The CBRN Threat. Perspective of an Interagency Response

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Abstract Current scenarios reveal new types of ever increasing dynamic and aggressive threats, which lead to a move from a traditional security management to a strategic vision for protecting citizens and assets in a more comprehensive way. In such an environment, the risk related to incidents involving the use of CBRN (Chemical, Biological, Radiological and Nuclear) agents must be considered a cause of potentially devastating consequences. Non-proliferation and disarmament operations can make an essential contribution to combat terrorism by preventing or reducing the access of non-state actors or non-authorised persons to chemicals, biological and nuclear dual-use materials but this could be not enough. Illicit proliferation of chemical weapons, clandestine production of toxins and biological agents, ‘dirty bombs’ and trafficking of fissile material are just some examples of the use of CBRN agents for terrorist purposes. This chapter argues that, in order to address these issues, the integration of human, instrumental, technological and financial resources should be improved and reinforced. For that purpose, an effective strategy to mitigate and reduce the risk of using CBRN materials requires a high level of coordination across national agencies. Further development of interagency CBRN defence capabilities remains a top priority for global security.

Keywords Chemical · Biological · Radiological · Nuclear warfare agents · Interagency response · Open challenges · Non-conventional threats
1 Definition of the CBRN Threat

The acronym C-B-R-N refers to non-conventional Chemical, Biological, Radiological and Nuclear hazardous agents and materials, which can be used to cause damage to people, animals, vegetation, equipment, countries’ economies and political stability. CBRN events can be classified in three main classes, according to the nature of the cause, which generated them: (1) intentional events, when they are due to deliberate malicious purposes (use of non-conventional hazardous materials in warfare, guerrilla, terrorism, sabotage, etc.); (2) technogenic events, when they are generated by unintentional errors, mistakes or failures that occurred in technological activities (in industrial sites, where hazardous materials are produced, manufactured, handled, transported or disposed); and (3) natural events, when hazardous agents are diffused in the environment during and/or after a natural disaster (e.g. volcanic emissions, pandemic disease outbreak, major forest fires). When one or more CBRN agents are included in a device for the dissemination of the hazardous substances into the environment, the ensemble can therefore be considered as a non-conventional CBRN weapon (US Code 1925).

1.1 Chemical Threat

From a security perspective, the chemical threat represents a deliberate release of highly hazardous chemicals or mixtures of hazardous materials into the environment. Toxic chemical agents are poisonous vapours, aerosols, gases, liquids or solids that can cause adverse toxicological effects on human beings, animals or plants (OPCW 1993). The dissemination of a chemical agent can take place via unintended or deliberate means, such as through a spill from a damaged tank or an explosion at an industrial facility with resultant contamination of air, ground, water or food. The most relevant accident involving toxic chemicals happened in 1984, in the Indian city of Bhopal, where more than 3000 people died after a highly toxic cloud of methylisocyanate (an intermediate chemical for the manufacture of agrochemicals) was released by a pesticide factory. Analogously, in 1976, in Seveso (Northern Italy), an uncontrolled runaway reaction in a small chemical production plant resulted in the highest known exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD or ‘dioxin’) in residential populations. After the accident, 3300 animals were found dead and some 450 people suffered skin lesions or minor diseases. Both disasters gave rise to numerous scientific studies and standardised industrial safety regulations.

The deliberate release of toxic chemicals into the environment can occur in crowded areas (typically indoors, using ventilation/air conditioning systems) or involving industrial facilities dedicated to the production and storage of hazardous substances or, again, contaminating food, water and land with toxic materials, thus spreading panic into the civilian population (American Medical Association 2005).
A crucial aspect to cope with the risk of deliberate uses of chemical toxic agents is the proactive interagency cooperation by the affected community, particularly among healthcare services and security actors. A thorough involvement of first responders in the preventive risk assessment process is essential to identify threats, define strategies and plan a response capacity, which would reflect the classification of the risk. The security sector can then provide information related to threats, unexpected capabilities of potential terrorists as well as strategic targets or locations considered as a high priority. The latter information is often driven primarily by the security and intelligence agencies and is the starting point for any additional assessment.

In the case of a deliberate use of chemical warfare agents, these toxic substances can also be released by bombs, artillery shells, missiles, mines, sprayed from aircraft, boats, vehicles or drones, or even used as a liquid for sabotage, aiming at inducing fear in people and posing a threat to the environment. One of the most recent massive usage of chemical weapons in a war scenario occurred in the Kurdish city of Halabja in Iraq in 1988 during the Iran-Iraq war, when Iraqi forces killed more than 4000 people, most of them civilians, with bombs and shells loaded with mixtures of blister and nerve agents (Dworkin et al. 2008). Such an attack turned out to be highly effective, as the target population was completely unprotected and untrained to face this kind of highly toxic chemicals.

