Arch. Immunol. Ther. Exp. (2014) 62:437–444
DOI 10.1007/s00005-014-0306-x

CONFERENCE PROCEEDINGS

Economic Impact Profiling of CBRN Events: Focusing on Biological Incidents

Simona Cavallini · Fabio Bisogni · Marco Mastroianni

Received: 7 March 2014 / Accepted: 9 July 2014 / Published online: 22 July 2014

Abstract Chemical, biological, radiological and nuclear (CBRN) incidents, both caused accidentally by human error or natural/technological events and determined intentionally as criminal/malicious/terroristic acts, have consequences that could be differently characterized. In the last years many efforts to analyze the economic impact of terrorist threat have been carried out, while researches specifically concerning CBRN events have not been extensively undertaken. This paper in particular aims at proposing a methodological approach for studying macro-level economic impact profiles of biological incidents caused by weaponized and non-weaponized materials. The suggested approach investigates the economic consequences of biological incidents according to two main dimensions: type of large-scale effect and persistence of effect. Biological incident economic impacts are analyzed taking into account the persistence of effect during time as short-term impact (i.e. immediately after the incident), medium-term impact (i.e. by a month) and long-term impact (i.e. by years). The costs due to preventive countermeasure against biological threats (e.g. prevention, protection and preparedness expenses) are not taken into account. To this purpose, information on the key features of past biological incidents can be used as case studies to try to build impact profiles taking into account the proposed two main dimensions. Consequence management and effect mitigation of CBRN emergencies and disasters may benefit from an ex ante definition of the impact profiling related to this kind of incidents. The final goal of this paper is to define an approach to organize information on possible biological events according to their impact profile for supporting more effective and efficient first responders' prompt actions and policy makers' strategic decisions after the event occurrence.

Keywords CBRN events · Biological incidents · Impact profiles · Persistence · Economic impact

Introduction

Chemical, biological, radiological and nuclear (CBRN) incidents are addressed with a special attention by the policy makers for their potential impact. "*While so far major incidents involving CBRN materials… have been relatively few, the consequences of such an incident could be devastating*" (Council Conclusions 15505/1/09 rev.1) and "*it is not a question of* ***if*** *a CBR event will occur, but effectively a question of* ***when*** *an event will occur…*" (National Infrastructure Advisory Council 2008).

Most of the effects are strictly related to materials causing incidents. Chemical, biological, radiological and nuclear materials (weaponized or not) impacts differently both at micro and at macro level.

The effects of the CBRN materials are well known and defined referring to specific cases (e.g. health effects of contact with Anthrax spores); first responders' and policy makers' perspective information on the potential macro level economic impacts may support prompt actions and strategic decisions [e.g. large amounts of cesium-137 and

Presented at IAP Scientific Seminar "Natural or Deliberate Outbreak—How to Prevent or Detect and Trace Its Origin: Biosecurity, Surveillance, Forensics" co-organized by the Polish Academy of Sciences and the Military Institute of Hygiene and Epidemiology on December 6, 2013 in Warsaw.

S. Cavallini (✉) · F. Bisogni · M. Mastroianni
Fondazione FORMIT, Via Giovanni Gemelli Careri 11, 00147 Rome, Italy
e-mail: s.cavallini@formit.org

other dangerous isotopes spread by winds as in the case of Fukushima, WHO (2013)] in order to mitigate potentially devastating and long-term economic losses. In this context, elements affecting the seriousness of the potential economic impact are several (e.g. density of population of the affected area, geographical features of the affected area, quantity of dispersed material, health-care response efficiency); many of such parameters have a cascading effect to greatly worsen the economic impact in terms of geographical extension and endurance, i.e. long-term effects).

Nevertheless, the structural effects of CBRN incidents, and biological events in particular, can be generally profiled through an ad hoc methodological approach.

To this purpose, our approach for biological incidents investigates two main dimensions: (a) type of large-scale economic effect and (b) persistence of effect.

