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CBRN RISK COMMUNICATION WITH THE PUBLIC: MINIMISATION OF HEALTH EFFECTS CAUSED BY ACCIDENTS OR TERRORIST ATTACKS

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Abstract. *CBRN (Chemical, Biological, Radiological, and Nuclear) risk communication with the public is critical to emergency preparedness and response. Effectively communicating with the public during and after incidents or terrorist attacks involving CBRN hazards is essential for minimising health effects and ensuring public safety. Fundamental principles and strategies for CBRN risk communication include some of the following key elements: timeliness and accuracy, transparency, empathy and understanding, consistent messages, plain language, media coordination, and feedback mechanisms. Applying this approach, emergency responders and authorities can enhance CBRN risk communication with the public, ultimately minimising health effects and fostering community resilience in the face of any emergency involving the uncontrollable release of CBRN agents. By incorporating these aspects into risk communication strategies, authorities can enhance their ability to effectively convey information, build trust, and promote public safety when dealing with dangerous substances. The paper reflects on the latest situation in this area where effective risk communication is crucial when dealing with CBRN and other dangerous substances to ensure the safety of individuals and the community.*

Keywords: *CBRN, risk communication, agents, release, accidents, attacks.*

Introduction

The paper addresses the role of CBRN risk communication in choosing and considering appropriate safety measures to protect the public by following relevant instructions of rescue teams and other professionals dealing with the accident or attack. Accidental or deliberate CBRN events are widely considered low-probability events, which might significantly impact citizens and society. Whenever and wherever they happen, they usually deserve a gradual (regional, national, international) and multi-faceted approach as they tend to provoke severe and unexpected physical, psychological, societal, economic and political effects that might also easily cross the borders. In that context, detection, protection and decontamination against potentially harmful CBRN agents is particularly important. It is needed for military staff but also for civilians, including an extensive range of users like firefighters, health services, police, and civil protection operators who might be involved in such events, whether they are due to terrorism attacks, accidents or natural disasters.

In order to characterise the concept of risk communication, it is also important to clarify its relation to risk assessment and risk management, including their role in the minimisation of CBRN hazards.

On the research side, last but not least, considerable investments in CBRN detection, protection and decontamination are carried out under the umbrella of national and international security research cooperation programmes (EU, NATO, etc.). They provide testing and validating complementary new solutions, tools, equipment, protocols, and systems as well as draft standards for CBRN reference materials, reference sampling, and analytical methods. The EU is indeed currently supporting tens of CBRN-related projects financially.

Risk communication measures serve to raise awareness of various issues. First of all, it is imperative need to define the information one wants to report precisely. Combining a specific activity (measure) with examples of good practice will motivate the persons and institutions concerned to reduce risks and provide additional incentives. On the one hand, the target groups should be aware of the possible dangers and understand the potential risks. It must be apparent where the problems are and who is affected by them. In addition, it must also be presented which steps can be taken to minimise risks and which risks cannot be avoided.

Risk is an almost ubiquitous term with many different terminological and conceptual connotations. In modern society, threat perception has changed from a rather one-dimensional focus on war to multidimensional threats. Thus, applying the concept and meaning of risk to the civil protection system is necessary.

In the assessment of the risk, it is essential to define how this quantity can be defined, where the damage, reflecting the consequence or impact of the event and the probability that such a case happens, should be considered as their quotient, i.e.

$$\text{Risk} = \text{Probability} \times \text{Damage}.$$

This concept can also be applied to any dangerous substances, including CBRN, which, under specific situations, may potentially present danger to people and the environment (KEMI, 2021). Here, we have to distinguish between the risk affecting the general public, which is usually unaware of the possible threat, and those who are trained to work with such substance and are familiar with the essential danger relevant to the use of dangerous agents and fundamental protection measures to minimise the risk associated with such materials. Qualified workers dealing with individual components of CBRN agents know how to protect themselves and others from the danger associated with the production, transport, use, storage and disposal of these materials.