In tackling such events, response professionals must first protect themselves by means of individual protective equipment devices (e.g. protective CBRN suits, respiratory protection apparatuses and chemical-resistant gloves and boots). Then, the risk of secondary contamination must not be overlooked, since cascade contamination with even minimal amounts of these substances (particularly, in the presence of highly toxic anticholinesterase nerve agents) can be lethal to rescuers too (Clarke et al. 2008). For this purpose, the rapid and efficient deployment of specialised Hazardous Materials teams, HazMat, is critical to manage and control an attack carried out with chemical agents. Although most major cities and emergency response systems have plans and equipment in place to address these situations, all first responders must be aware of the basic principles involved in managing single-patient or mass-casualty events where victims were exposed to non-conventional toxic chemicals (Malizia et al. 2016).

### 1.2 Biological Threat

Biological hazardous pathogens include bacterial, viral, fungal and parasitic organisms that cause severe disease or kill people, livestock and crops (WHO 2004). Human exposure to these agents may occur through inhalation, cutaneous exposure or ingestion of contaminated food or liquids. In the last years, a growing concern was recorded at the international level about the potential deliberate use of highly virulent pathogens or hazardous biological agents by terrorists aiming to influence the behaviour of governments or intimidate civilian populations (bioterrorism) (Jansen et al. 2014). For instance, in the US in 1984, a group of followers of a religious sect
attempted to control a local election by incapacitating the population by contaminating raw vegetables in bars, restaurants and shops with \textit{Salmonella typhimurium} bacteria in the city of The Dalles, Oregon. The attack infected 751 people with severe food poisoning but no fatalities were recorded. Again, the US suffered from a bioterrorism attack in 2001, when several mail letters were found to be contaminated by \textit{Bacillus anthracis} (anthrax) spores and five people died (Enserink 2001).

However, epidemics, or even pandemics, resulting from recurring infectious diseases can also cause widespread civil panic and conditions similar to those of a bioterrorism event. The dramatic H1N1 influenza pandemic (the so-called Spanish Flu Pandemic) in 1918–1920 caused a far larger number of fatalities than World War I, and it is recalled as one of the deadliest epidemics in human history. At the beginning of twenty-first century, the Severe Acute Respiratory Syndrome (SARS) in 2002–2003 affected 26 countries and resulted in more than 8000 cases around the world, with 774 deaths, causing major problems in the movement of people and food commodities at a global level. In that case, only the close cooperation between scientists and disease-prevention state agencies in various countries averted the occurrence of a new deadly pandemic wave at a worldwide level (Geller et al. 2012). Nevertheless, the novel-Coronavirus-2019 disease pandemic, COVID-19, which moved from the Hubei region in central China at the end of 2019 (Wu et al. 2020) and rapidly affected all the world’s continents in the first months of 2020, causing a very large number of confirmed cases and fatalities,\footnote{At the time of the preparation of the present text, the number of cases and deaths is continuously evolving, being in the order of \textit{ca.} 1,300,000 confirmed infections and \textit{ca.} 73,000 deaths in mid-April 2020, all over the world (https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200407-sitrep-78-covid-19.pdf).} remarkable problems in the healthcare system and major socio-economical disruption in most countries, has clearly shown how fragile our societies can be, when facing new pathogens, against which a preventive countermeasure, i.e. a vaccine, is not readily available, and whose characteristics, in terms of clinical management, ease of transmission, resistance in the environment and effectiveness of protective equipment, are not well known. Surely, the COVID-19 pandemic will be recalled as one of the most severe crises the world population had to cope with after World War II, as it has not only heavily struck the medical and healthcare services of many countries, but also deeply influenced short- and mid-term strategic, economic, financial, societal and domestic security decisions of most national governments on a worldwide level.

Generally, biological agents can be diffused through different means, such as natural (e.g. seasonal outbreaks, spill over from natural reservoirs), accidental (e.g. unintentional release from bio-laboratories) or deliberate actions (e.g. bioterrorism). Even though natural events occur more frequently, bioterrorism is raising an ever-increasing attention as an emerging threat. The malicious use of hazardous contagious biological agents, indeed, would involve a very large number of subjects, causing serious illness and facilitating the spread of the disease, since—especially during the initial latency time—the presence of the pathogen can be hard to detect when non-specific symptoms arise. Striking strategic areas with bio-contaminated aerosols
would provoke, as a main consequence, damages at economic and environmental levels, undermining the stability of a country (or a group of countries) and causing an unsustainable burden to health care systems at a large scale (Saker et al. 2004).

