



Communicating Risk

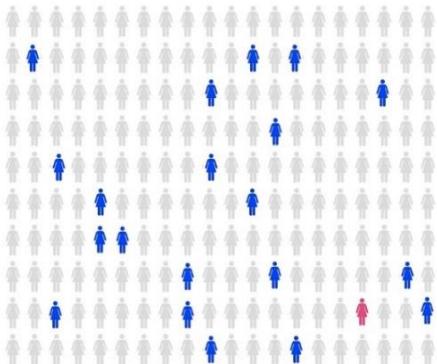


FIGURE 1. RISK OF BREAST CANCER FOR WOMEN IN THEIR 50S AFTER 5 YEARS OF HORMONE REPLACEMENT THERAPY

Risk communication covers a range of issues, from consumer advice on savings, to informing patients about the benefits and harms of screening. How these risks are communicated shapes people's response to them. This POSTnote defines risk and describes the key stakeholders communicating it. It also examines the factors that shape how people perceive and respond to such risks and summarises evidence on effective risk communication strategies.

Background

Virtually all decision making involves some implicit or explicit assessment of risks. Individuals make their own personal risk assessments throughout their daily lives whilst different groups within society are responsible for formal risk assessments, including NGOs, governmental departments and businesses. People's perceptions of risk are often different to the actual risk that a behaviour or hazard entails. Risk communication includes any communication that informs individuals about the existence, nature, form, severity, or acceptability of risks. It can have many aims including:¹

- Increasing knowledge or awareness of a risk, for example potential side effects from taking particular medicines.²
- Encouraging individuals or groups to alter their behaviour in relation to a risk, such as reducing incidences of unprotected sex to lessen levels of sexually transmitted infections.³
- Defusing concerns about a risk during a crisis, for example communicating during an emergency to

Overview

- Risk communication seeks to alter people's beliefs about, or behaviour towards, a risk.
- Poor risk communication can lead to confusion, distrust and potentially fatal outcomes.
- Government and the media provide people with key sources of information about risk. Social media is being used increasingly to communicate information about risk.
- People's perception of risk is shaped by many factors, including the language used to communicate the risk, individual attributes such as their gender, the type of risk and cultural factors.
- Challenging aspects of communicating risk include clarifying how risks are measured and explaining any uncertainties involved.
- People's responses to risk are better when risk is communicated visually, across multiple formats, such as face-to-face and TV communications, and when communication is personalised to them.

ensure appropriate mitigation steps are taken, whilst avoiding unnecessary anxiety.

- Preventing or mitigating disasters such as spreading information to help prepare a population for a disaster, help aid efforts or assist in recovery.⁴

Approaches to risk communication vary depending on the purpose, the intended audience, the timeline and the nature of the risk. For example, different strategies are needed to communicate the risks of drinking alcohol whilst pregnant versus explaining the risk of a potential terrorist attack to the whole population.^{5,6,7} Risk communication in these two cases varies by:

- Purpose: Advisory - focusing on providing information and culture changing, influencing people's behaviour - versus Protective - focusing on providing assurance and building trust and credibility in the actions being taken.⁸
- Intended audience: Specific sub-population group versus whole population.

- Potential audience reaction: Confusion due to incongruence with other advice available versus fear and possible widespread public reaction;
- Timescale: Longer term and ongoing versus immediate.

Box 1. Examples of Good and Bad Risk Communication

Good risk communication enables people to make an informed decision about what to do and how the decision will impact their interests and values. For example, effective risk communication in public health can limit morbidity and mortality, such as those caused by communicable diseases, in addition to minimising impacts on national economies and public health infrastructure.⁹ Poor risk communication on the other hand can lead to mistrust and anger, which magnifies fear and stress and may, in some cases, lead to more serious outcomes.¹⁰ Two examples are provided of good and bad risk communication.

Bad risk communication

The mis-selling of mortgage endowments during the 1980s was a complex, sector-wide problem. Communication issues included inaccurate projections of the expected returns on policies, different interpretations of the risk inherent in the products among consumers and suppliers, and people's 'financial literacy'.¹¹

Good risk communication

Between 1979 and 2010 the number of people killed or seriously injured following drink driving incidents fell from 27 per day to 4. The sustained risk communication effort by the Department for Transport is thought to have a substantial role in this decrease¹². The communication strategy tailored messages to young men, the most likely group to drink and drive.

Communicators of Risk

Many stakeholders communicate risks in an official capacity, including the media, government, non-governmental organisations, businesses as well as individual professionals and practitioners, such as doctors. There are examples of good and bad risk communication for all of these stakeholders (Box 1). Many people get their information from the media and studies suggest that it is a trusted source of information about risk ([POSTnote 559](#)).^{13,14} It is often blamed for sensationalising risk topics,¹⁵ but has also been shown to sometimes report risks accurately or even underrepresent risk.^{16,17} Different agencies have their own guidelines on communicating risk. For example:

- Media. Media guidance on communicating risk is produced by individual sources such as the BBC and other bodies, such as the Science Media Centre.^{18,19}
- Government. Guidance on communicating risk has been produced on different policy issues (including flooding and public health) by a number of different government agencies.^{20,21,22} The Government has published principles that it expects Departments to follow when handling and communicating risk information to the public.²³