Of course, the safety is never absolute (100%), or there is no risk at the zero level. Among other factors and reasons, such as accidents, terrorist attacks or natural events (earthquakes, tornadoes, etc.), the cost of countermeasures plays an important role to reduce the risk, where the probability that something dangerous happens is always above zero.

It is evident that the public informed about dangerous situations and their consequences in terms of their health impact will be better prepared for such events since they can apply some protection measures to reduce the risk and actively cooperate with the rescue teams during emergencies. For these reasons, communication with the population is crucial in dealing with dangerous events to achieve the best results and reduce the number of casualties and people affected by the accident. In order to respond to such situations, the public has to be familiar with the basic protection measures applied to reduce the risk to the very minimum under the circumstances. In order to achieve this goal, those who are supposed to communicate the risk to the public have to be trained in how to do it professionally. Different dangerous substances require specific protection measures, and even differences among individual components of the CBRN agents have to be considered since they differ substantially.

In general, risk communication strategies aim to increase awareness regarding different issues. Initially, it is crucial to outline precisely the information intended for dissemination. Pairing specific actions (measures) with instances of successful implementation will encourage relevant individuals and organisations to mitigate risks and offer further motivation. On the one hand, diverse audiences should grasp potential hazards and comprehend associated risks. At the same time, it is essential to delineate the nature of problems and identify those that are impacted. Conversely, it is also imperative to outline steps available for risk mitigation and acknowledge risks that cannot be completely mitigated.

Characteristics and danger of individual CBRN components

Individual CBRN agents differ enormously in terms of their properties, chemical and physical parameters, health effects, behaviour, dispersion, etc. (UNODC, 2018).

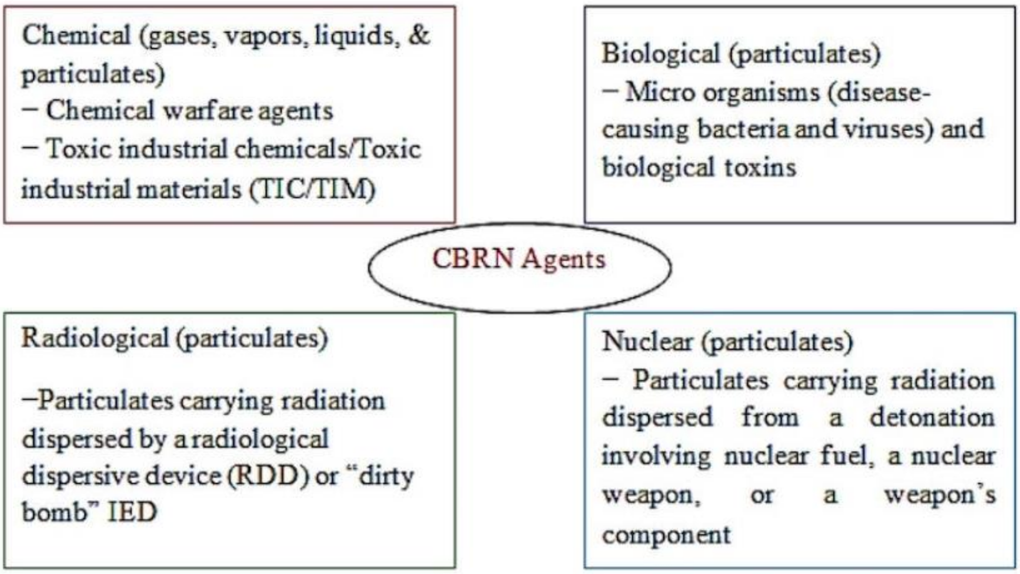

Figure 1. Brief overview of CBRN agents

These factors must be emphasised when communicating the risks and proposed protection against their dangerous consequences. Therefore, it is desirable to summarise some basic characteristics of each CBRN component. The basic overall characteristics of individual agents are shown in Fig. 1 -based on (KTJ, 2023). Their more detailed description follows.

