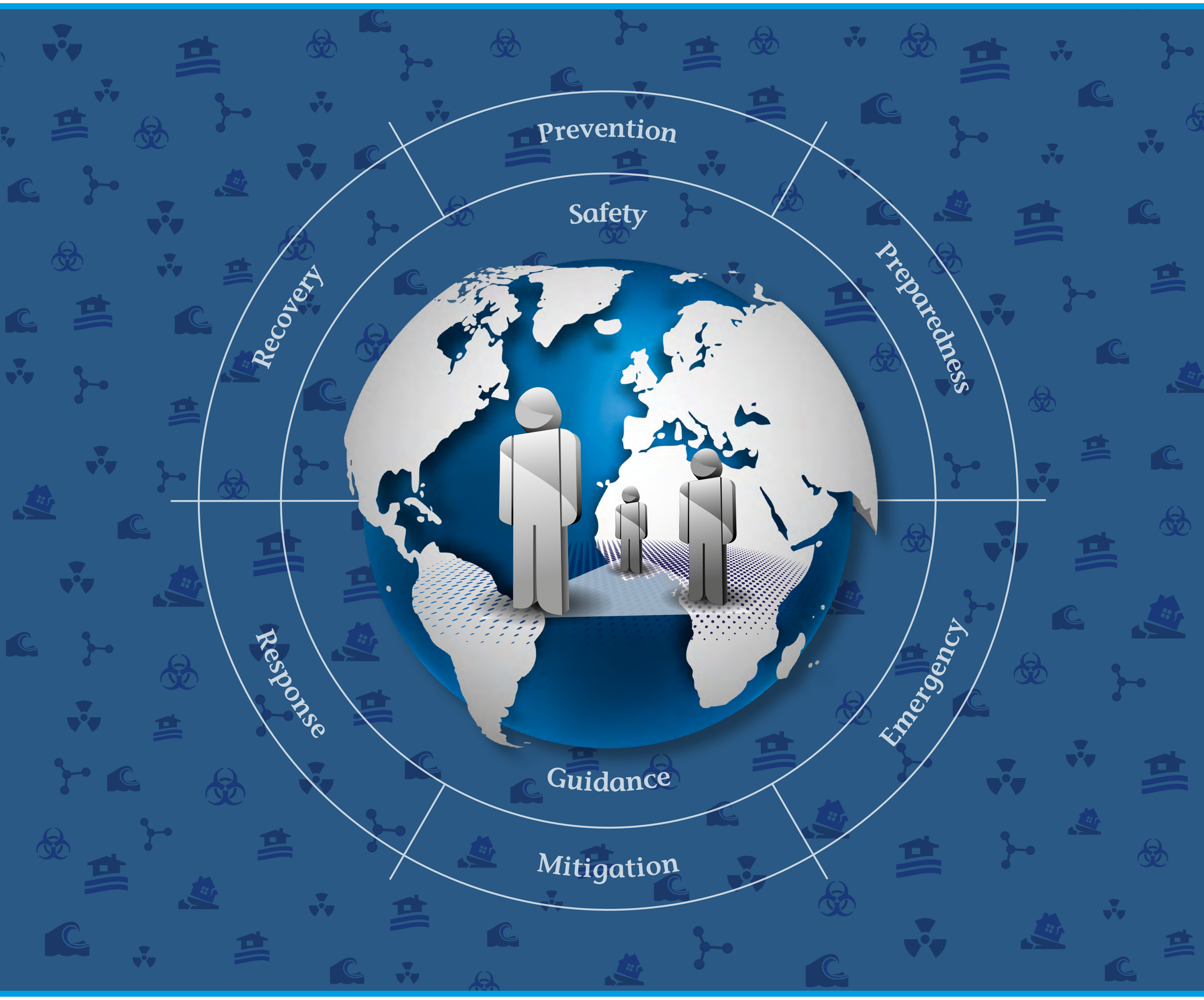
Towards an All-Hazards Approach to Emergency Preparedness and Response

Lessons Learnt from Non-Nuclear Events



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Radiological Protection

Towards an All-Hazards Approach to Emergency Preparedness and Response

Lessons Learnt from Non-Nuclear Events

NEA No. 7308

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The OECD Nuclear Energy Agency (NEA) was established on 1 February 1958. Current NEA membership consists of 33 countries: Argentina, Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, Romania, Russia, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission and the International Atomic Energy Agency also take part in the work of the Agency.

The mission of the NEA is:

- to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally sound and economical use of nuclear energy for peaceful purposes;
- to provide authoritative assessments and to forge common understandings on key issues as input to government decisions on nuclear energy policy and to broader OECD analyses in areas such as energy and the sustainable development of low-carbon economies.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

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Foreword

Matters related to nuclear emergencies have long been a focus of the Nuclear Energy Agency (NEA). These efforts have been aimed at continuously improving the effectiveness of nuclear emergency preparedness and management at national and international levels. A key aspect of these efforts has centred on preparing, conducting and evaluating the International Nuclear Emergency Exercise (INEX) series, which have been organised by the NEA since 1993. The experiences and lessons learnt from these exercises have provided a substantial base for the development of subsequent strategies and recommendations for improving emergency management systems both nationally and internationally. Particularly as lessons learnt are absorbed from the accident at the Fukushima Daiichi plant, the subject of nuclear emergencies continues to be a major priority for NEA countries as reflected in the NEA Strategic Plan for the 2017-2022 period.

While the NEA and other international organisations such as the International Atomic Energy Agency (IAEA) focus their work on the important area of nuclear emergency preparedness, it is clear that emergency management is not an area that is specific only to the nuclear field. While the topic of nuclear emergency preparedness and management is broad, complex and dynamic in and of itself, in the post-Fukushima context emergency preparedness and response (EPR) is more than ever seen as part of an even broader framework. For that reason, the Council of the Organisation for Economic Co-operation and Development (OECD) has recognised the importance of a strong and unified response and have urged the inclusion of nuclear and radiological emergency preparedness into the more comprehensive domain of "all-hazards emergency planning". In 2015, the OECD Council issued a recommendation on the governance of critical risks, advocating that "members establish and promote a comprehensive, all-hazards and transboundary approach to country risk governance to serve as the foundation for enhancing national resilience and responsiveness". Achieving such a comprehensive, all-hazards, transboundary approach to country risk governance is not an easy endeavour and will be a long-term process that implies the involvement of multiple actors, both at national and international levels. It will also mean approaching the process from a multidisciplinary perspective.

NEA countries have over the years built robust emergency management systems, which are regularly tested and enhanced through lessons learnt. Many lessons may arise from the use of nuclear emergency management infrastructure in responding to non-nuclear incidences. Nevertheless, it is the nature of nuclear operations and regulation, including emergency management, to learn from all experiences. Experience arises from both exercises and from real accidents. If we hope to achieve an all-hazards approach, a major step in this process will be to take into account experiences from the emergency management of hazards other than those that may emanate from the nuclear sector. As an agency within the framework of the OECD, the NEA is uniquely placed to act as a focal point for co-ordination with other disciplines and actors in nuclear and non-nuclear emergency management in order to foster an integrated all-hazards approach to emergency preparedness and response.

Guided by this logic, and from a strategically placed position, the NEA Working Party on Nuclear Emergency Matters (WPNEM) began to gather lessons from non-nuclear events. The activities of the WPNEM, led by Ms Patricia Milligan from the United States Nuclear Regulatory Commission (NRC), prompted the NEA Secretariat to join forces with the OECD Working Group on Chemical Accidents (WGCA), the OECD Public Governance and Territorial Development Directorate's High Level Risk Forum (HLRF) and the European Commission's Joint Research Centre (JRC), which operates the Major Accident Reporting System (eMARS) database. This collaboration resulted in the present report, which consists of a set of expert contributions that have been enriched with national experiences from countries such as the United States and Japan in an effort to learn from non-nuclear events and build an all-hazards approach to EPR. As an example of how a cross-disciplinary approach may provide new insights, this report provides special attention to the advent of mental health issues in the aftermath of an emergency situation. Mental health arose as a significant, long-term public health problem that ensued from nuclear accidents at Three Mile Island and Chernobyl. These issues remain a pressing public health concern in the aftermath of the Fukushima Daiichi accident. To raise awareness on the mental health side of emergencies, the report includes a chapter on public health lessons from accidents involving exposure to toxic substances, based on the work of experts in this field, and particularly J.M. Havenaar and E.J. Bromet.

The report represents a major milestone towards building an all-hazards approach, as well as towards the strategic goal of working more closely with the OECD family and other international organisations. Experts from outside of nuclear and radiological fields participated in this NEA report, analysing databases and drawing from published works in an effort to assist the nuclear and radiological response community. The NEA has ensured the overall co-ordination of the report, while respecting the different approaches, styles and terminology of the authors.

The report is presented primary for the interest of the international community and does not represent an analysis or an endorsement by the WPNEM. Our intention is to demonstrate a similarity in emergency planning and preparedness across sectors and identify lessons learnt and good practices. These lessons, originating from the multidisciplinary perspectives of fields outside of the nuclear sector, can be used by countries, as appropriate, to enhance already existing, robust nuclear emergency preparedness and response systems. Countries implementing the OECD Council Recommendation on the Governance of Critical Risk may also benefit from such lessons.

The NEA Committee on Radiological Protection and Public Health (CRPPH) has underlined the tremendous value of this work and the efforts undertaken by the WPNEM towards an all-hazards approach to emergency preparedness and response, and it has encouraged the WPNEM to continue in this direction, emphasising the importance of such a multidisciplinary perspective. The NEA will continue to foster its long-term relations with the IAEA, the European Commission (EC) and the World Health Organization (WHO), and strengthen the fruitful collaboration with the OECD Working Group on Chemical Analysis and the EC Joint Research Centre, as well as with the OECD Directorate for Public Governance.

The principles underpinning these interactions are linked to a desire to identify synergies, co-ordinate efforts and avoid duplication of work so as to optimise resources. The overall aim is to join forces in order to continue improving already robust nuclear emergency management systems and contribute to building an all-hazards approach in OECD and NEA member countries. The next steps in this process will be to organise an international joint workshop bringing together EPR experts from different sectors addressing different types of hazards – either natural or human-made – to share experiences, identify best practices and issue recommendations to further move towards an all-hazards approach to emergency preparedness and response. Involving the public, the media (traditional and social media) and other relevant stakeholders will be an important part of this process.

William D. Magwood, IV
Director-General
Nuclear Energy Agency

"An all-hazards approach to emergency management is the most efficient use of available resources, including stakeholders". (*Practices and Experience in Stakeholder Involvement for Post-nuclear Emergency Management* – NEA, 2011)

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Patricia A. Milligan	US Nuclear Regulatory Commission, Washington, DC, United States, and Chair of the NEA Expert Group on Lessons Learnt from Non-nuclear Events – EGNE (Chapter 6)

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Chapter 5 on public health lessons learnt from other disasters involving exposure to toxic substances was produced by Olvido Guzmán of the NEA, based on publications by J.M. Havenaar of the Altrecht Institute for Mental Health Care, Utrecht, Netherlands and E.J. Bromet of the Department of Psychiatry, Stony Brook University, Stony Brook, New York, United States. The NEA is grateful to Dr Havenaar and Dr Bromet for having provided the main references used in this chapter, and particularly for their permission to reproduce many parts of their publications, as well as for their useful comments on the chapter.

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List of abbreviations and acronyms

BLEVE	Boiling liquid expanding vapour explosion
CCPS	Centre for Chemical Process Safety (United Kingdom)
DRR	Disaster risk reduction
EC	European Commission
EGNE	Expert Group on Lessons Learnt from Non-nuclear Events (NEA)
eMARS	Electronic Major Accident Reporting System
EPR	Emergency preparedness and response
EPZ	Emergency planning zone
EU	European Union
FEMA	Federal Emergency Management Agency (United States)
GDP	Gross domestic product
HSE	Health and Safety Executive (United Kingdom)
IAEA	International Atomic Energy Agency
JRC	Joint Research Centre
LPG	Liquefied petroleum gas
MAPP	major accident prevention policy
Natech	Natural hazard triggering technological accidents
n.d.	No date
NEA	Nuclear Energy Agency
NPP	Nuclear power plant
NRC	Nuclear Regulatory Commission (United States)
OECD	Organisation for Economic Co-operation and Development
SPI	Safety Performance Indicator
UNEP	United Nations Environment Programme
VCM	Volatile Condensable Material
WHO	World Health Organization
WPNEM	Working Party on Nuclear Emergency Matters (NEA)

Executive summary

Over the years, member countries from the OECD Nuclear Energy Agency (NEA) have developed effective emergency preparedness and response (EPR) arrangements for nuclear facilities and off-site response organisations. These arrangements have usually been tested through exercises involving the facility and off-site response organisations. EPR arrangements have thus been enhanced as necessary to include lessons learnt from nuclear emergency exercises, nuclear power plant accidents such as the accident at Fukushima Daiichi and changes to international guidance.

While nuclear power plant accidents are very rare, industrial non-nuclear events and natural disasters occur more frequently and can have a potentially large impact on populations and on widespread geographical areas. As a result of these events, populations may be required to take part in protective actions such as sheltering, evacuation and the restriction of food supplies. Research on these types of non-nuclear events and natural disasters has been extensive and has led to an understanding of factors that have supported the effectiveness of response activities, as well as those factors that may have degraded the response. This type of information can be used to enhance existing preparedness efforts for nuclear power plants, for other industrial facilities and for natural disasters in an "all-hazards" framework.

In recognition of the importance of an all-hazards approach to preparedness and response, the International Atomic Energy Agency (IAEA) General Safety Requirements (GSR No. 7), *Preparedness and Response for a Nuclear or Radiological Emergency* (IAEA, 2015), encourage, to the extent practicable, the inclusion of the emergency management system in an all-hazards framework. The OECD Council similarly supports the integration of a nuclear emergency management system into a comprehensive, all-hazards and transboundary approach to country risk governance as a foundation for enhancing national resilience and responsiveness. Contributions to this report support the value of such an all-hazards approach to EPR.

Lessons learnt: Insights into emergency preparedness and response

The chemical industry

The nuclear and chemical industries share common elements in terms of how they seek to prevent, prepare for, respond to and recover from accidents. In the framework of the OECD Chemical Accidents Programme, five legal instruments, adopted by the OECD Council, have been developed to support member countries in the prevention of, preparedness for and response to chemical accidents, and in helping to shape policies concerning major accidents in member countries. Some of these instruments and tools can offer valuable input to enhance similar documents in the field of nuclear power generation. The following two key guidance documents are of particular interest. Both were developed by the OECD Chemical Accidents Programme.

The first document, "Guidance on Developing Safety Performance Indicators (SPIs): Guidance for Public Authorities and Communities" allows for an assessment of the performance of programmes for chemical accidents prevention, preparedness and response. Safety performance indicators aim to assist relevant stakeholders in establishing programmes for assessing their own performance related to the prevention of, preparedness for and response to chemical accidents. They aim to help improve the ability of interested industrial enterprises, public authorities and community organisations to measure whether the many steps that are taken to reduce the likelihood of accidents, and improve preparedness and response capabilities, truly lead to safer communities and less risk to human health and the environment.

The second guidance document on “Corporate Governance for Process Safety: Guidance for Senior Leaders in High Hazard Industries” draws the attention of industry leadership to the need for high standards of corporate governance in relation to the management of high-hazard industries. This guidance document encourages every director, CEO and president of a major hazard company to check themselves against a set of self-assessment questions and evaluate their awareness and knowledge of the safety process.

Major accidents and emergency responses

Recent experience, including major accidents not involving nuclear or radiological material in countries with extensive legal requirements and administrative frameworks, has demonstrated that legislation and regulations, while necessary, are not sufficient to ensure the prevention of accidents or adequate preparedness. It is therefore important for stakeholders to undertake additional initiatives and learn from the experience of others in different fields of work.

The comprehensive review of EPR carried out by the European Union’s Joint Research Centre (JRC) on accidents registered in the worldwide Major Accident Reporting System Database (eMars) identified some important lessons and has offered support to existing nuclear EPR programmes. Identification of possible accident scenarios is an important step in the development of EPR programmes. A common issue shared by both the nuclear and non-nuclear industries is that of identifying a wide range of accident scenarios, from design-basis to beyond-design-basis accidents. Consideration of such a broad range of accident scenarios would ensure that planning efforts are robust and would provide for adequate protection of public health and safety.

Training and emergency drills have also been identified as essential for successful emergency response both on-site and off-site. Training that is tested by exercises leads to appropriate actions in response to an emergency situation; knowing how to implement protective actions such as evacuation or sheltering can save lives. Exercises also test participants’ knowledge of assembly points/areas, power and water supplies, safe shutdown procedures for facilities, the location of emergency operation centres with incident commander and media information centres, medical facilities and first-aid areas, as well as how to use communication systems that are internal to the impacted facility and other means to ensure public communication. Exercises allow for interplay between emergency response workers, officials and facility staff in accordance with the seriousness of the scenario.

Events reviewed from eMars have also highlighted the importance of selecting appropriate personal protection measures such as equipment for emergency responders, as well as that of increasing awareness of the hazards involved in the event. Emergency responders have died or been injured in major accidents, either during the intervention or after it takes place. In most cases, the root cause identified was a lack of knowledge about the types and hazards of the dangerous substances involved in the accident. Without this essential information, emergency response personnel were not able to make a decision on the level and type of personal protection to be used.

The review of events from eMars also identified another important consideration, namely that emergency planning can be successful only if it encompasses all three elements: preparedness, response and recovery. All these elements should be addressed early in the planning phase.

Preparing for the future

Building on lessons learnt from crises that have taken place in OECD countries, the OECD High Level Risk Forum and the Directorate for Public Governance have gathered practical tools seeking to improve risk governance. One of the main conclusions of this work has been that governments must develop crisis-management capacities to cope with the complexity, novelty, ambiguity and uncertainty that characterise many modern crises. Emergency response plans are necessary tools for conventional crisis management. They are designed with reference to past events and work well for routine emergencies. Flexible approaches, however, are needed for rare and unpredictable events. The report presents an overview of the main outcomes of this work, which can contribute to efforts towards a comprehensive, all-hazards and transboundary approach to country risk governance and to ensuring more resilient societies. Some of the most relevant lessons learnt concern the areas described below.

Social media

Social media in its many forms is revolutionising communication. Large groups of people can be reached almost instantly with messages to take protective actions, and these same people can be reached just as quickly with false information. Using social media effectively in crisis communication requires that appropriate resources be devoted to the management of social network messaging during the event. It is important to ensure that the information circulating in the various social media platforms is accurate because accurate information leads to public trust in officials. Such trust in leadership results in the public following the emergency directives issued by leadership. Lives are thus saved and people are removed from harm.