In case of a biological incident, casualties and impacts on health are the main effect to be mitigated by first responders; they are essentially prepared for safeguarding human lives and reducing mass casualties. Policy and decision makers have the challenging task to restore the normal-life situation with the least economic losses in the shortest time. Additionally, health impact has an important economic weight (e.g. health service cost, life insurance.

Kaufmann et al. (1997) modeled an economic analyses of a theoretical biological post-attack due to three classic agents of biologic warfare (*Bacillus anthracis*, *Brucella melitensis*, and *Francisella tularensis*) released as aerosols in the suburb of a major city (the population exposed amounting to 100,000 persons); for each type of considered agent, the economic impact was measured exploiting as main parameter the Cost of Hospitalization and Outpatient Visits. The research considered that only persons with symptoms (i.e., case-patients) would use medical facilities. The remainder of the exposed and potentially exposed population would receive post-exposure prophylaxis. They stressed the time-dependent effectiveness factor of the response: "*The speed with which a post-attack intervention program can be effectively implemented is critical to its success*".

Other researchers (RAND Corporation 2005) analyzed the possible insured losses related to two different types of Anthrax attack: one inside a single large building and the other widely dispersed outdoor. In this case the chosen parameters are relative to the geographical extension, property damaged insured and workers' compensation while time-dependent ones are not weighed.

A methodological approach to the economic profiling of biological incident can be crucial for both immediate response of policy makers and to reduce bio-security cost. Several response plans have been implemented for the risk assessment and potential impacts of potential biological events. The document related to the chemical, biological, radiological and nuclear risk assessment published by GAO (2012) reviews response plans (i.e. STRATPLAN for biological attacks, Biological incident annex of the National Response Framework) in order to define the response capabilities to biological incidents of the USA first respondents.

Similar investigations activities are carried out at the European level (European Commission 2012): implementation of biological actions ranges from adoption of risk management standards to codes of conduct in bio-issues for laboratories, from funded research project on bio-security to a structural activity for ensuring bio-safety and bio-security of the European Centre for Disease Prevention and Control.

The proposed analysis aims to integrate the previous research experience and policy actions on impact assessment of biological events providing an immediate information approach to make policy makers' strategic decisions more effective and efficient in case of such incidents.

Aiming to this purpose, this document is structured as follows: the next section describes the type of large-scale economic effects within the proposed approach followed by a section that defines the second dimension investigated, the persistence of the effects; possible indicators to be taken into account to measure the economic impact are illustrated in the subsequent section, followed by an attempt to profiling the economic impact of biological incidents. The last section summarizes the main findings of the research and proposes new related domains of impacts of biological events to be investigated.

The Proposed Approach: Type of Large-Scale Economic Effects

Defining the economic effects of a critical event is essential to set the boundaries of the current research. CBRN events, caused accidentally or determined intentionally, mostly occur in an environment with intense socio-economic activities. This implicates that a series of economic impacts should be considered when profiling an incident. According to Ramseger et al. (2009), the economic-related effects to be investigated in case of CBRN events are at least three: the economic impact of the past disasters, the probable financial impact of possible incident scenarios, and the financial efforts to prevent chemical, biological or radiological attacks or to minimize their consequences.

The current research focuses only on the first type of effects, those occurring in the aftermath of an incident, aiming to contributing at research studies on the other two domains. In this context, heterogeneity of assessment approaches and lack of public available data strongly affect

the opportunity to compare different cases. As already stated by Ramseger et al. (2009), parameters used in these studies vary, as do the number of examined or estimated damaging events. Few studies look at the impacts both at long-term and short-term effects and at macroeconomic and microeconomic effects and most of the times focus on a single case.

Economic effects of a biological incident may be assessed differently according to the selected methodologies and to the adopted indicators. Enders and Sandler (2011) review some works related to potential consequence scenarios for CBRN attacks. In the biological case, assessment of the consequences ranges from 26.2 billion dollars for an aerosol spray of Anthrax spores with 100,000 people exposed to 254 billion dollars for 10 kg of Anthrax slurry in a large city. Another large part of the literature related to the assessment of the effects of large-scale critical events relies on the evaluation of consequences on assets and unavailability of infrastructure network disregarding causes. Any effect is the target of investigation; one of the main difficulties in its assessment to be considered is the definition of the incident key elements.