Chemical agents

Chemical agents, such as solids (dust, fumes, fibres, powders), liquids (vapour, mists) or gases, can exist in different forms. Various forms of a chemical may present diverse hazards. Chemical agents fall into four categories: choking agents, blister agents, blood agents, and nerve agents. Choking agents irritate the nose, throat, and lungs when inhaled and include chlorine (Cl), chloropicrin (PS), diphosgene (DP), and phosgene (CG). The effects of chemical agents include runny nose, watery eyes, drooling, excessive sweating, difficulty breathing, dimness of vision, nausea, and vomiting. At first sight of symptoms, immediately remove the victim's clothing and flush eyes and skin with plenty of water, then seek medical attention. There are antidotes for specific chemical agents. Chemical agents are hazardous substances that usually would make you sick immediately. Examples of chemical agents include mustard gas, cyanide, and sarin.

A chemical substance is considered extremely toxic if it has an LD50 of fewer than 5 mg/kg of animal body weight. The Lethal Dose - LD50 – is the abbreviation used for the dose which kills 50% of the test population. This is the equivalent of a taste (less than 7 drops) to humans. It is highly toxic if it has an LD50 of between 5 and 50 mg/kg of animal body weight to a human, this would be about a teaspoon. The Lethal Dose - LD50 – is the abbreviation used for the dose which kills 50% of the test population.- It represents the quantity corresponding to the exposure concentration of a chemical substance lethal to half of the affected population. LD50 is expressed in mg per kg of body weight of the test animal, which must be mentioned (Tate, A., 2021).

Some chemicals are specially developed to be as toxic as possible, can kill more people than any soldier with a machine gun could ever hope to. It doesn't take a cloud of bullets to cause mass death. Now, all it takes is a cloud. This is where the world of chemical weapons enters the fray. Chemical Warfare Agents (CWA) made their brutal introduction in modern theatres at the Second Battle of Ypres in World War I. Although many in the developed world think of chemical warfare as a relic of the past, the threat from these agents never truly went away. If anything, the risk of being a victim of chemical weapons has only increased with time. Part of the problem is that the general population lacks knowledge regarding chemical weapons. You cannot prepare to survive a threat you do not know is out there. Among the world's most toxic chemicals are chlorine, mustard, phosgene, lewisite, hydrogen cyanide, tabun, sarin, soman, VX, and ricin (SWA, 2023). A chemical weapon is any toxic chemical that can cause death, injury, incapacitation, or damage to the senses. It is deployed via a delivery system, such as an artillery shell, rocket, or ballistic missile. A chemical weapon can be deployed via a delivery system, such as an artillery shell, rocket, or ballistic missile. Exists in three states: solid, liquid, and gas.

Biological agents

Biological agents include bacteria, viruses, fungi, and other microorganisms and their associated toxins. They can adversely affect human health in various ways, ranging from relatively mild allergic reactions to severe medical conditions—even death.

A biological threat is an infectious disease with the potential to spread and cause an outbreak. Infectious diseases are illnesses caused by germs (such as bacteria and viruses). These agents include deliberately using pathogens or toxins against humans, livestock, or crops for military purposes. The primary pathogens (infection micro-organisms) are viruses, bacteria and fungi.

Many of the micro-organisms and toxins (organically produced poison) that may be used as such biological weapons can easily be acquired and mass produced. The dissemination of aerosols of ~~from~~ these biological agents can result in mass casualties. The most dangerous biological agents/diseases include anthrax, botulism, plague, smallpox, and Ebola.

The most used bioweapon includes bacillus anthracis, a spore-forming bacteria that causes disease in humans and livestock. The bacteria are found in two forms: cutaneous anthrax and inhalation anthrax. An important distinction is between the infectious agents and the toxins (which are non-infectious and can be regarded as a form of chemical agent). Infections take a variable time to develop and become evident. Some biological hazards, such as mould growth following a flood, may develop due to an incident.

Offensive biological warfare in international armed conflicts is a war crime under the 1925 Geneva Protocol and several international humanitarian law treaties. In particular, the 1972 Biological Weapons Convention (BWC) bans the development, production, acquisition, transfer, stockpiling and use of biological weapons (Wikipedia, 2024).