Social media has great promise in supporting two-way crisis communication. Governments, industries, response organisations and others must develop dedicated crisis communication strategies for the effective use of social media in crisis management. However, since some segments of the public may not be easily reachable through social media, inclusive crisis communication also requires the use of traditional communication channels.

Engaging with the private sector

Engaging the private sector in crisis-management efforts is crucial, particularly when the scale and complexity of a crisis requires a "whole-of-society" approach. The private sector has many resources, including staff and equipment, which can be shared to support an effective emergency response. Governments should set up the right incentives for co-operation with the private sector in times of crisis.

Training leaders

During a crisis, strategic-level decision makers are forced to act under challenging conditions and often with incomplete information. Leaders must be identified prior to the crisis, and they along with their teams, organisations and key partners must be sufficiently prepared to cope with the challenges presented by the crisis. Effective leadership training is a prerequisite for effective strategic crisis management.

The importance of exercises

All contributions to this report underline the importance of exercises for testing and improving emergency management systems, a finding which supports the long-standing drill and exercise programmes in place at nuclear facilities. The report also presents recommendations on enhancements to aspects of traditional drills and exercises.

Emergency planning and response to a natural hazard-triggered technological accident (Natech)

Natural hazards can lead to technological secondary effects or a so-called "natural hazard-triggered technological accident" (or a "Natech accident"). Natech accidents are frequent in the wake of natural disasters, and they have repeatedly had significant and long-term social, environmental and economic impacts. Awareness of Natech risks is increasing worldwide, but there is a continued lack of Natech risk assessment methodologies and little guidance exists on Natech risk management for industry and competent authorities. From an emergency management point of view, special planning is required to account for the potentially large impact of major natural events affecting populations and the building stock as well as industry and other infrastructures. To ensure sufficient preparedness in industry and an effective emergency response, several points are proposed for consideration:

- On-site emergency plans for accidents involving hazardous materials should take natural hazard risks into account.
- Off-site emergency response plans for hazardous industries in natural hazard-prone areas should consider the impact of hazardous material releases on populations and on rescue operations.
- The vulnerability of emergency response resources to natural events and hazardous material releases should be assessed.
- Medical services should be involved in the preparation of the external emergency plan.
- Emergency response plans, both at installation and community level, should be periodically reviewed and tested to make certain they consider the consequences of natural hazard impacts.

Public health lessons learnt

The definition of health proposed by the World Health Organization (WHO) incorporates physical, mental and social well-being. Despite the enormous psychological and social cost of toxic disasters, until recently assessments have tended not to take into account this aspect in assessing the adverse effects of disasters. The public health perspective shows how each phase of a disaster and each player in disease onset (host, agent, environment) interact. Underneath these interactions are individual perceptions – by the sufferers, the health care providers, government agency officials and the media – and these perceptions drive the magnitude, persistence, evolution and even the risk and protective factors that are identified after major ecological catastrophes. It is important to understand the variables that promote health and protect against adverse mental health outcomes after disasters, or build resilience among the affected populations.

These factors will be a key challenge for disaster recovery and knowledge of such aspects can be used in the formulation of potentially successful interventions. New interventions should be careful to take cultural factors into account. They should maximise the ability of people to cope with stressful circumstances and to make sense out of what is happening to them. It is a well-known observation that disasters and periods of extreme collective strain can sometimes strengthen social cohesiveness and thus enhance the resilience of communities. Identifying the optimal type and quantity of supportive interventions will be one of the foremost priorities. This report presents an overview of lessons learnt for each phase of the disaster (i.e. preparedness, immediate response and long-term response), taking into account the different points of view of victims, professionals, authorities and the general public. The section of this report on public health lessons learnt is primarily based on the work of E.J. Bromet and J.M. Havenaar.

The experience of NEA member countries – incorporating lessons learnt from non-nuclear events into nuclear and radiological EPR

The final chapter in this report recounts experiences in two NEA countries, the United States and Japan, both of which have enhanced nuclear emergency preparedness and response through the integration of lessons learnt from non-nuclear events.

While there has been only one radiological-related evacuation in the United States, an overview of evacuations in that country has shown that emergency evacuations of at least 1 000 people generally occur about every three weeks in the United States (NUREG/CR-6864). A review by the NRC on lessons learnt from large-scale evacuations (Hurricanes Katrina, Rita and Wilma) demonstrated that existing criteria, plans and procedures are already in place for nuclear power plants (NPPs) to address the issues that were experienced in the large-scale evacuations studied. These regulatory requirements and guidance are well established, and some of the applicable lessons learnt from the study were captured in the NRC 2011 Emergency Preparedness rule change. Others were captured in NRC/Federal Emergency Management Agency (FEMA) guidance documents.

As a result of its natural conditions, Japan is prone to virtually every type of natural disaster, including snowfalls, sediment disasters, volcanic eruptions and earthquakes. Disasters in Japan have triggered the introduction over time of disaster management systems and regulations integrating lessons learnt from those disasters and leading to a comprehensive disaster management system. Japan's legislation for disaster management systems, including the Disaster Countermeasures Basic Act, addresses all of the disaster phases of prevention, mitigation and preparedness, and emergency response, as well as recovery and reconstruction, with the roles and responsibilities among national and local governments clearly defined. It is also stipulated that the relevant entities of the public and private sectors are to co-operate in implementing various disaster countermeasures. The Disaster Countermeasures Basic Act has been regularly reviewed and amended since its first enactment, including with lessons learnt from the Great East Japan Earthquake. Provisions were thus added for the enhancement of measures concerning support activities carried out by local governments (2012), or of measures to ensure the safe and smooth evacuation of residents and to improve the protection of affected people (2013).

Overall, the report demonstrates a similarity in EPR planning across all sectors dealing with different hazards. It also identifies lessons learnt and good practices from a multidisciplinary perspective. Incorporation of these lessons learnt and good practices ultimately will build strong emergency response measures and national resiliency. The OECD and the IAEA have recognised the importance of a strong and unified response, and they have urged that, to the extent possible, radiological emergency preparedness be included in a greater, comprehensive, all-hazards emergency planning system. Contributions to this report support the value of such an all-hazards approach to EPR. The many examples outlined of lessons learnt from EPR in fields other than the nuclear sector can effectively be used by member countries, as appropriate, in enhancing their nuclear emergency management systems.

Because the NEA operates within the framework of the OECD, the agency's Working Party on Nuclear Emergency Matters (WPNEM) is well placed strategically to share information in this regard in order to foster an integrated all-hazards approach to EPR through co-ordination with relevant OECD bodies and other organisations. Indeed, the NEA Committee on Radiological Protection and Public Health (CRPPH) has underlined the value of this work and the efforts undertaken by the WPNEM towards an all-hazards approach to emergency preparedness and response, and it has encouraged the WPNEM to continue in this direction, noting that it is the first time that experts outside of the nuclear field have participated in an NEA report on EPR and underlining the value of such a comprehensive and multidisciplinary perspective.

Chapter 1. **OECD activities on chemical accident prevention, preparedness and response**

by Marie-Ange Baucher and Peter Kearns[1]

Over the past decades, successive major accidents – from the deadly toxic gas release in Bhopal, India in 1984 to more recent examples including the Gulf of Mexico Deep Water Horizon oil spill, the Texas City refinery explosion (United States) and the Buncefield fire (United Kingdom) – have raised major concerns regarding the prevention and management of disasters and the sustainability of the affected communities and areas. Even more significantly, across the world there are hundreds of unnoticed chemical accidents every year that cause severe harm to workers, families, towns and their businesses, natural resources and quality of life. There are places that still suffer from the disastrous impacts of events that happened years before. The United Nations Environment Programme's Global Chemicals Outlook (UNEP, 2013) *highlights an increasing chemical intensification of the economy. Industrialised countries still account for the bulk of the world chemical production and the risk of accidents remains most significant in these countries. Yet the production, use and disposal of chemicals is steadily spreading to developing countries and countries with economies in transition, which are often at particular risk of adverse effects from such accidents because of limited regulations or incomplete enforcement of existing rules, reduced awareness of risks and inadequate preventive measures.*

Overview of the OECD Chemical Accidents Programme

It was following two major accidents in Bhopal, India, and Schweizerhalle, Switzerland, in the mid-1980s that OECD governments declared, during an OECD Environment Committee meeting at Ministerial Level in June 1985, that "they will ensure the existence of appropriate measures to control potentially hazardous installations, including measures to prevent accidents." Their discussions resulted in the creation at the OECD of a chemical accidents programme in the 1990s. The programme is managed by the Working Group on Chemical Accidents.

Five legal instruments, adopted by the OECD Council, have been developed in the framework of the Chemical Accidents Programme to support OECD member countries in the prevention, preparedness and response to chemical accidents and help shape the policies concerning major accidents in member countries:

- Recommendation of the Council concerning the Application of the Polluter-Pays Principle to Accidental Pollution.
- Recommendation of the Council concerning Chemical Accident Prevention, Preparedness and Response, which directly refers to the implementation of the "OECD Guiding Principles on Chemical Accidents Prevention, Preparedness and Response".

1. Marie-Ange Baucher and Peter Kearns are from the Secretariat for the OECD Working Group on Chemical Accidents.

- Decision-Recommendation of the Council concerning Provision of Information to the Public and Public Participation in Decision-making Processes related to the Prevention of, and Response to, Accidents Involving Hazardous Substances.
- Decision of the Council on the Exchange of Information concerning Accidents Capable of Causing Transfrontier Damage.
- Council Act on the list of non-confidential data, which has two elements related to chemical accidents: safe handling precautions to be observed in the manufacture, storage, transport and use of the chemical; and safety measures in case of an accident.

The Chemical Accidents Programme is also a forum for participating stakeholders to share experiences on accidents and to learn from each others' challenges and progress. It aims to develop common principles and policy guidance for chemical accidents prevention, preparedness and response, focusing on key issues such as natural hazard-triggered technological (Natech) disaster, involvement and awareness of senior leaders in process safety, ageing of hazardous installations, ownership change in hazardous installations and others. Over the years the programme has held many workshops focusing on a wide range of topics, many of which led to the development or launching of guidance or other publications.[1] These workshops have been held by the OECD as well as jointly or in close co-operation with other partners in the field of chemical accident prevention, preparedness and response such as the International Maritime Organisation, the European Union and industry. As the landscape of the chemical industry evolves, the OECD Chemical Accidents Programme facilitates discussions on new and emerging issues in relation to chemical accidents prevention, preparedness and response.

Key guidance publications developed by the OECD Chemical Accidents Programme include:

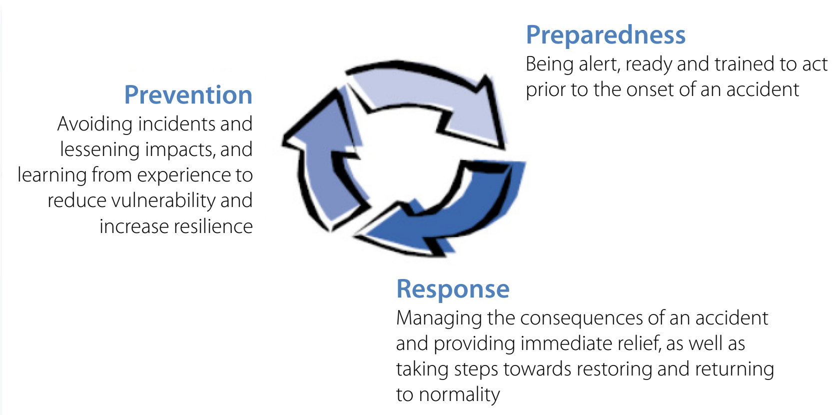
- "OECD Guiding Principles for Chemical Accident Prevention, Preparedness and Response and the addendum on Natech Risk Management". The Guiding Principles set out general guidance for the safe planning, construction, management, operation and review of safety performance of hazardous installations, and, recognising that such accidents may nonetheless occur, to mitigate adverse effects through effective land-use planning and emergency preparedness and response.
- "Guidance on Developing Safety Performance Indicators for Industry, and for Public Authorities and Communities/Public". These documents aim to help enterprises, authorities and communities to develop an approach for assessing whether the actions designed to improve safety are meeting their objectives and to help set priorities in this area.
- "Corporate Governance for Process Safety: Guidance for Senior Leaders in High Hazard Industries". This publication establishes best practice for senior decision makers who have the authority to influence the direction and culture of their organisation.

1. All the publications of the OECD Chemical Accidents Programme are available at www.oecd.org /env/ehs/chemical-accidents.

Supporting prevention, preparedness and response to chemical accidents: "The OECD Guiding Principles"

Recent experience, including major accidents in countries with extensive legal requirements and administrative frameworks, demonstrates that legislation and regulations, while necessary, are not sufficient to ensure prevention of accidents or adequate preparedness. It is therefore important for all stakeholders to undertake additional initiatives and learn from the experience of others. The "OECD Guiding Principles for Chemical Accidents Prevention, Preparedness and Response" (OECD, 2003a) aim to help public authorities, industry and communities worldwide to prevent chemical accidents and improve preparedness and response, should an accident occur. The principles provide guidance to help stakeholders take appropriate actions within a safety continuum, to prevent accidents involving hazardous substances and to mitigate the adverse effects of accidents that do nevertheless occur (see Figure 1.1).

Figure 1.1. **The safety continuum**



The principles were first published in 1992 and then reviewed in 2003 with the publication of a 2nd edition. They are being revised by the Working Group on Chemical Accidents for a new edition to be available in 2020.

These principles provide advice to public authorities, industry, employees and their representatives as well as members of the public potentially affected in the event of an accident, and non-governmental organisations. The guiding principles apply to all hazardous installations, i.e. fixed plants or sites that produce, process, use, handle, store or dispose of hazardous substances where there is a risk of an accident involving the hazardous substance(s). These principles also apply to transfer facilities where hazardous substances are loaded and/or unloaded. The transportation of hazardous substances external to a hazardous installation (by pipelines, road, rail, sea or air) has not been addressed, although many of the principles can be applied.

These guiding principles are based on the assumption that all hazardous installations should be expected to comply with the same safety objectives regardless of size, location or whether the installation is publicly or privately owned. They have been developed with the understanding that there must be flexibility in their application because of significant differences that exist among countries, such as legal and regulatory infrastructures, culture and resource availability. In addition, there may be differences in approach in applying the principles to new and to existing installations. These guiding principles apply to a wide range of industries and types and sizes of installations.

An addendum to the guiding principles was published in January 2015, and addresses specifically Natech risk management. The addendum consists of a number of amendments to the guiding principles and of the addition of a new chapter to provide more detailed guidance on Natech prevention, preparedness and response.

The application of the guiding principles is the subject of an OECD Council recommendation; they have been translated into many languages, and are also used widely in non-member countries.

Assessing performance of programmes for chemical accidents prevention, preparedness and response: Guidance on safety performance indicators for industry and for public authorities

Safety performance indicators (SPIs) aim to assist relevant stakeholders to establish programmes for assessing their own performance related to the prevention of, preparedness for and response to chemical accidents. They aim to help improve the ability of interested industrial enterprises, public authorities and community organisations to measure whether the many steps that are taken to reduce the likelihood of accidents, and improve preparedness and response capabilities, truly lead to safer communities and less risk to human health and the environment.

"Guidance on Safety Performance Indicators for Industry" (OECD, 2003b)

SPIs provide important tools for any enterprise that handles significant quantities of hazardous substances (whether using, producing, storing, transporting, disposing of, or otherwise handling chemicals) including enterprises that use chemicals in manufacturing other products. Specifically, SPIs help enterprises understand whether risks of chemical accidents are being appropriately managed. The goal of SPI programmes is to help enterprises find and fix potential problems before an accident occurs. SPI programmes provide an early warning, before a catastrophic failure, that critical controls are not operating as intended or have deteriorated to an unacceptable level.

Specifically, SPI programmes provide a means to check whether policies, procedures and practices (including human resources and technical measures) that are critical for chemical safety are successful in achieving their desired results (i.e. safer facilities and a decreased level of risk to human health, the environment and/or property). An SPI programme can also help to identify priority areas for attention and the corrective actions that are needed. By taking a proactive approach to risk management, enterprises not only avoid system failures and the potential for costly incidents, they also benefit in terms of business efficiency. For example, the same indicators that reveal whether risks are being controlled can often show whether operating conditions are being optimised. This Guidance on Developing Safety Performance Indicators for Industry was prepared to assist enterprises that wish to implement and/or review SPI programmes.

"Guidance on Safety Performance Indicators for Public Authorities and Communities/ Public" (OECD, 2003c)

Any public authority or organisation that has a role to play with respect to chemical accident prevention, preparedness and/or response should consider implementing an SPI programme. In addition, any organisation representing the public or communities in the vicinity of a hazardous installation should consider establishing an SPI programme.

This "Guidance on Safety Performance Indicators for Public Authorities and Communities/Public" recognises that chemical risks are not being created by the public authorities nor by communities or the public, and that enterprises have primary responsibility for the safety of their hazardous installations. However, public authorities and communities and members of the public have important roles to play in chemical accident prevention, preparedness and response. For authorities, these roles may include: developing a regulatory framework; monitoring and enforcement; providing information to the public; siting and land-use planning; off-site emergency planning; providing trained police, firefighters, hazmat teams and emergency medical personnel; and cross-boundary co-operation. Key roles among communities and the public involve: information acquisition and communication; and participation in decision making and in the investigative processes. The guidance aims to help organisations understand the value of safety performance indicators, and to provide a plan for developing appropriate SPI programmes specific to their circumstances. In addition, this guidance can help those organisations that already have SPI programmes in place by providing a basis for reviewing their programmes and assessing whether improvements can be made or additional indicators would be useful.

The involvement of senior leaders in process safety: "OECD Guidance on Corporate Governance for Process Safety"

Over the last generation, successive major accidents have raised concerns among the public, stakeholders and regulators. Improvements in technical knowledge and management systems have helped to reduce the risk, but analysis of past incidents reveals that inadequate leadership and poor organisational culture have been recurrent features, with:

- a failure to recognise things were out of control (or potentially out of control), often because of a lack of competence at different levels of the organisation;
- an absence of, or inadequate, information on which to base strategic decisions – including the monitoring of safety performance indicators at Board level;
- a failure to understand the full consequences of changes, including organisational ones;
- a failure to manage process safety effectively and take the necessary actions.

The "Guidance on Corporate Governance for Process Safety" draws the attention of those at the top of industry to the need for high standards of corporate governance in relation to the management of high-hazard industries. The guidance encourages every director, CEO and President of a major hazard company to check themselves against a set of self-assessment questions and evaluate their awareness and knowledge of the safety process.

Leaders need to understand the risks posed by their organisation's activities, and balance major accident risks alongside other business threats. Even though major accidents occur infrequently, the potential consequences are so high that leaders need to recognise:

- major accidents as credible business risks;
- the integrated nature of many major hazard businesses – including the potential for supply chain disruption;
- the need for equal focus on the management of process safety risks and other business processes including financial governance, markets and investment decisions.