From the social point of view, CBRN incidents may cause behavioral, cognitive and physical damages to persons that, together with economic costs due to cascading effects for failures of potential critical infrastructures and assets, may increase the number of victims.

Basically this approach follows the European Union point of view related to the relevance of critical infrastructures. According to the Directive 2008/114/EC on *the identification and designation of European critical infrastructures*[1] *and the assessment of the need to improve their protection*, impacts of failures should be assessed in terms of the so-called "cross-cutting criteria", including the effects of cross-sector dependencies on other types of infrastructure.

In particular, according to Article 3, the identification process of each Member State should include, as detailed in Comma 2:

- *"casualties criterion (assessed in terms of the potential number of fatalities or injuries)*;
- ***economic effects criterion*** *(assessed in terms of the* ***significance of economic loss and/or degradation*** *of products or services; including potential environmental effects)*;
- *public effects criterion (assessed in terms of the impact on public confidence, physical suffering and disruption of daily life; including the loss of essential services)."*

[1] Infrastructures located one of the Member States of the European Union and whose destruction or malfunction would have a significant impact in at least two Member States of the EU.

Also within the CBRN context, at least the same three types of large-scale effects of the post-event period should be considered. This approach is confirmed by what is mentioned in the introduction of the Communication COM 273 final (2009), on *Strengthening Chemical, Biological, Radiological and Nuclear Security in the European Union—an EU CBRN Action Plan*: *"it is clear that no public authority can afford to ignore this threat given its potentially very significant consequences in terms of human life and its* ***economic effects****. There is also a consensus amongst experts that the case of a somewhat limited attack needs to be carefully considered because the psychological, health and economic effects on the population of even a small scale attack using such materials would be significant"*.

In this regulation context, each CBRN incident can be characterized according to three types of large-scale effects:

- Casualties (effects in terms of persons)
  - Injuries
  - Fatalities
- Social impact (effects in terms of persons, assets and infrastructures)
  - Changes in social confidence
  - Changes in quality of life
  - Movement of communities with personal/cultural losses
  - Effects of unemployment, etc.
- Economic impact (effects mainly in terms of assets and infrastructures)
  - Damages to productive infrastructures
  - Costs for re-building
  - Costs for decontamination (including environment losses, costs for improve health assistance), etc.

This EU perspective is generally relative to any CBRN events but the chosen parameters are unfitting to measure the large economic impact for biological events.

Biological incidents may also have large-scale effects on the social and economic point of view. To this purpose, strategic decision makers and policy responsibles should be prepared to set up appropriate measures to reduce potential societal impacts in the short, medium and long term. For instance, contaminated sites may generate economic costs for interrupted/impossible-to-recover productive activities (such as those related to the abandoned areas) and/or for decontamination actions for making available appropriate public health assistance (such as those for medium-term hospitalization of victims of different degrees). For example, "Damages to productive infrastructures" and

"Cost for re-building" can hardly be profitable to assess the economic losses in case of Antrax spores release or a virus outbreak.

Referring to scientific literature, specific studies have been carried out on the economic perspective, even if not tailored for biological events.

Ramseger et al. (2009), for instance, hypothesize a two consecutive step methodology to assess the economic impact of the CBRN threat. The first step is based essentially on the identification of the substances involved in the incident and on the analysis of the related categories of costs. Adapted to the biological case, this results in the identification of four types of substances (Enders and Sandler 2011):

- Poison (ricin, botulinum toxin)
- Viruses (smallpox, viral hemorrhagic fevers, virulent flu)
- Bacteria (anthaxa, brucellosis)
- Plagues (black plague, tularemia)

The second step is related to the definition of the main element of the four cost categories of the CBRN incident: first-response measures, recovery, reconstruction and restoration, indirect damage, macroeconomic loss (Table 1).