Biological weapons disseminate disease-causing organisms or toxins to harm or kill humans, animals or plants. They can be deadly and highly contagious. In effect, biological warfare is using non-human life to disrupt — or end — human life. Because living organisms can be unpredictable and incredibly resilient, biological weapons are difficult to control, potentially devastating on a global scale, and prohibited globally under numerous treaties.

Biological agents include bacteria, bacterial spores, bacterial and other toxins and virus particles.

Due to the potential exposure to deadly micro-organisms, a bioterrorism incident poses a considerable health risk to those exposed and “first responders”. These responders may include public health officials, law enforcement, firefighters, paramedics, and military personnel.

In the pre-planning stage, the following issues related to biological agents have to be considered:

- Contamination may not be detected for at least several days until people start to show common symptoms;
- Occupants may be infected by agents in air, water, food or on surfaces, or by contact with other infected people;
- Infection is generally more likely to occur the higher the level of contamination, but for many agents, exposure to only a small amount of material is required to cause infection;
- Contamination within the building may remain active for periods of up to several weeks or even years, depending upon the agent;
- Once contamination is known to be present, the agent must be identified by sampling;
- Decontamination methods will depend upon the agent; and
- The effectiveness of decontamination will need to be verified. This will include sampling by specialist agencies and analysis by independent laboratories.

Radiological agents

These agents are nothing else but radioactive materials. In fact, the name used for this category of dangerous substances is not strictly correct since radiological sources also include radiation generators, such as machines producing X-ray radiation or particle accelerators. The latter two categories of radiation sources do not produce any radiation if they are switched off, while radionuclides emit radiation continuously, and this process cannot be stopped.

Radioactive sources are either permanently sealed in a capsule or bonded in a solid form, or they are in the form of unsealed substances in various physical and chemical forms. The closed sources may expose persons externally, so they have to be in an appropriate shield when stored, transported or not in use. On the other hand, unsealed radioactive sources may present internal exposure after they enter the body via ingestion or inhalation.

Radionuclides find broad applications in many areas where they are very useful, e.g.:

- Medical – cancer therapy and blood irradiation;
- Non-medical irradiation of products – sterilisation and food preservation;
- Gauging systems – material thickness, material density, and fluid level;
- Imaging systems – radiography of welds and other materials;
- Materials analysis – moisture gauge;
- Miscellaneous uses – smoke detectors, lightning rods, and self-luminous signs;
- Common sealed radioactive sources for other non-medical uses include the following
  Gamma sources:
  Cs-137 – calibration source, radiography, gauges, and well logging;
  Co-60 – radiography, sterilisation, gauges, and lightning rods;
  Ir-192 – radiography;
  Ra-226 – gauges, some smoke detectors, and lightning rods.

To assess radiation risks to estimate health effects, it is important to use adequate radiation protection quantities and their units correctly. Since we have more than ten quantities defined in a rather complicated way for this purpose, there is a lot of confusion on how to apply these quantities, even among those working with radiation sources or responsible for radiation protection at workplaces. For illustration, the most important radiation quantities include the activity, absorbed dose, exposure, kerma, dose equivalent, equivalent dose, effective dose, ambient dose equivalent, directional dose equivalent, committed dose equivalent, committed effective dose and collective dose (Sabol, J., 2023; Sabol, J., 2022) [7,8]. A further complication is related to the problem of distinguishing between the assessment of stochastic and deterministic effects. One has also to realise that some quantities can be used only for specific types of radiation (photons, charged particles, neutrons). Confusion may also arise from conditions under which some quantities can be used (in free space, in phantoms, etc.).

Nuclear agents

Nuclear weapons based on fission and fusion are the most dangerous weapons on earth. One can destroy a whole city, potentially killing millions and jeopardising the natural environment and lives of future generations through its long-term catastrophic effects. The dangers of such weapons arise from their very existence. The fission process is also used in nuclear reactors as a major source of energy in nuclear power plants. Nuclear reactors are widely applied in research. In both cases (nuclear weapons and nuclear reactors), huge amounts of various radioactive materials are produced. At a normal situation, the release of radioactivity from nuclear reactors is strictly controlled and regulated, but in case of an accident or terrorist attack, radioactive substances are dispersed to the environment and contaminate areas far away from the source of radioactivity.