Defining Risk

The terms 'hazard', 'risk' and 'uncertainty' are often confused. The UK Health and Safety Executive defines a hazard as a potential source of harm or adverse effect.²⁴ Hazards can affect people, property or the environment.²⁵ Technically, risk is sometimes defined as the likelihood or

chance that a hazard will give rise to harm. There are two aspects to this: the likelihood of the hazard occurring and the severity of harm.²⁶ Flying in a commercial plane is hazardous (big consequences from mechanical failures for example) but not particularly risky (low chance of such failures happening due to the number of precautions in place). In practice, people understand risk subjectively. Assessing risk therefore involves both calculating the realistic probability of exposure to a hazard and the magnitude of the consequences.^{27,93} Risk is often associated with uncertainty.²⁸ Uncertainty can arise from the inherent variability, or incomplete knowledge, of complex systems such as the climate, or of the human body and how it can react to medicines.²⁹ Uncertainty can result from potential inaccuracies in measurements and methods of analysis (for example statistical errors or experimental designs) and the strength or validity of the underlying evidence about the risk.³⁰

Factors Shaping Risk Perception

The way people perceive risks will affect their responses to them.^{31,32} Some risks are taken rationally in the view that benefits outweigh possible negatives (such as taking drugs for medicinal purposes). Other risks exist in the background of life and arise irrespective of whether people choose to take them or not (such as flooding). The perception of risk can differ at an individual or a societal level. For example, a person may be willing to break the speed limit if they are alone but not if they also have their baby in the car. Similarly, a person may think it acceptable to break the speed limit themselves, but society as a whole may not consider it acceptable. Where a person's choice to take risks impacts others, such as speeding while driving, questions arise over personal interest versus the common good. Sometimes, taking such risks is legislated against or deterred by financial and other penalties.

People's perceptions of risk are influenced by many different factors. These factors can be grouped into four categories:

- The presentation of risk.
- Individual attributes.
- The nature of the risk.
- The context in which the risk occurs.

Presentation of Risk

Language

Framing messages about risks positively can significantly encourage risk reduction behaviour.^{33, 34, 35, 36} For example, "exercising helps you lose weight" is a positively framed message whilst "not exercising will cause you to gain weight" is negatively framed.

Probability and Statistics

Choices made about how to convey risk numerically can alter people's perception of that risk. People understand risk differently when it is expressed as probabilities, for example 'a drug has a 5% probability of leading to a particular side effect' compared to when it is presented as actual numbers of people or 'natural frequencies', for example 'out of 20

people like you taking this drug, we'd expect one to have this side effect'. The way that probabilities are expressed can also be significant (Box 2).

Box 2. The Risks of Eating Processed Meat

In November 2015 the World Health Organization's (WHO) International Agency for Research in Cancer (IARC) announced its findings from an expert group evaluation of the carcinogenicity (the extent that substances and exposures can lead to cancer) of the consumption of red meat and processed meat. The evaluation classified processed meat as a Group 1 carcinogen, putting it in the same category as cigarettes and asbestos. The report measured the hazard of processed meat; its potential to be carcinogenic. This finding was presented variously using different measures. A 2014 review found that people perceived risk differently depending on which of these measures was used to communicate the risk (see section 'Presenting risk numerically' below). Examples are provided below:

- Relative risk reductions (**RRRs**) are proportional measures estimating the size of the effect of a treatment compared with other interventions or no treatment at all. The IARC reported its findings using this approach 'eating 50g of processed meat daily is associated with 18% increased risk of getting bowel cancer'³⁷.
- Absolute risk reductions (**ARRs**) are the number of incidences in one group minus the number in another group. Presenting the risk of bowel cancer from processed meat in this format would be 'your chance of experiencing bowel cancer from eating 50g of processed meat each day is 6%'.
- 'Numbers needed to treat' (**NNTs**) is the number of patients that need to be treated in order for one to benefit. Using the example of bowel cancer and processed meat for this approach would be '100 people would need to eat 50g of processed meat every day, for one extra case of bowel cancer to occur'.^{38,39}

Individual Attributes

Perception of risk has been shown to vary depending on individual attributes.

- Gender. Men tend to underestimate the level of risk and have a higher risk appetite compared to women, although this can be mediated by other factors such as age. A number of studies examine the relationship between gender and risk perception. Most rely on self-reported data, although one meta-analysis included observational studies. Many studies focus on health risks but other areas include food safety, terrorism and emergency responses (such as natural disasters).^{40,41,42,43,44,45,46,47,48,49,50,51,52}
- Ethnicity. Risks can be perceived differently by people from different ethnic groups. A number of systematic reviews have been conducted in the area of health but a couple of studies based on self-reporting data have focused on environmental issues. This evidence reports variously that ethnic minority groups tend to underestimate some risks and over-estimate others. For example, one US-based study found that, after controlling for key socioeconomic variables, African Americans and, Latino and Mexican immigrants perceived greater risks from air pollution produced by automobiles than non-Hispanic US-born Caucasian people.⁵³ In contrast, another US study found that Caucasian women who had survived breast and/or ovarian cancer had a higher perception of cancer risk

than African American breast and/or ovarian cancer survivors.^{54,55 56,57,58,59,60,61,62}

- Emotions. Risk communication strategies that appeal to fear can make people perceive themselves as both more susceptible to risk and for such risks to be seen as more harmful.⁶³ Risks that are perceived to be more harmful can shape people's behaviour towards that risk. For example, fear of HIV is associated with reduced likelihood of undergoing HIV testing.⁶⁴
- Biases (see Box 3).

