



Lloyd's Register
Foundation

Foresight review on the public understanding of risk

Reconciling facts and fears

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About the Lloyd's Register Foundation

Our vision

Our vision is to be known worldwide as a leading supporter of engineering-related research, training and education, which makes a real difference in improving the safety of the critical infrastructure on which modern society relies. In support of this, we promote scientific excellence and act as a catalyst working with others to achieve maximum impact.

The Lloyd's Register Foundation charitable mission

- To secure for the benefit of the community high technical standards of design, manufacture, construction, maintenance, operation and performance for the purpose of enhancing the safety of life and property at sea, on land and in the air.
- The advancement of public education including within the transportation industries and any other engineering and technological disciplines.

About the Lloyd's Register Foundation Report Series

The aim of this Report Series is to openly disseminate information about the work that is being supported by the Lloyd's Register Foundation. It is hoped that these reports will provide insights for the research community and also inform wider debate in society about the engineering safety-related challenges being investigated by the Foundation.

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Executive summary

With increasing technological and social complexity, risk plays an important role in our interconnected world. To manage risk wisely, we need to acknowledge its inherently subjective and multifaceted nature. Increasing the public understanding of risk is a critical factor in improving the quality of individual, business and political decisions in the face of risk.

Increasing the public understanding of risk is a critical factor in improving the quality of individual, business and political decisions in the face of risk.

An improved public understanding of risk can help us use our resources more wisely, and make choices that are more aligned with our values. It can inform the choice of products we buy – or avoid; whether to invest in upgrading a house in a floodplain; whether to take a medical scan. It can help us improve strategic and operational business decisions. It can also help us make policy decisions to manage risk, such as food and road safety, technical standards and certification, and carbon reduction and climate adaptation strategies. An improved understanding of the complexity with which risk can be perceived and assessed can help us have meaningful discussions and fruitful negotiations when we disagree, such as can happen with regards to nuclear power or food safety.

This foresight review explores what we already know about how we understand risk, and what it means for our behaviour and for the private and public risk management in our societies. The review notes some critical limits to this understanding, and identifies opportunities for increasing the public understanding of risk.

'Risk' is a term with many meanings. This review uses a definition that includes not only the analysis of technical risk assessments but all the dimensions that matter to people. A better understanding of risk in this wider sense would be of benefit to technical experts, public and private sector policy makers, managers, regulators and professionals, such as clinicians and journalists, who communicate with the public about risk. All of these are considered 'the public' in this report.



The review outlines the subjective and multifaceted nature of risk and how our perception(s) of risk impact our decisions.

- Our values and objectives influence how we view a problem and how we define and analyse the risk, and hence shape the results and the apparent ‘best decision’. Technical analyses are useful tools which help guide decisions and support risk management. However, they contain subjective elements which are often unrecognised as such.
- The results of any one technical analysis might not align with other people’s objectives and views. These views, as well as our own, often come from a rapid intuitive assessment of risky situations. These assessments derive from our experiences and values, and are informed by our objectives.
- These intuitive perceptions of risk are a useful guide. However, our intuition can also mislead us in various ways, especially because it confounds costs, benefits and probabilities by using an overall ‘feeling’ of risk. ‘Probability neglect’ is an example, where we invest too much effort and resources in trying to avoid (or achieve) a very low probability outcome, in response to a strong negative (or positive) emotional reaction to that possible outcome.
- Risk perceptions are not fixed; they vary between individuals and between socio-economic groups, and people’s risk concerns change over time.

Looking at why the public understanding of risk matters, the review explores the implications of these insights on multifaceted perceptions of risk for the communication and management of risk.

- Risk perceptions are liable to be magnified through social interactions, which means that relatively small events can be amplified to events with significantly larger social and economic consequences. Technologies, places and products can be stigmatised as a result, especially when the risk management response is perceived as inadequate. These reactions not only pinpoint social concern, but may also result in undesirable outcomes if these reactions are a result of misleading intuitive biases.
- The choice of boundaries and assumptions in technical analysis can have material impact on the results, and so being aware of this, as well as seeking to understand and include dimensions of public concern, can be important. When designing public policy, proposed policies may prove less effective, or even be unimplemented, if value-based dimensions of concern about risk are not considered.
- How risks are presented can influence people's responses, for example, how the chance of an event is described. Choices about how a risk is framed and communicated are unavoidable and should be carefully considered.
- Our responses to low-probability, high-consequence events are not calibrated, showing either overreaction or neglect in planning for them, especially for events whose outcomes we have not experienced before. A better understanding of those risks by all members of the public, as well as suitable policy responses, can help rectify such failures.





Much of the existing research in to the public understanding of risk has been conducted in a Western context. There is a need to expand this into different cultures, both to understand what is truly universal and what important differences exist in the perceptions and responses to risks in different cultural settings.

There are opportunities for improving the public understanding of risk. Such understanding needs dialogue to understand the concerns of different groups about specific risks. Notably, it is not a top-down approach to inform people of the findings of technical analyses. There is an opportunity for trusted organisations to help in this, especially through developing risk-literate intermediaries and institutions. The emergence of new risks and new technologies provides new opportunities, as well as new challenges in studying and improving public understanding of risk.

The report ends with recommendations for Lloyd's Register Foundation that focus on the newly established Lloyd's Register Foundation Institute for the Public Understanding of Risk (LRFI) at the National University of Singapore (NUS). Although the recommendations are specific to the LRFI the Foundation itself may wish to draw on these recommendations in considering any further activities to support the public understanding of risk.

It recommends a multi-disciplinary but social-science based institute with an Asian focus. Through the use of in-depth real-world case studies that focus on existing as well as new and emerging risks, the Institute will be well positioned to advance the study of public understanding of risk and to impact real-world outcomes. The report recommends that the Institute adopts a framework that sees the understanding of risk as a dynamic process, which can be harnessed by working at the interface of technical risk assessment, intuitive risk perception and integrative risk management, and seeking iterative learning from interventions. In identifying and taking forward dynamic case studies, the Institute should work with partners and stakeholders who work with, or impact on, the general public, as well as harnessing new digital and social media technologies and data.

Foreword

People perceive risk intuitively all the time. These risk perceptions can reflect concerns and values unjustly over-looked by technical analyses. At other times, they can be subject to misleading biases in our perceptions. Regardless of their origin and our agreement on their appropriateness, perceptions of risk influence our behaviours and can lead to poor decisions.

Differences in the perceptions of risk, inherently a subjective construct that is influenced by our values and objectives, can lead to disagreement and conflict. In an increasingly complex yet interconnected world, risks are becoming more systemic as they also become more interdependent. As a result, people's responses to those risks can also be more easily amplified.

The Lloyd's Register Foundation has already seen the importance of improving public understanding of risk and has established the Lloyd's Register Foundation Institute for the Public Understanding of Risk, in a joint enterprise with the National University of Singapore.

This foresight review provides a timely reflection on recent insights into how we understand risk and how these insights might be used to improve the public understanding of risk. It provides both an overview of the current state of knowledge and recommendations for promising directions for the nascent Institute so that it can achieve maximum impact in line with the Foundation's charitable aims. It examines how developments in the area of public understanding of risk might improve outcomes for individuals and society, to enable better decisions for a safer world... because life matters.

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Background

This report is the seventh in a series commissioned by the Lloyd's Register Foundation. It relates to its strategic theme of promoting safety and public understanding of risk as outlined in its published Strategy 2014-2020¹. It examines how developments in the area of public understanding of risk might improve outcomes for individuals and society, and to enable better decisions for a safer world in line with the Foundation's charitable mission.

This report is the seventh in a series commissioned by the Lloyd's Register Foundation.

The Lloyd's Register Foundation is a charity and owner of the 257 year-old Lloyd's Register Group Limited (LR). LR is a leading global provider of engineering and technology-centric professional services to clients in a range of sectors, primarily in energy and maritime, but also in food, healthcare and manufacturing.

In view of the importance of this topic in the Foundation's charitable objectives, the Foundation, in partnership with the NUS, has set up a new centre, the Lloyd's Register Foundation Institute for the Public Understanding of Risk (LRFI). This review provides both an overview of the current state of knowledge and recommendations for promising directions for the nascent LRFI to achieve maximum impact in line with the Foundation's charitable aims.

The Foundation is a charity with a global role. Reflecting this, it assembled an international and cross-sectoral expert advisory panel which met in Princeton, USA, in March 2017. This report contains the output and findings from that panel.

¹ <http://www.lrfoundation.org.uk/strategy/>



Expert panel membership

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What is public understanding of risk?

Each of the three words in the title of this report deserves some attention. What is 'risk'? What is meant by 'understanding'? And who is the 'public'?

We are all engaged in assessing risk in our daily lives - when we cross the road, when we take a new job, when we buy a new product. Assessments of risk by others also structure the world around us (how should the road be built?) and our own assessment often informs our choices (should we drink the tap water?). Differences in the assessments of risk can sometimes lead to confusion and conflict (is nuclear power-generated electricity safer than coal-generated electricity?). If we can better understand our perceptions and assessments of risk, we can improve decisions about managing risks, and hence the outcomes for ourselves and for others.

The word 'risk' is used in different ways. It may be a probability, a consequence or a threat that blends likelihood and severity into an overall measure. It may be calculated analytically or felt emotionally. It may be quantified or unquantifiable.

Many professional fields consider risk as a number based on quantified analysis. Sometimes risk is taken to mean the chance of a negative event, a probability; for example, the chance of an accident on the way to work. Professions with well-established methods of risk assessment and risk management use systematic analytical tools to consider both the likelihood of the event and the scale of its impact. For example, insurers of a teenage driver will consider both the chance of accidents and their likely severity. These technical risk analyses are designed to formalise decisions under risk and uncertainty and to help decision-makers manage risk.