Considering the above-mentioned characteristics of nuclear agents produced by the fission and fusion result, they finally become radioactive materials. In fact, the CBRN component N then contributes to component R.

A summary of the fundamental properties of ensuring adequate protection against individual CBRN agents is presented in Fig. 2 - based on (RK, 2016).

AGENTS	SUMMARY CHARACTERISTICS		
	Time to effects	Potentional impact	Availability
BIO	Days to weeks	Local to global	Low
RAD	Minutes to Hours	City to Region	Medium
CHEM	Seconds to Hours	City Blocks	High

Figure 2. Some specific differences between biological (BIO), radiological (RAD), and chemical (CHEM) agents

CBRN risk assessment and communication

CBRN risk communication with the public is critical to emergency preparedness and response. Effectively communicating with the public during and after incidents or terrorist attacks involving CBRN hazards is essential for minimising health effects and ensuring public safety. Fundamental principles and strategies for CBRN risk communication include some of the following key elements: timeliness and accuracy, transparency, empathy and understanding, consistent messages, plain language, media coordination, and feedback mechanisms. Applying this approach, emergency responders and authorities can enhance CBRN risk communication with the public, ultimately minimising health effects and fostering community resilience in the face of any emergency involving the uncontrollable release of CBRN agents. By incorporating these aspects into risk communication strategies, authorities can enhance their ability to effectively convey information, build trust, and promote public safety when dealing with dangerous substances.

There are some relations between risk assessment, risk management and risk communication (Fig. 3). The public has to be informed about the risk of any potentially dangerous materials produced or used near the installations engaged in such activities. If any accident happens, the rescue teams are involved in minimisation of its impact on the local population and the environment. Risk assessment is essentially based on science and technology analysis, while risk management relies on the supervision of the police in critical situations that appear after accidents or terrorist attacks. Both these components are essential to risk communication.

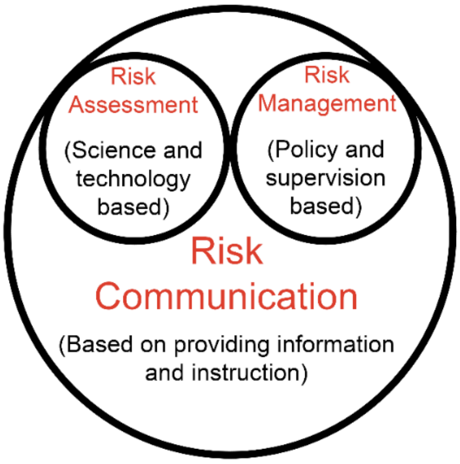

Figure 3. Relation between risk communication and its two important tools - based on (Yoe, Ch. et al. 2010)

CBRN dangers come from the release, or potential release, of harmful chemicals, germs, radiation, or nuclear materials. These threats can be accidental, due to poor safety practices, or intentional, like a terrorist attack. CBRN events are tough to spot and deal with because they can happen anywhere. However, incidents in cities are especially risky for civilians.

CBRN defence encompasses efforts, methods, and measures aimed at reducing the dangers posed by such incidents and shielding against their consequences. These incidents, while regrettable, are a tangible threat capable of inflicting extensive harm. They necessitate tailored CBRN defence tactics to limit their potential harm. The most effective course of action involves equipping responders with comprehensive planning resources to bolster CBRN training and develop well-informed, pre-emptive response plans. By leveraging intelligence tools effectively, teams can guarantee readiness to address various CBRN scenarios.

Comprehending CBRN dangers and their effects on individuals is crucial for developing knowledgeable strategies. It is necessary to explore CBRN incidents and their implications for public health, while also discussing how responders can be enabled to respond with efficacy and efficiency. The extent of CBRN effects hinges on various factors, including the nature of the hazard, the setting, and the response's effectiveness. Urban CBRN incidents possess significant potential to inflict enduring and severe harm on individuals, locations, and economies.

