. To support policymakers in making adaptation decisions, accurate flood risk assessments that account for the influence of complex adaptation processes on the developments of risks are essential. In this study, we integrate the dynamic adaptive behavior of homeowners within a flood risk modeling framework. Focusing on building-level adaptation and flood insurance, the agent-based model (DYNAMO) is benchmarked with empirical data for New York City, USA. The model simulates the National Flood Insurance Program (NFIP) and frequently proposed reforms to evaluate their effectiveness. The model is applied to a case study of Jamaica Bay, NY. Our results indicate that risk-based premiums can improve insurance penetration rates and the affordability of insurance compared to the baseline NFIP market structure. While a premium discount for disaster risk reduction incentivizes more homeowners to invest in dry-floodproofing measures, it does not significantly improve affordability. A low interest rate loan for financing risk-mitigation investments improves the uptake and affordability of dry-floodproofing measures. The benchmark and sensitivity analyses demonstrate how the behavioral component of our model matches empirical data and provides insights into the underlying theories and choices that autonomous agents make.

**以下是书评：**

**16. Title: The Alignment Problem: Machine Learning and Human Values by Brian Christian**

**Authors: Louis Anthony Cox Jr.**

**Abstract:** The article reviews the book “The Alignment Problem: Machine Learning and Human Values” by Brian Christian and Brilliance Audio.