Good process safety management requires the active involvement of senior leaders, and it is important that they are visible within their organisation, because of the influence they have on the overall safety and organisational culture.

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Chapter 2. Lessons learnt from major accidents relating to emergency response

by Dr Zsuzsanna Gyenes and Maureen Heraty Wood[1]

Introduction

With the purpose of contributing to the NEA study produced by the Expert Group on Lessons Learnt from Non-nuclear Events (EGNE), an analysis of accidents associated with emergency response was conducted by the Major Accident Bureau (MAHB) of the EC Joint Research Centre (JRC). Cases were selected from the JRC database, the Major Accident Reporting System (eMARS).

The eMARS reporting system was first established by the European Union's (EU) Seveso Directive 82/501/EEC in 1982 to facilitate reporting of major chemical accidents by EU member states to the European Commission and has remained in place with subsequent revisions to the Seveso Directive (currently the Seveso III Directive, 2012/18/EU). The purpose of the eMARS reporting system is to facilitate the exchange of lessons learnt from accidents and near misses at fixed facilities involving dangerous substances in order to improve chemical accident prevention and mitigation of potential consequences. The eMARS database contains 1 000+ reports of chemical accidents and near misses provided to the JRC from EU, the Organisation for Economic Co-operation and Development (OECD) and China (as part of a collaboration in partnership with the United Nations Environment Programme – UNEP). Reporting an event to eMARS is compulsory for EU member states when a Seveso establishment is involved and the event meets the criteria of a "major accident" as defined by Annex VI of the Seveso III Directive. Transport accidents are not obligatory to report to eMARS by member states but competent authorities can include them. For non-EU OECD countries reporting accidents to the eMARS database is voluntary and furthermore chemical accidents in transport may also be reported. The accident report is entered into eMARS directly by the official reporting authority of the country in which the accident occurred.

The goal of emergency response is to prevent and reduce further harm to the maximum extent possible. However, it is well known that there are many accidents in which the emergency response is inadequate and may even commit errors of gross proportions. The West Fertilizer disaster of April 2013 in West, Texas, the United States is perhaps one of the most recent and tragic examples of an emergency response failure with devastating consequences. The deaths of 12 firefighters stemmed mainly from inadequate preparation and training as a result of a general lack of awareness in the community of the risks associated with fertiliser-grade ammonium nitrate.

This chapter reveals findings of the analysis of accidents reported in eMARS regarding emergency response. The analysis shows that emergency plans sometimes fail and provides insight into why they may fail. Studying these failures can make a significant contribution to improving emergency response and reducing severity of accident consequences resulting from a poor emergency response.

1. Dr Zsuzsanna Gyenes and Maureen Heraty Wood are from the European Commission (EC) Joint Research Centre (JRC), Directorate for Space, Security and Migration in Ispra, Italy.

The analysis reported here identifies common mistakes and critical areas where failure can significantly undermine effective planning and execution of emergency response without identifying the requirements of the content of the emergency plan. These findings can help operators and the emergency response community to assess and identify the strengths and weaknesses of their own preparedness and response plans. Resulting improvements could ensure that response efforts indeed meet expectations for preventing further harm and are not themselves a cause of harm.

Emergency planning in the Seveso III Directive

The directive defines main obligations for operators and the member states authorities. Among those obligations, it imposes requirements relating to emergency planning in Article 12 and Annex IV.

(16) To prepare for emergencies, in the case of establishments where dangerous substances are present in significant quantities, it is necessary to establish internal and external emergency plans and to establish procedures to ensure that those plans are tested and revised as necessary and implemented in the event of a major accident or the likelihood thereof. The staff of an establishment should be consulted on the internal emergency plan and the public concerned should have the opportunity to give its opinion on the external emergency plan. Sub-contracting may have an impact on the safety of an establishment. Member States should require operators to take this into account when drafting a MAPP [Major Accident Prevention Policy document]*, a safety report or an internal emergency plan.*

Further to these requirements, it is important to point out that preparing for emergencies is an element of the Safety Management System (SMS). Annex III *(v)* of the directive explicitly states that planning for emergencies shall include the adoption and implementation of procedures to identify foreseeable emergencies by systematic analysis. It is furthermore required to prepare, test and review emergency plans to respond to such emergencies and to provide specific training for the staff concerned. Such training shall be given to all personnel working in the establishment, including relevant subcontracted personnel.

The directive now applies to more than 10 000 industrial establishments in the European Union where dangerous substances are used or stored in large quantities, mainly in the chemical, petrochemical, logistics and metal refining sectors.

Objective of the analysis

The requirements of emergency planning have already been set out in many publications. For example, the UK Health and Safety Executive (HSE) published its guidance document on *Emergency Planning for Major Accidents* in 1999 (HSE, 1999) and the Centre for Chemical Process Safety (CCPS) also issued *Guidelines for Technical Planning for On-Site Emergencies* that cover "the technical knowledge needed for proper planning end effective response to on-site emergencies" (CCPS, 1995).

The analysis presented in this chapter is a supplementary contribution to this literature. It aims to fill gaps in the learning drawn from emergency responses to reported accidents, and specifically to answer the questions of why emergency plans fail and which deficiencies have been observed in emergency responses.

The objective is also to address the following questions:

- What are the main lessons learnt?
- Which errors are being repeated?
- Which emergency management areas typically concentrate errors?
- Which preparedness procedures and responses can be singled out as good practice?
- What are the most common failures in evacuation and sheltering practices?

- How could these failures be corrected to mitigate the consequences of the accidents on the public?

Furthermore, the chapter considers some secondary impacts that should be addressed in emergency planning:

- Which risks are associated with the presence of spectators at the accident scene?
- Which mental health issues arise from large-scale accidents?

Material analysed

The analysis focused on major accidents reported from OECD countries to the database from 1990 through 2015, in both fixed facilities and transport. Accidents occurring prior to 1990 were excluded from the analysis, as well as near misses between 1990 and 2015. In addition, reports not yet finalised (as a result of legal or investigation procedures) by the time the study was completed were not considered. After the application of these exclusion measures, 753 reports were analysed.

Analytical approach

All accident reports were submitted using the eMARS reporting form but the reports varied considerably in terms of detail and quality of contents. The form provides check boxes to enter the different response actions taken, e.g. a firefighter response, evacuation or shelter-in-place. In several cases the associated free text field contained no further detail on the emergency response activity. In other cases, emergency response actions were not checked, but details in the free text and in the lessons learnt sections indicated some of the actions that had been taken. Where additional information on an accident was available from another source, the analysts incorporated these findings.

To identify cases with relevant lessons learnt, the study relied on objective responses to emergency response fields as well as data mining using key words and covering all free text fields including the sequence of events and the lessons learnt.

The analysis classified each lesson learnt relative to the following emergency response elements:

- on-site evacuation/sheltering;
- off-site evacuation/sheltering;
- on-site emergency response;
- off-site emergency response;
- on-site and off-site injuries to firefighter/intervention team members.

Findings

The findings presented focus on response actions associated with efforts to separate people from the impacts (evacuation and shelter-in-place), firefighter/emergency response team actions, and inadequate and complex emergency response (because of size and/or complexity of response needs). By singling out failures, the analysis highlights important aspects of emergency response where a deficiency or failure could be critical to response effectiveness. It also provides feedback from reports of successful emergency response efforts which fulfilled the objective of preventing the occurrence of more severe consequences.

Evacuation

Mitigation of accident-related exposure to dangerous chemicals can be carried out in two ways, by means of evacuation or of shelter-in-place/confinement. Evacuation is when people are moved away from the effects of the accident, leading them towards an assembly point/centre or other designated areas (schools, public areas, etc.). Both on-site (internal) and off-site (external) evacuation procedures can be successful if they are planned prior to the occurrence of any accidents. Evacuation procedures are normally written in the internal and external emergency plans.

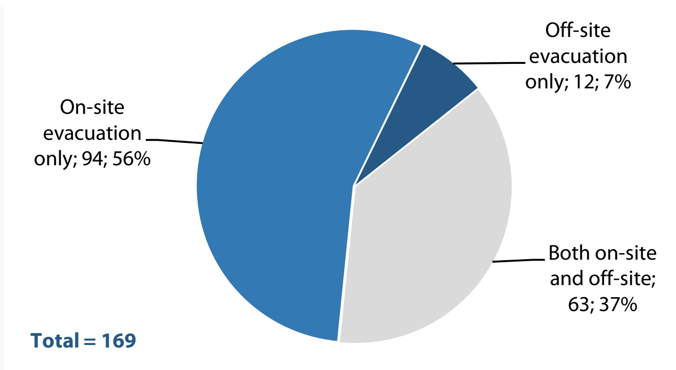
As Lees has summarised:

> … principal mitigating features are shelter and escape. Escape may be by personal initiative or by pre-planned evacuation. It should not be assumed that emergency measures are synonymous with evacuation. A combination of evacuation, shelter-in-place as well as other measures may be taken based on the event as well as preplanning evaluations. For releases of flammable substances, evacuation of non-emergency personnel is always beneficial and leads to reduction of casualties. On the other hand, for toxic releases, the emergency instructions may be to evacuate the area but are more likely to be to stay indoors and seal the house. Emergency measures may be of great value in reducing the toll of casualties from a major incident. For an explosion that gives no advance warning, there is no time for emergency measures such as evacuation. This does not mean, however, that evacuation has no role to play as far as fire and explosion are concerned. On the contrary, although the initial event may be sudden, there are frequently further fire and explosion hazards. Evacuation may then be applicable. (Lees, 2012)

The current analysis identified cases where either employees of the affected establishment or neighbouring establishments or the public were evacuated. On-site evacuation concerns employees and other workers (contractors, office workers) within the company affected by the accident, while off-site evacuation means evacuation of workers from the neighbouring facilities and the public – in other words, everybody outside the premises of the affected company who is not involved in the emergency response.

Of the 753 accident reports 169 involved cases of evacuation actions. Figure 2.1 presents the distribution of on-site and off-site evacuations. In 56% of the reported cases (94 reports) only on-site evacuation was practised; in 7% (12 cases) off-site evacuation was required. In 63 cases (37%), both on-site and off-site evacuations were necessary. The number of reports with evacuations required appears to be proportionally small compared to the overall number. It is important to note however that not all accidents result in the necessity of evacuation. Examples may include accidents where the loss of containment was stopped or reduced significantly immediately after the release; accidents where fire was extinguished shortly after it broke out or where the part of the unit affected by the accident was very limited; or events in closed buildings which did not escalate and had no effect on workers. In other cases, especially in explosions, emergency response could not be performed because the explosion is rapid and the consequences are immediate and no mitigating measures can be taken. Also, where environmental pollution occurred as a result of a loss-of-containment event, some cases occurred in which the operator observed the release too late to be able to take any protection measures against the environmental impact.

Figure 2.1. **Distribution of on-site and off-site evacuation in reported accidents**



Examples

- On-site evacuation

  At about 8.23 pm on 1 February 1994 there was a release of reactor solution from a recirculating pump near the base of a 25 tonne ethyl chloride reactor vessel at a chemical factory. About 100 minutes after the release occurred, whilst firefighters tried to control the leakage, the pool of ethyl chloride was ignited resulting in a fire. After the fire started, foam was applied to the two process vessels to prevent their rupture. The southern half of the site had to be shut-down and was evacuated for the duration of the fire and more extensive evacuation was considered but in the end it was not necessary. The off-site emergency plan was activated. A nearby road was closed and two neighbouring premises were alerted in case evacuation became necessary. As a result of the accident, one employee and 17 firemen received treatment during the night of the incident, but no one was seriously injured. (HSE, 1996)

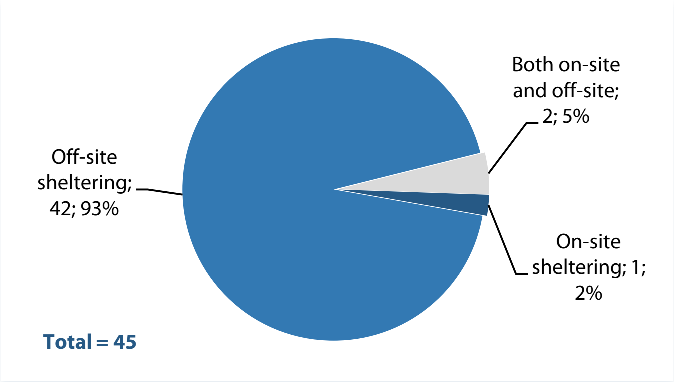
- Off-site evacuation

  During still and cold weather conditions large quantities of vapour were seen emanating from a bund at an oil depot. This was followed by a massive explosion and several other lesser explosions. A large fire ensued that engulfed 21 of the tanks on-site. The police and fire service led the emergency response and at the peak of the incident there were 180 firefighters tackling the blaze using 26 fire pumps and over 700 000 litres of foam were used. About 2 000 people were evacuated. Sections of the nearby motorway were closed. As a consequence of the accident 20 businesses employing 500 people were destroyed and the premises of 60 businesses employing 3 500 people were badly damaged. 60 people received minor injuries, typically from flying debris. There were no fatalities. (eMARS, n.d [no date] – No. 529)

Sheltering or confinement

Sheltering or confinement of people is a response intended to protect people from possible exposure by requiring them to stay indoors (e.g. at home or in public areas such as offices, schools, etc.). Figure 2.2 shows that the vast majority of cases consisted of off-site sheltering or confinement whereas only a tiny portion of cases involved on-site sheltering or confinement. Of the 45 accidents where the launch of sheltering procedures was reported, 22 cases included the evacuation of plant employees and/or citizens ordered to stay indoors either because of the toxic dose measured or simply as a precautionary measure. In the other 23 cases, evacuation of on-site personnel did not take place or was not reported, and off-site sheltering was reported only for the population in the vicinity of the establishment.

Figure 2.2. **On-site/off-site sheltering and their combination in reported accidents**



Examples

Fire of sodium dichloro-isocyanurate associated with the release of chlorine and chlorine compounds, forming a toxic cloud which affected neighbouring urban areas occurred. The on-site emergency plan was activated; an attempt was made to control the fire with on-site extinguishing equipment, but eventually external assistance was also requested. The off-site emergency plan was activated and the population sheltered in place as a protective measure. The post-accident evaluation discovered that the off-site emergency plan did not consider the scenario of a fire with smoke containing a certain percentage of chlorine; scenarios of accidents caused by the release of chlorine and the formation of a toxic cloud were considered. These accident scenarios foresaw much more serious consequences than those of the actual accident which occurred. The fact that the population living in the vicinity was alerted and requested to take shelter in their homes and to close doors and windows certainly contributed to reducing the consequences of the event. Initially the smoke cloud was moving towards the two nearest municipalities, later the wind direction changed. For this reason, the nearby municipalities, which could have been potentially affected by the cloud, were informed about the occurrence and were requested to alert the population to immediately take shelter; the total number of the population sheltering were approximately 20 000 inhabitants. (eMARS, n.d. – No. 264)

A runaway exothermic reaction occurred in a road tanker loaded with 20 tonnes of product – a 75% solution of 2-chloro-5-chloromethyl thiazole and dimethyl carbonate. The road tanker relief valve lifted, releasing a mixture of hydrogen chloride, carbon dioxide and a solid by-product into the air. The on-site and off-site emergency plans were activated, site-access roads were closed and more than 300 personnel on adjacent sites were confined to toxic gas refuges for 3 hours. The confinement of people indoors exceeded 500 person hours. There were no injuries or off-site damage. The lost production and clean-up costs were GBP 700 000. (eMARS, n.d. – No. 511; HSE, 2001a)

There have been a number of instructive incidents involving evacuation and/or shelter. They include those at La Barre in 1961, Glendora in 1969, Potchefstroom in 1973, Houston in 1976 and Mississauga in 1979.

> In 1961, a rail crash occurred at La Barre, Louisiana, involving a chlorine rail tank car, only 50 yd from a house. A father was looking after a baby in the house, the infant began to choke and gasp, and the frantic father carried them outside, where the gas concentration was higher still. The child died in hospital.
>
> In 1969, a group of eight rail tank cars containing VCM were involved in a crash at Glendora, Mississippi and one started to leak. That evening one of the tank cars ruptured, with subsequent ignition of the leak. A heavy fog was observed over the area and it was considered that it might be VCM. The responders stated that in a VCM fire, phosgene could be formed. Further advice was sought from the manufacturer's representative, who stated that the principal problem was likely to be HCl and smoke, and university chemists, who stated that burning VCM could create phosgene that was potentially dangerous up to a radius of 35 miles. An evacuation was initiated involving some 30 000 people.
>
> In 1973, a sudden failure occurred in an anhydrous ammonia storage tank at Potchefstroom in South Africa. Workers in a building 80 m from the release survived, but people who left their houses 180-200 m from it died.
>
> In 1976 at Houston, Texas, a tank truck carrying 19 tons of anhydrous ammonia ruptured at a highway intersection. The resultant gas cloud enveloped the Houston Post building but the workers inside were not affected. Outside, 94 people caught in the cloud were injured, of whom 5 died.
>
> A very large evacuation occurred on Saturday, November 10, 1979 at Mississauga, near Toronto. At 11:52 p.m., a train crashed and several propane rail tank cars exploded. The train manifest was found, but it was in code. A strong smell of chlorine was detected. At 1:30 the next morning, a readable version of the manifest was obtained. A rail tank car containing some 90 t of chlorine was identified as being in the train and it was concluded that this car was among the burning wreckage. At 3:00, the decision was taken to evacuate the surrounding population. An evacuation was begun which involved a total of about 215 000 people. The chlorine tank car was identified by helicopter and found to have a visible hole in it. At 9:00 on Tuesday morning, an initial attempt was made to plug the hole, but this failed; a second attempt later was successful. The tank was subsequently emptied. During Tuesday afternoon 43 000 evacuees were allowed to return to their homes in the areas more distant from the crash. The rest returned only after a total absence of 6 days. (Lees, 2012)

Firefighter/emergency response team effects

The analysis considered cases in which firefighters and/or other emergency response team members, e.g. hired by the company, were affected by the accident, and were injured or died during or after the intervention.

Between 1990 and 2015, in total 56 of the 753 accidents (5%) were reported as having resulted in the death or injury of one or more emergency response team members.

Figure 2.3 shows the cases which resulted in firefighter casualty or death. Overall, 13 emergency response team members died responding to a chemical accident and quite a large number suffered injuries. Figure 2.4 shows the fatalities and injuries per accident.