Short-term ramifications encompass immediate effects on public health and the economic resources allocated towards managing the fallout. In contrast, the enduring consequences of such incidents can extend over many years. They encompass broader economic implications, the emergence of health hazards and pollution in affected regions, as well as enduring psychological trauma. Safeguarding public health stands as the foremost priority when responding to CBRN events. This responsibility falls upon emergency services, first responders, governmental bodies, and private organizations, all tasked with mitigating the impact on affected communities. Enhanced response efficacy hinges on comprehensive understanding, from established protocols to nuanced insights into the nature and dynamics of the incident. Acquiring and leveraging extensive information thus emerges as a critical imperative, empowering responders to safeguard as many lives as possible. While certain aspects of CBRN events may be anticipated through training and existing knowledge, a deeper comprehension of the event's nuances and characteristics remains indispensable for effective response.

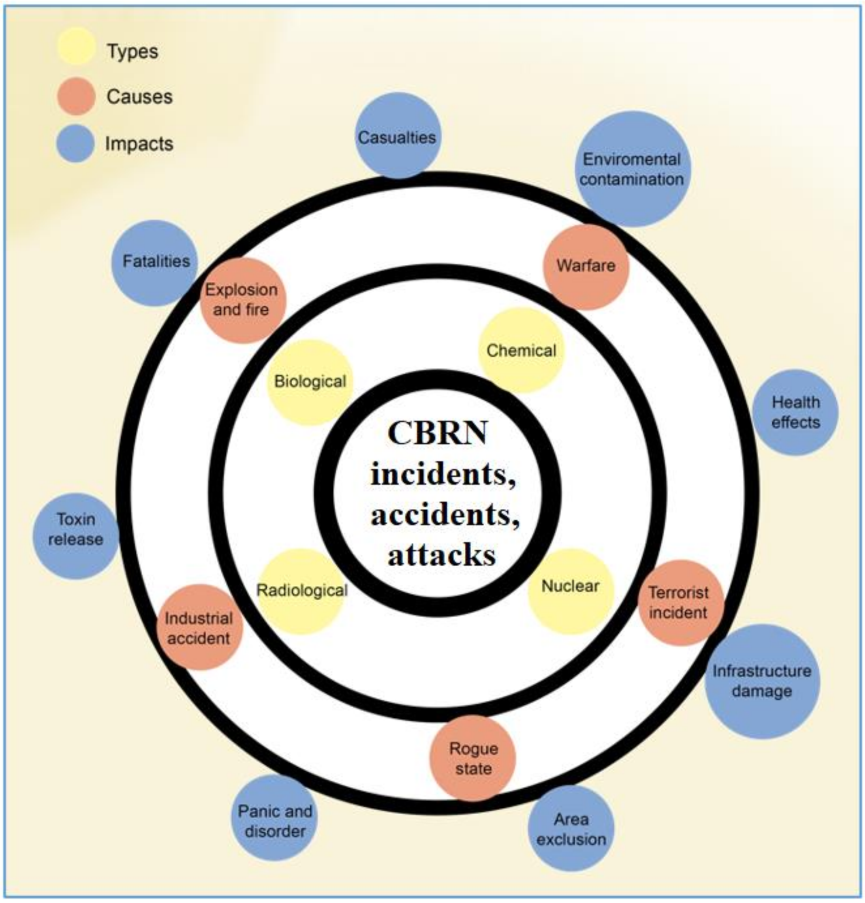

Figure 4. CBRN threats and the tools to manage them

The essential details responders require are:

- The type of incident and substance involved;
- Where and how large the incident is;
- The seriousness of the situation; and
- Potential spread of the incident.

Likely impacts Figure 4, modified from (Riskware Ltd., 2023), illustrates various factors crucial in CBRN emergencies and tools for managing them to mitigate the overall risk posed by these agents.

How to communicate CBRN risk to the public effectively

Effective communication is crucial during crises, especially in situations involving nuclear CBRN threats. Instances of such CBRN incidents (Morton, H., Johnson, Ch., 2021) include the coordinated Sarin nerve agent attacks on the Tokyo metro system in 1995, the bombings in Madrid and London in 2004 and 2005, and the ricin-based biological attack in Salisbury in 2018, all of which impacted the public. However, CBRN incidents can be triggered not only by terrorist acts but also by natural disasters like the 2011 tsunami in Japan, which resulted in a nuclear crisis at the Fukushima nuclear power plant (IAEA, 2015).