While risk may have negative connotations, in certain circumstances it can be positive, such as when we actively seek out and take risks, be it in sports or in investments.

The tools of risk assessment are broadly similar across many professions, but nonetheless risk has somewhat different meanings or focuses in different fields. For example, finance looks at the relationship between risk (potential spread of outcomes) and return (their expected value); insurance focuses on the risk probability and expected costs of negative events and risk sharing; health, safety and environmental professionals generally consider hazard and exposure; health professionals consider the impact of actions (for example eating choices, travel) and possible interventions (for example advice, incentives, surgery, vaccinations); and the wish to avoid accidents and failures informs engineers' view of risk.

People at large typically take a broader definition of risk than these technical definitions. This wider, natural language, concept not only incorporates the uncertainty of the outcome and a measure of its size, but also feelings related to the specific hazard, possible actions and outcomes. Do people feel they have control over their exposure to the hazard? Does the distribution of possible costs and benefits seem fair? How dire does the consequence seem? How catastrophic would it be? Do we see benefits from the risky activity? These considerations affect how people view risk and their responses to it. These more experiential and value-based considerations are often left out of technical risk analyses focused on probabilities, consequences and expected losses.



The International Organization for Standardization defines risk as ‘the effect of uncertainty on objectives’. This definition highlights that risk and the perception of risk is always linked to decision makers’ objectives – and thus their goals and values. Not only may there be different views about the uncertainties, but responses to those uncertainties may differ and people might want to achieve different things. For the same possible actions, we can bring different objectives. For instance, we may want more nuclear power to ‘keep the lights on’ for a secure energy and environmental future, provide jobs, expand our business, and various other things.

Furthermore, risks may be difficult to quantify because of some important unknown factors. We may not know the precise likelihood or the size of some risk – the ‘known unknowns.’ Such uncertainty can be dealt with in different ways. Insurers typically increase premiums when they lack information about the probability or the consequences of some risk, or may even decline to offer policies. Confidence ratings or intervals also help to convey how much is known about a risk estimate, such as the Intergovernmental Panel on Climate Change’s five levels of confidence (from ‘very low’ to ‘very high’) in the validity of a scientific finding based on amount and quality of the evidence, and the extent of agreement. Rough, non-numeric risk assessments for both probability and impact (for example high, medium, low) may be more commonly used to manage risk in fields such as law, defence and business management, where situations are complex and critically dependent on the choices and actions of others who may not wish to reveal their own assessments.

When talking about ‘risk’ in this report, we use the expanded meaning which pays attention to all dimensions that matter to people. Risk is a concept that society has constructed to help us understand and cope with the dangers and uncertainties of life. It does not exist ‘out there’, independent of our minds and cultures, waiting to be measured. There is no such thing as ‘real risk’ or ‘objective risk’. Risk is necessarily subjective. Seen like this, technical risk assessments that are based on probability and consequences, while they can help to inform a complete understanding of risk, can only serve as part of a wider dialogue.

Improving the understanding of risk therefore is also a broad concept, and must be based on meaningful two-way communication between scientific experts and other interested parties. It is not a top-down, technically-led activity to ‘better inform’ people about risk. It must acknowledge that the perceptions of the public may well contain valuable insights and understanding. It must acknowledge the limits of technical assessments and engage in dialogue to explore what matters and what should matter. It may consider how relevant information can be presented to people to better align their intuitive responses with a more deliberative and systematic understanding of risks.

This means that a wide range of people could benefit from having an increased understanding of risk. All of the following are considered 'the public' for this report:

- Technical experts could better understand what the concerns and values of the broader society may imply for their analyses and the communication of their findings.
- Policy makers and regulators could be better equipped to understand the full spectrum of risk considerations on a given topic in developing policies, including the need to promote dialogue with the wider public to fully understand the relevant risks. In implementing policies that manage risks, they could be better equipped with tools to communicate effectively, and also consider how their policy instruments may be used to communicate the nature and response to risks.
- Professionals whose job predominantly, but not exclusively, includes communicating risk (for example clinicians, lawyers, forensic experts, scientists and engineers) could also be better equipped with tools to communicate and help others deal with risk more effectively.
- Professional communicators, including the media, could better understand specific scientific and technical issues underpinning public risk discussions, as well as the impact of intuitive thinking on risk understanding in general.
- Professionals in industry could be better equipped to understand and communicate workplace risks and benefits of risk management.
- Laypeople could better understand the risks and consequences of various choices of action and inaction, both individually and collectively, as well as to know what questions to ask in assessing evidence and claims about risk.

The mission of the Lloyd's Register Foundation is to enhance the safety of life and property and to advance public education. This begs the question, in whose eyes is the world a safer place as a result of the Foundation's work? The answer is in the eyes of society, that is, all facets of the general public described above. The public understanding of risk can have major economic and safety consequences. This is the reason behind its study.

An improved understanding of risk has the potential to improve decisions across a broad spectrum of daily decisions that impact people's lives, as well as technical and policy choices. A better understanding of public concerns will guide professional decision makers in their design and implementation of policies that increase public welfare and safety, and to spend resources more effectively. A better informed public can also have a significant impact through changing public discussions and, thereby, the decisions and actions of government, business and individuals.



From perceptions of risk to action on risk

As discussed above, risk can be seen as both analysis and feelings. ‘Risk as feelings’ is an age-old way of assessing danger. More formal risk analysis gained prominence in the 17th century when the tools of probability and scientific notions of causality led to the creation of the modern insurance industry for protecting life and property. Risk assessments can be seen as a systematic way of dealing with hazards and insecurities introduced by modernisation. While the study of risk perception is more recent, it has nonetheless been around for over 50 years. Risk perception and risk communication have been studied empirically in the laboratory and in the field, and this has enhanced our understanding of risk.

The subjectivity of technical risk assessments

Risk analysis, by necessity, needs to restrict its assessment of risk. This can make it controversial when people care about the outcomes, but they make different personal risk assessments and arrive at different answers. We have come to understand that, while technical risk analysis can provide us with much-needed tools to understand and evaluate risk, it does not make the assessment of risk any less subjective or value-laden. Technical risk assessments are based on theoretical models that include subjective judgments at every stage: from the initial structuring of a risk problem, through choice of inputs, to deciding which endpoints or consequences to include in the analysis. For example, in considering potential costs of climate change – and hence informing our choice of risk management strategies – a common approach is to capture the societal costs of carbon pollution in a ‘cost of carbon’. This requires choices about the treatment of scientific uncertainty, our concern for future generations, issues of global equity, and expected technological progress. The choice of what is put in, or left out of, the analysis can have significant political consequences, as well as underpin disagreements to proposed risk management strategies.



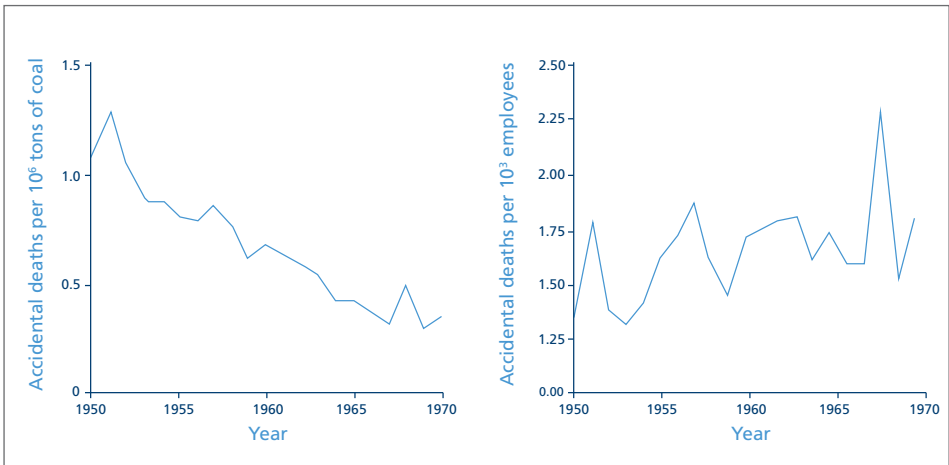


Figure 1. Metrics matter. Accidental coal mining deaths in USA 1950-1970 by tons of coal and employees respectively²

At a very simple level, how we choose to analyse and present analytic data can lead us to different conclusions on risk. For example, loss of life in coal mining has been declining in the US as a function of the amount of coal mined, but not as a function of the number of people employed (see figure 1). What matters here, and to whom? Whoever defines the risk influences what is believed to be the correct solution to the problem at hand. By defining risk in a certain way, one option will appear better than others: the most cost-effective, the safest, etc. The framing of risk, broadly defined, matters to the judgments we make and the decisions we take – both as laypeople and as experts. Framing contextualises the issue and focuses our attention differently, and thus shows ‘risk as politics’.

When someone knows the outcomes that they want to achieve (for economic, political or other reasons), they may unintentionally choose frames that help themselves and others see their preferred choice as the best one. Cultural factors, such as organisational procedures or hierarchies, which can limit ‘acceptable’ views and input into assessments and debates, can also lead to a skewed view of a risk, as in the space shuttle Challenger failure. A special

² Crouch, E. A. C. and Wilson, R. (1982) Risk/Benefit Analysis, Cambridge, MA



Case study 1: Actions to change risk perceptions of tobacco

It is well documented that medical and public health professionals had long understood the health risk posed by tobacco and that the industry supported disinformation campaigns which sought to undermine the science. These campaigns specifically aimed to make the public believe that there was greater uncertainty about the negative consequences of smoking than was supported by the evidence.