Figure 2.3. **Number of accidents with firefighter effects**

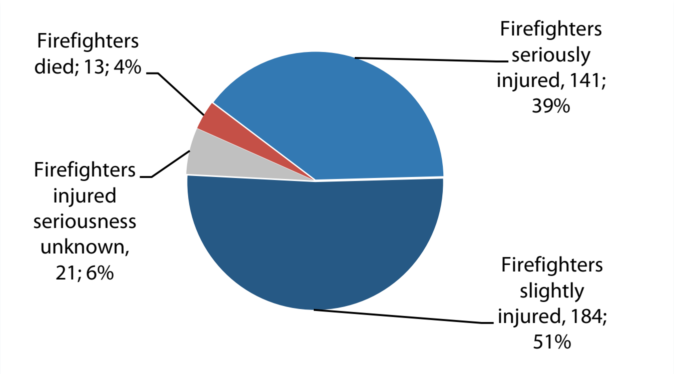
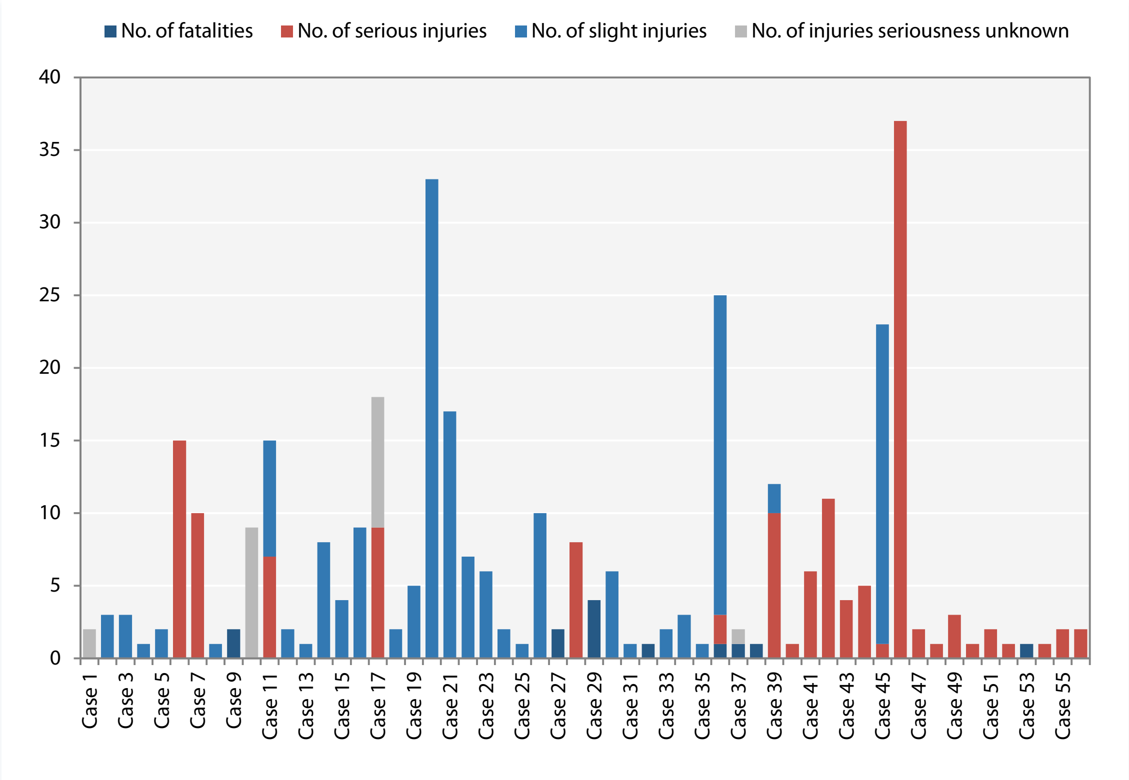


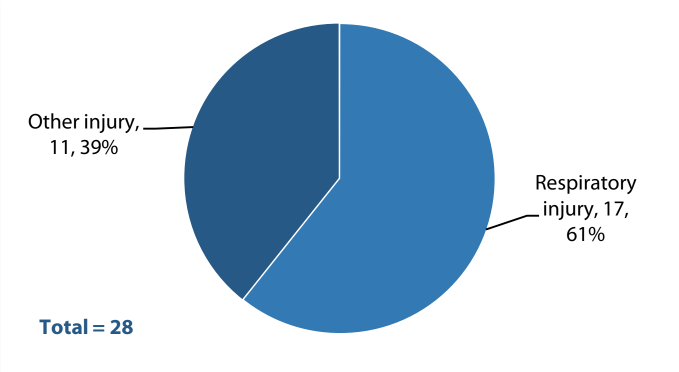
Figure 2.4. **Number of fatalities/injuries per case**

Cases with firefighters' effects



Out of the 28 cases with slight injuries, 11 accidents involved firefighters who suffered broken bones or hearing injuries. In the 17 remaining cases, injuries consisted mainly of respiratory or burn injuries as a result of intoxication or smoke inhalation (Figure 2.5).

Figure 2.5. **Distribution of slight injuries**



From the information contained in the reports, a number of contributing factors could be presumed as follows:

- A sudden, unexpected explosion occurred while firefighters were battling the fire.
- Firefighters lacked knowledge about the types and hazards of dangerous substances involved in the accident.
- The site lacked sufficient water to put out the fire, delaying the intervention significantly.
- Firefighters lacked sufficient personal protective equipment.
- After an explosion, some firefighters suffered serious injuries that were not directly caused by the blast effect, but instead were generated by indirect shockwave effects (collapse of structural elements, projectiles, etc.).
- There was an inadequate supply of public water available as a result of blocked access to fire hydrants. In other cases, the public supply network lacked sufficient pressure to send water all the way through the hose to the point of delivery, requiring responders to set up a shuttle system with tanker trucks in order to ensure continuous fire hose supply throughout the intervention.
- The presence of large quantities of combustibles made the intervention even more difficult.
- Emergency responders were not able to maintain good communication with each other throughout the response effort because of a lack of mobile phone network coverage.

Examples

> Among the seriously injured, one fire-fighter experienced a phenomenon known as pulmonary blast (many lesions on the lungs, causing over 80% respiratory blockage). This crew member was not wearing a self-breathing apparatus since he had not been directly involved in the fire-fighting effort. On the other hand, members in contact with the blaze were wearing such apparatuses and did not have to be treated for similar lesions, even though some were actually closer to the explosion epicentre. It appears therefore that this respiratory device was able to protect against blast effects. (ARIA, n.d. – No. 25669)

At a hydrocarbon depot located in an urbanized zone, welding work was underway on the 'emergency access track'. At 11:15 a.m., a leak of premium-grade gasoline occurred, succeeded by a sudden flash. Site technicians attempted to extinguish the ensuing pool fire. The operator activated the internal emergency plan, issued the order to close all motorised valves and called for assistance from petroleum industry partners. Firefighters deployed major resources to tackle such an intense fire. Unburned gasoline flowed towards the railroad and this caused the blaze to spread. One hour later, despite repeated operator denials, firefighters detected a source of leakage that several valve inspections could not locate. After hours of unsuccessful attempt to put out the fire, the foot valve on a gasoline tank was found open and ultimately closed, at which point the fire receded. According to the site director, this pipe should have been submerged in water during the onsite works and therefore was omitted from the valve closure checklist and control diagram. By the evening, the fire was extinguished. Intervention efforts were substantial and the toll quite heavy; 15 firefighters injured, 4 of whom seriously upon re-ignition of the pool of gasoline and explosion of 2 acetylene bottles. First responders encountered myriad difficulties: an ignited emergency track, fire water pipes bursting under the wheels of vehicles evacuating the zone, lack of information on the fire source, a pipe network diagram not updated following emergency shutdown. (eMARS, n.d. – No. 292; ARIA, n.d. – No. 3396)

On the second basement level of a factory in an urban area mixing and packaging aerosols, a stock of boxed supplies stored on pallets ignited. A fork-lift driver saw a flash appear under his fork-lift truck and the surrounding atmosphere catch fire. The presence of smoke and heat complicated the emergency response. An ensuing explosion (BLEVE, "boiling liquid expanding vapour explosion) caused by the aerosol containers slightly injured four firefighters, while 25 others suffered from gas inhalation and had to be hospitalised. Toxic fumes led to evacuating 59 inhabitants. Eight emergency response centres were mobilized, including 130 firemen and 42 rescue vehicles. Plant activity was suspended several months in order to modify and bring installations into compliance.[1]

Inadequate and complex emergency response

Cases were described in which emergency response was not adequately carried out or the emergency situation was so complex that the response was unable to manage all aspects effectively. The analysis used a number of criteria to judge the adequacy of the emergency response. The criteria were applied to the 87 cases where detailed lessons learnt from emergency response were provided. If the case met one or more of the criteria below, it was considered an inadequate response.

- a member of the emergency team/fire brigade injured or killed during the intervention;
- clear lack of communication or delayed communication to the public;
- clear failure to liaise with external emergency response teams (police, ambulance, etc.);

1. 18 months later, the company and its director were respectively fined 300 000 francs (200 000 of which were suspended) and 80 000 francs (20 000 suspended). The facility was also ordered to donate 20 000 francs in damages and interest to a defence association and a token contribution to a trade union. (eMARS, n.d. – No. 386; ARIA, n.d. – No. 15844)

- clear failure of the planned evacuation procedure that endangered workers and emergency responders;
- environmental impact as a result of overflow of contaminated water from the fire extinguishers;
- failure to have an emergency response plan (often because of insufficient awareness of the risks or how to manage them);
- severity of the accident making it impossible to activate most aspects of the emergency plan;
- failure to foresee clear deficiencies of the emergency plan, e.g. foreseen escape routes unavailable, offices placed close to the risky areas of the chemical installation, which was a design failure;
- accident scenario assessed as low frequency and thus discarded from consideration in the internal emergency plan, or never considered in any emergency plan, or not considered at all;
- lack of clear and consistent emergency response procedures or inadequate training and instruction to staff on what to do and how to behave in an emergency.

Examples

As an operator was mixing and heating a flammable mixture of heptane and mineral spirits, he observed a dense fog accumulating on the floor below the tank. He notified a senior operator and both shut down the operation. They evacuated and warned other workers to do the same. They even warned the contracted driver to evacuate, but apparently he was talking on his cellular phone and did not hear them. After 10 minutes the cloud ignited and there was an explosion. The contracted delivery driver died in the accident and one employee was injured. The local fire department battled a fire confined to a bagged resin storage area for about 3-4 hours. The company suspended the flammable liquid mixing operation indefinitely. Following the investigation, it was suggested that facilities handling flammable and combustible liquids should implement an Emergency Action Plan and practice evacuation drills at least annually, but more frequently if necessary to keep employees prepared. (eMARS, n.d. – No. 687)

One worker was fatally burned and about a dozen others were injured when a powerful explosion devastated a chemical manufacturing facility. At the time of the explosion, six employees including the manager and superintendent, gathered outside a doorway on the upper level while a seventh was on the lower level by the lab. The employee on the lower level was killed while those outside the doorway were injured, two of them seriously. During this incident, none of the production employees evacuated to a safe location. The company was unprepared for an emergency. Specifically, the Emergency Action Plan did not list events or describe situations that might necessitate a plant evacuation. Operating procedure did not specify employees' actions in the event of a chemical release or loss of reactor control. Employees were not trained on the Emergency Action Plan and evacuation drills were not conducted. The facility was not equipped with an emergency alarm system. The Department of Public Safety responded rapidly and called in mutual aid support from County and nearby municipalities. Employees and public safety officers assisted injured employees. The fires following the explosion generated thick smoke, and local residents were asked to shelter in-place for several hours. The fires were extinguished the next day. (eMARS, n.d. – No. 685)

Successful emergency response

Learning lessons from accidents is also possible from positive examples. In reviewing the accident reports and focusing on what went wrong and why emergency response was inadequate, some events where emergency response was very successful also emerged. These cases give real-life examples of how intervention teams can perform their role effectively when they are fully aware of the gravity of the accident, the accident has been foreseen to a large extent in emergency planning, and responders have trained to know precisely what to do if the event occurs.

Examples

> In the sulphur dichloride (SCl2) distillation facility in a chemical plant, a spillage of SCl2 occurred in the retention area for a distillation column in the final stages of distillation, after a leak from a recirculating pump. The SCl2 hydrolysed upon contact with ambient humidity, causing an intensive emission of hydrogen chloride (HCl), which was not detected by the column's HCl gas detector. A safety alarm installed in the facility went off; the automated system shut down the facility and set off a local audible and visual alarm, while alarm warnings were appearing on the screens in the control room. The internal emergency plan was activated and the 35 employees were evacuated. The internal fire team, supported by 40 external firefighters, equipped themselves with breathing apparatus and plugged the leak; the cloud of HCl was overcome using 4 lateral fire-hose lines. It was discovered that a similar accident had already taken place at the site in 2006. (eMARS, n.d. – No. 955; ARIA, n.d. – No. 31691)

> On July 24th, the weather was stormy. The company had stopped loading the trucks and the valve at the base of the tank was closed at around 4.35 p.m. Ten minutes later, the roof of one alcohol tank was struck by lightning. It was a tank, with capacity of 5 000 m³ containing 1 000 m³ of 96% ethanol exploded as a consequence of the lightning strike. A fire broke out. The tank shell remained intact and the fire does not propagate to the other storage tanks. In May of the same year, the operators had carried out an internal emergency plan training, based on the scenario of a fire involving one of the alcohol tanks. Therefore, the emergency services knew the site well, and the emergency equipment was set up quickly, in the context of a smoothly working emergency response system. (eMARS, n.d. – No. 394; ARIA, n.d. – No. 18325)

Lessons learnt from accidents from other sources

Accident reports in the eMARS database generally give feedback on the efforts of emergency responders. However, a number of accidents in the last few decades (and even before) have also suggested other issues that merit attention as part of the incident response. This section provides a brief summary of secondary impacts that may be worth considering in emergency planning, specifically the role of accident spectators and mental health impacts.

Spectators involved in the reported accidents

High visibility accidents usually attract spectators. The examples below show that the phenomenon is not new. In fact, the most tragic example is the Texas City disaster that occurred in 1947 where more than 500 people died and over 3 000 were injured. However, public behaviour in accident settings has changed significantly with the radical development of communications technology; it has become a regrettable trend that people gather to see the accident, trying to record it from the best angle possible to publish what is happening on social media networks. This is a challenge that emergency responders have to face. As Lees states:

> The effects of spectators are twofold. The number of people at risk may considerably increase, and routes of the emergency services can become congested, leading to delays. The problem of spectators has been investigated by Hymes (1985 LPB 65), who describes quite a large number of incidents in which spectators suffered injury. Some of the cases cited involve people who became exposed to the threat and stood watching it develop instead of making their escape, while in others they were attracted to the incident as sightseers. The control of spectators is therefore an essential part of an off-site emergency plan and of a transport emergency plan. The responsibility for such control rests with the police. (Lees, 2012)

Among the accident reports only a few cases highlighted that spectators were injured in these accidents. Nonetheless it is important to mention some major challenges associated with the presence of observers. The presence of the media can cause extra workload and stress for emergency responders. While it is advised to set up a media information centre to serve these professionals' needs, it may not be possible to set this up in time to contain their demand.

An accident gained extensive radio coverage when the local broadcast of confinement instructions was picked up by national stations. As a consequence of the quick spread of the news, a large number of press organisations arrived at the site before any overview of the situation could be obtained or the emergency operation centre set up. This situation created a strong pressure of information demand on all those involved in the emergency response operations, even before collecting reliable information from the operator on the event and its consequences. (eMARS, n.d. – No. 399)

Some examples

> The accident occurred in the morning of 1 September in 1992, during the shift change. The explosion was caused by the ignition of a vapour cloud of hydrocarbons. The cloud spread in a large area of the unit and was then ignited by some sources of ignition, exploding. The high pressure wave that was caused resulted in shattering or collapse every window in the vicinity. Inside the establishment 14 people were killed by the explosion and 33 people were injured. Three workers injured in the accident belonged to the administrative staff. Apparently, they rushed to a window in their office to see what had happened, and one sustained severe burns from flames that burst in. (eMARS, n.d. – No. 541)
>
> A catastrophic fireworks explosion occurred at a fireworks depot on 13 May 2000 in Enschede. The fire led to an enormous explosion which killed 22 people including four firefighters, and injured 947 people; 50 of whom suffered serious injuries. The most common injuries from the explosion were injuries caused by flying objects. A very intense deflagration accompanied by a fireball 85 m in diameter then rocked the zone. The force of the main explosion was evaluated at between 4 and 5 tonnes of TNT equivalent. The smoke column was visible 40 km away; glass panes and store windows were blown out over a radius in the hundreds of metres. As the fire was spreading, many curious onlookers were able to approach the scene, since the safety perimeter set up by police and emergency services ran too close to the explosive zone. A large crowd of spectators assembled, attracted by the spectacle of the exploding fireworks. Many of them recorded the event with video cameras even as explosions

occurred. Police and ambulance personnel managed to clear the neighbouring street with some difficulty. Over 2 000 local residents had to be evacuated; 500 houses were destroyed or heavily damaged. Hundreds of rescue workers were needed to extract the injured. The municipality provided psychological help, financial support and new housing for the people. (eMARS, n.d. – No. 626; ARIA, n.d. – No. 17730)

The following incidents have been described in the study of spectators. At Deer Lake, Pennsylvania, in 1959, a road tanker carrying liquefied petroleum gas (LPG) was struck by a following truck in a wet street. LPG was released and ignited, engulfing the rear of the tanker. Fire services arrived, but expended water on a nearby building, and in due course the tanker suffered a boiling liquid expanding vapour explosion (BLEVE). Fragments, which included most of the tank, killed 11 spectators and injured 10 more. Emergency services were hampered both before the rupture and after it.

At Meldrin, Georgia in 1959, a rail tank car suffered a partial rupture near a picnic site. A large gas cloud spread and for some time did not ignite. When it did ignite, a flash fire occurred. There were 23 dead, many of whom were found in their cars. Emergency services were greatly hampered because the site was remote and served only by a dirt road congested by spectators and relatives of the casualties.

At Kingman, Arizona in 1973, a rail tank car carrying propane developed a leak that ignited. Despite police discouragement, a large crowd of spectators jostled to get a view. In due course the tank car underwent a BLEVE and a huge fireball erupted. Some 90 spectators 300 m away suffered injury.

Other incidents in which many of the deaths occurred among spectators are those at Texas City in 1947, and Caracas, Venezuela, in 1982. In the Texas City disaster, a fire developed aboard a ship in the harbour. The ship was carrying ammonium nitrate. In due course the ship disintegrated in an enormous explosion, killing all those in the dock, including firemen and spectators. This explosion and a further one in another ammonium nitrate carrier killed 552 people and injured another 3 000. The Caracas disaster involved a fire in an oil tank sited on a hill. A boil-over occurred and the burning oil flowed down the hill. Forty firefighters were killed, together with many civil defence workers and spectators, giving a fatality toll of 153 with 7 missing. (Lees, 2012)

Mental health issues

The eMARS database does not specifically require information about post-accident medical activities or psychological support to the injured or affected people. Nonetheless, there are some reports available with such information. Nine accident reports contained information about people suffering from shock after the accident. Furthermore, after high visibility accidents such as those at Buncefield, Toulouse and Enschede mental health effects were the subject of considerable study by both national governments as well as the research community. Hence, there are a number of publications on the topic of mental health impacts following a major chemical accident and technological disasters in general.