Nature of the risk

- People are more likely to underestimate risks that they consider to be 'natural', such as cheese made of unpasteurized milk than those seen as artificial, for example horsemeat in beef.^{65,66}
- People overestimate risks with which they are unfamiliar and underestimate risks they are familiar with.⁶⁷ For example, people who have worked for a long time with the same machinery may become complacent to risks whilst new workers may be more careful.
- People are more willing to accept risks when they perceive themselves as having some control over them. For example, people bet more money on games of skill than on games of chance, even when these games offer similar probabilities of success.^{68,69}
- People are more fearful of risks when they judge the consequences to be catastrophic and threatening to future generations, such as nuclear accidents.^{70,71}

Box 3. Biases shaping people's perception of risk

- Unrealistic optimism. In general, people tend to be unrealistically optimistic about their own susceptibility to risk.⁷²
- Over- or under-estimation of risk magnitude. People tend to overestimate the likelihood of low probability/high consequence risks, and underestimate the risk of more common threats.^{73,74,75}
- Cognitive dissonance. People may ignore risk information that conflicts with their preconceptions or beliefs.⁷⁶
- Availability heuristic (cognitive shortcut or rule of thumb). People may make judgments about the low probability/high consequence likelihood of an event based on how easily it comes to mind.⁷⁷
- Affect heuristic. People are more likely to judge an event as low risk if they already hold positive feelings towards it.⁷⁸

Context in which risk occurs

- People's perception of risk increases in acute or crisis contexts.^{79,80,81} In general, people tend to be more tolerant of risk when the consequences are in the future.^{82,83}
- People are more willing to accept information on risks from individuals and organisations that they trust.^{84,85} Studies suggest that trusted sources of risk information include family and friends,^{86,87} the media,⁸⁸ experts in particular fields such as medicine.⁸⁹

Challenges to Communicating Risk

Challenges to communicating risk include:

- Communicating how risks are classified or measured.
- Communicating uncertainty around risks.

Communicating How Risks Are Classified

Risk assessment is the formal process for evaluating the likelihood and consequence of a hazardous event. The metrics used to assess risk can have impacts for communication. For example, the International Nuclear and Radiological Event Scale (INES) was used during the 2010 Fukushima meltdown. INES uses a numerical rating to explain the level of risk arising from events associated with sources of ionizing radiation. The scale ranks nuclear and radiological accidents and incidents by severity from one to seven. Levels 1–3 are “incidents” and Levels 4–7 “accidents”. Level 7 is the highest level on the INES and describes an accident serious enough to require a country to implement countermeasures to protect the public from potential health and environmental effects of radiation. The lack of granularity in the scale meant that Fukushima was placed at the same level on the scale as Chernobyl, even though, the release of radioactive material at Chernobyl was almost ten times greater.^{90,91} Repeated clarifications in the media were necessary to communicate that although the two were placed at the same level on the scale, the incidences were not as damaging as each other.⁹²

Communicating Uncertainty Around Risks

Explaining the uncertainties of potential risks to non-specialists is a major challenge.⁹³ Poor communication of uncertainty can result in unnecessary hesitation or unwarranted confidence when making decisions.⁹⁴ A number of approaches can be used to support systematic consideration of uncertainties ([POSTnote 220](#)).

Effective Risk Communication

Effective communication builds awareness of risk and informs people about actions they could take to reduce their risk (Box 1). The evidence on effective risk communication identifies five key themes.

Presenting risk numerically

Existing evidence highlights the need for communicators of risk to consider how people interpret statistics and numerical statements of risk.^{95,96} A 2014 systematic review examined the effectiveness of different types of numerical presentations of data. For example, the study found that patients perceived risk differences more accurately when it was presented as ARR^s than RRR^s (Box 2). However, RRR^s were found to be more influential on patients’ deciding to initiate therapy. NNT^s were found to make understanding probability more difficult for patients than ARR^s and RRR^s.⁹⁷

Openness in communication

Existing evidence emphasises that communication about risk should be open and make as much information as possible available to the public.^{98,99,100} A 2010 systematic review found that one-time communications were effective at increasing knowledge of environmental health risks. However, the impact diminished over time suggesting that regular communication is important.¹⁰¹

Real-time information flows facilitated by social media have been shown to be an effective method of communicating information about risk, for example in the 2008 Mumbai terror attacks.¹⁰² During the 2009 Swine Flu pandemic, the Centre for Disease Control (CDC) encouraged users to post their concerns about the virus on the CDC Facebook page. This allowed the CDC to refute some misconceptions, including the false claim that flu vaccines caused Swine Flu.^{103,104} The role of social media in communicating risk is likely to grow as the proportion of UK adults consuming news in this way increases ([POSTnote 559](#)).

