The importance of trustworthy sources of scientific information in risk communication with the public

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ABSTRACT

In the event of a nuclear accident or radiological emergency, effective communication with the public on radiation risks is important in order to contain and rein in damage to physical and mental health, and social and economic consequences. The purpose of this paper is to summarize features of trustworthy sources of scientific information, and to convey their importance in radiation risk communication by recalling other aspects influencing the effectiveness of that communication. This will draw on key references in the literature, augmented with some experience and insight gleaned from a professional career of more than 35 years at the national and international level, including contributing to the International Atomic Energy Agency’s (IAEA) work on the consequences of the Chernobyl accident (1990–1995), heading its incident and emergency centre (1996–2005), and as the secretary (2005–2018) of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), which conducts scientific reviews on the levels and effects of radiation exposure. The paper highlights the necessity of sound science and trustworthy sources, and recapitulates the main elements needed both to ensure solid conclusions on radiation epidemiology and to foster trust. The paper concludes that, while sound science and trustworthy sources are necessary, they are in themselves to a greater or lesser degree insufficient to ensure fully effective risk communication. Some of the major problems in communicating this science are highlighted to help others charged with preparing for and conducting this onerous task in the future.

INTRODUCTION

Radiological emergencies are relatively uncommon, and nuclear accidents with serious consequences are fortunately even more rare. Based on reviews of lessons from such events around the world over the past several decades, including those from the 2011 accident at the Fukushima Daiichi nuclear power station, 13 international bodies have been able to jointly develop and co-sponsor international safety standards for preparedness and response for a nuclear or radiological emergency [1]. These standards set out goals of emergency response, among them, ‘To reduce the risk of stochastic effects’, a goal directly related to public health. However, we should recall that the World Health Organization’s definition of health [2] is ‘not merely the absence of disease or infirmity but a state of complete physical, mental and social well-being’, and that, following the 1986 accident at the Chernobyl nuclear power plant in the former Soviet Union, there were significant psychological health disorders among the population affected, such as anxiety, depression and various psychosomatic disorders associated with mental distress. The psychological effects of the accident were recognized to have resulted from the lack of public information (particularly immediately after the accident), the stress and trauma of relocation, the breaking of social ties and the fear that any radiation exposure was damaging and could damage people’s health and their children’s health in the future. It was understandable that people who had not been told the truth for several years after the accident continued to be sceptical of official statements and so believed that illnesses of all kinds that seemed more prevalent must have been due to radiation exposure. The distress caused by this misperception of radiation risks had been extremely harmful to people. The situation had been further complicated in the years after the accident by incomplete and inaccurate public information on the accident’s consequences and on measures for their alleviation, which had led to a worsening in the quality of life and of public health and to unfavourable effects on social activity. It was concluded that the symptoms such as anxiety associated with mental stress may have been among the major legacies of the accident [3].

Accordingly, it was appropriate that the international standards on emergency preparedness and response also set out other relevant goals of emergency response, namely (i) to mitigate, to the extent practicable, non-radiological consequences; (ii) to prepare, to the extent practicable, for the resumption of normal social and economic activity; and, specifically, (iii) to keep the public informed and to maintain public trust.
It is thus generally recognized that effective public communication crucially affects the outcome and consequences of a radiological emergency, in terms of physical and mental health, and social and economic impact. There are many issues on which the public would require accurate information, but significant elements of communication probably relate to the magnitude and nature of radiation risks (highlighted herein), and the efficacy of any countermeasures. These elements are amenable to scientific analysis based on facts and evidence, in contrast to elements related to valued judgements on, for example, ethical issues and policy making.

At the time of the 1986 Chernobyl accident, the transmission and sharing of relevant scientific information around the world was much more limited as seen from the perspective of today. Following the advent of the internet and the subsequent dramatic increase in sharing of information globally, by the time of the Fukushima Daiichi nuclear power station accident, there seemed to be almost the opposite problem, namely the circulation of too much information of varying quality, including much that was false, and associated commentaries and opinions from non-experts and lay people.

There are many examples of bad science that have gained unwarranted traction in popular culture through mainstream media poorly reporting on health and science issues [4], e.g. the risks of side effects from vaccinations, fake cancer cures and homeopathy. In the ongoing COVID-19 pandemic, there were even theories widely circulating about mobile telephone masts being the cause, though there have been some movements lately of the larger social media platforms changing their policy to rein in the sharing of false information in this regard. Controversy over the risks of these various hazards can lead to increasing concern and anxiety among the general population, and even actions that, while certainly having social and economic costs, can actually increase their overall risk of health effects. In open societies, reducing such controversy requires drilling down to the basic scientific evidence and its soundness, and exposing the noise that has been introduced by misinterpretation, misunderstanding and miscommunication.