Bland statements on packages about possible risk ('may be hazardous to health') that were required in the 1960s and 1970s in Europe and the US were gradually replaced by clearer messaging on risk of specific diseases. These were accompanied by health campaigns, restrictions on advertising and taxation. The public gradually became more aware of the health risks. Vocal groups of government health agencies, non-governmental organisations and health professionals increasingly lobbied for more effective measures to combat smoking. The World Health Organization Framework Convention on Tobacco Control (2005) was the first global health treaty and provides an international framework to take action on the 'globalised tobacco epidemic'.

Smokers do not rationally weigh the costs and benefits in considering whether to start or continue smoking. Recent measures to reduce smoking have adopted approaches which directly engage smokers – and potential smokers – with the risks on a more emotional level. New measures have sought to change the perceived benefits by undermining the attractiveness of the product (for example by plain packaging), and (intentionally or not) have also created a social exclusion through the banning of smoking in public places. In addition, images of dreaded diseases and other impacts on the packaging has been sought to increase smokers' perceived risk. Experiments have shown that smokers have found graphic warnings more credible and memorable than text-only warnings, and are more likely to change their feelings about smoking³. There has been a dramatic decrease in smoking, especially by young people, in countries with such measures.



³ For example, Evans, AT et al. (2015). Graphic Warning Labels Elicit Affective and Thoughtful Responses from Smokers: Results of a Randomized Clinical Trial. PLOS ONE, 10(12), e0142879.

commission appointed by the US President, found NASA's organisational culture and decision-making processes had been key contributing factors to the accident.

People can also intentionally choose risk analysis methods and frames to help ensure that their preferred outcome is seen more favourably. Such tactics have been documented in the communications by the tobacco and oil industries which have focused on the benefits of their products (and by-products), minimising the risk, and/or over-emphasising the uncertainty of the science. These campaigns have effectively misled the public (case study 1 on the previous page).

Intuitive risk assessments

Most day-to-day risk perceptions are likely determined by fast, intuitive 'gut' feelings, rather than by careful deliberation. Risk as a feeling is a powerful and potentially helpful force, an early-warning system of sorts that can use our experiences and our values to guide us. This fast and intuitive thinking (sometimes called System 1 thinking) uses feelings and other associations, as well as stories and images, and is often unconscious. It is in contrast to our slow, deliberate analytical decision-making system (System 2) that uses symbols and numbers and conscious appraisal.

Research has investigated how a range of qualitative concerns influence people's risk perception. For example, is risk from cancer worse than risk from car accidents? Is a risk imposed on a child more serious than a known risk accepted voluntarily by an adult? This research has shown that there are a number of psychological risk dimensions that can tip our perceptual scales when we are faced with risk (figure 2).

We may engage our ethics and values, or worry about potential regret. For example, risk with a given expected death toll is perceived as greater and less acceptable when exposure to the hazard is involuntary, the risk is not under one's control, when the costs and benefits are not equitably borne, or when children may be affected. Our feelings about potential outcomes matter. If the outcomes may be catastrophic or evoke feelings of dread, then the perceived risk is greater. Conversely, if the potential benefits are large and readily identifiable, the perceived risk is smaller. Our feelings about uncertainty also matter; if the risk concerns a new or unfamiliar technology, or is perceived as not well known to science or to those who might be harmed, we may perceive the risk as larger. In contrast, if we have no personal experience of the consequence, we may simply perceive the risk to be smaller.

Many of the qualitative influences noted above can be explained as incorporation of our experience and values into our own intuitive risk assessments. However, evaluating a given



situation in an intuitive, automatic and emotional way rather than through analysis has other consequences. We base our assessments on a feeling about the situation taken as a whole, and thus often perceive the uncertainties, costs and benefits of the situation as more related than they in fact are. In particular, we confound risk and benefit; activities that have high perceived benefits are seen to be low in risk, and those with low perceived benefits as high in risk. This can explain why we often underestimate the risks or volatility of well-performing stock, contrary to the well-established fact that higher returns come with greater risks in efficient financial markets.

We may also be unduly focused on unlikely outcomes, paying them more attention than they deserve based on their likelihood, if we have a strong positive or negative emotional reaction to these possible outcomes. This ‘probability neglect’ can explain people waiting in long queues to buy lottery tickets when the jackpot is high and our overreaction to unlikely terrorist incidents.

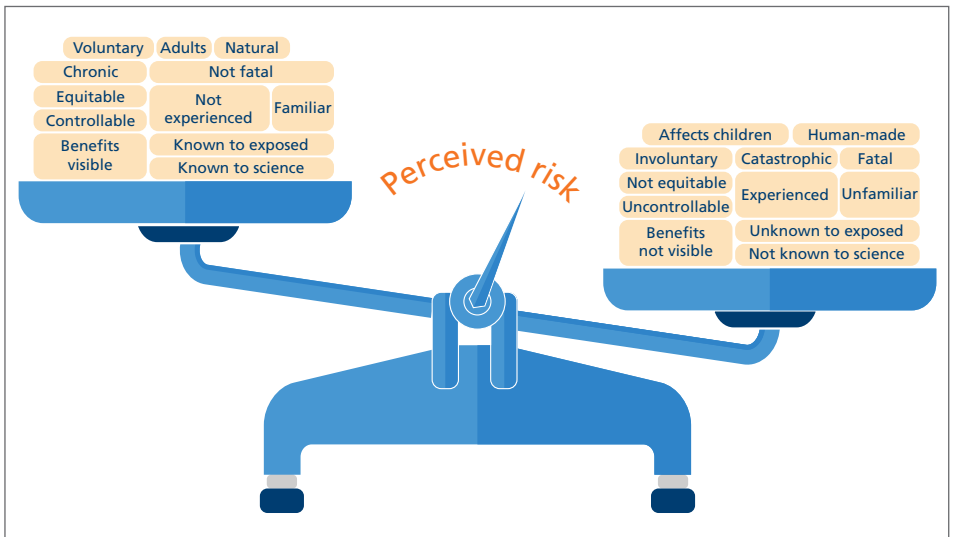


Figure 2. Influences on our risk perceptions. Qualitative concerns can tip our perceptual scales and increase the perceived risk. These influences may be related to our values (for example equity, voluntariness), whereas others may be misleading biases (for example visibility of benefits), or a mixture.

From perception to action: risk tolerance

Decisions and actions in the face of risk by an individual are a result of both their perception of the risk (with its uncertainty, potential costs and benefits) as well as their tolerance or attitude towards risk. A person can be risk-seeking, risk-averse or risk-neutral. A psychological approach acknowledges the importance of subjective risk perception and then considers the tolerance towards this risk (perceived-risk attitude). This contrasts with the approach in economic analysis which often infers people's risk attitude directly from observed behaviour or revealed preferences, assuming an objective definition of risk. When analysed on the basis of perceived risks, people tend to be risk-averse or risk-neutral. Research suggests that while there are individual differences in perceived-risk attitudes, many individual, group and cultural differences in risky decisions and behaviours can be explained by differences in risk perception. How perceived-risk attitude and risk perception influences outcomes and depends on our values and objectives is shown in figure 3.

Risk perceptions are not fixed

Different individuals and different socio-economic groups perceive risk differently. As noted previously, research suggests that familiarity and control are important influences on our perception of risk. Beyond affecting our perception of specific risks, feelings of familiarity and perceived control may influence our general risk taking behaviour, giving us latitude to take risks. This suggests that dominant groups who exercise greater societal control are likely to be more risk taking. This is supported by generally lower levels of risk perception and higher levels of risk taking by white men, especially those who are educated, in North American society. In contrast, people from minority ethnic groups and white women generally perceive risks to be greater and take fewer risks. One exception is the social sphere, usually considered women's domain in American culture, and here research suggests that women's perceptions of risks are lower than men's and their risk-taking is greater.

Perceptions of risk can differ as a function of community or family support. Singapore, for example, has a history of ethnic-based 'clan associations' that were formed by the original migrant generation for mutual support in a new environment.

Chinese decision-makers have been shown to be less risk-averse in their financial investment decisions than similar Americans. The 'cushion hypothesis' suggests that the seemingly riskier investments by the Chinese were made possible by their support from their social network, who could help out with money transfers. The Chinese decision-makers were only seemingly less risk-averse in their financial decisions, but not for risky health or academic decisions, because health or grades cannot be transferred between people.

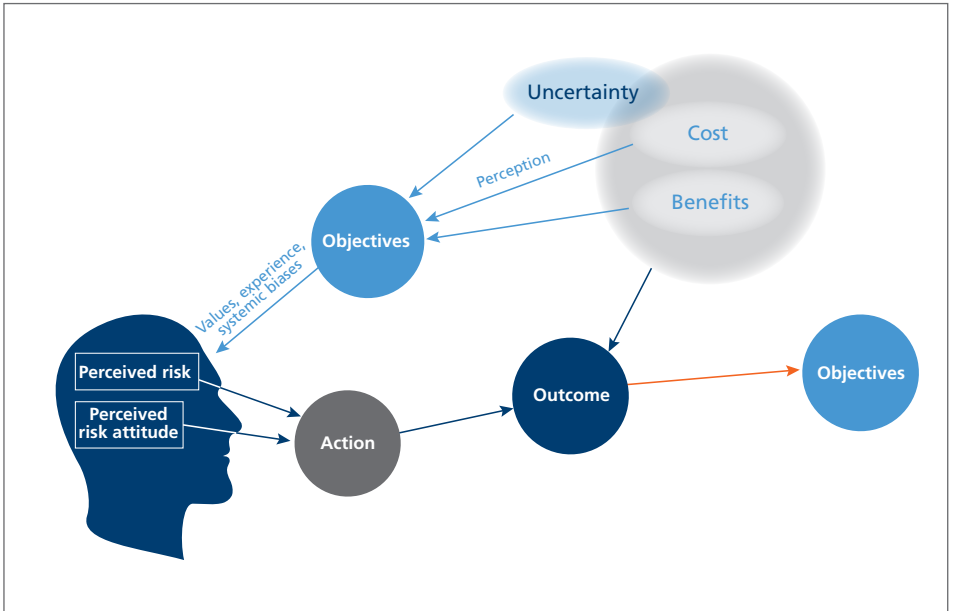


Figure 3. Risk perception affects our choices, and hence outcomes.