The following key principles will be applied to all communications activities undertaken under this plan:

The forthcoming communications activities within the risk communication process will adhere to the following core principles:

- Prioritising openness and transparency within the boundaries of security constraints;
- Ensuring accurate communication of risks, especially in situations of uncertainty;
- Engaging in two-way communication processes;
- Utilising established communication channels and protocols whenever feasible;
- Maintaining consistency and clarity in messaging;
- Providing tailored information regularly and promptly;
- Releasing public messages at an early stage;
- Addressing queries in a timely manner;
- Handling personal or confidential information with sensitivity;
- Employing social media judiciously when appropriate;
- Employing specialised communication methods to engage vulnerable populations;
- Adapting communication methods flexibly according to the current situation; and
- Employing a diverse range of communication methods to reach a wide audience.

There have been identified several individual factors associated with CBRN prevention and management strategies that affect public behaviour in CBRN incidents, which included communication. The public's perception of and the behaviour during CBRN incidents is strongly influenced by the overall crisis communication of CBRN events. It was confirmed that confusion due to a lack of knowledge about CBRN incidents affects compliance with instructions given.

Crisis communication traditionally pertains to communication during an emergency. Yet, it's important to note that recent research is broadening its scope to encompass communication before and after the crisis. This expansion aligns crisis communication research with studies on risk communication, which addresses potential future occurrences and strategies for readiness.

The diverse nature of individuals impacted by CBRN incidents highlights the necessity for tailored communication approaches that consider specific requirements. Past studies reveal a wide array of vulnerabilities linked to such incidents, encompassing various groups such as individuals with physical or mental impairments, children, non-native speakers, and ethnic minorities. These vulnerabilities stem from multiple factors, underscoring the importance of further investigation to enhance support for vulnerable populations in disaster scenarios. Given their significant communication and language hurdles, these groups require specialized assistance to engage effectively in communication processes.

For elderly individuals, utilizing various communication methods beyond media may be essential, considering potential challenges with hearing and vision. Similarly, children and individuals with mental health issues might benefit from messages tailored with simpler language due to their communication limitations. In addition to selecting suitable communication channels, it's crucial to convey messages using appropriate language and readability levels to promote inclusive communication. Plain language is particularly vital in crisis communication to ensure broader accessibility within diverse communities. Tailoring language formats to cater to vulnerable groups is pivotal for achieving successful outcomes in crisis communication efforts. The EU is currently funding numerous Security Research projects focused on improving the safety and security of CBRN agents, with an emphasis on risk communication, e.g., (Gromek, P., Szklarski, L., 2022).

Conclusions and recommendations

Accidental or deliberate occurrences involving CBRN materials are often viewed as unlikely but can have significant impacts on individuals, communities, and the environment. These incidents necessitate a comprehensive response at various levels - local, national, and international - due to their potential to cause severe and unforeseen physical, psychological, societal, economic, and political consequences that can transcend borders. Detecting, protecting against, and decontaminating hazardous CBRN agents is crucial in addressing such incidents, involving not only law enforcement, rescue teams, and workers but also civilians, including healthcare professionals and civil protection teams, who may be affected by terrorist attacks, accidents, or natural disasters.

Considerable investments in CBRN detection, protection, and decontamination are being made through international and national programmes, aimed at providing, testing, and validating new solutions, tools, equipment, protocols, systems, and draft standards for CBRN materials, sampling, and analysis methods. The EU is currently funding numerous Security Research projects focused on improving the safety and security of CBRN agents, with an emphasis on risk communication (e.g. [12]).

Existing research highlights the often overlooked communication needs of communities at risk during crises. Providing ample information enhances public understanding and encourages appropriate responses. Effective communication can increase adherence to provided instructions during CBRN incidents, thereby mitigating adverse emotional and behavioural outcomes.

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