Research demonstrates that severe technological accidents can cause not only public concern but also substantial fear, anxiety and even post-traumatic shock in populations. The effects can sometimes be of long duration.

Loss of personal, social and material resources resulting from traumatic events causes stress and negative changes in life circumstances, (Van der Meijden, 2006; Soeteman, 2009). The sudden changes triggered by the accident – for example loss of life of family members or other members of the community, loss of family properties or businesses – are shocking. Even if the population had already been aware of the surrounding risks of the hazardous establishment in the vicinity, even if many had worked in the establishment, they might never have expected an accident with such a huge intensity to happen. Neighbouring populations root their ability to live all year near a risky installation by attenuating their perception of this risk. Not only is it impossible to fully prepare for or simulate actual individual and community impacts of a major accident, but daily life depends to an extent on keeping such eventualities out of mind (Poumadère, 2009). Mental health impacts may be even worse when a large part of the local community is entirely unaware of the risks, a situation that has been particularly highlighted in the aftermath of the fireworks warehouse accident that killed 22 people in Enschede, the Netherlands in May 2000. The warehouse was in close proximity to residential and business areas, but in large part the surrounding population did not know that a warehouse with such a large amount of fireworks was located within this bustling urban area.

Even those people who were not directly touched by the physical effects of the accident can present different types of mental disorders following an accident. The trauma of having nearly missed serious consequences can sometimes be almost as harsh for bystanders as it is for those who are directly affected. Often bystanders who did not suffer impacts reported being unable to sleep or restrictions in daily functioning because of physical and mental problems, such as anxiety, depression, and feelings of insufficiency (van Kamp et al., 2006).

It appears that some of the reaction can be reduced if people get informed continuously during the event (van Kamp et al., 2006). Therefore, information to the public during the overall emergency response is a critical aspect. As an example, a fire at a chemicals warehouse and distributor in Moerdijk, the Netherlands in January 2012 obtained significant national attention, even though damages were mainly confined to the site and there were no injuries or deaths. However, poor co-ordination of communications from authorities regarding the emergency potential of the enormous fire caused considerable distress to the local communities.

Examples

> During a weekly test programme, two maintenance operators started to test the isolation valves and the spare piston pump. The spare pump was switched-on and, immediately after, a leakage from a piping located above the operators occurred. They quickly escaped towards the control room before the gas was ignited by the pyrolysis furnace. The internal emergency plan was activated. The unit was shut down and fire protection means were activated while the affected area was evacuated. One of the isolation valves could not be completely closed (because the accident occurred during a test) and therefore the duration of the fire was prolonged. After 10 minutes, other pipes were ruptured causing an escalation of the fire, which was finally extinguished after 13 hours. Inside the establishment 1 person was hospitalized by psychological shock due to the flash fire; outside the establishment 1 person (a 14 years' girl) was hospitalized and 10 pupils of a nearby school were examined by personnel of the hospital. (eMARS, n.d. – No. 290)
>
> The refinery was shut down completely for several weeks following the explosion, followed by a phased start-up. An adjacent oil refinery also sustained damage to buildings, although the process plant was unaffected. The explosion caused widespread damage to houses and businesses within a 1 km radius of the site. Around 370 individual reports were made of damage to buildings, mainly broken windows and cracks to ceilings and walls. There is evidence of residents suffering shock and distress by the blast, although they were not injured. 71 civil claims for injury damage are being pursued by members of the

public. Members of the local population expressed concern about the lack of communication; they did not know if there had been a release of toxic gas and what action they should take to protect themselves. The normal precaution of shutting doors and windows was not available to those whose doors or windows had been damaged. (eMARS, n.d. – No. 523; HSE, 2001b)

Common findings

This section summarises the lessons learnt pertaining to emergency response from all the accidents studied. In total, the findings are collected from 87 accident reports in which particular detail on the emergency response activity was provided. Information on emergency response was found in several reporting fields, including the accident description, consequences, emergency response and lessons learnt sections.

The following are the main highlights from this review:

Emergency response procedures

Typical failures

- Lack of clear, efficient and brief emergency response procedures with clear roles and responsibilities (noted in ten cases). In several cases the outcome was a requirement to prepare specific checklists to more efficiently track and support emergency field operations. In one case a short outline of the emergency response procedure was required to support better communication with the local authorities.
- General deficiencies in emergency response procedures or the emergency plan. In 14 cases, a revision of the procedures or plans was required. Off-site emergency plan review was necessary in three cases. In most of these cases it was impossible to determine from the report why the emergency plan required improvement after the accident but it is very likely that the emergency procedure was outdated or some information or procedures that could have helped in the emergency response were missing. Related standards may not have been updated (as indicated in one case).
- Deficiencies in shutdown procedures (noted in four cases). In reported events the isolation of the endangered part of the process was impossible because the fire spread in the direction of the isolation equipment. In one case an operator could complete the shutdown manually at the location of the process but there were no remotely operated shut-off isolation valves located on the section of plant under consideration.
- Lack of accident scenarios or relevant accident scenarios (six cases). In half of these cases the accident scenario which occurred in the facility was missing from the emergency plan because of its low probability (estimated frequency of occurrence).
- Lack of or inadequate training and emergency exercises (11 cases); lack of training for emergency responders, including hazardous materials training to be familiar with the main activities of the site.
- Inadequate evacuation plans; lack of or inadequate training and emergency exercises to assure effective evacuation (four cases). In one case the designated area for on-site evacuation was the control room. This created extra work load and stress for the control room operators. In another case an administrative employee died when escape from the office using the designated evacuation route was impossible because it was filled with smoke from the fire transported by ventilation systems.

- Inappropriate location of control room and command post (two cases). In two cases, the control room was badly damaged by the effects of the accident.
- Need to upgrade fire detection and/or extinguishing water system (ten cases). For example, better performance of the extinguishing system in terms of adequate water flow (delivery and capacity of the water supply) was highlighted in one case.
- No access to fire extinguishing water. In some cases, there was no source available or it was inaccessible because of the accident. An under-dimensioned water curtain delayed intervention.
- Inadequate public warning systems. Public warning systems including alarms and sirens were inaudible or confusing or underwent failure in 12 cases. In one case an independent alarm system was requested after the accident because the cable of the system was ruined by the fire and thus, the company could not use its own means. They needed to contact the off-site emergency response services to launch the alarm. In another case, the local community was not aware of the type and meaning of alarms and sirens which caused confusion. Because the site affected by the accident was located among a number of high-hazard facilities, all sites were subsequently requested to develop a co-ordinated system of alarms. Alarms caused confusion for the control room operator in one case as a result of the phenomenon of alarm flooding; pre-accident co-ordination and direction was poor and tracking progress and tackling alarm handling issues were limited.
- Inadequate communication and co-ordination between on-site and off-site services (eight cases). In one case the fire brigade was delayed at the gate of the establishment because of lack of communication between the operator and the local authorities. In another event the whole communication system with the fire brigade failed in the middle of the emergency response. A portable radio communication system was required subsequent to one case. In another case off-site emergency services found that the gravity of the accident was underestimated in information provided by the operator. By contrast the operator considered that the measures taken by the authorities were exaggerated with regard to the nature of the occurrence.
- Delay in informing the firefighters (two cases). In one case, the fire brigade was not alerted until three hours after the accident, and in another case the operator was simply not able to make the alert, because of the failure of the power cable system.
- Drainage system insufficient to prevent fire extinguishing water run-off (eight cases). This situation generally caused environmental damage.

Reported lessons learnt

A number of reports also included specific lessons learnt:

- The operator should set out the procedures to be followed, and the roles and responsibilities of staff should be clear with regards to the need of allocate resources.
- Specific procedures must be in place for critical functions, such as power or process shutdown. Remote shutdown facilities should be appointed.
- Companies should set up good warning systems. Everybody on-site should be informed about the emergency via an audible alarm or siren whose meaning is clear. Such systems should be tested regularly. In case of industries situated close to each other a co-ordinated system of alarms should be developed. Neighbouring facilities should be informed about the emergency situation.

- In the written emergency procedures, emergency contact details should be provided and relevant to the types of possible emergency situations. All parties (fire brigade, police, etc.) involved in the emergency response process should appear on the contacts list. The contact details should be placed in a visible and easily accessible location. The list should be kept up-to-date both on the flyer and in the emergency plan.
- In preparing emergency plans, internal or external, possible accidents should be assessed independently from their high or very low probability. Based on the identified accident scenarios, resources and capabilities must be assessed and appropriate preparedness equipment must be on hand.
- Training and refreshment trainings must be provided to both new and long-time employees as well as training to third party workers and visitors about what to do in case of an emergency.
- Emergency drills should be organised periodically to ensure that the staff with a formal role in emergency response are familiar with their responsibilities. The overall aim of such drills is to check the adequacy of the emergency plan and fix problems afterwards.
- Following an emergency exercise or an accident, the emergency procedures should be reviewed and updated if necessary.
- The external emergency plan should be tested regularly and updated based on the learning from drills.
- A post-accident follow-up process, for example notifying the regulator, organising trauma counselling or medical treatment would be advantageous.
- Improved co-ordination and communication between on-site and off-site emergency teams is necessary. Decision-making rules and procedures should be designed to ensure that emergency response is prompt and effective.
- In addition to the emergency operations centre that is designated to facilitate communication between the on-site and off-site services, a media centre should share information and assist collaboration with the media.
- Possible accident scenarios must be identified in evacuation plans and adequate evacuation routes designed and maintained. In case of a plant modification the emergency plan must be updated and extended with new scenarios if necessary.
- All escape routes and emergency exits should be checked to ensure that they are easily accessible and visible even under accident conditions. The air conditioning system should not carry smoke or toxic fumes resulting from the accident to the designated escape route.
- A single or dedicated emergency operation centre or command system should be established during the event. Its location should be carefully chosen with consideration given to the emergency situation, weather conditions, and the need for proper distance between the centre and other process areas of the establishment. In site design control rooms must be positioned such that they are not likely to be damaged by the effects of an accident and control room operators can continuously be in operation.
- First-aid stations should be allocated and employees trained to provide first aid in case of an emergency.
- Evacuation procedures should address all types of identified hazards which may arise. They also should cover everyone who may be present on-site and ensure safe evacuation via clearly identified routes to assembly points which are not

affected by the accident. Special attention must be paid to the evacuation of disabled persons and a process must be in place to account for persons including workers, contractors, customers and visitors. A similar accounting process should be applied in case of sheltering.

- A site map that illustrates the location of fire protection equipment, emergency exits and assembly points should be available for emergency responders.
- The correct type of fire extinguisher (water, foam, carbon dioxide or dry powder, etc.) must be available, maintained, regularly inspected and tested. Employees should be trained to use the fire extinguishers and to employ the correct one according to the type of fire. Refreshment trainings ensure that employees keep their knowledge up to date.
- The operator should provide adequate and alternate water supply from sources reachable in case of an accident to avoid critical situations where ponds, lakes or reservoirs are either not available because of the large extent of the accident or the amount of water is not enough.
- Personal protection equipment should be available for all workers who have roles in the emergency response. Each must be equipped with communication devices such as radio. The equipment should undergo a regular revision and test. Training and checks during the event should ensure that personal protective equipment is worn properly, based on the requirements of the emergency situation.
- Even though only one case was reported of emergency power supply being used during the accident, planners should verify that critical parts of the establishment have emergency power supply for all situations.
- Emergency plans should take into consideration possible environmental impacts stemming from major accidents and establish relevant and adequate emergency response. Adequate fire water containment should be in place to prevent fire water run-off.

Conclusions

As the analysis of eMARS reports have revealed, emergency plans occasionally fail and emergency response can be deficient. Among the main challenges in emergency preparedness is the identification of pertinent accident scenarios; if consequences could be large then scenarios that were identified as low-probability in the safety reports might usefully be considered among credible candidates. Based on the selected accident scenarios, necessary resources must be assessed in order to be prepared to intervene in the case of an emergency. Essential aspects include assembly points/areas, safe havens, power supply, water supply, electricity, proper shutdown procedure, emergency operation centre with incident commander, media information centre, dealing with spectators, medical facilities and first-aid areas, communication systems both inside the establishment and with the public, communication point, co-operation between emergency response teams, selection of the appropriate personal protection suite and equipment for emergency responders based on the hazards, as well as forces according to the level of seriousness of the event.

Training and emergency drills are equally important for successful emergency response both on-site and off-site. The public and employees must be involved in the planning phase, anticipating their possible involvement. Correct behaviour in case of emergency including evacuation or sheltering is crucial information to be shared with all involved parties.

Some case studies demonstrated that even emergency responders can die or be injured in major accidents, during or after the intervention takes place. In most cases these losses are due to a lack of knowledge about the types and hazards of dangerous substances involved in the accident. Without this essential information, firefighters did not have the satisfactory knowledge to make a decision on the level and type of personal protection to be chosen. In other cases, they suffered injuries because of a sudden, unexpected explosion while battling the fire. Response teams should have knowledge of the site and must be informed about the level of degradation, current situation and surrounding hazard sources. Backup forces and calculation of extra systems is necessary in case of an escalation of the accident or prolonged intervention.

There was some positive feedback from the analysis. Interestingly, information to the public seemed efficient in the analysed reports. For example, in cases where the accident had effects outside the establishment, neighbouring industries and the public were immediately advised to confine themselves or stay at home as a precautionary measure. Furthermore, positive examples revealed that establishments that had a good emergency plan, had written effective emergency procedures and ensured their employees were trained adequately and knew what to do in case of emergency were prepared when the accident occurred and were able to stop the escalation of the event and mitigate the consequences.

Emergency planning can be successful if all three elements of preparedness, response and recovery are covered from the start of the planning phase.

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Chapter 3. Lessons learnt from crises: Preparing for the future

by Jack Radisch, Charles Baubion and Catherine Gamper[1]

Introduction

The OECD plays a leading role in helping countries to share good practices in governance across the risk management policy cycle. This work has been welcomed by international forums, such as the G20 Finance Ministers and Central Bank Governors. Building on lessons learnt from crises that have hit OECD countries, the OECD High Level Risk Forum and the Directorate for Public Governance have gathered practical tools seeking to improve risk governance. One of the main conclusions of this work is that governments must develop crisis-management capacities to cope with the complexity, novelty, ambiguity and uncertainty that characterise many modern crises. Emergency response plans are necessary tools for conventional crisis management. They are designed with reference to past events and work well for routine emergencies. Flexible approaches, however, are needed for "black swan"[2] events. This contribution presents an overview of the main outcomes of this work, which aims to contribute guidance to a comprehensive, all-hazards and transboundary approach to country risk governance and more resilient societies.

The OECD High Level Risk Forum

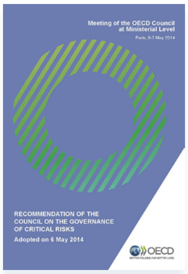
Increasing economic losses resulting from frequent natural and human-made disasters (cf. Annex 3.A.1) incited risk managers from OECD countries to set up the High Level Risk Forum in 2011. The Secretariat of the forum is part of the OECD Public Governance and Territorial Development Directorate. The forum brings together policy makers from OECD member countries and key partners, practitioners from the private sector and civil society, and experts from think tanks and academia. It examines a broad range of policies and partnerships to prevent and manage the consequences of potential hazards and threats, and to consider how to increase society's resilience to global threats. While the forum promotes an all-hazards approach, it has not conducted research on every type of hazard or threat, e.g. it has not studied policies related to nuclear accidents per se. Its focus has been to support governments in developing an integrated vision of risk governance. One of the forum's key networks includes crisis managers and enables countries to share lessons and support international co-operation for more resilient societies and safer livelihoods through a better response to complex crises.

1. Jack Radisch (Senior Project Manager), Charles Baubion (Policy Analyst) and Catherine Gamper (Policy Analyst) are from the OECD Public Governance and Territorial Development Directorate. This chapter is, for the most part, an excerpt of the OECD 2015 publication, *The Changing Face of Strategic Crisis Management* and of the forthcoming OECD publication, *National Risk Assessment: An OECD Cross-Country Perspective*, both from the series of OECD Reviews of Risk Management Policies.

2. "Black swan" events refer to rare and unpredictable events as explained in the book *The Black Swan: The Impact of the Highly Improbable*, published in 2007 by Nassim Nicholas Taleb.

Recommendations of the OECD Council on the Governance of Critical Risk

The "Recommendation of the Council on the Governance of Critical Risks", adopted by Ministers in May 2014, sets an OECD standard to better govern complex risks and crises. A series of workshops between 2012 and 2015 on strategic crisis management were jointly organised with the Swiss Federal Chancellery and contributed significantly to the development of the 2014 Council Recommendation.



This recommendation, adopted by the OECD Council on 6 May 2014, is in recognition of the escalating damages that occur due to extreme events. Total damage caused by natural and human-induced disasters in OECD and BRIC countries (Brazil, Russia, India and China) has been estimated at nearly USD 1.5 trillion over the last decade. New vulnerabilities and interconnections seem to amplify and spread the economic impacts across sectors and borders. Recent events are a stark warning for economic systems that are dependent on global supply chains (OECD, 2014c).

The recommendation proposes a fundamental shift in risk governance towards a whole-of-society effort. It proposes actions that governments can take at all levels of government, in collaboration with the private sector and with each other, to better assess, prevent, respond to and recover from the effects of extreme events, as well as take measures to build resilience to rebound from unanticipated events.

Recommendation of the OECD Council on the Governance of Critical Risk

Overview

II. RECOMMENDS that Members establish and promote a comprehensive, all-hazards and transboundary approach to country risk governance to serve as the foundation for enhancing national resilience and responsiveness.

To this effect, Members should:

1. Develop a national strategy for the governance of critical risks.
2. Assign leadership at the national level to drive policy implementation, connect policy agendas and align competing priorities across ministries and between central and local government.
3. Engage all government actors at national and sub-national levels, to co-ordinate a range of stakeholders in inclusive policy making processes.
4. Establish partnerships with the private sector to achieve responsiveness and shared responsibilities aligned with the national strategy.

III. RECOMMENDS that Members build preparedness through foresight analysis, risk assessments and financing frameworks, to better anticipate complex and wide-ranging impacts.

To this effect, Members should:

1. Develop risk anticipation capacity linked directly to decision making.
2. Equip departments and agencies with the capacity to anticipate and manage human-induced threats.
3. Monitor and strengthen core risk management capacities.
4. Plan for contingent liabilities within clear public finance frameworks by enhancing efforts to minimise the impact that critical risks may have on public finances and the fiscal position of a country in order to support greater resilience.