Perception of benefits, costs and the uncertainties is combined into a feeling about specific risks. Combined with our attitude to this perceived risk, we will take action, or not. Do we gamble, or not? Buy a product, or not? Favour a regulatory intervention, or not? Take – or prescribe – a medicine, or not? The uncertainty of the actual situation means that outcomes of our action – may, or may not – help us further our objectives.

Our objectives can shape our risk perceptions or even lead us to frame the analysis to give us the ‘right’ answer. In addition, (not shown in the diagram) our risk perception can be shaped by our views on possible actions themselves.

Concerns change over time

The study of risk perception has shown that our concerns change over time. What is deeply concerning today or this month may carry little interest at a later date and other risks may be of great concern. We appear to be anxious about specific risks for a limited time, especially after a highly visible failure or catastrophe. There seems to be a 'finite pool of worry', that is, when we feel concerned about something new, we pay less attention to one or more of our previous worries. For example, most Europeans and Americans are less concerned about nuclear power and more concerned about terrorism than they were 20 years ago. Figure 4 shows a recent analysis of different risk concerns in the USA.

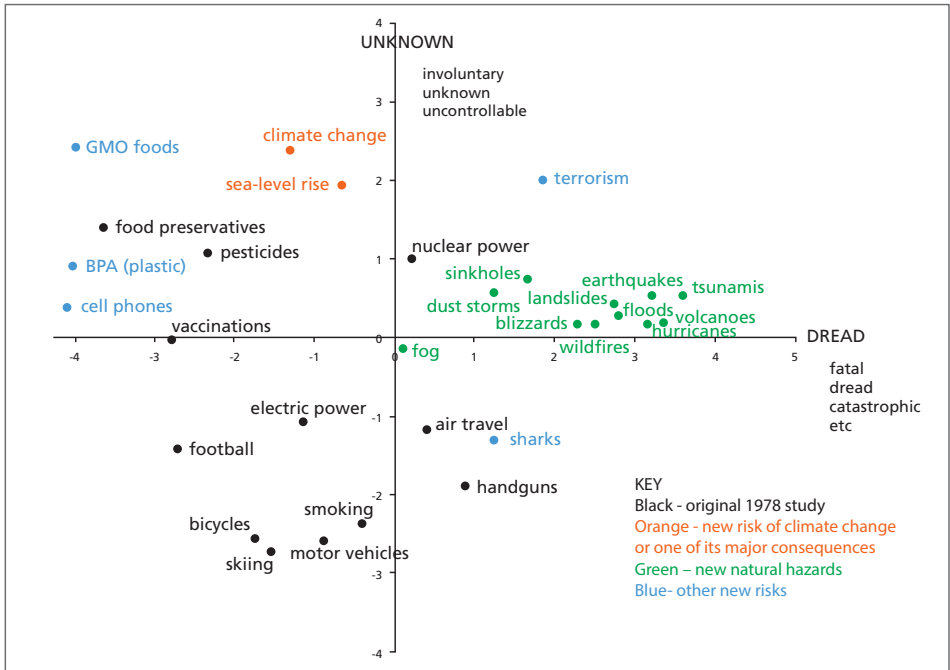


Figure 4. Assessments of different risks by the general public in the USA, according to their perceived degree of dread and fear of the unknown (Katherine Fox-Glassman, 2015). The placement of some of these risks have changed since first assessed in the 1970s (Fischhoff et al, 1978), and new concerns have emerged.



Why does public understanding of risk matter?

When there is a poor understanding of risk we make poor decisions, collectively and individually. We will use resources in ways that do not align with our interests or our values, such as spending money to save a single life, without realising that we could have used this money to save 10 more that would have been equally important to us. We will engage in risky behaviours that we underestimate and fail to prepare for potential consequences, for example, by not evacuating a danger zone in preparation for a potential storm or not preparing for drought. Individuals and organisations often fail to plan for and manage obvious risks, as well as not having adequate resilience to deal with unexpected or improbable events.

It has been suggested that in an advanced society, the production of wealth is systematically accompanied by the social production of risks. As a result of technological and economic progress, we are no longer only responding to natural risks, but also increasingly to risks we have created, many of which are systemic and highly interconnected. Science and technology can help us address these complex risks, but we must also account for people and politics to deal with issues of perception and response.



Improved public understanding of risk can help individuals make better personal choices which impact their health or finances, as well as help them to respond to new risks, for example stories in media, or on the internet. Informed individuals constructively shape public discourse, and hence public policy response, such as providing a mandate for action on tobacco or climate change. A better public understanding of risk will mean that we may hope to have fewer disagreements about risk, and that we can more meaningfully discuss why we disagree and thus look for solutions which satisfy more people's objectives. It should improve trust and contribute to inclusive growth for society at large.

Public policy choices to manage risk are wide ranging and include the approval of food products and pesticides, disposal of radioactive waste, investment in flood protection and low carbon energy, security measures at airports, regulation of the banking industry, as well as the design of welfare and health systems. Effective and cost-effective policies need to be based on a good understanding of the technical aspects of the relevant risks and of the risk perceptions – which can inform policy makers about important values-based aspects, as well as influence the demand for, and effectiveness of, policy measures. There may be a mismatch between analytical assessments of risk and public understanding or action. Public policy should not only respond to public concerns, but must also engage in and inform those concerns. An informed dialogue needs to underpin decisions on what level of preventative measures is appropriate given the risks (potentials costs and uncertainties).





The introduction of regulations (for example, on the use of seatbelts) and the design of economic incentives (for example, in the structure of insurance policies) can benefit from an understanding of public perceptions of those risks, but can also provide opportunities to help the public understand risk better through the communication of these measures, as well as through the design of the measures themselves.

Looking at why the public understanding of risk matters, this section now explores the implications of the insights on multifaceted perceptions of risk for the communication and management of risk.

Social amplification of risk

Risk perceptions get socially amplified, with impact on our societies and economies. Individuals' risk perceptions, interacting with social and institutional forces, can trigger massive social and economic impacts in response to even 'small' incidents. The framing, images, and stories of specific events by the media will interact with our intrinsic risk perception biases, and may generate a reaction that spreads far beyond those initially affected. It may cause anxiety in the wider public or specific communities, loss of sales, loss of investors and regulatory responses. Such amplified responses may generate stigma connected to a product or technology, or even a location, and impact the value of goods, products and brands. These socially amplified responses can lead to an overestimation of the risk, and can create a demand for a policy response which may not always be warranted. However, these responses can also be seen as justifiable in that they pinpoint social concern.

The responses may be transient if there is seen to be an adequate response to manage the risk – or they may generate a long-lived stigma where this is not the case. For example, following a number of deaths in the US from intentional contamination of Tylenol (paracetamol) capsules in 1983, the product was recalled and relaunched in a 'tamper-proof' format. Although sales initially plunged from 37% to 7% of the market share, through effective crisis management Tylenol regained its market share within a year. In contrast, the accidents at Three Mile Island and Chernobyl came to have lasting impact on public perception of nuclear power technology until this day, despite the new procedures and safety-focus it brought to the industry. The Fukushima disasters in Japan in 2011 reignited this concern and led Germany to shut down eight of its oldest reactors almost immediately, and commit to phase out its nuclear power by 2022.

Risks may also be collectively underestimated, with people taking cues from others in their risk assessments. These collective responses may in part explain the existence of bubbles in financial markets.

The need to account for the limits of technical risk assessment

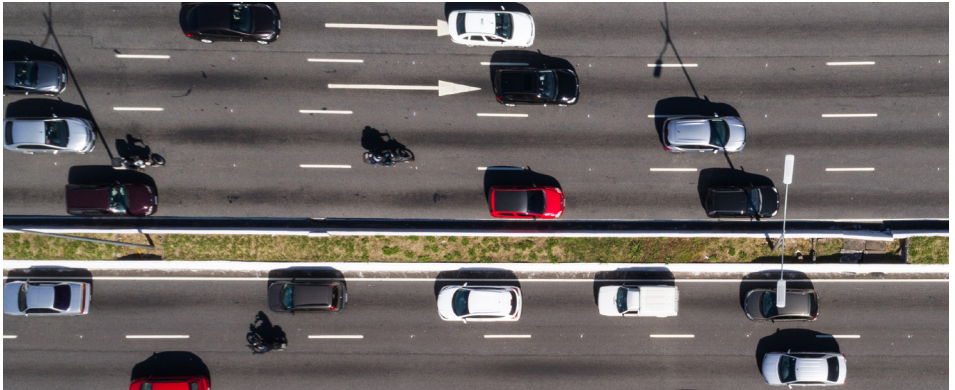
The previous discussion has shown that we incorporate our experience and values into our own intuitive risk assessments. These concerns, however, are often left out of technical risk assessments. If the analysis is expanded to include these aspects, it may produce a different ordering of proposed solutions. We cannot make fully informed decisions individually or collectively, unless formal analyses and the dialogue around them is extended to include these aspects. The omission of such aspects can give rise to controversies and disagreements about risk between different groups, notably between technical experts and the public. Debates about nuclear power have illustrated this. Public policy design would therefore be improved by explicitly exploring and taking account of these qualitative concerns.