SOUND SCIENCE IS NECESSARY TO ENSURE EFFECTIVE RISK COMMUNICATION

It is evident from its very nature that sound science is associated with establishing the truth about the natural world, using observations and other evidence, and that that truth is unchanging, even though the scientific assessment of that truth is incomplete and more can be revealed with new evidence. This contrasts with public and non-expert opinion that may be swayed by non-scientific factors that vary significantly with time, though which can be pressured to change as more incontrovertible evidence becomes available. Thus, if the goals of emergency response are to be addressed, sound science must be an essential component of effective risk communication.

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) is a committee comprising scientists from 27 designated Member States whose function is to assess the levels and effects of exposure to radiation. In operation since 1957, it has established a distinguished reputation for high-quality and independent scientific reviews of the relevant studies. Nevertheless, because of the attention brought to its work by the accident at the Fukushima Daiichi nuclear power station, and because its reports would probably be relevant to communicating radiation risks in Japan and elsewhere, the Committee decided to codify some of the existing practices used to conduct reviews of literature studies and, based on best practice and analysis, to enhance those practices where appropriate. The principles and criteria for ensuring the quality of the Committee’s reviews of epidemiological studies have since been published [5].

The key elements, as applied to individual studies of radiation epidemiology, include:

- Definition of the study population. Study populations must be clearly defined with regard to age, sex, period of observation, exposure and other characteristics relevant for the study
- Sound exposure assessment. While the absorbed dose (equivalent dose and effective dose are constructs for radiation protection purposes, and are not suitable for this purpose) to the relevant organ or tissue of everyone in the study is considered the gold standard as an exposure indicator, there are numerous constraints to its precise estimation. Scrutiny of the quality of experimental and observational data, and the methodology for exposure assessment and its application, is critical.
- Clear outcome definition. Explicit diagnostic criteria and coding with international standards must be applied for the disease endpoints under study, and, for example, distinguishing the underlying cause of death from immediate or contributory causes.
- Avoidance of bias. Bias is any process at any stage of study design and conduct that tends to produce results or conclusions that differ systematically from the true exposure–disease association. The main categories of bias are selection bias, which relates to how the actual study group is selected and may differ from the intended target group, and information bias, where there may be systematic differences in information between groups being compared (e.g. the incidence of thyroid cancer in an exposed group who have undergone intensive ultrasound screening, compared with the incidence in a control group who have not).
- Treatment of confounding. Confounding is when a third factor is associated with the exposure under study and also affects the outcome of interest. For example, in studies of high background radiation, there could be differences between high-exposure and control areas in lifestyle or other environmental factors that influence the cancer risk. Several methods exist to reduce the effects of confounding.
- Rigorous analysis against hypotheses. An appropriate analysis is based on an a priori plan that specifies any categorizations that might be used, how time factors are to be treated, the output statistics to be evaluated and how statistical uncertainty is to be evaluated.
- Thorough handling of uncertainties. Uncertainties in the measurement and observational data and in the models used for analysis, including various sources of bias, need to be identified and considered. Various techniques exist to account for these uncertainties and to assess the likely uncertainties in the output statistics of the study.
- The quality of reporting. While a study itself may be of high quality, the written report may not be of the same quality, e.g. presenting only selected aspects of the analysis or omitting critical details of the study plan and procedures. A report should include a proper description of the setting, eligibility criteria, definition of the exposures, outcomes and confounding variables, sources of information and methods of assessment, description of statistical methods and how missing information has been dealt with. In interpreting the findings, any limitations of the study and whether they can be generalized considering previous findings should also be reflected.

Authors are often careless about distinguishing frequentistic approaches deriving estimates of relative frequency of disease from Bayesian approaches expressing risks as probabilities. They also frequently make many assumptions that are not explicitly recognized.

The most suitable approach to synthesize the evidence of multiple studies is that of systematic review—developed in the last decade or...
so in the context of evidence-based medicine (notably championed by the Cochrane Foundation [6]). Such reviews consist of defining the topic under investigation, using set procedures for literature search, evaluating the quality of each individual study, combining the results if appropriate and grading the overall strength of the evidence to reach an overall conclusion.

For a scientific evaluation of a defined research topic, UNSCEAR recommended a systematic approach that includes the following steps:

- Step 1. Transparent and systematic collection of information, based on a protocol.
- Step 2. Abstraction of relevant data from selected studies or other sources of information.
- Step 3. Assessment of individual study quality following unambiguous and consistent standards.
- Step 4. Synthesis of information.
- Step 5. Drawing of conclusions.

Its internal processes before publication also included critical review by external independent reviewers, quality assurance mechanisms for checking numerical analysis, careful editing by technical editors and international review by the Committee’s members.