Tailoring to the needs of the target audience

The need to tailor communication to the needs of the target audience is highlighted as important in the wider literature because no single approach works for all populations or for all environmental risk situations.^{105,106} Risk communicators are advised to think about “the public” as comprising lots of different groups with differing understandings and appetites for risk information.^{107,108}

Communication across different mediums

Multi-dimensional approaches make use of different types, and mediums, of communication. For example, a public service campaign that covers radio, television, Internet and print media is more effective than one that relies on a single media source.¹⁰⁹

Using visualisations

Visualisations such as graphs of numerical expressions of probability including bar and line charts and icons (graphical representations consisting of stick figures, faces, circles, or other icons symbolising individuals who are affected by some risk).¹¹⁰ For example, the image on page 1 shows the risk of getting cancer for women aged in their 50s who take Hormone Replacement Therapy (HRT) for five years. Based on estimates from Cancer Research UK about the baseline lifetime risk of getting breast cancer, we would expect around 20 women of 200 who take HRT to eventually develop breast cancer. This risk increases to 21 women of 200 who take HRT for 5 years.¹¹¹ Two reviews found that transparent and well-designed visual aids robustly improved risk understanding in diverse audiences and led to improvements in attitudes, trust, and healthy behaviours.¹¹² Visual aids were found to be particularly beneficial for vulnerable people.¹¹³

Endnotes

- 1 World Health Organisation (2001) [Water Quality: Guidelines, Standards and Health](#), Chapter 14
- 2 Brewer N (2009) Communicating Risks and Benefits: An Evidence-Based User's Guide, Chapter 2
- 3 Public Health England (2017) [Sexually transmitted infections and chlamydia screening in England, 2016](#). Health Protection Report, Volume 11, Number 20.
- 4 Bradley D, McFarland M, Clarke M (2014) The Effectiveness of Disaster Risk Communication: A Systematic Review of Intervention Studies, PLOS Current Disasters 1, DOI:10.1371/currents.dis.349062e0db1048bb9fc3a3fa67d8a4f8,
- 5 Mamluk L, Edwards H, Savović J, Leach V, Jones T, Moore T, Ijaz S, Lewis S, Donovan J, Lawlor D, Davey Smith G, Fraser A, Zuccolo L (2016) [Low alcohol consumption and pregnancy and childhood outcomes: time to change guidelines indicating apparently 'safe' levels of alcohol during pregnancy? A systematic review and meta-analyses](#) BMJ Open. 7:e015410. DOI: 10.1136/bmjopen-2016-015410
- 6 Freedman L (2005) The politics of warning: Terrorism and risk communication, Intelligence and National Security, 20:3, 379-418, DOI: 10.1080/02684520500281502
- 7 Fischhoff B (2011) [Communicating about the risks of terrorism \(or anything else\)](#). American Psychologist. 66(6): 520-531. DOI: 10.1037/a0024570
- 8 Cabinet Office (2011) [Communicating Risk Guidance](#)
- 9 Infant J, Sixsmith J, Barry M, Núñez-Córdoba J, Oroviogoicoechea-Ortega C, Guillén-Grima F. (2013) [A literature review on effective risk communication for the prevention and control of communicable diseases in Europe](#). Stockholm: ECDC
- 10 WHO (2016) [1986-2016: Chernobyl at 30. An update](#)
- 11 Lunt P, Livingstone S & Kelay T (2006) [Risk and regulation in financial services and communications](#). Social contexts and responses to risk network (SCARR). Working paper 2005-06. University of Kent, Canterbury
- 12 Bullmore J, Watkins S, Burnett L. ["Department of Transport: how thirty years of drink drive communications saved almost 2,000 lives"](#)
- 13 Fitzpatrick-Lewis D, Yost J, Ciliska D & Krishnaratne S (2010) Communication about environmental health risks: A systematic review. Environmental health. 9:67. DOI: 10.1186/1476-069X-9-67
- 14 Higgins O, Sixsmith J, Barry M, Domegan C (2011) A literature review on health information seeking behaviour on the web: a health consumer and health professional perspective. Stockholm: ECDC
- 15 Klemm C, Das E & Hartmann T (2014) Swine flu and hype: A systematic review of media dramatization of the H1N1 influenza pandemic. Journal of Risk Research. 19(1): 1-20, DOI: 10.1080/13669877.2014.923029
- 16 Ropeik D (2012). The Perception Gap: Recognizing and Managing the Risks that Arise When we Get Risk Wrong', Food and Chemical Toxicology, 50: 1222–5.
- 17 Ashe, T (2013) How the Media Report Scientific Risk and Uncertainty: A Review of the Literature, Reuters Institute for the Study of Journalism
- 18 BBC (2005) [Editorial Policy. Guidance Note: Reporting Risk](#). Accessed 27 September 2017
- 19 Science Media Centre (2012) [10 best practice guidelines for reporting science and health stories](#). Accessed 27 September 2017
- 20 Flood and Coastal Erosion Risk Management R&D Programme, "Public dialogues on flood risk communication"
- 21 Department of Health (1998) ["Communicating About Risks to Public Health: Pointers to Good Practice"](#)
- 22 Government Office for Science (2012) ["Blackett review of high impact low probability risks"](#)
- 23 Cabinet Office (2011) [Communicating risk guidance](#).
- 24 Health and Safety Executive (2001) [Reducing risks, protecting people](#). HSE's decision-making process.
- 25 Canadian Centre for Occupational Health and Safety (2017) [Hazard and Risk](#)
- 26 Edwards A & Elwyn G (2001) Understanding risk and lessons for clinical risk communication about treatment preferences. Quality in Health Care 10 (Suppl 1): i9-i13
- 27 Renn O (1998) Three decades of risk research: accomplishments and new challenges, Journal of Risk Research, 1:1, 49-71 DOI: 10.1080/136698798377321
- 28 Cabinet Office (2011) [Communicating Risk Guidance](#)
- 29 Politi M, Han P, Col N (2007) Communicating the uncertainty of harms and benefits of medical interventions. Medical Decision Making 27(5): 681-695. <https://doi.org/10.1177/0272989X07307270>
- 30 Nath C (2012) [How to tell policymakers about scientific uncertainty](#)
- 31 Vernon S (1999) Risk Perception and Risk Communication for Cancer Screening Behaviors: a Review J Natl Cancer Inst Monogr 25 (25): 101-119. DOI: 10.1093/oxfordjournals.jncimonographs.a024184
- 32 Brewer N, Chapman G, Gibbons F, Gerrard M, McCaul K, Weinstein N (2007) Meta-analysis of the relationship between risk perception and health behavior:

- The example of vaccination. *Health Psychology*, 26(2), 136-145. DOI: 10.1037/0278-6133.26.2.136
- 33 Gallagher K, Updegraff J (2012) Health Message Framing Effects on Attitudes, Intentions, and Behavior: A Meta-analytic Review, *Annals of Behavioural Medicine* 43 101-116, DOI 10.1007/s12160-011-9308-7
- 34 Tversky A & Kahneman D (1981) The framing of decisions and the psychology of choice. *Science* 211(4481):453-8 DOI: 10.1126/science.7455683
- 35 Gallagher KM, Updegraff JA (2012) Health Message Framing Effects on Attitudes, Intentions, and Behavior: A Meta-analytic Review, *Annals of Behavioural Medicine* 43 101-116, DOI 10.1007/s12160-011-9308-7
- 36 Tversky & Kahneman (1981) The framing of decisions and the psychology of choice. *Science* 211(4481):453-8 DOI: 10.1126/science.7455683
- 37 Bouvard V, Loomis D, Guyton K, Grosse Y, El Ghissassi F, Benbrahim-Tallaa L, Guha N, Mattock H, Straif K (2015) Carcinogenicity of consumption of red and processed meat. *The Lancet*. 16(16): 1599-1600. [https://doi.org/10.1016/S1470-2045\(15\)00444-1](https://doi.org/10.1016/S1470-2045(15)00444-1)
- 38 Spiegelhalter D & Pearson M (2009) [Understanding uncertainty: 2945 ways of spinning risk](#). [Accessed 26 September 2017]
- 39 Ahmed H, Naik G, Willoughby H & Edwards A (2012) Communicating Risk, *BMJ* 344: e3996 DOI: <https://doi.org/10.1136/bmj.e3996>
- 40 Kinateder M, Kuligowski E, Reneke P, Peacock R (2014) [A review of risk perception in building fire evacuation](#). National Institute of Standards and Technology, US Department of Commerce
- 41 Finucane M, Slovic P, Mertz C, Flynn J, Satterfield T (2000) Gender, race, and perceived risk: The 'white male' effect, *Health Risk and Society* 2(2) DOI: 10.1080/713670162
- 42 Spurrier M & Blaszczynski A (2014) Risk perception in gambling: A systematic review. *Journal of Gambling Studies*. 30(2):253-76. DOI: 10.1007/s10899-013-9371-z.
- 43 Harris C, Jenkins M & Glaser D (2006) Gender differences in risk assessment: Why do women take fewer risks than men? *Judgement and Decision Making*. 1(1): 48-63
- 44 Byrnes J, Miller D & Schafer W (1999) Gender differences in risk taking: A meta-analysis. *Psychological Bulletin*. 125(3): 367-383.
- 45 Weber E, Blais A & Betz N (2002) A domain-specific risk-attitude scale: Measuring risk perceptions and risk behaviors. *Journal of Behavioral Decision Making*. 15(4): 263-290
- 46 Bieberstein A. (2014) Systematic Literature Review on Gender and Food Risk Perception. In: An Investigation of Women's and Men's Perceptions and Meanings Associated with Food Risks. Springer VS, Wiesbaden
- 47 Liu T, Xu Y, Zhang Y, Yan Q, Song X, Xie H, Luo Y, Rutherford S, Chu C, Lin H & Ma W (2013) [Associations between risk perception, spontaneous adaptation behavior to heat waves and heatstroke in Guangdong province, China](#). *BMC Public Health*. 2(13): 913 DOI: 10.1186/1471-2458-13-913.
- 48 Lemyre L, Lee J, Mercier P, Bouchard L & Krewski D (2006) The structure of Canadians' health risk perceptions: Environmental, therapeutic and social health risks. *Health, Risk & Society*. 8(2): 185-195
- 49 Lerner J, Gonzalez R, Small D & Fischhoff B (2003) Effects of fear and anger on perceived risks of terrorism: a national field experiment. *Psychological Science*. 14(2): 144-150
- 50 Bourque L, Regan R, Kelley M, Wood M, Kano M & Milet D (2012) An examination of the effect of perceived risk on preparedness behaviour. *Environment and Behaviour*. 45(5): 615-649