Risk management strategies can place a value of a human life, either implicitly or explicitly. These values can differ across arenas. For example, different values may be used in cost benefit analyses by the different relevant authorities when deciding policies for road safety and environmental protection. Furthermore, different implicit values of a human life in different arenas can be inferred from the spending on safety measures for each statistical life saved. These differing values may be an historical and accidental artefact, or may reveal something about the way we view different risks. The extent to which society is using its resources appropriately depends on careful consideration of such questions and warrants further study.

Communicating risk in the context of intuitive risk perception

Although our intuition can provide insights into qualitative concerns worthy of consideration, it can also mislead us. For example, we do not have an intuitive understanding of probabilities, so how chances are presented can make a significant difference in how we perceive the risk and influence our actions – or even inaction.

- People, including experts, routinely judge low percentage chances as higher when presented as a relative frequency: one-in-a-hundred seems a higher chance than 1%. A poor understanding of percentages certainly contributes to this, but that is not the only reason. In the case of relative frequency presentations, we tend to imagine the few individuals who may be affected, which can lead to greater 'feelings of risk'. Presentations in terms of percentages are less likely to induce such mental images and feelings.
- People tend to think that timescales used to communicate risk are the timescale over which there is concern. As such, we may ignore lower probability events. For example, we may worry less about a 100-year flood, or a 1% flooding risk, and worry more if the same event is described as a one-in-four chance of flooding over 25 years. In the latter case, the timescale is relevant to personal experience – and mortgage terms – and the chance seems relatively high. As a result, we might not buy that house, or we may take protective measures for one we already own.



Risks can also sometimes be effectively communicated by comparing them with other risks, or by other analogies in the form of intuitive units of risk. A micromort is a one-in-a-million chance of death and can be used to compare the size of acute risks, ie activities which may result in immediate death. Thus, going under general anaesthetic, taking a skydive or riding 60 miles on a motorcycle in the UK are all comparably sized risks: 10 micromorts⁴. A 'banana-equivalent dose' has been used to explain exposure to radioactivity (ie eating how many bananas would expose you to the same levels of radioactivity).

As we have already seen, our intuition confounds feelings relating to possible benefits, downsides and uncertainties. When we see things as highly beneficial, we take risks that are beyond those that we would rationally take, even considering the benefits. For example, we underestimate the risks of painkillers and other medicines. In addition, we tend to focus on outcomes to which we have a strong emotional response, even when the chance of that outcome is vanishingly small. Our personal worries about potential shoe bombers, as an example, are also reflected in policy responses. This leads to a huge loss of our time as we remove our shoes at the airport in response to a very small risk. Arguably our resources may be better spent elsewhere.

Risk communicators can seek to portray the evidence objectively. For example, presenting statistics in different ways (see case study 2 overleaf) or communication tools can be used explicitly to try to change behaviours, as the recent regulatory approach of using images and information on dreaded diseases on tobacco products (case study 1, page 16).

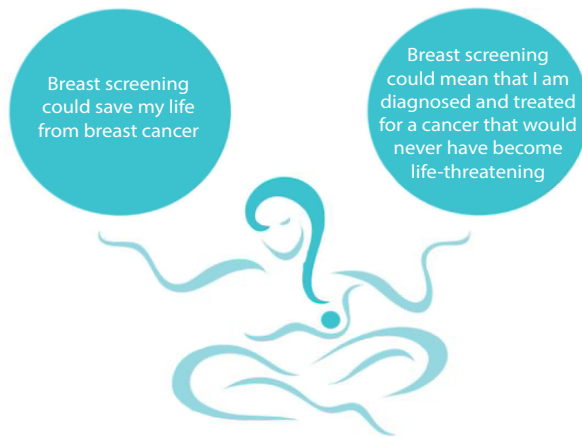
⁴ <http://www.bbc.com/future/story/20120209-a-lesson-in-risk>

Case study 2: Breast screening facts leaflet

A UK's NHS leaflet on breast screening uses graphics to help people weigh costs and benefits, and relative frequencies to help people understand likely outcomes.

Weighing up the possible benefits and risks of breast screening

There is debate about how many lives are saved by breast screening and how many women are diagnosed with cancers that would never have become life-threatening. The numbers below are the best estimates from a group of experts who have reviewed the evidence.



Saving lives from breast cancer

Screening saves about 1 life from breast cancer for every 200 women who are screened. This adds up to about 1,300 lives saved from breast cancer each year in the UK.

Finding cancers that would never have caused a woman harm

About 3 in every 200 women screened every 3 years from the age of 50 to 70 are diagnosed with a cancer that would never have been found without screening and would never have become life-threatening. This adds up to about 4,000 women each year in the UK who are offered treatment they did not need.

Overall, for every 1 woman who has her life saved from breast cancer, about 3 women are diagnosed with a cancer that would never have become life-threatening.

Image credit: Felton Works / Sandy Haight



Preparing for low-probability, high-consequence events and interdependent risks

Although we tend to focus on highly desirable (or highly dreaded) events even when the chance of that outcome is small, in other contexts we often underestimate and underprepare for low probability but high consequence events. Such under-preparedness can have devastating consequences.

The reasons why people sometimes appear to spend too many resources to avoid highly unlikely events, yet in other cases clearly remain underprepared for unlikely-yet-potentially catastrophic risks (for example, global climate change, asteroids), deserves further study. Hypotheses for the difference include how emotionally engaged we are with the possible outcome or how immediate the risk seems.

We may make decisions on questionable rules-of-thumb, such as treating a potential disaster as below our threshold of concern. We may underestimate the likelihood of its occurrence and the potential consequences if we have no experience of the hazards or their consequences, such as a large-scale electromagnetic storm or a geomagnetic pole reversal. This ‘tragedy of the uncommon’ may be in play in our relatively muted response to potentially catastrophic climate change. Public policy has a role to play in addressing such systemic failures: through regulation, economic intervention and incentives as well as improved communication.

On the other hand, after a disaster, because of its recent prominence, there is a tendency to overestimate the likelihood of the event occurring and people consider undertaking protective measures, but only for short periods of time. To illustrate, those at risk for floods often do not purchase insurance voluntarily even at subsidised rates until after the disaster occurs – when it is too late. If they have not suffered a loss for a few years, they cancel their policy because they view it as a poor investment rather than a protective measure.

These issues may become increasingly important with the rising complexity and interconnectedness of our world. Contemporary technological designs are increasingly tightly coupled and complex, leading to cascading failures and confounding human operators of the system. This points to resiliency, especially to the effects of unexpected and low probability events, as an increasingly important feature to understand, communicate and build into our systems. Critical infrastructures that form the backbone of developed communities are now viewed as a complex system of systems where the underlying web of interconnections defines its resiliency to cascading failures. In 2003, a power line which supplied electricity from Switzerland to Italy was damaged during a storm. The cascading

effects resulting in a blackout affected a total of 56 million people, the most serious blackout in Italy in 70 years. Engineers are now developing 'learn as we go' adaptive strategies. The finance industry has adopted stress testing to identify and mitigate unexpected vulnerabilities that may emerge from the dynamic complexity of the network.

Furthermore, impacts in one sphere or region can spill over into another. A volcanic eruption in Iceland in 2010 disrupted travel plans of millions of people, and resulted in shortages of some goods in Northern Europe and the cancellation of cultural events. The impacts could have been mitigated by better contingency planning for the event of long-term grounding of air traffic, as well as technical risk assessments of airborne ash concentrations which were agreed by both regulators and the airline industry. In 2011 severe flooding in Thailand had major humanitarian and economic consequences for the country. There were significant international impacts including on rice prices and computer hard disk supply. After the floods the government pledged to invest in long-term prevention projects, including the construction of drainage canals.





East meets West

Most of the work that studies the public understanding of risk has taken place in a Western context. There are, however, important cultural, social and other reasons why it would be wrong to assume that the findings can be universally applied.

We know that objectives, values and experience all influence risk perception. Objectives and values also inform the choices individuals and societies might make to manage risk. Social and cultural differences in values, norms and expectations can shape the perceptions and management of risk. There is some evidence that people use different decision-making processes in different cultures, that the social context influences risk perceptions, and that different thinking styles may influence our ability to deal with long-term issues and risks.

Although there are significant differences worthy of exploration between Western cultures, greater differences may arise between East and West. Eastern cultures that are more collectivist, for example, assign greater importance to social relationships and engage in more holistic thinking. The public in these countries may perceive and manage risks differently from people in the more analytic, individualistic West. Furthermore, risk attitudes are found to be significantly different across cultures. Cross-cultural studies of IBM employees in multiple locations around the world find that uncertainty avoidance can be viewed as one of the six major dimensions of cross-cultural differences.

Exposure to different social, political and economic structures can also affect risk perceptions and behaviours. The East is heterogeneous and economically, culturally and politically diverse, and there is opportunity to consider the impact of these different realities on risk perceptions, attitudes towards risk, and behaviours and risk management approaches. In addition, there is an opportunity to consider how risks and responses to risks propagate and amplify in different settings.

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From barriers to opportunities: improving public understanding of risk

The role of trust

Trust is critical in risk communication, and specifically for the acceptance of risk. However, there is a significant 'trust asymmetry'; trust is hard to earn and easy to lose. This may be because negative events are more sharply defined (for example, specific and memorable examples of accidents) compared to positive ones (the numerous positive events that result in functioning accident-free complex systems and technologies on a daily basis). It may also be because a violation of trust itself is seen as highly meaningful, and therefore results in a strong response.

There are opportunities for institutions not aligned with specific issues or debates to become trusted sources of advice on risks, especially where they are technically literate and sensitive to issues of perception and values. There are also specific opportunities to increase the capacity of already-trusted channels to help communicate risk more effectively (see more about this in the section below).