WHILE SOUND SCIENCE IS NECESSARY TO ENSURE EFFECTIVE RISK COMMUNICATION FOLLOWING A RADIOLOGICAL EMERGENCY, IT IS NOT SUFFICIENT

From the earlier discussion, it is already clear that misinterpretation, misunderstanding and miscommunication can interfere with the effective communication of risk, measured by how well the message is received and understood. It is interesting that the Greek philosopher, Aristotle, in the fourth century BCE had written a treatise entitled ‘Rhetoric’ on the art of persuasion, and this still has great relevance today. Aristotle expounded three ‘appeals’ of persuasive messaging: logos, ethos and pathos. Logos represents the hard scientific observations and the logic of the argument to present them; ethos the credibility of the communicator; and pathos is about moving the emotional state of the receiver to one in which they can best assimilate the message. While Aristotle was focused on persuasion, this breakdown is also a helpful perspective and mnemonic for those charged with developing communication plans, including those that involve both imparting information and exchanging information in an interactive manner; moreover, it is also not out of line with recent studies on the subject. For example, Peters et al. examined trust and credibility in the context of environmental risk communication, and found that perceptions of trust and credibility were dependent on three factors: perceptions of knowledge and expertise; perceptions of openness and honesty; and perceptions of concern and care.

LOGOS

A section above discussed the necessity of sound science for radiation risk communication. Logos is about taking that science and effectively communicating the information with logic and reasoning to the receiver. There are many challenges in doing this, and some examples follow.

Technical expression of risk

Even at the technical level, the scientific community itself has problems in expressing risk, usually as excess relative risk or excess absolute risk, accompanied by a confidence interval conveying statistical precision. However, there are serious questions as to whether these are appropriate measures to express the concerns of the public, even if they could understand them. For example, they often overlook the major feature that radiation-related cancer risk varies over time and for an individual may become manifest at an unknown time, possibly decades after exposure. For example, Fig. 1 illustrates how the average individual risk of solid cancer attributable to exposure of 1-year-old male infants to 100 mGy is estimated to vary with attained age. Note that up to age 40, perhaps only 10% of the lifetime risk is expressed. There is a major challenge to reflect this important subtlety in communicating with mothers who are concerned about the nature of any risks to their young infants who might have been exposed to radiation.

Moreover, radiation protection regulators will often present the linear no-threshold hypothesis as a fact and not as the model or assumption that it strictly is, and thereby misrepresent our scientific and factual knowledge on radiation risks. In addition, there are many more uncertainties that need to be reflected other than just statistical uncertainties to honestly convey the confidence in results. Terminology is also a problem — scientists often use imprecise or overcomplex jargon that can lead to serious miscommunication.

Problems in understanding risk

In general, the public have difficulty in understanding probability expressed as a percentage or a fraction. On the other hand, it seems they can assimilate relative frequencies (such as 5 in 100), and betting odds (such as 100 to 1 against). In communicating numerical information, consideration should be given to expressing evidence on health effects as a relative frequency, and to convey any uncertainties using language related to judgement/betting odds (as opposed to fact).

People also have difficulties in appreciating very small ratios, such as 1 in a million, because it is difficult to visualize this from everyday experience. Using an analogue of length, e.g. 1 millimetre in a kilometre, or recalling the numbers of people in say a sports stadium can help people better appreciate the scale.

In conducting public outreach after publication of its assessment of the radiological consequences of the Fukushima accident [9], UNSCEAR tried to distinguish data and facts from interpretation and assumptions, because the public feel that they are entitled to make assumptions themselves, based on the known facts. This is in line with the Committee’s 2012 Report on the attributability of health effects to radiation, where clear separation of data from models was expounded [10]. The wide variability of audiences also required information to be prepared and presented in a layered way, i.e. simple high-level messages first, that could be expanded to increasing levels of detail as needed.

ETHOS

Trustworthiness of information sources

People will be concerned that the source of the scientific information is trustworthy and unbiased, and that the communicator is both truthful and honest. After the Chernobyl accident, studies indicated that people had more trust in the media than in industry or the regulator, and often
more trust in foreign scientists than in their own nationals [11]. With this in mind, UNSCEAR and its Japanese delegation recognized very soon after the Fukushima accident that Japan’s government and authorities would be likely to have problems of credibility, that a report by foreign independent experts would probably be seen as more credible, that UNSCEAR had a long-standing widely accepted high reputation and that the United Nations had a good ‘brand name’. Some of the guiding principles in conducting the Committee’s assessment of the accident were to be able to demonstrate objective analysis, by recording all decisions and data shared, ensuring all experts were scrutinized for possible conflicts of interest and met requirements for expertise, that groups of collaborating experts were selected for balance and providing different perspectives, that calculations and assessments were documented and checked so that they could stand up to scrutiny and criticism, that the unknowns would be honestly conveyed, and that science would be clearly separated from any policy matters. All of these were to support any challenges to the credibility of the report.