Unlike conventional weapons or non-conventional chemical or nuclear warfare agents, the onset of a biological attack can be more insidious. A covert release of a contagious biologic agent has the potential for large-scale spreading before effective identification and detection (Cenciarelli et al. 2013). In addition, in the case of pandemic agents, secondary and tertiary transmission may continue for days or weeks after the initial attack. An effective response to a disease outbreak depends on the rapid identification of the causative agent and specific diagnosis. Any delay in medical treatment could result in a potentially devastating number of casualties and, to mitigate such consequences, early identification and intervention are imperative. First response efforts also require coordination and planning among emergency management teams, law enforcement agencies, health care facilities and social services agencies (Ranghieri et al. 2010).

In the best-case scenario, resource integration is absolutely necessary to establish an adequate capacity to initiate rapid investigation of an outbreak, raise awareness across the public, begin mass distribution of antibiotics, antivirals and/or vaccines (when they are available and if they can be necessary or useful), ensure mass medical care, and to mitigate public anger and fear. State and local officers are therefore expected to work together to develop community and hospital response plans for the management of bio-based emergencies. First responders must be aware of such plans and the network of scientific or technical experts to contact in an emergency situation. Any suspected or confirmed exposure to biological pathogens should be reported to international, state and local authorities. Then, a coordinated communication network is critical for transmitting reliable information not only to emergency professionals, but also to the major public, in order to avoid irrational concerns and panic (CDC 2000).

1.3 Radiological-Nuclear Threat

A radiological emergency involves the release of potentially dangerous radioactive materials into the environment. Such incidents can occur at any location where radioactive isotopes are used, stored or transported and may contaminate houses, workplaces, public transport vehicles and other critical structures. Such an event requires extensive and costly decontamination and remediation procedures and can lead to long-term health problems in the population as well as to the partial or total disruption of habitability of vast areas for extended periods of time. In this regard, serious psychological problems can arise in those who are—or are supposed to be—exposed to a radioactive contaminant, hence causing fear and panic.

A notorious case of radiological contamination due to the uncontrolled dispersion of a radioactive source happened in the Brazilian town of Goiania, in 1987. An old $^{137}\text{Cs}$ radiotherapy source (containing a radioactive isotope of caesium) was stolen
from an abandoned hospital site in the city. Four people died, 20 were hospitalised, 271 contaminated and 112,800 monitored. If one considers that the radiation source in the Goiania accident was a small capsule containing about 93 g of highly radioactive caesium chloride, it is easy to understand the remarkably disruptive effect of an (apparently) minor radiological event on the human environment.

In the case of terrorist attacks or other radiation-related disasters, first responders will play a vital role as a source of authoritative and accurate information for patients, the public and the medical community. Indeed, in order to decrease morbidity and mortality after a radiological event, first responders must possess a basic know-how on radioprotection principles and fundamental countermeasures against radiation pathologies (Turcanu et al. 2016).

On the other hand, a nuclear event implies the occurrence of a nuclear detonation due to a nuclear fission and/or fusion process. Although the likelihood of a nuclear war is low, the possibility of either a single nuclear explosion or an incident involving unintentional or deliberate radiological contamination has increased. In fact, the most likely deliberate criminal radiological event involves the direct placement of a highly-emitting radioactive source in a public place (a radiological exposure device, RED), the spreading and diffusion of radioactive material (a non-explosive radiological dispersal device, NEERD) or the detonation of a high yield conventional explosive contaminated with radioactive material (a radiological dispersal device, RDD, also known as ‘dirty bomb’) (Acton et al. 2007).

In order to prevent or mitigate such adverse effects, international, state and local decision-makers must work together to develop community and first response plans for the management of radiation-related emergencies. Against this backdrop, a coordinated communication network is critical for transmitting reliable information from the incident scene to the incident management post and to treatment facilities. In addition, in the case of hazardous events involving: nuclear reactors, nuclear fuel manufacture, treatment or disposal facilities, or radiochemistry and nuclear medicine laboratories where radioactive sources are lost (‘orphan sources’, which are no longer under regulatory control), or damaged materials, a rapid and efficient cooperation among agencies at various level is crucial.

2 The Need for a CBRN Response

Notwithstanding the existence of a broadly, but not globally, accepted regime of international and supra-national agreements about the development, production, stockpiling, proliferation and use of CBRN weapons (Richardt et al. 2013), the potential use of CBRN weapons or substances cannot be excluded. Unfortunately, the restless advances of science and technology are unintentionally reinforcing these processes, aided by the free migration of information and technical know-how and expertise around the world. Likewise, an ever-growing urbanisation and the process of global industrialisation enhance the possibility of accidental releases or deliberate misuse of hazardous industrial materials. Fulfilling the mission of assuring prevention and
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more the responder is protected, the greater their mobility is restricted (Northington et al. 2007). In fact, a responder overloaded with unnecessary personal protective apparatuses is a burden, rather than a resource. So, the balance between level of protection and responder’s performance must always be carefully evaluated.