Other crucial parameters for the profiling, authors say (Ramseger et al. 2009, p. 72), could be the economic loss, due to casualties but *"it is important to distinguish clearly between the economic value assumed for a lost life and compensation demands for a lost life.(…) According to a representative from an international insurance company (i.e. American International Group), insurance companies have experienced that legal claims in respect of loss of human life are settled quite differently in different regions of the world. Publicly available loss statistics indicate that typically, settlements of fatality claims in the USA are often in the order of some million euros. The costs for the life-long support of a young invalid* ***are much higher than the economic loss caused by his death.*** *The average economic values given represent a rough approach and can only be used to* ***approximately estimate the economic impact****"* of a biological event.

Our approach is exploiting such two-step methodology to the study of biological events but adding a second dimension to further enrich the analysis: the persistence of the effect.

Table 1 Breakdown of the CBRN incidents costs

Type of cost	Chemical/biological/radiological/nuclear incidents: potential economic effects
First response measures	• Rescue of injured and threatened people
	• Evacuation
	• Registration of contamination
	• Blocking the spread of dangerous CBRN materials
	• Immediate decontamination
	• Measures to cordon off the contaminated area
Recovery, reconstruction, restoration	• Health care for injured people
	• Costs for the deceased (medical forensics, funerals, life insurances)
	• Pensions, etc. for disabled people
	• Cleaning up measures and thorough decontamination
	• Reconstruction of buildings
	• Resettlement and relocation
	• Restoration of infrastructure: transport system, public services (water supply, electricity, telephone network)
	• Gathering of infected animals
	• Clearance of contaminated cadavers and plants (CBRN waste management substances)
Indirect damage cost	• Loss of earnings caused by loss of consumer confidence
	• Loss of earnings caused by (preventive) culling
	• Loss of earnings caused by decline in tourism
	• Loss of earnings resulting from injuries/sicknesses or death of employees
	• Loss of earnings because of state of emergency (regional and international)
	• Economic impact of temporary infrastructure breakdown: transportation system, public services (water supply, electricity, telephone network)
Macroeconomic loss	• Consequential costs from loss of income (multiplier effects)
	• Loss of investor confidence/propensity to save

Source: Ramseger et al. (2009)

The Proposed Approach: Persistence of the Effects

Analysis of the persistence of the effects should be strictly related both to specific scenarios and to the idiosyncratic features of the biological domain, for instance, seriousness of contamination of an environment as consequence of a biological incident, exposure, contamination and free-floating and capability of the material.

Nevertheless, the main features of the substances may be identified in terms of symptoms displays, casualties' appearance and persistence in the environment.

Differently from the chemical, radiological and nuclear (CRN) materials incidents, biological agents pose more difficulties in the identification process. Elaborating the

Table 2 Main elements characterizing biological and CRN materials

	Biological material	Chemical material	Radiological material	Nuclear material
Symptoms displays	Delayed	Rapid	Rapid and delayed	Immediate and delayed
Casualties appearance	Gradual and in a spread way	Simultaneous and concentrated	Simultaneous, gradual and in a spread way	Simultaneous, gradual and in a spread way
Persistence in the environment	High	Low	Very high	Very high

Source: Elaboration of indications of Garcia et al. (2011)

Table 3 Main elements affecting persistence

	Biological material	Chemical material	Nuclear/radiological material
Onset	Slow	Rapid	Rapid
Transmission/infectivity	Slow, agent dependent	Fast, agent dependent	Particulate only, fast
Detection	Difficult	Easier	Easier
Resource consumption	Gradual, long term	Rapid, short term, some long term	Rapid, short and long term
Public health involvement	Short and long term	Short term	Short and long term
Bed use	Mixed	Hospital	Hospital
Decon. requirements	Agent dependant	Critical for all	Critical for particulate
Antidote	Agent dependant	Class dependant	None

Source: Kollek (2006)

main indications from Garcia et al. (2011), three main elements characterized the biological materials from CRN ones: symptom displays, casualties' appearance, persistence in the environment (see Table 2). In most of the biological cases, symptoms are delayed, casualties start to appear gradually and in a spread way and persistence of the material is high (although not as in radiological and nuclear cases).