- 51 Watson J & Newby R, (2005) Biological sex, stereotypical sex-roles, and SME owner characteristics. *International Journal of Entrepreneurial Behavior & Research*. 11(2): 129-143 <https://doi.org/10.1108/13552550510590545>
- 52 Linnenbringer E, Roberts J, Hiraki S, Cupples L & Green R (2010) "I know what you told me, but this is what I think:" Perceived risk of Alzheimer disease among individuals who accurately recall their genetics-based risk estimate. *Genetics in Medicine* (2010) 12, 219–227; DOI:10.1097/GIM.0b013e3181cef9e1
- 53 Macias T (2016) Environmental risk perception among race and ethnic groups in the United States. *Ethnicities*. 16(1): 111-129. DOI: <https://doi.org/10.1177/1468796815575382>
- 54 Macias T (2016) Environmental risk perception among race and ethnic groups in the United States. *Ethnicities*. 16(1): 111-129. DOI: <https://doi.org/10.1177/1468796815575382>
- 55 Chakraborty J, Collins T, Grineski S & Maldonado A (2017) Racial differences in perceptions of air pollution health risk: Does environmental exposure matter? *International journal of environmental research and public health*. 14(2). DOI:10.3390/ijerph14020116
- 56 Rouyard T, Kent S, Baskerville R, Leal J & Gray A (2016) Perceptions of risks for diabetes-related complications in Type 2 diabetes populations: a systematic review. *Diabetic Medicine*. DOI: 10.1111/dm.13285
- 57 Hann K, Freeman M, Fraser L, Waller J, Sanderson S, Rahman B, Side L, Gessler S & Lanceley A (2017) [Awareness, knowledge, perceptions, and attitudes towards genetic testing for cancer risk among ethnic minority groups: a systematic review](#). *BMC Public Health*. 17: 503. <https://doi.org/10.1186/s12889-017-4375-8>
- 58 Rosen D (2016) [The prevalence and determinants of cardiovascular disease risk perception: A systematic review](#). King's College London
- 59 Shavers V, Underwood W & Moser R (2009) Race/ethnicity, risk perception, and receipt of prostate-specific antigen testing. *Journal of the National Medical Association*. 101(7): 698-704
- 60 Tilburt J, James K, Sinicrope P, Eton D, Costello B, Carey J, Lane M, Ehlers S, Erwin P, Nowakowski K & Murad M (2011) Factors influencing cancer risk perception in high risk populations: A systematic review. *Hereditary Cancer in Clinical Practice*. 9:2. doi: 10.1186/1897-4287-9-2
- 61 Forster A, Rockliffe L, Chorley A, Marlow L, Bedford H, Smith S & Waller J (2017) [Ethnicity-specific factors influencing childhood immunisation decisions among Black and Asian Minority Ethnic groups in the UK: a systematic review of qualitative research](#). *Journal of Epidemiology and Community Health*. 71:544-549.
- 62 Vaughan E & Nordenstam B (1991) The perception of environmental risks among ethnically diverse groups. *Journal of cross-cultural psychology*. 22(1): 29-60. DOI: 10.1177/00222191221005
- 63 Witte K & Allen M (2000) A meta-analysis of fear appeals: Implications for effective public health campaigns. *Health Education and Behaviour*. 27(5): 591-615. DOI: 10.1177/109019810002700506
- 64 Evangelisti M, Pady K & Wroe A (2016) [Which psychological factors are related to HIV testing? A quantitative systematic review of global studies](#). *AIDS and Behaviour* 20(4): 880-918