IV. RECOMMENDS that Members raise awareness of critical risks to mobilise households, businesses and international stakeholders and foster investment in risk prevention and mitigation.

To this effect, Members should:

1. Encourage a whole-of-society approach to risk communication and facilitate transboundary co-operation using risk registries, media and other public communications on critical risks.
2. Strengthen the mix of structural protection and non-structural measures to reduce critical risks.
3. Encourage businesses to take steps to ensure business continuity, with a specific focus on critical infrastructure operators.

V. RECOMMENDS that Members develop adaptive capacity in crisis management by co-ordinating resources across government, its agencies and broader networks to support timely decision making, communication and emergency responses.

To this effect, Members should:

1. Establish strategic crisis-management capacities to prepare for unknown and unexpected risks that provoke crises.
2. Strengthen crisis leadership, early detection and sense-making capacity, and conduct exercises to support interagency and international co-operation.
3. Establish the competence and capacities to scale up emergency response capabilities to contend with crises that result from critical risks.
4. Build institutional capacity to design and oversee recovery and reconstruction plans.

VI. RECOMMENDS that Members demonstrate transparency and accountability in risk-related decision making by incorporating good governance practices and continuously learning from experience and science.

To this effect, Members should:

1. Ensure transparency regarding the information used to ensure risk management decisions are better accepted by stakeholders to facilitate policy implementation and limit reputational damage.
2. Enhance government capacity to make the most of resources dedicated to public safety, national security, preparedness and resilience.
3. Continuously share knowledge, including lessons learnt from previous events, research and science through post-event reviews, to evaluate the effectiveness of prevention and preparedness activities, as well as response and recovery operations.

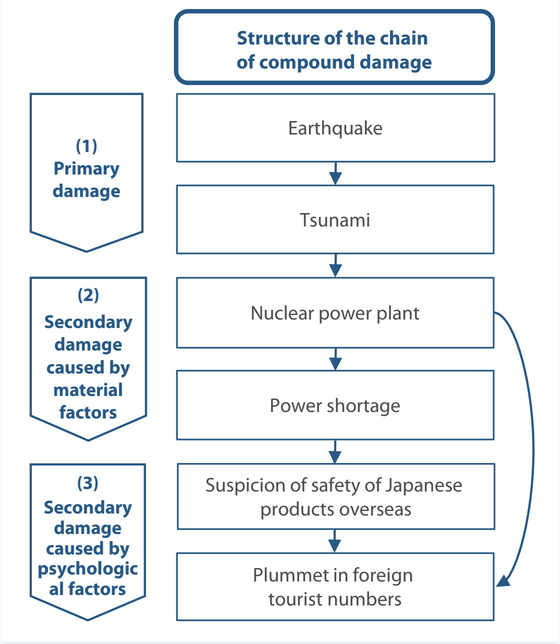
Defining new crises

Recent crises have challenged political leadership and risk managers in many countries, often due to unexpected or unforeseen circumstances, but also due to governance gaps and information bottlenecks. Examples include the H1N1 virus (swine flu) outbreak in 2009, the 2010 volcanic ash cloud over Europe, and the 2011 Great East Japan Earthquake, in which the ensuing tsunami and the Fukushima Daiichi nuclear accident resulted in cascade effects (Figure 3.1). Country risk management processes and structures were unprepared to deal with these crises, which differed significantly from past events in several respects:

- Their novel or unprecedented nature – at least in human or crisis managers' memories – or their unusual combination (Leonard, 2012).
- Their unexpectedly large-scale or particular geographic distribution.

- Their transboundary nature (Ansell et al., 2010), which here refers not only to their effects having crossed physical geographic borders, but also the involvement of public authorities from national and sub-national levels, relevance of several policy fields, and mobilisation of different sectors (public, private, non-governmental, etc.).
- Their consequences, which stir deep uncertainties in the minds of the public, challenge government structures and aggravate tensions between many stakeholders in the public and private sectors.

Figure 3.1. **Cascading effects of the Great East Japan Earthquake**

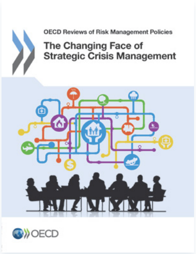


Source: Adapted from Kaji, 2012.

These transboundary effects can expand to become what the OECD has characterised as a "global shock", that is, a "rapid onset event with severely disruptive consequences covering at least two continents" (OECD, 2011). This concept takes into account another pattern of novel crises: cascading risks that become active threats as they spread across global systems, such as transport, health, financial or social systems. A traditional crisis can become transboundary and develop into a global shock at a later stage.

The Changing Face of Strategic Crisis Management

New crises call for new and innovative crisis management responses



Recent large-scale natural hazards, terrorist attacks, global pandemics, refugee crises and industrial accidents have demonstrated the diversity and complexity of today's crises. The increasing interconnectedness of modern societies makes them also vulnerable to shock events originating outside their national territory, as socio-economic impacts can cascade across physical borders.

Citizens expect effective leadership from their government in planning for and managing crises, and increasingly hold their leaders accountable. This is fundamental for building and maintaining public trust, which is particularly tested during emergencies. Close media scrutiny – including through social media – has put increasing pressure on governments to be more open, transparent and accountable in crisis situations. While citizen expectations have increased, the capacities of governments to plan for and respond to shock events of an unprecedented nature are still a work in progress.

Table 3.1 summarises key differences between traditional crisis management and how to deal with novel crises. While governments need to adapt their crisis-management capacities to the characteristics of novel crises through developing new doctrines and tools, they should also maintain the ability to deal with more classic crises, where robust preparation is vital.

Table 3.1. **Different approaches in crisis management: Traditional crises versus dealing with novelty**

Traditional crisis management	Crisis management dealing with novelty
Preparedness phase	
• Risk assessment based on historical events. • Scenario based emergency planning. • Training to test plans and procedures. • Early warning systems based on monitoring, forecasting, warning messages, communication and link with emergency response.	• Risk assessment including horizon scanning, risk radars and forward-looking analysis to detect emerging threats. • Frequent updates and different timescales, international analysis sharing and multidisciplinary approaches. • Capability-based planning and network building. • Strategic crisis-management training to learn agility and adaptability and create networks and partnerships. • Strategic engagement from centres of government.
Response phase	
• Command and control system. • Standard operating procedures. • Strict lines of responsibilities. • Sectoral approaches. • Principle of subsidiarity. • Feedback to improve standard operating procedures.	• Crisis identification/monitoring engaging expertise. • Flexible and multipurpose crisis-management teams and facilities. • Common concepts across agencies to inform leadership with high adaptive capacities. • Similar tools and protocols utilised for multi-crises. • International co-operation. • Management of large-response networks. • Ending crisis and restoring trust. • Feedback.

Adapted from OECD, 2015; Table 1.1, p. 35.

Drawing on the discussions during the above-mentioned workshops, the OECD High Level Risk Forum has proposed a fundamental shift in crisis management to help governments adapt to the new risk landscape through agile systems that can handle the unexpected. In its publication *The Changing Face of Strategic Crisis Management*, practical recommendations are put forth to develop strategic crisis-management capacities in order to minimise the impacts of large-scale shocks.

Key messages and recommendations

Governments should develop robust crisis-management frameworks to cope with the complexity, uniqueness, ambiguity and uncertainty that characterise many modern crises. New crisis governance frameworks are needed for these major "black swan" events.

Leadership during a crisis is fundamental for maintaining trust in public institutions. It requires developing professional capacity and skills through specialised training; addressing in particular crisis sense making, decision making and meaning making.

When confronted with unprecedented emergency, strategic crisis managers should be able to quickly identify and mobilise the most relevant and trustworthy expertise to help make sense of the crisis. Such knowledge management systems and expert networks need to be set up in advance and across multiple sectoral, professional and disciplinary boundaries.

Social media presents opportunities to enhance crisis communication, but also come with new challenges. Governments should therefore develop dedicated crisis communication strategies for the use of social media in crisis management.

Engaging the private sector in crisis-management efforts is essential as the scale and complexity of major crises requires a "whole-of-society" approach. Governments should set up the right incentives for co-operation with the private sector in times of crisis.

International co-operation offers fruitful opportunities with the need to strengthen international partnerships. This may concern areas such as joint response planning, early warning and sense making, and may involve information exchange, joint exercises and drills.

For the purposes of this contribution, we will focus on two areas of ongoing work by the NEA: the use of social media for crisis communication; and the development, implementation and evaluation of strategic crisis-management exercises. These contributions are excerpted from the OECD 2015 publication, *The Changing Face of Strategic Crisis Management*, from the series of OECD Reviews of Risk Management Policies.

Social media use for crisis communication

Traditional crisis communication consists of communicating messages on the status of a crisis, its impacts, and the actions and measures that have been mobilised. It is usually designed to feed the media with facts and demonstrate to citizens that the government or other authority is managing the incident as well as possible. Political leaders are often called upon to communicate through broadcast media, and therefore require specialised training.

In the age of social media, where both essential and false information is communicated widely from a large number of sources, crisis managers need to use these tools to share information and communicate. Dedicated social media response teams can be very useful for sharing crisis information with citizens. Traditional ways of communication should not be abandoned, however, as certain population groups do not make use of modern social media. Furthermore, certain crises may entail damage to telecommunications networks and thereby disrupt access to many social media platforms. In such cases, diversified communications platforms prove their value.

When a crisis reaches a level of severity that means the trust in the government is severely challenged, crisis communication enters into a new phase, where leadership is critical. When citizens' expectations are at their highest, leaders need to find the right words to provide meaning to what is happening. This "meaning-making" function of leadership refers to the capacity to provide not only information, but also a narrative that responds to public expectations. Reducing public and political uncertainty is fundamental to enhancing crisis management. The leader needs to convince the public that they should trust the government at a very critical moment. Finding the right words or the capacity of "persuasion" sometimes requires taking a step back from the event to tailor key messages that focus on the values of society. Setting a few officials aside from the heat of the crisis in crisis cells can be a useful tactic to protect them from the unsettling dynamics of the events and from media demands for immediate information.

Using social media effectively in crisis communication requires avoiding certain pitfalls, and appropriate resources need to be devoted to the management of social networks during a crisis to ensure responsiveness. Ensuring the reliability of information circulating through social networks, managing rumours and avoiding panic are fundamental to success. Information overload can cause distractions for crisis managers. As some segments of the public may not be easily reachable through social media, inclusive crisis communication also requires using traditional communication channels.

Table 3.2. **The different types of social media used in risk and crisis management**

Type of social media	Examples	Use for risk and crisis communication
Social networking	Facebook Myspace Friendster	Enhance co-ordination among volunteers and emergency services. Allow to share information inside a community. Provide swift update on emergency situation.
Content sharing	YouTube Flickr Vimeo	Enhance situational awareness in real time through exchange of pictures and videos. Allow emergency services to easily launch viral campaigns about risks. Help identify missing individuals, victims.
Collaborative knowledge-sharing social media	Wikis Forums Message boards Podcasts	Enhance dialogue between victims and emergency services.
Blogging and microblogging	Blogger Wordpress Tumblr Twitter	Convey recommendations and warnings. Share facts. Twitter enables immediate information sharing with a wide reach and feedback possibilities.
Specialised crisis-management platform managed by volunteer technology communities (VTCs)	**Mapping collaboration** OpenStreetMap Crisis mappers Google map maker **Online and on-site contribution** Ushahidi CrisisCommons Sahana Foundation Geeks without Bounds **Public-private-people partnership** Random Hacks of Kindness (with Google, Microsoft, Yahoo, NASA, World Bank)	Mapping of emergencies. Community Emergency response team facilitator.

Adapted from: OECD, 2015; Table 3.1, p. 79.

Key messages:

- Social media are revolutionising communication. They have great potential to support two-way crisis communication at a low cost and with high efficacy, and can maintain trust in government by developing a direct relationship with citizens at a time when expectations are high.
- There are three main ways that social media is used in crisis management:
  - as a situation awareness tool by monitoring eye-witness reports (bottom-up);
  - as a state communication tool to convey official statements of what is known about a situation, what is unknown, and what actions the public should take (top-down);
  - as an interactive platform to support crowd-sourced verification of events.
- The challenges of using social media in crisis communication include: the multiplicity of players, the amount of information generated, the question of open data, privacy and confidentiality, the question of liability, the expectation of the population, and the issue of security.
- Governments should develop social media strategies to support their crisis communication strategies before, during and after a crisis. Guidelines can encourage the use of social media by emergency managers and should address the implications of an increased use of social media (resources, reliability, information overload, etc.).
- Governments should foster citizen-led social media use and enable communities and individuals to self-initiate and volunteer in emergency efforts through the development of technological platform and tools.
- Governments should maintain traditional media in their crisis communication strategies to ensure the inclusion of all segments of the population.

Strategic crisis-management exercises

During a crisis, strategic-level decision makers are forced to act under very difficult circumstances. Leaders, along with their teams, organisations and key partners must be prepared to cope with the uncertainties that pervade contemporary crisis management. Training leaders is thus a prerequisite for efficient strategic crisis management.

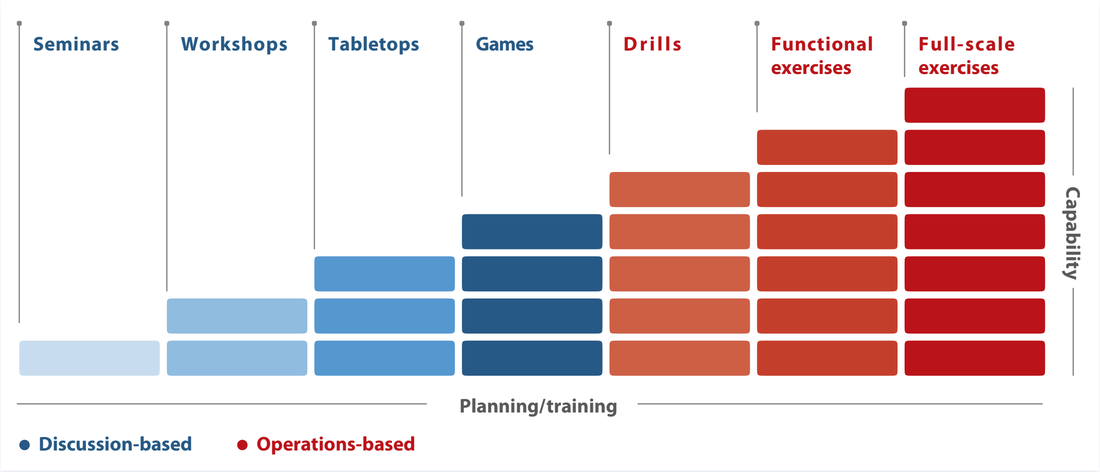
International co-operation and partnerships should be further strengthened in areas such as joint response planning, early warning and sense making through information exchange and joint exercises and drills. Despite the challenges involved, engaging with the private sector internationally in strategic crisis-management exercises is necessary for the development of a shared crisis-management culture and for creating trust across borders.

Key messages

- Developing the skills and capacities to manage and prepare for complex crises, as well as for unknown and "black swan" events, is key to effectively fulfilling leadership functions.
- Strategic crisis-management exercises are essential for developing and "stress testing" the capacity of leaders to cope with novel crises and large-scale emergencies.
- Engaging leaders in strategic crisis-management exercises requires the design of dedicated exercises and for a convincing case to be made.

- Exercise formats, designs and techniques should be adapted to the goals and purposes of a given exercise.
- Good exercises should appear to be simple, while masking their complexity. There should be a theoretical underpinning and elements of surprise included.
- Joint crisis-management exercises can contribute to building efficiencies and trust between governments and the private sector, which is essential in many complex crises. Incentives and a good understanding of private-sector constraints can facilitate private-sector engagement.
- Developing further international crisis-management exercises is necessary for improving capacities to cope with the cross-border effects of complex and large-scale crises.

Figure 3.2. **Different types of crisis exercises**



Source: OECD, 2015, Figure 4.1, p. 113.

Key recommendations for designing and developing strategic crisis-management exercises

To help governments design and develop strategic management exercises, the following actions should be considered:

- Establish strategic crisis-management exercise programmes for leaders and high-level public officials to train them in the leadership roles they are expected to play during crises and to confront them with the new realm of complex crisis management. Exercises should be adapted for individuals, groups, and organisations and take into account their prior frames of reference, previous experience and levels of proficiency.
- Clarify early on the objectives of strategic crisis-management exercises and make this goal clear to participants. Exercises can test and highlight different functions, abilities and capacities. They can be used for multiple purposes, such as familiarisation, skill building and preparedness testing. Exercise formats, designs and techniques should be consciously and explicitly adapted to the goals and purposes of a given exercise. One size (and one instructional design) does not and cannot fit all.

- Develop the right incentives for the private sector to develop their crisis-management skills in partnership with government, including at the leadership level. The scale and complexity of major crises requires whole-of-society co-operation under difficult conditions. Engaging the private sector, although potentially difficult, is essential.
- Engage across borders in international crisis-management exercises, including among leaders. Many of the most significant threats and hazards do not respect national boundaries. Conducting exercises is essential for developing, testing and improving the ability of nations to co-operate effectively under adverse condition. International exercises, although challenging to arrange, design, develop, and implement, can play a key role in improving preparedness.

International co-operation: Bi-lateral and multi-lateral exercises

In addition to the institutional formalities and national capacities mentioned above, it is important to develop transboundary capacities as many crises traverse national borders. The conduct of multi-lateral simulation exercises is a useful form of international co-operation to test preparedness and collaborative capacity. Simulations take place regularly under the auspices of organisations such as North Atlantic Treaty Organisation (NATO), the European Union and other regional or global international organisations. A good example in 2016 was the VITEX exercise organised by the government of the Netherlands, in which government bodies and transportation system operators from a large number of EU member states engaged in a cross-border scenario concerning energy shortage. In the field of civil nuclear energy, exercises also take place under the auspices of the IAEA and the NEA.

International exercises targeted at the strategic level may be particularly difficult to design, arrange, and implement, as experience has uncovered various obstacles and challenges that participants need to overcome. The selection of a risk scenario and its development for the exercise might prove difficult when participants perceive risks differently in terms of the likelihood, consequence or both. A risk scenario that is highly relevant for one participating country may be of little interest to another, or participants may have very different levels of prior preparation, skill and experience in managing the risk in question.

Differences in institutional arrangements for crisis management may also lead to obstacles in effective co-operation. Assumptions are often made about who should be included and who the appropriate national focal points should be for participation, but differences abound across countries in terms of governmental structure, the division of responsibility for crisis management, and available resources among public, private and non-profit sectors. The use of novel crisis scenarios in particular may encounter difficulties in selecting international partners as the relevant responsibilities may not have been clearly assigned within and across countries. The development of exercises may be challenged by issues of organisational or technical inter-operability and information sharing among nations. Nonetheless, the conduct of training exercises provides valuable opportunities to identify and overcome these challenges.