Trust networks are a key element of social media, where people control their own channels. One result may be an increase in the speed and depth of amplification of public responses to (perceived) risk, possibly in specific sectors of the community. Social media often also relies on greater use of 'fast thinking', using individual examples, narrative and imagery. These may therefore be increasingly playing a role in people's perception of the world, which leads to a challenge – and an opportunity – to develop tools to improve risk understanding. At the same time, because of the opportunity to track reactions in real time, social media provides an opportunity to learn about the dynamic nature of risk (what are the present concerns and their manifestation) and the ways in which social amplification of risk concern develops.

Risk-literate intermediaries and institutions

Opportunities exist to improve the public understanding of risk through the application of existing knowledge. However, significant translation into practical applications is required before this can impact on the wide range of different publics and the different types of risks and choices they face. To be able to reach individuals making choices and help them take actions that are aligned with their goals, we need trusted communicators as well as public policy institutions that are risk-literate.

Risk literacy is a dual understanding of the pros and cons of both 'risk as feeling' and 'risk as analysis'. Risk literacy means understanding the technical analysis, its limits and subjectivity, as well as understanding the importance of potential value and biases in subjective risk perception.



Professional communicators in the media, domain professionals who speak to the public (for example healthcare professionals) and educators are influential and accessible voices. They therefore have particularly important roles to play in shaping public understanding of risk, both in general and on specific topics. Educators can fruitfully develop new ways to teach about risk and uncertainty, as well as to foreground the role of risk-taking, in learning. By bringing the expertise and channels of risk-literate communicators to specific issues, we can build better public conversations about risk, as well as design more effective interventions for better individual choices.

Regulators and policy makers have critical roles, both as decision makers and as public communicators. They sit between the public reaction and technical analyses, where different approaches to risk may collide. Better policy outcomes can be achieved by applying a greater risk literacy to designing interventions and policies. Risk-literate policy makers will identify the facts relevant to choices and seek to understand people's thinking about risk, how it may result in different choices and what lies behind it (see case study 3 overleaf). Public deliberation of different aspects of risk perceptions and risk acceptance is an avenue to have more constructive disagreements on issues of risk, or even resolve disputes (see case study 4 on page 34). Experience shows that risk literacy of regulators and governments can be achieved by developing sustained relationships between the institutions and experts in the public understanding of risk.



Case study 3: Managing flood and storm risk

Studies have shown that residents in the US are typically underinsured in hazard-prone areas, and do not take even relatively affordable measures to protect their homes against storm damage. For example, even after major property damage along the US Atlantic and Gulf coasts in 2004 and 2005 hurricanes, less than 20% of residents had taken steps to fortify their homes by May 2006 (10 months after Hurricane Katrina). Such collective under-preparedness can lead to systemic failures and require substantial state financing when disaster strikes.

Building codes and spatial planning restrictions are often used to minimise the damage from floods and storms. In the Netherlands there has been a policy shift in relation to water and spatial planning, due to considerations of the impact of climate change on this low-lying and highly water-managed country. In recognition of the uncertainty of the impact of climate change on flood risk, policies have put greater emphasis on natural systems and societal and economic resilience, rather than relying solely on engineering solutions to keep water out. This fundamental shift has provided opportunities for national dialogue on the underpinning risks.

Planning restrictions and building codes may be politically difficult to enact or inadequately enforced. Annual flood-risk insurance policies do provide some protection – but policies may be withdrawn in future years, especially if the hazards are increasing (although agreements between governments and the insurance industry can help address this). Furthermore, annual policies do not provide adequate financial incentives for investment in protective measures (such as raising on stilts, or proofing foundations and internal walls). There may be opportunities to explore innovative regulatory and financial mechanisms, such as statutory requirements for multi-year policies which could better financially incentivise protective investments, as well as communication about the risk and mitigating actions.





Case study 4: Management of radioactive waste: where technical assessments and ethics meet or miss, a comparison of US and UK experiences

The Committee on Radioactive Waste Management (CoRWM) in the UK was set up in 2003 to review the options for managing the UK's higher activity solid radioactive waste, and to make recommendations on the option, or combination of options, that could provide a long-term solution, providing protection for people and the environment. CoRWM's work was based on explicit foregrounding of ethical considerations, wide participation and expert knowledge. It used deliberative processes to ensure a democratic outcome and integration of different knowledge to provide implementable solutions. The Committee provided a set of 13 recommendations in 2006 which its members saw as interdependent, for managing legacy waste. Their report 'set out the constraints and uncertainties, technical and social, that will influence the achievement of the recommendations'.

The UK has yet to build a geological disposal facility and siting remains contentious. New wastes are now expected as a result of a new nuclear power station programme. The Committee's work is an example of how public concerns, consideration of values and ethics can be practically combined with technical analysis of uncertainty and risk. It successfully provided recommendations (including geological disposal) that technical experts, NGOs, local residents, school children and concerned citizens had transparently shaped. In doing so, it radically changed (if not resolved) the debate on geological disposal of nuclear waste in the UK.

This contrasts with the approach in the US, which adopted a technical approach starting from the necessity of geological disposal and focused on assessing the geological suitability of specific sites. There was little consideration of issues such as fairness, cultural values and heritage, and arguably insufficient attention to transport risk or adequate consideration of other technical options (such as keeping some wastes more accessible for potential future use). The project at Yucca Mountain in Nevada has faced sustained local opposition since its approval by the US Congress in 2002. In light of ongoing concerns and opposition, federal funding was withdrawn in 2012. The US now no longer has a route to geological disposal of radioactive wastes, despite over US\$9 billion being invested in the facility.

Using knowledge of risk perception to shape toolkits and decision processes

We can use our knowledge of the way people process information to (re-)frame decisions in ways that align the perceptions of risk of experts and the public. For example, we can use relative frequency to discuss low probability events; present probabilities over human time-scales rather than hundred-year events; or portray worst case scenarios to heighten concern for improbable events with severe consequences that that have not been experienced by the relevant public to bring them closer to the experience (for example fictive or documentary story-telling). The choices made by people are influenced by the ways that the risk is presented. Using the science of risk perception consciously to affect those choices may invite concerns of paternalism or manipulation, but such concerns need to acknowledge that any presentation of risk influences perceptions and actions. As there is no value-neutral way of presenting information and some presentation format has to be selected, there seems to be ample justification to present risks in ways that increase the public welfare, decrease mortality, provide increased protection against unlikely events or natural disasters, or reduce genocide.

Different representations of the choices people are facing and their potential consequences (for example decision trees, risk influence maps and representations of uncertainty) can help people take better decisions. Such toolkits can help people overcome barriers to good decisions, including not having time, motivation or capacity to consider the trade-offs when presented with the information in technical or standard forms, as well as instinctual biases.

Given the importance of risk perception, people's behaviour can be fruitfully studied as a function of their perceived risks. This is likely to result in a different understanding of people's risk-taking/avoiding behaviour than an analysis in terms of a calculated objective risk. Such results would suggest different possible interventions to effectively change that behaviour.





New risks and new technologies

We also need to continue to develop our understanding of new and emerging risks. There are new technological, health and environmental risks, all of which deserve attention in their own right. Cybersecurity is emerging as a risk of concern for governments, business and individuals in an increasingly deeply interconnected world. This increasing interconnectivity - of tightly-coupled global economic, environmental and physical systems - is itself a potential source of increased fragility and vulnerability. Understanding, assessing and communicating these interconnected risks poses a significant challenge for the coming years.

New information and communication technologies (ICT) - especially new media and big data – are both sources of new risk (for example privacy, identity theft, cyber attack and systemic failure) and new opportunities to study risk perceptions and risk behaviours. ICT also provides opportunities to interrogate disparate information sources. There are also opportunities to develop innovative and personalised approaches to provide more pertinent and effective risk-based advice. There is a similarity here to precision/personalised medicine where an intervention is tailored in accordance to an individual's DNA.

Recommendations for Lloyd's Register Foundation

The science of the public understanding of risk is well established. There are significant opportunities to apply this body of work to generate better public understanding and response to risks. In particular, there are opportunities in countries and regions of the world where there is limited expertise in, and appreciation of, the public understanding of risk. Furthermore, there is opportunity to use the insights generated by the application of existing knowledge, especially in previously understudied regions of the world, to further advance the science of the public understanding of risk.

The Foundation has established the LRFI at the National University of Singapore (NUS) as a centre of expertise for the public understanding of risk. The Foundation in partnership with NUS will steer the LRFI strategy and plans. This section gives recommendations on how the LRFI can make a distinctive difference. Although the recommendations are specific to the LRFI the Foundation itself may wish to draw on these recommendations in considering any further activities to support the public understanding of risk.

Considering the new and emerging opportunities and challenges, the LRFI and the Foundation could make a valuable contribution by developing a centre of expertise. With such expertise, the LRFI could establish itself not only as a trusted voice in the region but also one with a global presence. The following recommendations fit together as an interconnected set of recommendations, which provide the frame and the focus of the Institute together with the necessary mutually supporting ways of working.

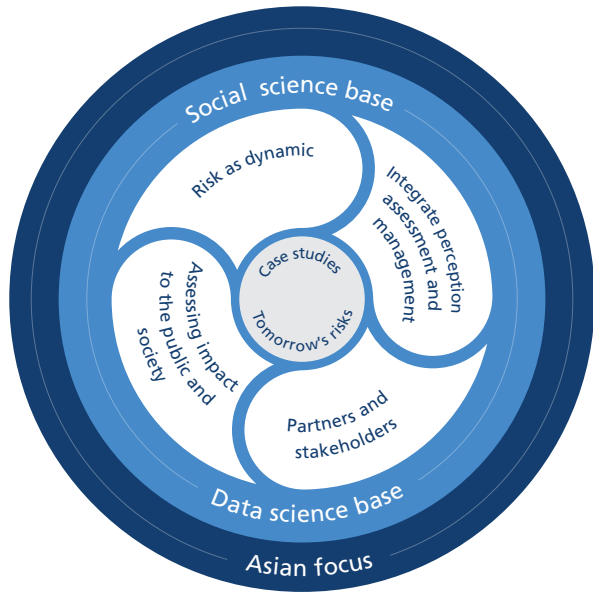
Asian focus

Asia is the most populous continent and home to the fastest growing economies. There is little expertise in natural, social and technological risks, and the science of risk perception in Asia's academic institutions, policy sphere and media. Therefore, there is a significant opportunity to build capacity that will have material impact. In developing an Asian focus, risks and risk concerns that are more important in an Asian context should be

The science of the public understanding of risk is well established. There are significant opportunities to apply this body of work to generate better public understanding and response to risks.