Decontamination is the key activity aiming at removing or, at least, mitigating chemical, biological or radiological agents, so that they are no longer hazardous to human beings and to the environment. For victims and unprotected operators, the most important and most effective treatment is the decontamination done within the first minutes after exposure (Cibulsky et al. 2015). To this aim, a good planning of the decontamination procedures and a proper training of the operators on the scene can save lives. From a technical point of view, a fast-physical removal of the hazardous agent is imperative, since none of the chemical decontamination means destroy or neutralise chemical, biological or radiological agents instantaneously. In addition, because radiological hazardous agents cannot undergo degradation, radiological contamination can only be removed by physical means. Such an approach is thus a good choice when there is no detailed knowledge about the characteristics of the contaminant (Koenig et al. 2008). It is, indeed, important not to use decontamination chemicals, which may react further with the contaminant agents and give rise to the formation of by-products that are as toxic as the pristine contaminants.

3 The Key-Role of an Interagency Approach

An effective CBRN management involves a multi-service and multi-jurisdictional effort and stresses the need for decision-making, communication, cooperation and coordination between different services and jurisdictions that should be included in a structured interagency response. The internal hierarchy and the main roles of the different agencies are defined along with the hierarchical structure of the general organisational chart of the overall mechanism for managing the event. The distribution of functions and responsibilities may vary among different countries but it is always present in interagency response plans.²

Ideally, the existence and the implementation of a pre-defined command system would reduce the risk of doubts and conflicts on organisational matters and roles and responsibilities, which may arise during the response activities. The organisational model of an interagency response has to be well defined but at the same time flexible, in order to be adjusted according to different incidents and scenarios. With this in mind, key factors for an effective interagency response are:

• Emergency plans: They may be distinguished as generic, describing control and coordination procedures for any multi-agency intervention, or specific, regarding a specific type of emergency or scenario.

²For instance, the Major Incident Procedure Manual of the London Emergency Liaison Panel identifies the primary functions that police, fire brigade, ambulance services, national healthcare services, local government authorities and the Coast Guard must carry out.
- **Interoperability**: All procedures, tools and software used by responders and different emergency services involved in the incident response should be linked to each other in order to facilitate a fluent exchange of information, a continuous collaboration between agencies and individuals as well as a smooth management of the operation. Interoperability should also be considered in relation to the terminology used.

- **Mutual trust**: The existence of mutual trust among the involved actors is necessary for an interagency environment to succeed. In this regard, regular coordinated activities and joint training sessions provide agencies participating in the response with the opportunity to create relationships and trust both within and between organisations.

- **Cultural differences**: Different working approaches between agencies must be considered with regards to possible emerging issues but also to the added value resulting from the integration of different professional backgrounds involved in the response. In case of international interagency intervention, languages and general heritage must be taken into account.

The main activities to be considered to cope with a CBRN incident focus on the following series of priorities: (1) preserve and protect lives; (2) mitigate and minimise the impact of a CBRN incident; (3) inform the public and maintain public confidence; (4) prevent, deter and detect crime and (5) assist in an early return to a new normality. More in detail, the main actors who can be involved in a CBRN interagency response are first responders, media and policymakers.

### 3.1 First Responders

The saving of lives must take priority over all other on-scene priorities and activities. Any CBRN incident is likely to result in injuries to those in the immediate vicinity, and preservation of life always has precedence over any forensic considerations. However, essential steps are ingrained into responders concerning the establishment of cordons, recording of entry and exit to a scene, selecting rendezvous points and marshalling to begin scene preservation. It is imperative that actions taken by first responders are thoroughly recorded to report what they have moved or touched, notifying any replacement to the Scene Forensic Manager, in particular when dealing with casualties. Moreover, first responders must identify safe locations for response infrastructures (e.g. advanced command posts, advanced medical posts, decontamination corridors) as well as safe routes to allow access to and egress from the scene. The latter tasks should be done without delay, although it must be done properly, in order to avoid the risk of unnecessary danger or hazardous (secondary) exposure to CBRN agents.