In fact, casualties (and related economic losses) are strongly dependent on the specific agent/material and its features such as contamination capability, free-floating capability, incubation period, virulence, and lethality temperature. In addition, context/event conditions may affect the persistence of the effects. Among these: scale, exposure, distance, duration, climate, transmission mechanism.

In this paper, incident impacts are proposed to be analyzed also by taking into account the persistence of effect during time as short-term impact (i.e. immediately after the incident), medium-term impact (i.e. by a month) and long-term impact (i.e. by years). Table 3 depicts a comparison between CBRN material effect in terms of elements affecting persistence; as noted before, the number of casualties also has an important impact on the national economy because of the consequent costs for the Health Care System due to any single patient/deceased people; such impact is strongly time dependent.

According to the previous indications on persistence relevance of the biological material, the tailored "Ramseger approach" can provide useful suggestions on the period of reference of the detailed economic losses in case of an incident (Table 4).

A Case Study: A Preliminary Information Collection for a Possible Profiling

Information on key features of past biological incidents was collected both on the type of large-scale effects and on the persistence of this effect. In particular, quantitative data were gathered in order to define homogeneous indicators useful to build comparable impact profiles.

For the selected case study, different types of official sources were investigated in order to define a general profile of the incident. The most relevant information on the affected area is reported in order to attempt to build impact profiles at least for the effects in economic terms also taking into account loss in casualties.

A Case Study for a Biological Incident: 18 September 2001, USA

Starting 18 September 2001, four unknown letters with bacteria Anthrax were delivered to news media offices and to US Democratic Senators. The terroristic attack was supposed by many official sources to be organized by Al Qaeda. The effects in terms of casualties were 5 fatalities,

Table 4 Breakdown of the biological incidents costs by persistence

Type of cost	Short term	Mid term	Long term
First response measures	• Rescue of injured and threatened people • Evacuation • Registration of contamination • Immediate decontamination • Measures to cordon off the contaminated area	• Blocking the spread of dangerous biological materials	
Recovery, reconstruction, restoration	• Health care for injured people	• Cleaning up measures and thorough decontamination • Resettlement and relocation • Restoration of infrastructure: transport system, public services (water supply, electricity) • Gathering of infected animals • Clearance of contaminated cadavers and plants (Biological waste management substances)	• Costs for the deceased (medical forensics, funerals, life insurances) • Pensions, etc. for disabled people
Indirect damage cost	• Loss of earnings caused by loss of consumer confidence • Loss of earnings caused by decline in tourism • Loss of earnings resulting from injuries/sicknesses or death of Employees	• Loss of earnings because of state of emergency (regional and international) • Loss of earnings caused by (preventive) culling • Economic impact of temporary infrastructure breakdown: transportation system, public services (water supply, electricity, telephone network)	• Economic impact of temporary infrastructure breakdown: transportation system, public services (water supply, electricity, telephone network)
Macroeconomic loss		• Consequential costs from loss of income (multiplier effects)	• Loss of investor confidence/propensity to save

Source: Elaboration of Ramseger et al. (2009)

22 serious injuries (11 cases of inhalational anthrax and 11 cases of cutaneous anthrax).

According to the data collected by Ramseger et al. (2009), the economic costs for the above-mentioned categories are summarized in the Tables 5 and 6.