The recommendations fit together as an interconnected set of recommendations, which provide the frame and the focus of the Institute together with the necessary mutually supporting ways of working.



given greater prominence than they have in much of the work on risk perception done to date (for example different health and worker safety concerns, which have less of a regulatory history in Asia).

A focus on Asia means that current insights about the nature and impact of perceived risk be tested and refined in a much broader range of cultural contexts. This could substantially advance the intellectual foundations of our understanding of risk perception and its impacts. The heterogeneity of the region brings real challenges for developing applications. At the same time, it also presents significant opportunities to increase theoretical understanding by systematically exploring how existing insights do and do not apply in Asian settings.

Singapore's geographically central position and connections to the region make it well situated for such a focus. There is also a need to develop public understanding of risk in other parts of the world, especially in Africa. A successful institute in Singapore might act as a model for future centres of study and application of broader insights into the public understanding of risk.

Social science-based, data science-enabled

The social sciences should provide the guiding disciplinary basis, rather than being an afterthought to an otherwise technologically-focused institute. This will distinguish the Institute from other centres and allow it to partner with more technologically-focused centres on risk. It should establish the standard for ensuring that communications about risk are not only grounded in research, but also empirically evaluated. There are lessons to be learnt from the successes in existing centres, in particular the practical application focus of the Winton Centre (see appendix B) and the psychology and social science focus of the Center for Research on Environmental Decisions (CRED) at Columbia University and Carnegie Mellon University's Behavior Decision Policy Working Group.

There are exciting opportunities for data science to help provide new insights and understanding through interrogation of new data sources, including many classes of big data and social media. We therefore see an opportunity for data science to play a critical role in advancing understanding of the public understanding of risk.

Developing understanding through tackling real issues

Working through interdisciplinary and multi-agency case studies

By taking forward a small number of deep case studies, the Institute can both have a real impact on public understanding of important issues, as well as advancing the science of the field, such as worker safety (including maritime safety), climate change, nuclear decommissioning, health/medical risks such as the Zika virus, gene editing and the use of biomedical big data.

The focus on a specific topic will provide an opportunity to engage the different expertise and interests of a range of institutions and intermediaries who are working on, or affected by, this topic. Such multi-stakeholder multi-disciplinary working will be critical to success. The case studies provide an excellent way to bring together risk assessments, risk perception and risk management strategies – all of which will influence outcomes. By working closely together with communicators and public policy institutions, the Institute would be excellently placed to help identify and implement (pilot) interventions targeting risk assessments, risk perception and/or risk management strategies.

Exploring spaces where there is little consensus

The Institute should focus its efforts where there is little public consensus on the importance of the problem or on the proposed solutions. It should also focus in areas where it can have impact due to the expertise it can bring or leverage, and on the willingness of key stakeholders (including government and regulators) to engage. The potential case studies



may be analysed according to the degree to which there is a lack of public consensus on either the problem or solution, how much it relates to personal choices or to public policy choices, and the extent of technical/scientific knowledge about the problem. The Institute should articulate how its proposed interventions relate to these characteristics.

Integrating public dialogue and risk management approaches into the studies

As this review has set out, dialogue with the public and stakeholders must be integral to this work. This will identify and agree with the public the relevant and measurable components of perceived risk, costs and benefits in the case study. Perceived risks and willingness to take risks will be measured on this basis, alongside analytic measures. Opportunities to assess individual risk perception, risk attitudes and actual risk-taking from new data sources should be explored. Given the heterogeneity of the region and known cultural influences on risk perception, the analysis will need to consider nationality, language, type of government, and religion, alongside age and gender. Through the continued study of risk perceptions, attitudes and behaviours after implementation, a greater understanding of the dynamic risk response could be developed.

Potential strategies and policies to manage and mitigate the risk, both individually and (sub) nationally/regionally should be explored. How the strategies interact with risk assessment and risk perception should be considered in designing (pilot) interventions and in the assessment of the intervention.

Developing expertise in tomorrow's risks

Many modern risks are a result of our highly technological societies, be it directly or indirectly. There is limited understanding on how we can deal with the consequences from emerging technologies. In these cases there is limited knowledge of ramifications, growth outpacing understanding and generating new social norms. This is arguably an example where a combination of 'unknown unknowns' is posing a severe challenge to risk management.

The Institute is well placed to look at and understand future risks, particularly from the use of emerging technologies. It should seek to understand public perceptions and the implications of these, in order to become a trustworthy and independent source of advice on such new and emerging risks, such as cybersecurity.

The Institute may also develop collaborations and methodologies specifically to consider how to understand and manage the complex systemic risks that become increasingly important in our interconnected world. This may include how to characterise and improve resiliency towards low probability and even unexpected events.

Risk perception and risk-taking as dynamic

An exciting new opportunity is emerging to appreciate risk more fully as a dynamic subject of study and intervention.

Focus on studying the dynamic process of risk evolution and impact of interventions

The Institute should study how risk perceptions impact action and risk management choices, and their outcomes, and how these in turn influence changes in risk perception. This includes identifying, assessing, and extracting systematic learning from:

- external shocks or interventions, especially those from the Institute
- evolving risk landscape, including the impact of our current choices on this as well as the need for monitoring capabilities to detect emerging risks and the evolving responses to meet new and emerging challenges
- iterative learning processes between public institutions and the public by analysing the effectiveness of public interventions and further refining interventions, and by increasing the awareness of public institutions of the concerns of the public.

Developing new data: new digital sources and more traditional means

Developments in ICT can provide a range of new and innovative data sources and interaction platforms to enable this study of the dynamics. In particular, the panel recommends the Institute explores joint collaborations involving new/social media companies and university-



based departments. The Institute should work with ICT, social science and other experts to map out existing and future potential sources of relevant data.

It should also explore the opportunities and limitations of using internet analytics and social media to continuously monitor risk topics that the public and society are concerned about. This 'risk pulse' could monitor trends and perceptions and seek to understand the reasons why such risks emerge, grow or fade away.

Furthermore, the Institute should seek to work with national governments or supra-national groups to establish regular data collection relevant to risk perception, attitudes and behaviours, as well as opportunities for sharing data on incidents relating to health and safety.



Working at the interface of risk assessment, risk perception and risk management

Improving communication of risk

As set out in this review, understanding risk requires two-way information provision and discussion. It is not just an exercise in improving technical literacy, or 'top-down' information. However, communication of risk can be improved in a number of ways. For example, people need help in overcoming gaps in their understanding, their interest or time in doing so, as well as intuitive biases when faced with risks. The Institute should work in partnership with communication professionals, as well as other relevant professions (for example medical professionals) in creating visualisation and design approaches to help the communication of risk to the general public. Such interventions should be assessed for their impact on risk perception and choices.

The Institute should become a trusted go-to source for independent advice and commentary on everyday risks, where it has suitable expertise. It should use its expertise in risk perception to help inform that advice and help shape public communication. The leadership of the Institute will need to ensure that this reactive work is managed so that sufficient resources remain available from the proactive programme which is described in other parts of the recommendations.

In taking forward its work programme, the Institute should be always conscious of the tension between 'informing not persuading' and 'helping people achieve their objectives', and should develop a clearly articulated approach to this. This includes, for example, setting out the aim of communication aids and visualisations, against which evaluations of risk perception can be made.

The Institute should focus its efforts on equipping others to communicate more effectively and to assist relevant partners in developing a public dialogue. However, there may also be merit in some (low cost) outreach directly to the public, notably through the Institute's own website.

Designing and assessing risk management strategies

The Institute should develop a vision and a work programme that uses knowledge of risk perceptions and the public understanding of risk to inform the choice and design of risk management strategies. Risk management strategies may be personal choices (for example on health), or institutional policies which manage risk directly or indirectly (for example worker safety). Such a work programme will encompass economic, political and psychological tools (for example, incentives, regulation and social norms). This will be especially fruitful when coupled with a dynamic understanding and exploration of risk, and seeking to learn from these interventions.





Integrating understanding of individual and collective behaviours

There are significant opportunities for the Institute in integrating an individual and a group focus. Group identity, norms, relationships and dynamics are important in both shaping individual risk perceptions and actions, as well as reaction to public policy responses, and this is especially true in an Asian context that puts greater emphasis on collectivist values and processes.

Working with and through partners and stakeholders

The Institute will need to work closely with stakeholders in order to improve the public understanding of risk. This has been noted in the preceding recommendations, but is separately highlighted here.

To facilitate a dynamic process of learning from interventions, the Institute will need to actively engage stakeholders such as policy makers and regulators, as well as technical experts and industry to identify suitable case studies. It will need to work with these partners to understand their perspectives and those of the general public. In designing communications and risk management strategies or policies, it will also need to work closely with media and communication professionals, as well as with others who may be communicating to the public (for example doctors) or responsible for decision-making (for example spatial planners). It will need to continue to work closely with all these partners and stakeholders to facilitate the dynamic learning that is recommended here.