Main methodologies of response are based upon a precise and well-established structure both internally and in relation to external cooperation with different agencies. Usually, levels of response are identified as Strategic, Tactical and Operative.
Each of those needs to be addressed according to specific tasks and duties in order to guarantee a proper response to a hazardous event as well as to respect previously defined roles and responsibilities. A simplified structure of this concept can be described as follows:

- The Scene Commander will generally be the ‘Scene Manager’ with other sub-commanders carrying out individual activities. An appropriately located Incident Command Post must be established as soon as possible.
- Early contact should be made with partner agencies to ensure coordination at the scene. That should be agreed upon between partners and clearly identified so that each responder knows where to go and who to speak with.
- An initial Multi-Agency briefing is crucial to ensure that early information and intelligence is shared. This will enable each agency to have a complete picture of the situation as soon as possible, making everyone’s response more effective and more focused.
- Once fundamental information has been shared, a risk assessment should be carried out by the on-scene commanders to determine priority actions and identify hazards/resources available. Activities should be undertaken only when the benefit outweighs the risks. For example, saving life will justify a much higher level of risk to responders than saving property (unless, for example, the saving of property will directly contribute to the saving of life).
- Commanders should agree upon initial actions using Initial Operational Response principles and direct these in a controlled manner. For example, it may be possible for fire brigade teams, crews wearing standard firefighting suits and conventional breathing apparatuses to undertake snatch rescues, if properly briefed (i.e. by staying out of the most contaminated areas, snatching victims, dragging casualties upwind/uphill, then withdrawing and waiting for decontamination).
- Law Enforcement responders are tasked with the establishment of the cordonning of the area involved in the incident and control the access to/egress from the contaminated zone. Entry and exit to the incident scene must be strictly controlled, not only to protect members of the public close to the scene, but also to maintain forensic integrity. A scene log must be kept with accurate, timed entries for all actors moving across the access control point.

3.2 Media

Media play a decisive role, too. When any large-scale CBRN emergency occurs, the general public needs to be informed about how best to maintain their own safety (Rubin 2012). As long as the information does not interfere with any investigative process or with the integrity of involved persons such as victims or people in proximity to the victims, the information should be distributed to the population. Informing the population during an emergency is most adequately viewed as an additional part of the operational context. This task is best performed by a dedicated department or press office. Establishing interagency co-ordination of information at
an early stage in an incident is a key step in reducing confusion and inconsistency. This may include production and distribution of a core media brief to be distributed among key stakeholders, a central coordination of the interviews or, even, a centralised press office. Keeping staff informed and up-to-date is an important part of an organisation’s overall response. It can also be useful to circulate messages received from the community, especially relying on social media communication tools, as they can offer insights into reactions and support on the ground. In general, the press office should be the first reference to the incident, with the objective of giving coordinated, accurate and appropriate information to the population (FEMA 2010).

3.3 Policymakers

Policymakers’ perspectives on the potential socio-economic impacts of the specific event may support prompt actions and strategic decisions in order to mitigate potentially devastating and long-term socio-economic losses, being aware of the complexity of the elements affecting the seriousness of the potential impact (e.g. density of the population in the affected area, geographical features of the affected area, quantity of dispersed material, health-care response efficiency). Many of these parameters have cascading effects, which can greatly worsen the economic impact in terms of geographical extension and endurance, stressing more and more the importance of an interagency approach (Cavallini et al. 2014).

4 Innovative Aspects to Be Considered in a CBRN Event

4.1 Are Civil and Military Approaches Complementary?

The first comprehensive and planned response to non-conventional CBRN events was developed by the military, especially in the Cold War period, when the threat of a massive use of chemical, biological or nuclear weapons on a battlefield was relevant and felt as real. For this reason, in the last decades of the twentieth century, the armed forces of each country, at worldwide level, established technical units with specific technical capabilities able to operate in CBRN-contaminated scenarios and to ensure adequate countermeasures and defence in the case of an attack carried out with non-conventional warfare agents. In the same period and in most countries, civilian first responders created hazardous materials, HazMat, teams (mostly within the fire brigade corps) to cope with events and disasters implying the accidental release and diffusion of toxic chemicals and hazardous industrial materials. Later, after the attacks of the Twin Towers in New York in September 2001, the need for a civilian capability to manage and mitigate CBRN threats within fire brigade, police and emergency medical services was felt to be a priority. This shift from a
Table 1 Differences in the response to an event involving CBRN agents by either military or civilian first responder units

| Aim                        | Civil first responders | Military responders |
|----------------------------|------------------------|---------------------|
| Orientation                | Zero risk-oriented     | Mission-oriented    |
| Agent likelihood           | TIM* and pollutants > CWA* | CWA > TIM > pollutants |
| Priority                   | Priority of safeguarding forensic evidence | Forensics, no (or secondary) priority |

*TIM: toxic industrial material; *CWA: chemical warfare agent

military to a civilian CBRN response, indeed, received a relevant boost when the increasing threat of the use of toxic chemical warfare agents, toxins or radiological sources for terrorist attacks, sabotage actions or illicit purposes started to attract major attention in governmental agencies (Ellis 2014). It is thus worth highlighting the main differences in the approach to CBRN responses for CBRN specialists from military units and for those from civilian agencies (Table 1).