Indirect economic effects should be included in the computation of the incident losses due to the persistence of health damages of the affected people. Reissman et al. (2004) stress that "*…long-term effects of bioterrorism-related anthrax infection are essentially related to the psychological impact of the exposure and are as significant as the physical effects of the disease. The study involved 15 of the 16 adult anthrax survivors from September to December 2002, approximately one year after they were infected as a result of the bioterrorist attacks. The results showed that the anthrax survivors reported moderate to severe symptoms affecting many body systems. Eight of the survivors had not returned to work since their infection. The most commonly reported also health complaints included: Chronic cough, Fatigue, Joint swelling and pain, Memory problems. The most frequently cited symptoms of psychological distress were: Depression, Anxiety, Obsessive–compulsive behavior, Hostility*".

An Attempt at Impact Profiling

In attempting to profile impacts in terms of economic damages, the proposed indicator is the severity of the direct (i.e. first response measures, recovery, reconstruction, restoration) and indirect (i.e. indirect damage cost, macroeconomic loss) effects in the area of reference.

In terms of economic effects, economic values of damages of biological incidents should be reported in absolute terms. The main obstacles to provide reliable values are two: lack of information/data on specific cost elements with the risk of underestimation of the overall economic losses; and differences in the assessment approaches used to define the cost elements with the risk of bias estimation of the overall economic losses.

Immediate effects of a biological incident are highly severe in terms of victims, probably less than a comparable

Table 5 Economic costs by event during the attack with bacteria Anthrax on 18 September 2001, USA

Attack date	Event	Economic cost	Potential economic effects (adapted by the "Ramseger approach")
15 January 2002	US postal and law enforcement officials announce that the reward for information on the perpetrator(s) of the anthrax attacks will be increased to 2 million USD	2 million USD	• Security measures
22 January 2002	Official announcement of the increase in the reward for information: In addition, postal and law enforcement officials announce that they will send out 500,000 flyers targeting central New Jersey and Bucks County (PA) in a search of additional information. The Hart Office Building officially reopens after 96 days of quarantine and decontamination. The Environmental Protection Agency estimates that it has spent 13.3 million USD on clean-up operations, and expects the total cost to rise to 20 million USD	13.3–20 million USD	• Registration of contamination • Immediate decontamination
26 March 2002	Postal officials estimate that it will cost 35 million USD to clean both the Brentwood and Hamilton (NJ) postal facilities	35 million USD	• Cleaning up measures and thorough decontamination • Resettlement and relocation • Restoration of infrastructure: transport system, public services (water supply, electricity)
26 July 2002	Postal service officials hold a press conference to announce that a test of decontamination techniques at the Brentwood facility will be conducted on 29 July. Postal officials also estimate that it will cost approximately 22 million USD to decontaminate the facility	22 million USD	• Cleaning up measures and thorough decontamination • Resettlement and relocation • Restoration of infrastructure: transport system, public services (water supply, electricity)
30 July 2002	Postal service officials in New Jersey announce that the Trenton Processing and Distribution Center in Hamilton will be reopened in the spring following a 20 million USD decontamination and renovation process	20 million USD	• Cleaning up measures and thorough decontamination • Resettlement and relocation • Restoration of infrastructure: transport system, public services (water supply, electricity)

Source: Elaboration of Ramseger et al. (2009)

CRN incident. Concerning the economic effects, medium persistence is a characterizing element of a biological incident: generally chemical cases do not generate casualties after the first month while the radiological and nuclear ones continue over time.

Desk research on public available data on the attack with bacteria Anthrax on 18 September 2001 in the USA gave no opportunity with the collected information to define a detailed profiling of the economic impact of such incident. In any case the adapted "Ramseger approach" applied to the Antrax attack allows to create a general curve of the economic impact for biological events.