- 65 Nordgren L, Van der Pligt J, Van Harreveld F (2007) Unpacking perceived control in risk perception: The mediating role of anticipated regret. *Journal of Behavioral Decision Making*, 20, 533-544. DOI: 10.1002/bdm.565
- 66 Frewer L, van der Lans I, Fischer A, Reinders M, Menozzi D, Zhang X, van den Berg I & Zimmermann K (2013) Public Perceptions of Agri-food Applications of Genetic Modification – A Systematic Review and Meta-analysis. *Trends in Food Science & Technology* 30 (2): 142–152. DOI:10.1016/j.tifs.2013.01.003.
- 67 Weyman A & Kelly C, Sreenivasan B (1999). Report on the proceedings of the Health Directorate Workshop on Risk Perception and Risk Communication – Gatwick, January. *Health and Safety Laboratory Report*. EWP/99/20.
- 68 Nordgren L, Van der Pligt J, Van Harreveld F (2007) Unpacking perceived control in risk perception: The mediating role of anticipated regret. *Journal of Behavioral Decision Making*, 20, 533–544. DOI: 10.1002/bdm.565
- 69 Spurrier M, Blaszczynski A (2014) Risk perception in gambling: A systematic review. *Journal of Gambling Studies*. 30(2): 253-276
- 70 Slovic P (1987) Perception of risk. *Science* 236(4799): 280-285
- 71 Slovic (2010) The psychology of risk. *Saúde e Sociedade*. 19(4). <http://dx.doi.org/10.1590/S0104-12902010000400002>
- 72 Keyworth C (2015) [Risk communication and lifestyle behaviour change in people with psoriasis](#). Thesis submitted to University of Manchester, Faculty of Medical and Human Sciences.
- 73 Lichtenstein S, Slovic P, Fischhoff B, Layman M, Combs B (1979), Judged frequency of lethal events., *Journal of Experimental Psychology: Human Learning and Memory*, Vol 4(6), 551-578. DOI: 10.1037/0278-7393.4.6.551
- 74 Hertwig R, Pachur T, Kurzenhäuser S (2005) Judgments of risk frequencies: tests of possible cognitive mechanisms. *J Exp Psychol Learn Mem Cogn*, 31(4):621-42. DOI: 10.1037/0278-7393.31.4.621
- 75 Hertwig R, Pachur T, Kurzenhäuser S (2005) Judgments of risk frequencies: tests of possible cognitive mechanisms. *J Exp Psychol Learn Mem Cogn*, 31(4):621-42. DOI: 10.1037/0278-7393.31.4.621
- 76 Gaspar R, Luís S, Seibt B, Lima M-L, Marcu A, Rutsaert P, Fletcher D, Verbeke W & Barnett J (2016) Consumers' avoidance of information on red meat risks: information exposure effects on attitudes and perceived knowledge, *Journal of Risk Research*. 19(4): 533-549. DOI: 10.1080/13669877.2014.1003318
- 77 Tversky A & Kahneman D (1974) [Judgement under uncertainty: Heuristics and biases](#). *Science*, New Series. 185(4157): 1124-1131
- 78 Finucane M, Alhakami A, Slovic P & Johnson S (2000), The affect heuristic in judgments of risks and benefits, *Journal of Behavioral Decision Making* 13(1):1-17. DOI: 10.1002/(SICI)1099-0771(200001/03)13:1<1::AID-BDM333>3.0.CO;2-S
- 79 Glik D (2007) Risk Communication for Public Health Emergencies. *Annual Review of Public Health*, 28, 33-54. DOI 10.1146/annurev.publhealth.28.021406.144123
- 80 Pidgeon N, Kasperson R & Slovic P Eds (2003) The social amplification of risk. Cambridge, Cambridge University Press.
- 81 Bradley D, McFarland M, Clarke M (2014) The Effectiveness of Disaster Risk Communication: A Systematic Review of Intervention Studies. *PLOS Currents Disasters*. Aug 22. Edition 1. DOI: 10.1371/currents.dis.349062e0db1048bb9fc3a3fa67d8a4f8.
- 82 Coble K, Lusk, J (2010) At the nexus of risk and time preferences: An experimental investigation, *Journal of Risk and Uncertainty* 41(1) 67 DOI: 10.1007/s11166-010-9096-7