The Institute should provide forums and other opportunities for these different stakeholders to better understand each other, and to learn about the science of the public understanding of risk as it relates to themselves.

Identifying and assessing impact

The Institute should draw on best practice in developing its work programme, in particular by articulating how its proposed actions will improve the public understanding of risk. A theory of change should be developed before engaging in specific interventions. It must also ensure that evaluation of its actions and interventions is prioritised, in order to achieve the benefits of the dynamic process of learning set out above. Finally, the Institute should develop metrics of success to help identify the impact of its work.

Appendix A: Further reading

General reading

Blastland, M & Spiegelhalter, DJ. (2014). *The Norm chronicles: stories and numbers about danger and death*. New York, New York: Basic Books.

Beck, U. (1992). *Risk society: towards a new modernity*. London: Sage Publications.

Douglas, M & Wildavsky, AB. (1982). *Risk and culture : an essay on the selection of technical and environmental dangers*. Berkeley: University of California Press.

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Kahneman, D. (2011). *Thinking, fast and slow*. New York: Farrar, Straus and Giroux.

Perrow, C. (1999). *Normal accidents: living with high-risk technologies*. Princeton, NJ: Princeton University Press.

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Taleb, N. (2007). *The Black Swan: The Impact of the Highly Improbable*. New York: Random House and Penguin. 2007.

Thaler, RH & Sunstein, CR. (2009). *Nudge : improving decisions about health, wealth, and happiness*. Rev. and expanded ed. New York: Penguin Books.

Wucker, M. (2016). *The Gray Rhino: How to recognize and act on the obvious dangers we ignore*. New York: St Martins Press.

World Economic Forum Headquarters. (2017). *The Global Risks Report 2017 12th Edition Insight Report*, 41 2744.

For regulators and policy officials

Fischhoff et al (eds) (2015). *Communicating Risks and Benefits: an Evidence-Based Users Guide*. US Food and Drug Administration.

<http://www.fda.gov/AboutFDA/ReportsManualsForms/Reports/ucm268078.htm>

Some illustrations of good communications, useful tools etc.

Naru, F & Cavassini, F. (2016). *Cracking the behavioural insights nut: Behavioural sciences and their application to policy design and delivery*. OECD Report GOV/RPC(2016)21.



NUGENIA. EU Nuclear Public Engagement Toolkit.

<http://s538600174.onlinehome.fr/nugenia/nugenia-eu-nuclear-public-engagement-toolkit>
Comparisons of national public engagement approaches relating to nuclear risks.

NUS School of Public Health. Global Health White Paper Series.
<https://sph.nus.edu.sg/research/public-health-white-papers>.

OECD (2008). Policy Issues in Insurance Financial Management of Large-Scale Catastrophes
Policy Issues in Insurance, OECD Publishing, 2008.

OECD. Risk governance. <http://www.oecd.org/gov/risk/>
Series on risk governance, including surveys and recommendations on government action and communications.

Spiegelhalter, DJ. A visualisation of the information in NHS Breast Cancer Screening leaflet.
<https://understandinguncertainty.org/visualisation-information-nhs-breast-cancer-screening-leaflet>.

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Selected peer-reviewed papers and book chapters

Centeno, MA; Nag, M; Patterson, TS; Shaver, A & Windawi, AJ. (2014). The Emergence of Global Systemic Risk. *Annual Review of Sociology*, 41(1), 65–85.

Finucane, ML; Slovic, P; Mertz, CK; Flynn, J & Satterfield, TA. (2000). Gender, race, and perceived risk: The ‘white male’ effect. *Health, Risk & Society*, 2, 159–172.

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Weber, EU; Siebenmorgen, N & Weber, M. (2005). Communicating asset risk: How name recognition and the format of historic volatility information affect risk perception and investment decisions. *Risk Analysis*, 25, 597-609.

Weber, EU; Blais, A-R & Betz, N. (2002). A domain-specific risk-attitude scale: Measuring risk perceptions and risk behaviors. *Journal of Behavioral Decision Making*, 15, 263-290.

Weber EU & Hsee, CK. (1999). Models and mosaics: Investigating cross-cultural differences in risk perception and risk preference. *Psychonomic Bulletin & Review* 6 611-617.

Weber, EU. (2017). Risk as Feelings and Perception Matters: Psychological contributions on risk, risk taking and risk management. In: Kunreuther, H, Meyer, R & Michel-Kerjan, E. *The Future of Risk and Risk Management*. Philadelphia PA: University of Pennsylvania Press.

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Appendix B: Other related risk centres

Decision Research

Founded in 1976, Decision Research is dedicated to helping individuals and organisations understand and cope with the complex and often risky decisions of modern life. Its research is based on the premise that decisions should be guided by an understanding of how people think about risk and how they value the potential outcomes - good and bad - of their decisions. Information about the institute and its extensive library of publications can be found at www.decisionresearch.org.

Institute of Risk and Uncertainty, University of Liverpool, UK

The Institute is dedicated to helping people and organisations create a safer world, by quantifying, mitigating and managing risk and uncertainty in many fields.

The multi-disciplinary research team includes experts from architecture, engineering, environmental sciences, financial and actuarial mathematics, computer science, electrical engineering and electronics, economics and finance, social sciences and psychology.

The Institute draws on a large range of methodologies, tools and experience to explore the issues of risk and resilience associated with building design, climate analysis, reliability engineering, software reliability and materials science. It also touches on financial modelling, methods to reduce any socio-political harm and critical incident management.

The Institute has many connections with industry as well as a large academic network with other universities and research centres.

Institute for Risk and Reliability, Leibniz University, Germany

The Institute addresses research, educational and industrial needs in engineering and beyond in the combination of advanced uncertainty quantification with most efficient computational models and simulation techniques.

International Institute for Risk and Regulatory Research, UK

The International Institute for Risk and Regulatory Research (I2R3) brings together the University of Manchester and of the UK's Health and Safety Executive (HSE) in seeking to understand failures, leading to injury, ill-health and death, in the workplace. It aims to deliver research, training and learning in national and global forums. The Institute studies the science, psychology and medical impact of technical, human or procedural failures in the workplace. Building on the experience and insights gained from over 40 years investigation of accidents and ill health, the Institute aims to transform the handling of complex risk, delivering a safer, happier workplace.



One of its goals is to extend, collate and mine the UK's HSE database, using the breadth and depth of expertise available through the University and within the Science Directorate of HSE. The Institute aims to deliver:

- world-class education and best practice to those places, sectors and communities that can most benefit in the UK and beyond
- world-class science and engineering, medical and management research that impacts upon productivity and growth to reduce unplanned downtime and minimise risk. The Institute is seeking to work with a network of international partners.

I2R3's work is structured around six key areas: major hazards; population health; human factors; workplace psychology; risk and transformation; data analytics; and education and training. I2R3 aims to establish and maintain a world health and safety database. It will launch the National Centre for Safety Testing that offers the promise of creating a resource for world safety organisations.

Wharton Risk Management and Decision Processes Center, University of Pennsylvania, US

Established in 1985 in the University of Pennsylvania, the Wharton Risk Management and Decision Processes Center is a nexus of people and projects devoted to furthering the practical understanding of how to manage situations of risk involving health, safety and the environment in both the private and public sectors of our society. For over 25 years, the Center has been at the forefront of research into the management of low-probability/high-consequence events. In addition to working on programmes of basic and applied research, Center faculty serve on national and international advisory committees, with partnerships in government, academia, industry, and NGOs.

Building on the disciplines of economics, decision sciences, finance, insurance and marketing, the Center's research programme is focused on descriptive research and prescriptive analyses. Descriptive research focuses on how individuals and organisations interact and make decisions regarding the management of risk. Prescriptive analyses propose ways that individuals and organisations, both private and governmental, can make better decisions regarding risk. The Center supports and undertakes field and experimental studies of risk and uncertainty to better understand the link between descriptive and prescriptive approaches to decision making in coping with technological and natural hazards under various regulatory, environmental and market conditions. Center research investigates the effectiveness of strategies such as incentive systems, insurance, regulation and the communication of risk information.

The Center actively engages multiple viewpoints, including the expertise of top-level representatives from the worlds of insurance, industry, academia, environmental concern, law and government.

Winton Centre for Risk and Evidence Communication, University of Cambridge, UK

The Winton Centre for Risk and Evidence Communication was founded in 2016 through a philanthropic donation. It sits within the Department of Pure Maths and Mathematical Statistics at the University of Cambridge in the UK, but it has significant links to the University's Department of Psychology, and its small team are multidisciplinary and aim to work internationally.

The Centre's focus is on translating research knowledge into the real world. Its work covers many fields - anywhere where people are making important decisions, either for themselves as individuals, or on behalf of others or society (eg policy decision). It concentrates both on helping provide the quantitative evidence on which those decisions can be based in as clear and balanced a way as possible, and on supporting and training people who need to communicate evidence in how to do that effectively. This includes, for example, helping doctors communicate to patients, barristers to a jury, journalists to the public and government advisors to ministers.

All the work that the Centre does is designed to be carefully evaluated for measures of success and to feedback information learned to the academic community.



Appendix C: Other contributors

A draft of this review was made available for public comment and those who responded made a valuable contribution to the review. The following are those contributors who agreed for their names to be published:

Adrian Bull, Director of External Relations, National Nuclear Laboratory

James Catmur, Director

Nicholas Koh, Manager (Strategy), Research Office, National University Health System

Markus Labude, Research Associate, NUS Centre for Biomedical Ethics

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Owen Schaefer, Research Assistant Professor, NUS Centre for Biomedical Ethics

Lutfey Siddiqi, NUS Adjunct Professor & LSE Visiting Professor-in-Practice

Michele Wucker, CEO, Gray Rhino & Company



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