First, the main goal of civilian operators working at an emergency site is to save as many lives as possible. Conversely, the goal of a military unit is mission-oriented and, under particularly extreme conditions, some non-negligible losses in terms of lives and casualties can be considered acceptable in order to fully achieve the given target. For these reasons, a civilian first responder always follows a zero-risk policy and any highly risky search-and-rescue operation, in which life-threatening operations might be carried out (i.e. the exemplar cases of firefighters and ‘liquidators’ in the Chernobyl and Fukushima disasters; Sarin 2011) must be undertaken on a fully voluntary basis by each operator. From a merely technical point of view too, military and civilian CBRN first responders often show a slightly different approach. Detection instruments, protective equipment and decontamination devices for military CBRN units have been mainly designed and developed to be used in the presence of contamination due to chemical or biological warfare agents, CWA (chemical warfare agents) or BWA (biological warfare agents), or to radioactive dusts originating from the fallout of a nuclear weapon detonation. Indeed, for instance, a typical full-face canister-filter military mask or a semi-permeable CBRN military protective suit cannot be used in the presence of toxic industrial materials and are completely unsafe when several kinds of permanent gas contaminants (such as carbon monoxide, hydrogen cyanide, phosphine, etc.) are present. Likewise, analytical devices for CBRN military use are mainly sensitive to chemical warfare agents rather than to commercially available hazardous materials (the so-called TIMs, toxic industrial materials). On the other hand, CBRN specialists from civilian hazmat teams typically must use a broader variety of equipment, tools and devices than their military colleagues. Civilian responders indeed are expected to identify and recognise a very wide range of hazardous substances, such as industrial chemicals (TIMs), environmental pollutants, dangerous substances found in waste materials, explosives, illicit drugs, etc., in addition to warfare agents (CWAs) potentially used for criminal scopes. In fact, from
a general point of view, on a daily basis, it is more likely that civilian CBRN specialists deal with industrial hazardous materials or common pollutants than with classical chemical weapons. Because of this larger uncertainty, the highest level of achievable protective equipment is always chosen by civilian responders, especially when nature, amount and characteristics of contaminant species are completely unknown.

Finally, a last aspect makes the approach of civilian and military CBRN response teams different and, in some sense, complementary: military operators seldom have the need and capability to carry out a complete forensic investigation aimed at identifying the perpetrator of the criminal act, whereas carefully safeguarding the incident scene is a priority for civilian CBRN hazmat specialists working in close contact with police forces. These few, but remarkable, differences often lead to a quite dissimilar approach in the response to the CBRN event and to different (and sometimes complementary) operating procedures in terms of rescue priorities, hazard identification, protective equipment to be used, definition of the exclusion zones and approach to decontamination. This gap is frequently a problem, when major emergency events occur and a joint effort by civilian and military organisations is required.

4.2 Can the Equipment Be the Solution to All Issues?

During the planning step, before a CBRN-related event occurs, it is essential to manage and define four main aspects:

- Satisfactory training for the personnel who will be deployed at an incident site.
- Adequate equipment to be used by the operators for detection, protection and decontamination purposes.
- A suitable set of operational procedures and protocols to be applied for a coordinated multi-agency response.
- The legal framework, which the first responders and the population have to comply with in the case of an emergency situation, linked to an accidental or intentional release of hazardous agents.

All of these points have to be considered in a holistic and well-balanced way. However, in most cases, decision-makers and leaders of first responder agencies consider the availability of technical equipment as the main source of their concerns and the first point on the priority list.

This approach can be detrimental for the setup of an effective CBRN response plan, particularly when a limited budget for the acquisition of such expensive equipment is available, when small institutions or organisations with scarce human and economic resources are involved in the planning activity or, again, when a discontinuous availability of funds is foreseen. In these cases, in fact, some problems may arise not only in the purchase of innovative technical equipment, but also in the periodic maintenance services, in the constant re-calibration of measurement devices and in the procurement of expired consumables and spare parts (e.g. canister filters...
for gas masks, refills for gas cylinders and breathing apparatuses, decontamination solutions).

There are indeed several model cases that have shown that paying excessive attention (and resources) to equipment, overlooking other fundamental aspects can lead to an inadequate response and even to dramatic consequences. For example, during the 1st Gulf War in 1992, the threat of Iraqi missile attacks with chemical warfare agents against the Israeli civilian population prompted the local government to provide the entire population of circa 4 million with full-face gas masks. Some Israeli cities were eventually hit by missile attacks, although none of them carried chemical or non-conventional warheads. However, during the airstrikes, the wrong use of protective masks by common citizens led to seven fatalities due to asphyxia caused by unplugged canister filters (Danon and Shemer 1994). Other casualties included 230 cases of unjustified self-injection of atropine (as an antidote against nerve toxic warfare agents) by people who assumed (with no reasons) to be intoxicated by chemical weapons. This dramatic outcome is undoubtedly due to panic and poor self-control by gas mask users under stressful conditions but this also reveals a major lack of effective training and instructions about how to properly use these protective devices.