If possible, it is important to minimize discrepancies between scientists or groups in conveying risks of effects—this is easiest if they commit to talking about hard facts and evidence and acknowledging uncertainties, rather than speculating about their own theories with valued judgements. This can be challenging, for example, when scientifically based bodies make assessments that are for public health decision-making or radiation protection policy, where such valued judgements are necessary to meet the goals of those assessments, but thereby open up their conclusions to wider controversies surrounding those judgements. People typically begin to believe information if three or four respected independent sources agree and reach similar conclusions, especially if there are no major dissenting respected sources.

(In this regard, the separate publications of the UNSCEAR [9], WHO [11, 12] and IAEA assessments, as well as crowdfunded assessments with similar conclusions, may be considered to have been helpful to re-establish confidence in Japan after the Fukushima accident).

PATHOS

Pathos relates to moving the receiver’s emotional state to one where the message can best be understood and assimilated.

Emotional aspects

The rules on communication change under highly stressful situations, such as after an accident, where doubt and fear will be major emotions experienced by many. It is extremely important for the communicator to express empathy with the audience, expressing compassion with individuals, validating their feelings and committing to their cause [14, 15]: ‘People only care about what you know after they know that you care’. Moreover, people under stress usually will find hearing, understanding and remembering information difficult and will typically focus more on negative information than on positive information [14, 15]. Most people will be satisfied to hear that their levels of exposure are below regulatory limits, a further fraction of the population will become satisfied after comparisons are made between the levels of exposure (including background) before and after the accident, while a smaller fraction will expect comparisons of the risks with other hazards. The communicator needs to be responsive to people’s concerns, to enhance trust and minimize conflict.
Risk perception

Many factors affect how risk is perceived, including whether it is voluntary, whether there are benefits, whether it is natural, whether it is under control, whether it is fairly distributed, whether there is an open, transparent and responsive process or a secretive unresponsive one, whether the risk is diffused over time and space or sudden and catastrophic, whether the risk is to adults or children and whether the hazard is a familiar one. The communicator needs to be aware that these perceptions may influence the way in which he or she chooses to present risks and especially risk comparisons. Moreover, they need to be prepared to help people face uncertainty and to appreciate ethical considerations.

Wieder picks up again on Aristotle and expounds that storytelling is a better way to convey information than simple facts, because it requires the receiver to go through a series of thought processes to see how the information applies to them. Such stories encourage the receiver to develop generalizations for themselves that are easier to apply to their situation. The media convey news through stories all the time—they have much to contribute for professionals charged with communicating radiation risks.

MAKING IT WORK—HAVE A SYSTEM AND REHEARSE IT

Finally, some remarks about putting in place management systems for communicating [16, 17]. There is intense stress early on after an accident, and communication arrangements need some preparation in advance to be effective. Clearly radiation risk communication is only a small but important component of all the aspects of communication that will be involved. A communication strategy needs to: appreciate the different audiences involved (e.g. children, parents, older people, mothers and workers); what people want to know in order to help them make decisions about their future and the various routes of communication (e.g. through schools, through the mass media, via websites, using social media, community meetings and helplines); identify the intended outcome of the communication; and decide on the techniques to be employed (e.g. whether they are to simply broadcast information, or to provide opportunities for interaction). The strategy would also clarify authorities and responsibilities for communicating with the public, describe the mechanisms for quality assurance and consider different tools, including printed material [18], presentations, press conferences, helplines, interviews, websites and social media sites. In order to be cost-effective, communication needs to be designed with a graded approach, and mechanisms to respond to false information, rumours and public concerns must be established. Relevant training, testing and exercising is needed for all involved, such as teachers, spokespersons, scientific experts, medical staff, counsellors and advisors.

CONCLUSIONS

In conclusion, although there are many communication issues in the aftermath of an accident, the effective communication of radiation risk is likely to be a not insignificant issue. High-quality science and trustworthy sources are necessary to underpin effective risk communication, but these are not sufficient. In high stress situations, human factors such as empathy and credibility become more imperative. A communication strategy using a graded approach needs to be planned, prepared and exercised.

The Aristotelian model of logos, ethos and pathos is a useful mnemonic for those charged with radiation risk communication, but it is also important to frame this model within a system of preparedness. Apart from a formal emergency preparedness system, it would be helpful in general to teach children how to scrutinize sources of information, to educate and train scientists in the principles of risk communication and to encourage communicators to develop a deeper understanding of the science. All involved would benefit from anticipation, preparation, practice and exercise.

CONFLICT OF INTEREST

None.

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