Figure 1 illustrates a potential profiling of the severity of economic costs for four different points in a timeline

Table 6 Overall impact of the attack with bacteria Anthrax on 18 September 2001, USA

Preventive costs	2 million USD (€1.78 million) to get information on the perpetrator(s)
Costs for decontamination	90.3 million USD (€80.46 million)
People killed	5
People injured	22

Source: Ramseger et al. (2009)

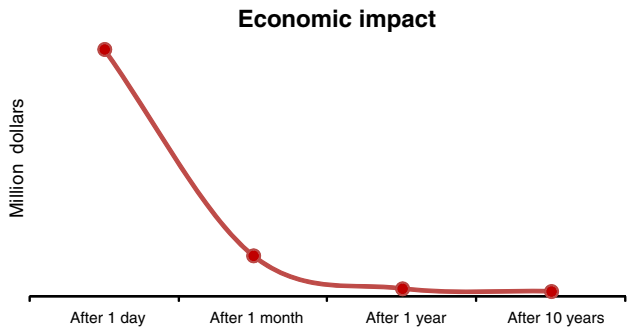

Fig. 1 Economic impact profiling of a biological incident

considering short-term, medium-term and long-term effects.

Although economic losses are not detailed in terms of millions of dollars such impact profiling gives a qualitative idea of the timing of costs and their related needed expenses in order to recover the socio-economic context affected by the biological incident.

Conclusions

Consequence management and effect mitigation of CBRN emergencies and disasters may benefit from an ex ante definition of the impact profiling. The main goal of this paper is to provide an information base to make first responders' prompt actions and policy makers' strategic decisions immediately after the occurrence of the events more effective and efficient. The leading perspective are the economics and the proposed methodology gains from previous research experience and approaches trying to create a profile of biological incidents according to the type of economic damage and its persistence. Numerous studies have faced the problem of the assessment of impact of past events and other investigations have been focused on the quantification of the economic losses, but heterogeneity of methods is the rule.

Further analysis on past biological incidents should be conducted through the proposed approach in order to both refine the impact profiling of these events and study the single components of the economic costs. Indirect effects and social impacts deserve additional research activities.

References

(2009) Communication COM 273 final, Communication from the Commission to the European Parliament and the Council on Strengthening Chemical, Biological, Radiological and Nuclear Security in the European Union—an EU CBRN Action Plan, 24 June 2009

Council Conclusions 15505/1/09 rev. 1 on Strengthening Chemical, Biological, Radiological and Nuclear Security in the European Union—an EU CBRN Action Plan, 12 November 2009

Directive 2008/114/EC of the Council (2008) On the identification and designation of European critical infrastructures and the assessment of the need to improve their protection, 8 December 2008

Enders W, Sandler T (2011) The future of terrorism. In: The political economy of terrorism. Cambridge University Press, Cambridge, UK

European Commission (2012) Progress report on the implementation of the EU CBRN Action Plan. Public version, May 2012

GAO (2012) Report to the Committee on Homeland Security and Governmental Affairs, US Senate. Chemical, biological, radiological, and nuclear risk assessment—DHS should establish more specific guidance for their use. United States Government Accountability Office, January 2012

Garcia AF, Rand D, Rinard JH (2011) Jane's CBRN Response Handbook, Chap 2, 4th edn. On-scene procedures, IHS Jane's

Kaufmann AF, Meltzer MI, Schmid GP (1997) The economic impact of a bioterrorist attack: are prevention and postattack intervention programs justifiable? Emerg Infect Dis 3:83–94

Kollek D (2006) CBRN overview, lesson at Public Health CBRN course of The Center for Excellence in Emergency Preparedness, Ontario

National Infrastructure Advisory Council—NIAC (2008) Final report and recommendation by the council: chemical, biological, and radiological events and the critical infrastructure workforce

Ramseger A, Kalinowski MB, Weiß L (2009) CBRN threats and the economic analysis of terrorism", prepared for the Network for the Economic Analysis of Terrorism (NEAT). Economics of Security Working Paper 9, Economics of Security, Berlin

RAND Corporation (2005) Distribution of losses from large terrorist attacks under the Terrorist Risk Insurance Act. RAND *terrorism risk management policy*

Reissman DB, Whitney EA, Taylor TH Jr et al (2004) One-year health assessment of adult survivors of *Bacillus anthracis* infection. JAMA 291:1994–1998

WHO (2013) Health risk assessment from the nuclear accident after the 2011 Great East Japan earthquake and tsunami based on a preliminary dose estimation. World Health Organization