-
- 83 Epper, T & Fehr-Duda, H (2012) The Missing Link: Unifying Risk Taking and Time Discounting. University of Zurich Department of Economics Working Paper 96
- 84 Poortinga W & Pidgeon N (2003), Exploring the Dimensionality of Trust in Risk Regulation, *Risk Analysis*, 23(5):961-972. DOI: 10.1111/1539-6924.00373
- 85 Slovic (1993), Perceived Risk, Trust, and Democracy, *Risk Analysis* 13(6):675-682 DOI: 10.1111/j.1539-6924.1993.tb01329.x
- 86 Peretti-Watel P, Seror V, Verger P, Guignard R, Legleye S & Beck F (2014) Smokers' risk perception, socioeconomic status and source of information on cancer. *Addictive Behaviours*. 39(9): 1304-10. DOI: 10.1016/j.addbeh.2014.04.016.
- 87 Forster A, Rockliffe L, Chorley A, Marlow L, Bedord H, Smith S & Waller J (2016) A qualitative systematic review of factors influencing parents' vaccination decision-making in the United Kingdom. *SSM-Population Health* 2. 603-612
- 88 Fitzpatrick-Lewis D, Yost J, Ciliska D & Krishnaratne S (2010) Communication about environmental health risks: A systematic review. *Environmental health*. 9:67. DOI: 10.1186/1476-069X-9-67
- 89 National Academies of Sciences, Engineering, and Medicine (2016) Food Literacy: How Do Communications and Marketing Impact Consumer Knowledge, Skills, and Behavior? Workshop Summary. Washington, DC: The National Academies Press. <https://doi.org/10.17226/21897>
- 90 International Atomic Energy Agency (2009) The International Nuclear and Radiological Event Scale: User's Manual, p17
- 91 House of Commons Science and Technology Committee (2012) "Devil's bargain? Energy risks and the public"
- 92 Spiegelhalter D, (2011) "A disastrous piece of risk communication?" Understanding Uncertainty blog, understandinguncertainty.org
- 93 Pidgeon N & Fischhoff B (2011) The role of social and decision sciences in communicating uncertain climate risks. *Nature Climate Change* 1, 35–41 (2011) DOI:10.1038/nclimate1080
- 94 Institute of Medicine. (2014). Characterizing and Communicating Uncertainty in the Assessment of Benefits and Risks of Pharmaceutical Products: Workshop Summary. Washington, DC: The National Academies Press. DOI: 10.17226/18870.
- 95 Frewer L, Fischer A, Brennan M, Bánáti D, Lion R, Meertens R, Rowe G, Siegrist M, Verbeke W & Vereijken C (2016) Risk/benefit communication about food – A systematic review of the literature. *Critical reviews in food science and nutrition*. 56: 17281745. DOI: 10.1080/10408398.2013.801337
- 96 Trevena L, Zikmund-Fisher B, Edwards A, Gaissmaier W, Galesic M, Han P, King J, Lawson M, Linder S, Lipkus I, Ozanne E, Peters E, Timmermans D & Woloshin S (2013) Presenting quantitative information about decision outcomes: a risk communication primer for patient decision aid developers. *BMC Medical Informatics and Decision Making*. 13(Suppl 2): S7. <https://doi.org/10.1186/1472-6947-13-S2-S7>
- 97 Zipkin D, Umscheid C, Keating N, Allen E, Aung K, Beyth R, Kaatz S, Mann D, Sussman J, Korenstein D, Schardt C, Nagi A, Sloane R & Feldstein D (2014) Evidence-based risk communication. A systematic review. *Annals of Internal Medicine*. 161:270-280. doi:10.7326/M14-0295
- 98 Gaspar R, Luís S, Seibt B, Lima M-L, Marcu A, Rutsaert P, Fletcher D, Verbeke W & Barnett J (2016) Consumers' avoidance of information on red meat risks: information exposure effects on attitudes and perceived knowledge, *Journal of Risk Research*. 19(4): 533-549. DOI: 10.1080/13669877.2014.1003318
- 99 Cikalo M, Fitzgerald A, Brown S, Edwards M & Glanville J (2014) "Overview of Systematic Reviews Exploring Complex Risk Communication" York, University of York
- 100 Reilly, P. & Atanasova, D. (2016) A report on the media and information flows during crisis situations, EU FP7 CascEff Project Deliverable 3.4, European Commission FP7.
- 101 Fitzpatrick-Lewis D, Yost J, Ciliska D & Krishnaratne S (2010). Communication about environmental health risks: A systematic review. *Environmental Health* 9(67). DOI: 10.1186/1476-069X-9-67
- 102 Veil S, Buehner T, Palenchar M, (2011) A Work-In-Process Literature Review: Incorporating Social Media in Risk and Crisis Communication, *Journal of Contingencies and Crisis Management* 19(2) 110-122 DOI: 10.1111/j.1468-5973.2011.00639.x
- 103 Reynolds B (2010) Building trust through Social Media: CDC's experience during the H1N1 influenza response
- 104 US Centers for Disease Control and Prevention (2014), "Crisis Emergency and Risk Communication" p1275
- 105 Edwards A, Ahmed N, Elwyn G, Pickles T, Hood K & Playle R (2013) Personalised risk communication for informed decision making about taking screening tests. *Cochrane Database of Systematic Reviews*. 2(CD001865). DOI: 10.1002/14651858.CD001865.pub3.
- 106 National Institute for Health and Care Excellence (2014), "Overview of Systematic Reviews Exploring Complex Risk Communication"
- 107 HM Government (2016) "National Flood Resilience Review" Annex 6
- 108 Government Office for Science (2009) "A Practical Guide to Public Risk Communication – The 5 Essentials of Good Practise"
- 109 Fitzpatrick-Lewis D, Yost J, Ciliska D & Krishnaratne S (2010) Communication about environmental health risks: A systematic review. *Environmental Health*. 9(67). doi:10.1186/1476-069X-9-67
- 110 Galesic M, Garcia-Retamero R & Gigerenzer G (2009). Using icon arrays to communicate medical risks: Overcoming low numeracy. *Health Psychology* 28(2): 210-216
- 111 Spiegelhalter D (2015) HRT, breast cancer, and the framing of risks. Understanding Uncertainty [blog]. 14 November. Accessed 13 November 2017
- 112 Zipkin D, Umscheid C, Keating N, Allen E, Aung K, Beyth R, Kaatz S, Mann D, Sussman J, Korenstein D, Schardt C, Nagi A, Sloane R & Feldstein D (2014) Evidence-based risk communication: a systematic review. *Annals of Internal Medicine* 161:270–280
- 113 Garcia-Retamero R & Cokely E (2017) Designing visual aids that promote risk literacy: A systematic review of health research and evidence-based design heuristics. *Human Factors*. 59(4): 582-627