Likewise, in the field of on-site decontamination from hazardous chemical and/or biological agents, a plethora of various decontamination mixtures, solutions and powders are commercially available on the market. Some of them are expensive or require a continuous maintenance or recharge service. Nevertheless, it is clearly proved by several specific studies that the most effective decontamination treatment is performed within the first minute after exposure to a toxic contaminating agent (Capoun and Krykorkova 2014). The most important factor is indeed time, since a timely and early decontamination from CBRN agents can be more efficient in saving lives (or mitigate the damages) than a thorough decontamination carried out later by means of specific or tailored decontamination tools. In emergency situations, appropriate decontamination solutions or tools may not be readily available. Therefore, a physical removal of the contaminant, also by simply water only, can be very effective in reducing the toxic effects on victims by a large amount. For instance, when an animal skin treated with the nerve agent sarin is flushed with water for two minutes, 10.6 times more agent is required to produce the same mortality rate (Levitin et al. 2003). Analogously, 1:10 diluted common bleach, that is a 0.5% sodium hypochlorite solution in water with alkaline pH, is one of the cheapest and most easily accessible universal liquid decontaminating agents, recommended for practically all biological hazardous agents (Rutala and Weber 2015). Actually, 0.5% hypochlorite-containing aqueous solutions are one of the options recommended by the World Health Organization for an effective cleaning and disinfection of surfaces and tools potentially contaminated by COVID-19 virus (WHO 2020). Therefore, the use of widely available household products (such as soap, detergents, bleach, baking soda, talc powder, etc.) can be a really effective and cheap alternative to high-tech complex decontamination systems (Stone et al. 2016).

With regards to medical countermeasures after an event involving CBRN agents, the availability of material is equally not the solution to all problems. For instance, in
October 2002 at the Dubrovka theatre in Moscow, Russian Federation, when some 850 hostages were seized by a group of armed Chechen terrorists demanding the withdrawal of Russian forces from Chechenia, 204 of the hostages present in the theatre hall died when the Russian Police special forces used a mixture of narcotics (presumably carfentanil and halothane; Riches et al. 2012) against the terrorists to neutralise them and carry out the rescue operation. Out of the theatre, the ambulance and emergency medical services had several sets of antidotes to immediately treat the victims and minimise the effect of exposure to chemical agents. While some of the first victims were indeed treated with atropine, the intervention proved to be fully ineffective. Instead, the medical service had no sufficient doses of naloxone, the effective antidote against this class of narcotic agents (Wax et al. 2003). This example also shows how the lack of timely communication among the first responders present on the site, the lack of technical information about the nature of the used agents, an inadequate treatment and the misuse of the antidotes available to the ambulance service combined to produce dramatic consequences for the victims and the population involved in the criminal event.

In the framework of a comprehensive emergency response to a CBRN event, it is therefore worth stressing the key role of ‘non-material’ factors beyond the procurement of ultimate equipment: (1) continuous training, to ensure an effective readiness of the operators at the incident site; (2) broad knowledge to know not only what to do, but, especially, what not to do with the available equipment; (3) robust initial action protocols, which can be put in place by ordinary first responders also when CBRN specialist units are not at the incident site; and (4) ability and flexibility by decision-makers and commanders at the tactical level to set up contingency plans and ‘quick-fix’ solutions when unexpected hurdles and last-minute changes occur.

4.3 Can Psychological Consequences of a CBRN Event Impact the Interagency Response?

In a modern approach to physical and psychological health integrity, it is necessary to consider the need for psychological support for all involved actors. This is particularly relevant for first responders who often cope with stress-generating situations such as CBRN incidents. Furthermore, mental fatigue associated with psychological stress is an important factor to be taken into account for firefighters, police officers, ambulance system operators, etc. This support is an essential tool to prevent the risk of chronic psychological and/or mental diseases. Moreover, when a CBRN attack occurs, the population depends on information delivered by mass media, press and social networks, and a mechanism of inability to gauge the concrete risk through everybody’s own perception might arise. Media can however be vectors of alarmism, since they can often base their information on scarcely objective or complete sources, paying a special attention to scoops and rumours, or more simply due to unfiltered
information. Between 1915 and 2015, 895 terrorist incidents, including 49,014 fatalities occurred worldwide (Johnston 2017). Among them, 20 attacks involved chemical or biological agents, and just eight of those counted more than ten deaths.