Additional challenges and obstacles include:

- political sensitivities related to real-world interests and conflicts among actors;
- political sensitivities related to scenario roles (victim of or party responsible for an attack), accident or disaster aid recipient (e.g. host country) or helper (provider of assistance);
- secrecy and classification rules;

- barriers to communication deriving from language and professional terminology/ jargon/acronyms;
- building trust;
- participants from different levels and organisations in their respective countries;
- different levels of prior knowledge, skills, and preparedness in general and with regard to specific contingencies;
- different cultural and historical frames of reference, and different cultures with regard to participation in exercises and evaluation.

Anticipation of potential crises

The OECD Recommendation on the Governance of Critical Risks calls upon Adherents to build preparedness through foresight analysis and risk assessments to better anticipate complex and wide-ranging impacts. Beginning in the first decade of the 2000s, a small number of OECD countries began a process at the central level of government to compare the different risks of major civil contingencies that could occur in their territories. These so-called “national risk assessments” assess different hazards and threat scenarios according to common criteria and then compare their relative likelihood and consequences. Previously, specialised departments and agencies in these countries conducted disparate risk assessments for different hazards and threats, using different analytical methods and criteria. As of 2016, the OECD Survey on Risk Governance reveals that three-quarters of all OECD countries now produce a central government portfolio view of the environmental, social and technological risks that could cause significant damage or disruption to their vital interests. This tool enables a more comparable view of risks across the entirety of central government with the final objective to reduce society’s vulnerability, enhance its resilience and reinforce public trust.

The scope of most national risk assessments includes such major risk scenarios as natural hazards, infectious diseases, industrial accidents and terrorist attacks. In some countries, they also cover such risks as labour strikes, sabotage of energy or transport infrastructures, and failure of institutions, which may also trigger the types of consequences that challenge governments to react quickly, often without prior anticipation and planning. An all-hazards approach is useful to identify interlinkages between natural phenomena and human-made events, and to develop risk scenarios from a multidisciplinary perspective. This improves knowledge about the possible sequencing of hazardous events and the knock-on effects they can cause across borders.

The two most common transboundary risks identified in national risk assessments are pandemics and nuclear accidents. Both these risks are considered as potentially high-consequence in several countries. Formal international processes are in place to monitor these types of risks, but capabilities to handle the consequences are uneven across countries. National risk assessments in several countries specifically refer to the risk of nuclear accidents in a neighbouring or nearby country as a risk of national significance. In countries without civil nuclear electricity production, there might be less capacity to handle the consequences of a transboundary event than in countries that have an established regulated nuclear industry. Communication protocols between neighbouring countries should be established and exercised to ensure effective management of the consequences of an eventual accident with transboundary effects; not only through diplomatic channels, but also through joint civil protection exercises.

The goal driving a majority of countries to conduct national risk assessment is the attainment of social and economic resilience. The results are meant to inform the building of capacities needed to implement a civil protection strategy or emergency management planning to anticipate, withstand, respond to and recover from natural and human-made disasters. In this respect the results are a useful tool for high-level policy makers to inform decisions about the allocation of resources for prevention and mitigation measures on a risk-informed basis.

A few countries are leading the way in conducting a "whole-of-society" national risk assessment in which experts are invited from beyond central government institutions to participate, including: different levels of government, research institutes and academia, and even experts from the private sector. Broader participation is a counterweight to "group think", it injects new knowledge into the exercise, questions assumptions, and fosters the identification of unknown and complex risks that arise from vulnerabilities and interdependencies across all sectors. It also clarifies ownership of specific risks, and joint ownership of complex risks, that might otherwise "fall between the cracks" of public bodies that assume that management of the risk belongs to a different institution.

The national risk assessment process can help to clarify risk ownership, meaning which ministry or agency has front-line responsibility for managing the consequences of risks, and this has proven important to establish accountability at an institutional level. The results are also used in a few countries to raise public awareness and nudge citizens and businesses to take self-protective measures. There is a divide in opinion among practitioners about the utility of communicating the results of national risk assessments to the public. Most practitioners agree that the results should be communicated to policy makers and used by emergency planners. Some practitioners support the idea that national risk assessments can be a tool for "open government" and inform public perception. A minority of practitioners argue that it is not useful to communicate the results and that more locally targeted risk communication is needed, e.g. localised risk analysis, to prompt demand for risk reduction measures.

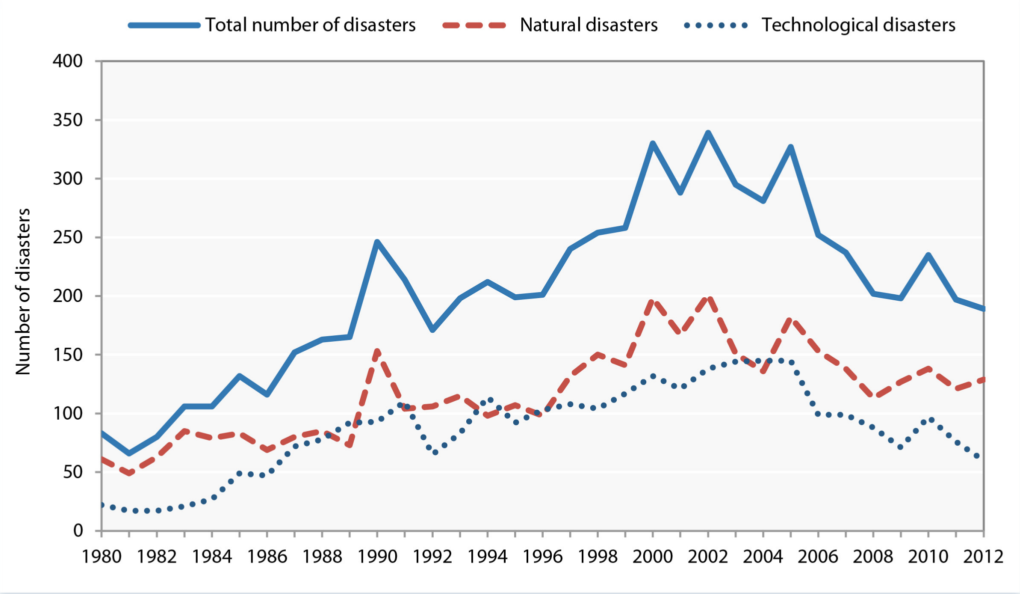
National risk assessments are an iterative process. Only a few countries consider their national risk assessment as a mature process, while most countries consider it a work in progress. The countries that were among the first to conduct a national risk assessment (e.g. Canada, Norway, the Netherlands, Sweden, the United Kingdom and the United States) committed to the production of several consecutive versions and made efforts to refine their methodologies over time. Countries that conduct an annual or biennial national risk assessment develop capacity to learn lessons from the production of previous versions. In a few countries formal reviews of the process and methodology have been organised which call into question basic assumptions, e.g. whether to base deterministic risk scenarios on a "reasonable worst case". Among the lessons learnt from these reviews is the need to obtain the best expert input to the process from across government, and to focus the attention of policy makers at the highest level to the results. A clear mandate to a designated co-ordination body is helpful to ensure the former, whereas connection to a Cabinet-level strategy or legislation is helpful for the latter, as well as close co-ordination with the centre of government.

Risk exposure across OECD countries

OECD countries have experienced significant negative impacts from past disruptive shocks, a trend that has been pointing upwards. In the last 30 years, disruptive events, including natural and human-made causes, have increased across OECD and BRIC countries (Brazil, Russia, India and China), decreasing again in recent years (Figure 3.3).

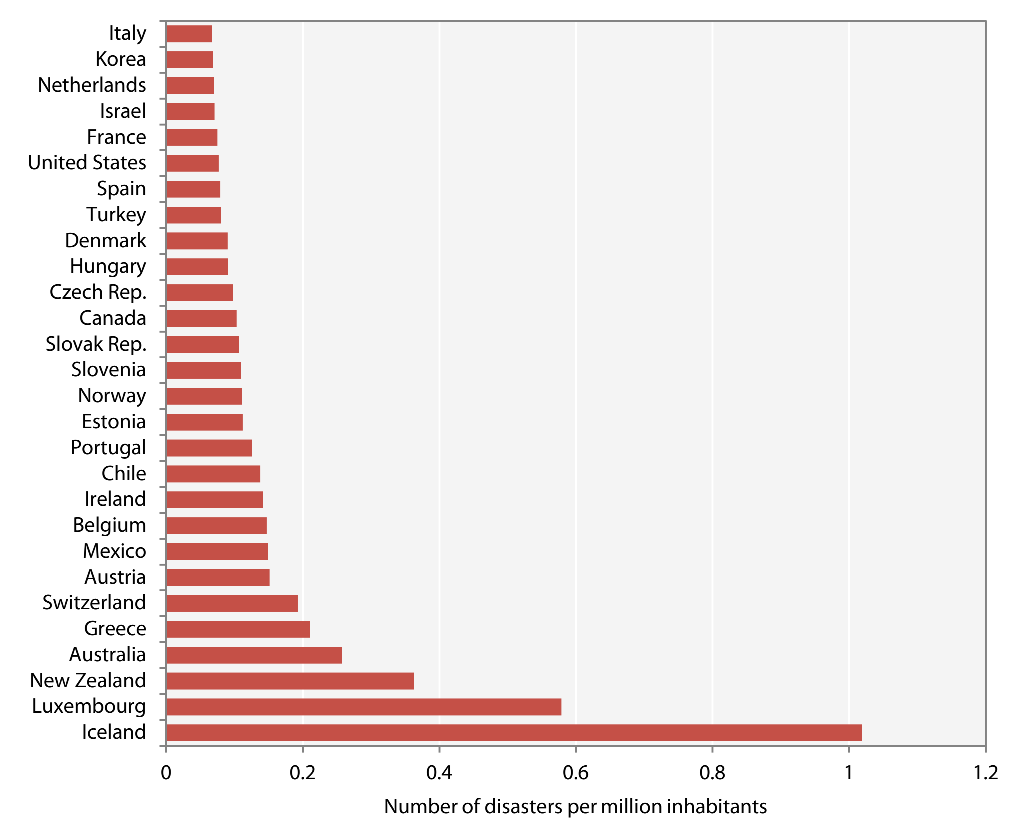
Within OECD countries, impacts are unevenly distributed. Looking at disasters proportionately to the size of the population, among the countries most affected by disruptive events across the OECD are Australia, Iceland and New Zealand (Figure 3.4). However, impacts are inversely distributed when compared to income. OECD countries with a lower gross domestic product (GDP) per capita experience relatively more fatalities from disasters, whereas countries with a higher GDP per capita see larger economic impacts.

Figure 3.3. **Number of annual disasters in OECD and BRIC countries: 1980-2012**



Source: OECD, 2014b; EM-DAT, 2013.

Figure 3.4. **Disaster exposure across OECD countries: 1973-2012**



Sources: OECD, 2014b; EM-DAT, 2013.

Resilience in the risk management cycle

"Resilience is the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks."

A general understanding of what constitutes the main activities of risk management systems is depicted in Figure 3.5. These include the identification and assessment of risks; mitigation and prevention of risks; preparedness in the case of a disruptive event; emergency response; recovery and rehabilitation. Resilience is the outcome of measures that have been put in place before, during and following a shock. Resilience is an activity that is consistent with prevention and preparedness as well as with enhancing crisis-management capacities.

Boosting resilience through innovative risk governance

Key policy recommendations

- Promote forward-looking risk governance that takes into account complex risks. In evaluating risk exposure, countries may want to not only rely on past disruptive shocks and linear risk modelling, but also consider evolving risk patterns, including demographic, economic, technological and environmental drivers, as well as their interdependencies and potential cascading impacts.
- Established resilience measures should be adapted to keep pace with the evolving changes in the risk landscape. Monitoring and evaluation systems can help inform such a process and forward-looking methods can support the identification of future, complex risks.
- Emphasise the role of trust. Past disruptive shocks have eroded trust in a government's ability to protect citizens from harmful impacts. Costly measures have been employed to restore trust after major shocks. Shocks can be an opportunity for governments to showcase long-term commitments to protect their citizens. Transparency and accountability in managing resilience are key factors to maintaining trust in the long run.
- Establish a shared understanding of acceptable levels of risk at all stakeholder levels. Identify methods that support governments, businesses and individual stakeholders to determine their optimal or acceptable levels of risks, based on which risk resilience strategies can be adopted.
- Decide on an optimal and complementary mix of resilience measures. Countries can consider a mix of hard (ex. infrastructure) and soft (ex. planning) measures that take into account a multi-hazard perspective and hence complement each other, while fostering economic development through positive spill over effects.
- Adopt a whole-of-society approach to engage all actors in strengthening resilience. Such a strategy is essential to align responsible risk actors and their institutional frameworks.
- Acknowledge the important role of institutions and institutional gridlock in making risk measures effective in increasing resilience. Previous shortcomings in the institutional set-up have caused government, market, and collective action failures in risk management that have impeded the achievement of higher levels of resilience. Once such institutional bottlenecks are addressed, they present very cost-effective opportunities for boosting resilience.

- Employ diagnostic frameworks to identify institutional barriers and realign incentives to boost resilience. Such frameworks can systematically detect what drives existing institutional shortcomings that impede increased resilience. The framework suggested in this report offers a possible guide for policy makers.

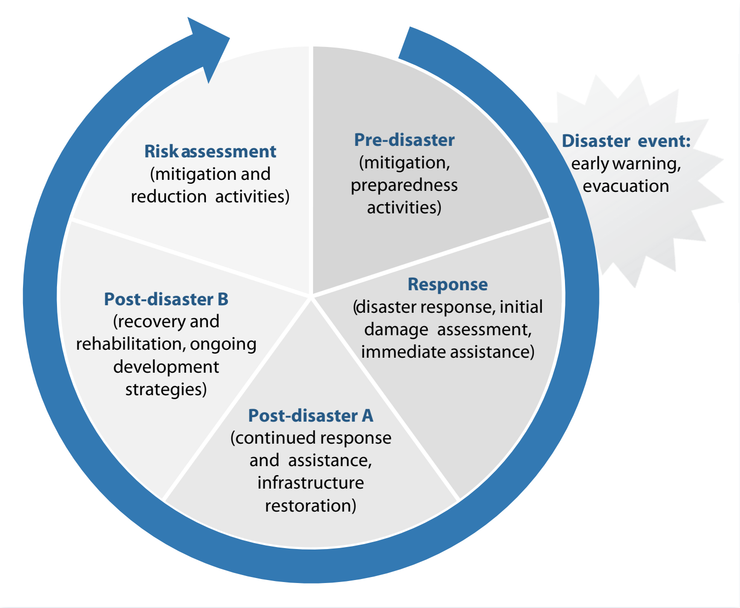
Table 3.3. **Human and economic losses across disaster types for OECD countries: 1973-2012**

Type of disaster	Average economic losses (in USD thousands)	Average people affected	Average people killed	Total number of events
Earthquake (seismic activity)	2 571 453	63 836	338	210
Drought	1 278 942	285 000	0	55
Storm	659 870	28 190	17	1 138
Flood	261 554	34 150	13	711
Wildfire	208 949	6 318	5	183
Extreme temperature	166 144	26 301	458	184
Industrial accident	136 681	3 250	16	261
Insect infestation	60 000	0	0	2
Mass movement wet	36 544	1 580	26	86
Volcano	32 373	10 011	8	33
Miscellaneous accident	5 943	58	29	212
Transport accident	49	8	34	679
Epidemic	0	55 674	13	47
Mass movement dry	0	333	94	3

Note: Average values per event, reported true to the year of the event. The number of affected people includes people requiring immediate assistance during a period of emergency; it can also include displaced or evacuated people.

Source: EM-DAT, 2013.

Figure 3.5. **The risk management cycle**



Source: Adapted from IED World Bank, 2011.

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Chapter 4. Emergency planning and response for Natech accidents

by Amos Necci, Elisabeth Krausmann and Serkan Girgin[1]

Introduction

Natural hazards, such as earthquakes, floods, storms, extreme temperatures, etc., can trigger fires, explosions and toxic or radioactive releases at hazardous installations and other infrastructures that process, store or transport dangerous substances. These technological secondary effects of natural hazard impacts are also called "Natech" accidents (from "natural hazard-triggered technological accident"). Natech accidents are frequent in the wake of natural disasters, and they have repeatedly had significant and long-term social, environmental and economic impacts (e.g. Krausmann and Cruz, 2013; Girgin, 2011; Krausmann, Cruz and Affeltranger, 2011; Godoy, 2007). It should be noted that Natech accidents can be triggered by any kind of natural hazard; a major natural hazard, like a strong earthquake or a hurricane, is not necessarily required to cause a Natech event.

Recent studies highlighted that the specific aspects of Natech risk are unfortunately often overlooked in chemical accident prevention programmes and disaster risk reduction frameworks, causing Natech accidents to recur (Krausmann and Baranzini, 2012). This is compounded by the predicted increase of Natech risk as a result of worldwide industrialisation, climate change, population growth and community encroachment on natural hazard zones. This outlook has triggered initiatives that aim to close gaps in Natech risk reduction. For instance, the OECD Working Group on Chemical Accidents has recently produced a Natech Addendum to the OECD Guiding Principles on Chemical Accident Prevention, Preparedness and Response (OECD, 2015).

This chapter will introduce the problem of Natech risks with a focus on emergency planning and response. It will present major lessons learnt that were obtained from an in-depth analysis of Natech accidents in the European Commission's eNatech accident database (http://enatech.jrc.ec.europa.eu) and make recommendations on how to close remaining gaps. A comprehensive treatment of Natech risks and how to manage them is available in Krausmann, Cruz and Salzano (2017).

This chapter is an original contribution to the EGNE report and has not been published in this form elsewhere. It reflects the authors' experience in this field, with supporting information from the references listed at the end of the chapter.

Challenges for emergency planning and response for Natech accidents

The extent and consequences of Natech accidents have often reached major proportions which is indicative of low preparedness levels. There is no single determining factor to explain this, but the reasons are manifold, the main problem being that the characteristics of Natech events differ significantly from those of conventional technological accidents both in terms of prevention and mitigation. Successfully

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controlling a Natech accident has often turned out to be a major challenge, if not impossible, in cases where no prior preparedness planning has taken place. For instance, when a natural hazard impacts a hazardous installation, it can trigger simultaneous hazardous materials releases from multiple sources over extended areas within a very short time frame. This poses a severe strain on emergency responders who are usually neither trained nor equipped to handle a high number of substance releases at the same time. For instance, the 1999 Kocaeli earthquake in Turkey triggered fires simultaneously in three different parts of a major refinery. International assistance was necessary to combat the fires and keep them from escalating (Girgin, 2011).