Often, psychological impacts can be more relevant than direct effects. For instance, during World War I, the ratio between psychopathologic ‘gas fear’ and chemical agent victims was three to one. Furthermore, following the Tokyo sarin attack (1995) more than 75% of 4023 patients checked into the emergency departments of the local hospitals needed only psychological support due to acute stress (Kawana et al. 2001). Among CBRN weapons, bio agents are typically the most insidious in terms of psychotogenic power. Their effects are not immediate, and latency creates anxiety. Even after only a suspicion of use, they are able to induce fear, behavioural abnormalities, panic and evident psychopathologies (e.g. fear due to uncertainty of hazardous agents and stress). First responders should be aware of these issues and ready to cope with them, until specialist advice arrives.

On the other hand, not only direct victims of an event (i.e. casualties, injured and their direct relatives), but also members of emergency response teams, who work 24 h/7 days a week at the incident site, can be psychologically affected by hazardous events. For this reason, first responders, medical staff, leaders and rescuers are classes of workers to be considered at risk and need periodic mental health support. Previous experiences in psychological disorder treatment show that when a disaster or a high emotional event occurs, a psychological trauma does not develop automatically in all cases, in people with a strong mental equilibrium. Thus, first responders must be professionally trained in rescue activities and should also possess a remarkable human and psychological capability not only to contain and control emotions, but also to guarantee a proper support to victims, team members and themselves. In addition, mental health professionals should use resources to analyse any psychological and behavioural changes to understand in advance if the stress-acceptability threshold would be reached, and to avoid the risk of subsequent chronic psychological diseases.

5 Conclusions

A proper definition of the CBRN agent is essential to understand whether we are facing a CBRN event or not. Public opinion and mass media often amplify misconceptions and false myths about non-conventional weapons and agents. An erroneous knowledge can lead to incorrect previsions and inappropriate evaluations of the situation and affect negatively the response action. Some common misconceptions referring to chemical warfare agents are, for instance, the following:

- ‘War gases’ are rarely gases. Most dangerous chemical weapons are typically in liquid (persistent agents) or solid phase. If first responders and personnel are well trained and adequately equipped, the threat posed by toxic chemicals—even the deadliest ones—can be efficiently reduced and sometimes virtually neutralised.
Chemical warfare agents have proved to be ca. 5% fatal on battlefields (Bismuth et al. 2004). They rather inflict large numbers of minor and major non-lethal injuries causing a significant logistical burden. The ‘real’ damage provoked by CWA is usually less than the one due to conventional weapons. However, the impact on the public opinion can be significant and overwhelming.

At equal charge and range, the damage provoked by conventional explosives is, on average, seven times higher than that due to unconventional CWAs (McCarthy 2003). Even more, in the last years, machetes, explosives, mines and the use of road vehicles or aircraft have proved to be atrociously efficient tools in episodes of genocide or terrorist attacks, with the dramatic examples of former Yugoslavia, Rwanda and the Twin Towers attacks clearly showing how a high-level technology is not the primary way to disseminate fear and inflict harm.

Mass media often report that terrorist groups and rogue nations are restlessly working to discover novel highly toxic compounds, even though that does not represent the reality (some 100,000 chemicals have been screened since WWI but some 60–70 compounds only have been found suitable for weaponization and criminal use; Pitschmann 2014).

Only correct awareness-raising campaigns and proper technical training activities can help CBRN response professionals to go beyond erroneous judgements given by non-expert opinion-makers and impartially evaluate immediate risks for the operators on the site and for the surrounding population, foresee both short-term and long-term consequences and adopt the most suitable medical countermeasures, decontamination strategies and recovery plans.

As in other fields of coordinated response to major emergency situations, in the case of an event implying the accidental or intentional release of hazardous chemical, biological and/or radiological agents, a careful and properly planned multi-agency response involving specialist units from fire brigade, ambulance service, hazmat teams, police forces, environmental services and armed forces is a winning strategy to cope with and manage all the phases of an incident, from the initial moments to the final recovery step. In only a few cases, however, at worldwide level, governmental agencies and institutions are ready and properly trained to work together according to a coordinated and well-organised plan. It is therefore crucial that civilian as well as military on-field CBRN responders, institutional decision-makers and academic researchers are all aware of these major gaps, in order to attain all of the main goals for a successful response to a non-conventional emergency event. This chapter laid out the most important aspects and considerations in preparing for and managing coordinated CBRN incidents outlining principles applicable for incidents from local to international levels. These can help to preserve and protect lives, mitigate and minimise the short-term and long-term impact of a CBRN incident, inform the public and maintain public confidence, prevent, deter and detect crime and, last but not least, assist the community in an early return to a new normality.
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