In situations of this kind, the risk of cascading disasters is high, especially in case of flammable-substance releases. During the Tohoku earthquake and tsunami that hit Japan in 2011, a large number of installations with major accident potential were damaged or destroyed by the natural disaster impact which eventually caused a series of hazardous materials releases and fires. The fires at the Chiba oil refinery involved 17 tanks storing liquefied petroleum gas (LPG) and resulted in at least five major explosions, the biggest of which generated a fireball of over 600 m diameter and height causing damage to nearby residential areas and assets (Krausmann and Cruz, 2013). Air dispersion of flammable vapours from ruptured LPG pipes and subsequent ignition, heat impingement from the burning LPG storage tank farm, as well as burning missile projection triggered fires at two neighbouring chemical facilities.

Safety barriers aim to protect industrial equipment as well as people from the effects of an accident. The barriers can be structural (e.g. containment dikes around tanks or vessels, deluge systems, etc.) or organisational (e.g. communication, transportation routes for evacuation, etc.). The natural event that causes damage at a hazardous installation will likely also disrupt or destroy safety barriers on- and off-site. For example, the storm surge that followed Hurricane Katrina in 2005 caused the spreading of oil from a spill at a refinery in Meraux, which contaminated a large area with over 1 800 houses. The hydrocarbon release triggered by the storm could not be contained, since the floodwaters had already filled the bund around the damaged tank that was supposed to contain the release (US EPA, 2006). Another example is the impact of the 1999 Kocaeli earthquake in Turkey where some 6 500 tons of highly toxic acrylonitrile were released into containment dikes and to the atmosphere. As a result of dike overflow and earthquake-triggered cracks at the bottom of the concrete dikes, the substance was eventually also released into the sea and the underground water aquifer. Many workers, first responders and residents of the nearby settlements suffered from acute toxicity effects (Girgin, 2011). The evacuation order that followed the toxic release forced a halt to the rescue activities and left people trapped under the debris generated by the earthquake.

Another frequent issue is the disruption of lifelines needed for accident prevention or mitigation during a natural event (e.g. power for keeping dangerous processes under control or for shutting them down safely, water for firefighting or cooling). The Kocaeli earthquake in Turkey not only triggered massive fires at a refinery in Körfez, it also caused the loss of electric power on-site, as well as a shortage of water supplies that resulted from damage to a main water pipeline. As a result, one of the fires burned out of control and engulfed many other units until a conflagration forced the responders to retreat (Girgin, 2011; Steinberg and Cruz, 2004). The accidents mentioned above highlight that simultaneous emergency response efforts are required to cope with the impact of the natural disaster on the population and the consequences of the Natech accident that pose a secondary threat. Often, in such a situation there is competition for resources that in the worst case might leave some urgently needed response mechanisms unavailable. They also demonstrate how Natech accidents can hamper emergency response to natural disaster victims when the released toxic, flammable or explosive substances endanger the rescuers themselves. In this case first responders will have to evacuate, possibly leaving people still trapped in buildings behind.

Standard civil protection measures commonly used during conventional technological accidents with substance releases, like shelter-in-place or evacuation, may not be functional or appropriate in case of a Natech accident. The natural event that caused the Natech accident in the first place could also have affected the structural integrity of the housing in the proximity of the damaged installation, thereby rendering shelter-in-place impossible. Similarly, access roads could have been washed away or be obstructed by debris, hampering access to the site and, eventually, evacuation.

State of play in Natech emergency planning and response

"Natech emergency management" is the set of all actions that aim to prevent, prepare for, respond to and recover from an emergency situation that has resulted from a Natech accident. A good emergency plan should always be based on a risk assessment through which potential emergency scenarios have been identified and their consequences assessed. This emergency plan should be followed by first responders when an emergency occurs.

Since the likelihood of an accident cannot ever be reduced to zero, the emergency plan should include actions or systems that limit the consequences of an emergency. In order to preserve the health and safety of people, property and the environment, as well as to support short-term recovery, this plan should include both physical (e.g. tank bunds, containment walls, levees and momentum breakers, firefighting equipment), and organisational prevention and preparedness measures (e.g. land-use planning, training of personnel), which are taken prior to the occurrence of the emergency.

Few countries have explicit provisions that require the operators of hazardous installations to consider Natech risks in their safety documents for accident risk assessment and management. Usually these requirements have been implemented in the aftermath of one or several major Natech accidents. These rules require companies to take any additional measures necessary to assess and to reduce the risk of accidents, to protect its workers and the public from any accidental releases caused by natural hazards.

In the European Union, Directive 2012/18/EC on the control of major accident hazards involving dangerous substances (Seveso III Directive) explicitly addresses Natech hazards. The national governments are thus required to ensure that installations routinely identify the natural hazards, such as floods and earthquakes, that could pose a risk to the installations, and to evaluate this risk in safety reports. The inclusion of Natech risks in the Seveso Directive acknowledges that awareness of this risk has been growing in Europe since the Natech accidents that occurred during the 2002 summer floods. Nevertheless, the level of concern about Natech events varies in EU member states.

As an example of Natech awareness, France passed a regulation (Decrees 210-1254 and 2010-1255, 2010) which introduced a new zoning for industrial installations in seismic areas. In order to identify Natech risks and to facilitate emergency planning, industrial establishments were split into two risk categories: "normal risk" and "special risk". Installations in the second category have to guarantee the containment of hazardous materials under seismic loading by complying with specific mechanical resistance requirements to ensure a structure's capability to withstand a given value of ground acceleration, chosen in accordance with the seismic zone (Planseisme, 2016).

Also, the German government passed a Technical Rule on Installation Safety 310 in 2012, according to which industrial establishments with major chemical accident potential are required to assess the risk of flood-triggered accidents at their installations, to take necessary risk reduction measures, and to consider the possibility of an increase of flood risk due to climate change (TRAS 310, 2012a).

In the United States, the State of California released the Accidental Release Prevention (CalARP) programme, which calls for a risk assessment of potential hazardous materials releases due to an earthquake (CalARP, 2014). The purpose of the CalARP programme is to prevent accidental releases of substances that can cause serious harm to the public and the environment, to minimise the damage if releases do occur, and to satisfy community right-to-know laws. Businesses that handle regulated hazardous substances are required to develop a risk management plan which includes a detailed analysis of the potential accident factors, together with the measures that can be implemented for prevention and preparedness.

In Japan, the Law on the Prevention of Disasters in Petroleum Industrial Complexes and Other Petroleum Facilities was updated after the Tokaichi-oki earthquake triggered several fires at a refinery in 2003 (Cruz and Okada, 2008). Moreover, the Japanese government has prepared the Large-Scale Earthquake Countermeasures Special Act, introducing amendments in the Japanese High Pressure Gas Safety Law, which requires companies to take any additional measure necessary for the protection of its workers and the public from any accidental releases caused by earthquakes and tsunamis.

Lessons learnt from Natech accidents

During past Natech accidents, emergency responders were often caught unprepared by the conjoint natural-technological disaster and some mitigation systems were either non-functional (e.g. flooded containment dikes) or inoperable (e.g. damaged firefighting systems). It is important to learn from past accidents to prevent the occurrence of the very same dramatic outcomes in the future.

Many Natech accidents showed that it is not enough to prepare only for a recurrence of events that have happened in the past. For instance, the catastrophic floods which severely affected the Czech Republic in 2002 caused the failure of several chlorine tanks after an industrial site was flooded with water exceeding by 1.3 m the 100-year water level against which the installation was protected (Hudec and Lukš, 2004). Climate change has started to affect the return period of many hydro-meteorological hazards, rendering numerous hazardous facilities vulnerable to the more severe natural hazard effects.

The forensic analysis of numerous past Natech accidents indicated that during the development of emergency plans the effect of natural disasters on the infrastructure in the territory (e.g. utilities, electricity, roads, communication lines) and on the population (e.g. non-feasibility of evacuation or sheltering in place, unavailability of internal or external emergency response resources) was often not considered. This meant that no or only few response measures were available to combat the consequences of a Natech accident. For instance, the unavailability of firefighting systems was observed during many earthquakes (Kocaeli, Tohoku) but also during other natural hazard events. A fire at a storage site in France in winter 2012 could not be responded to by the fire department as the water needed for extinguishing the fire had frozen inside the water pipes. The firefighters had to let the fire burn until the substances fuelling the fire were exhausted.

Another common issue during natural disasters is the hampering of response operations due to communication difficulties, phone-line unavailability due to damage or system overload, power outages, damage to or obstruction by debris of transportation lines, including roads, and slowed-down mobilisation of responders. This clearly also affects response to a Natech accident. Much can be learned from the major fires that involved hydrocarbon pipelines and three tanks (sulphur, asphalt and gasoline) at a refinery in Sendai during the Tohoku earthquake and tsunami. The force of the tsunami that washed into the refinery transported debris inland which blocked the access roads to the installation. After the fire ignited, the emergency teams had no means of accessing the site and it took days to effectively control the fire, during which time the blaze engulfed the entire western plant section (Krausmann and Cruz, 2013).

During natural disasters, Natech accidents that result in fires and explosions are likely to propagate to neighbouring production units or even to neighbouring industrial installations, in a process known as "domino effect". For this reason, the vulnerability of just one unit to a natural hazard impact may eventually cause damage to the entire installation or even to more than one installation, e.g. in an industrial park. This cascading behaviour is frequent during Natech events, as numerous accident reports indicate. For instance, heavy rain and a subsequent flash flood caused a fire and several explosions at a refinery in Morocco in 2002. Since the refinery's surface-water and waste-water drainage systems were not separated, the flood caused the waste waters which contained hydrocarbon residues to be lifted out of the drainage system. The hydrocarbons floating on the water surface ignited upon contact with hot refinery equipment and the fires spread with the floodwaters (Cruz, Steinberg and Luna, 2001). Similarly, in Egypt in 1994 heavy rains caused flooding at a fuel depot during a thunderstorm. The storm triggered fuel releases into the tank bunds which were, however, flooded and could not contain the releases. The fuel stratified on the surface of the floodwaters and was ignited by a lightning strike. The burning waters flowed into a village where they caused hundreds of fatalities and injuries (Renni, Krausmann and Cozzani, 2010).

Another important lesson is that targeted training (including psychological aspects), as well as sufficient and adequate equipment should be provided to emergency teams who must respond to a Natech accident. In many Natech cases, it became necessary for rescuers and firefighters to wear breathing apparatus, which were not always available in sufficient numbers for all teams called to respond the emergency (Girgin, 2011). Similarly, in case of past tsunamis, first responders intervening in the accident were not always endowed with lifejackets to ensure their own safety. Additionally, depending on the type of natural hazard that triggered the Natech accident, some response equipment might be preferable over others that fulfil the same purpose. For instance, it was found that responding to a Natech accident during flood conditions or after tsunamis is much facilitated using aluminium boats rather than rubber boats which are less suited for moving around in debris-laden water (Krausmann and Cruz, 2013). Moreover, emergency responders are subjected to high levels of stress, in particular during major Natech accidents. In addition to the risks to their own health due to hazardous material releases, fires and explosions, duty shifts can last long and there would be uncertainty as to when the response to the accident would be terminated. The psychological stress would be exacerbated by worry for the health of relatives possibly caught in the natural disaster.

Numerous Natech accidents also highlighted the importance of a robust emergency planning. In the aftermath of many Natech accidents, emergency procedures were found lacking and were subsequently rewritten to account for natural events. In the case of the Sendai refinery, the internal emergency procedure called for an inspection of the facility after the earthquake to check for damage. Four operators died when caught in the tsunami during this safety check (BARPI, 2013). Also the emergency response plan of the refinery that suffered heavy damage during the Kocaeli earthquake was found to be insufficient. Based on the lessons learnt during the management and co-ordination of the response activities, a disaster management plan was prepared to improve the efficiency in first response and the mitigation of consequences, including a revamping of fire and oil-spill fighting capacities, which were increased drastically (Görgün, 2007).

Conclusions and recommendations

Awareness of Natech risks is increasing worldwide and there is a growing body of research into the topic. Nonetheless, there is still a lack of Natech risk assessment methodologies, and little guidance on Natech risk management for industry and competent authorities. From an emergency management point of view, special planning is required to account for the fact that major natural events can impact large areas, affecting the population, the building stock, and industry as well as other infrastructures.

To ensure sufficient preparedness in industry and for emergency response to be effective, the following points should be considered (Krausmann, Cruz and Salzano, 2017):

- On-site emergency plans for accidents involving hazardous materials should take the risks from natural hazards into account. This includes consideration of potential multiple and simultaneous releases from different parts of the installation, as well as the possibility of secondary cascading accidents. Natech scenarios used for emergency planning should reflect the unavailability of instrumentation (e.g. sensors, alarms, indicators), safety-relevant devices and equipment (e.g. safety valves, firefighting equipment, flare stacks), personnel, and plant-internal and external lifelines during the natural event. Moreover, it is recommended that on-site emergency plans assume that off-site response resources are unavailable. Plans should also consider loss of communication with external emergency responders, as well as panic and flight behaviour of plant personnel which can result in a failure to take protective actions at plant level (e.g. blow-down of pressurised hazardous processes, safe plant shutdown, etc.) (Steinberg and Cruz, 2004). Mechanisms need to be identified to deal with the potential lack of personnel trained to handle emergencies.
- Off-site emergency response plans for hazardous industry in natural hazard-prone areas need to consider the impact of hazardous materials releases caused by natural events on the population and on rescue operations. These plans should prepare for emergency evacuation of the population in case of an accident, but consider that roads might be inaccessible, e.g. in case of floods or tsunamis. First responders should pay attention to possibly violent reactions of released chemicals with floodwaters or rain which can create secondary toxic or flammable compounds from less harmful precursor chemical compounds (Cozzani et al., 2010).
- The vulnerability of emergency response resources to natural events and hazardous materials releases should be assessed. This includes careful consideration of conflicting emergency management objectives like carrying out search and rescue operations while at the same time having to evacuate because of a hazardous materials threat. Law enforcement officers who help in the evacuation and who secure evacuation zones are also at risk of exposure to hazardous materials and should receive proper training to better protect themselves and the population (Girgin, 2011).
- Medical services should be involved in the preparation of the external emergency plan. If doctors and hospitals are not prepared for a major Natech scenario, they are likely to be overwhelmed by the onrush of natural disaster victims as well as of people who have suffered toxic effects or burns. They should be informed about the risks from neighbouring hazardous installations and natural events by competent authorities and they should ensure that sufficient and adequate medication to treat victims of hazardous materials releases is in stock.
- Emergency response plans, at both installation and community level, should be periodically reviewed and tested to make certain they consider the consequences of natural hazard impacts. This should include an assessment of the validity of assumptions made on the expected natural hazard frequency and severity which could be affected by e.g. improvements in hazard modelling or climate change. In this context, the possibility that natural hazard loading might exceed the maximum design specifications should also be considered.

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Chapter 5. Public health lessons learnt from other disasters involving exposure to toxic substances[1]

Introduction

This contribution focuses on a special type of disasters termed "toxic disasters". Like the other events described in this report, toxic disasters are human-made and profoundly affect the sense of safety people need in order to continue their lives. Such effects are also characteristic of war and natural disasters. Toxic disaster effects also differ from other effects because in many cases they are determined by concerns for the future, anxiety about what might still happen rather that what has actually happened. Human-made catastrophes involving toxic exposures with the potential to harm population health can have an even more severe and relentless psychological impact than natural disasters. Nuclear disasters fall into this category.

When focusing on nuclear disasters, we know that mental health was the biggest long-term public health problem that ensued from the nuclear accidents of Three Mile Island and Chernobyl, and mental health is again a pressing public health issue after the Fukushima Daiichi accident. Several reviews have concluded that disasters involving radiation exposure, whether real or perceived, have complex and persistent emotional effects, probably because the exposure is invisible and universally dreaded, and can pose a long-term threat to health.

The psychosocial consequences of disasters have been studied for more than 100 years. The most common mental health consequences are depression, anxiety, post-traumatic stress disorder, general distress, medically unexplained somatic symptoms (e.g. fatigue, severe headaches, muscle and joint pain) and stigma. The excess morbidity rate of psychiatric disorders in the first year after a disaster ranges from 25-75% depending on the severity of the disaster and on the timing and methodology of the assessment.

While the number of dead, injured or hospitalised can be counted, the psychological and social sequelae are harder to quantify – there is no universal unit for indicating the amount of anxiety, depression, social disruption or family hardship that these events produce. Despite the enormous physiological and social cost of toxic disasters, until recently there has been a tendency not to take into account this axis in assessing the adverse effects of these disasters.

It is therefore of interest to appraise what can be learnt from toxic disasters in general from the public health perspective in order to enhance the quality of future interventions should a nuclear accident happen in the future.

1. This chapter was produced by Olvido Guzmán of the NEA based on publications by J.M. Havenaar of Altrecht, Institute for Mental Health Care, Utrecht, Netherlands and E.J. Bromet of the Department of Psychiatry, Stony Brook University, Stony Brook, New York, United States.

Toxic disaster

Exposure to toxic substances in the environment is an ever-common event that may cause physical as well as physiological harm. When an entire community is exposed, the term “toxic disaster” is used. The mere threat of such an event may be a source of stress, associated with changes in mental health, physical health and changes in health related behaviours.

Such disasters are breaches of public safety and environmental security caused by natural or human processes that result from ignorance, accidents, mismanagement or design.

For the purposes of this contribution we refer to “toxic disaster” as an unpredictable or sudden, real or perceived collective exposure of recognisable population groups to hazardous substances or agents on such a scale that the stricken community needs extraordinary efforts to cope with the event and effects. It is an event with considerable societal impact in direct relation to an exposure or threatened exposure to what the military call ABC-type substances (atomic, biological, chemical).

Despite the apparent increase in toxic disasters in recent decades, environmental breaches have been recorded as far back as antiquity. The earliest recorded example occurred in Mesopotamia over four thousand years ago when agricultural lands were damaged from inadequate drainage systems, which led to high levels of salt in the soil (Environmental Disasters, 1998). Some toxic disasters, such as NPP accidents, oil spills or industrial accidents occur suddenly. Others develop insidiously, as occurred in Minimata, Japan where in 1956 it was discovered that mercury from industry waste contaminated the fish consumed by local residents. The ecological erosion in the area around the Aral Sea, gradually desiccated in the years since its source rivers were diverted in the 1960s, represents another example of creeping environmental disaster. Further examples of chronic environmental damage with disastrous proportions include that caused by massive burning of forests in the Borneo and Sumatra slashes and burn fires in 1997-1998. Toxic disasters stemming from industrial breaches include the 1984 Bhopal, India disaster when half a million people were exposed to methyl isocyanate (MIC) gas and other chemicals or the 1976 Seveso, Italy disaster which resulted in the highest-known exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in residential populations. This latter toxic disaster gave rise to numerous scientific studies and standardised industrial safety regulations (e.g. the EU industrial safety regulations gathered today in the Seveso II Directive).

Pathogenic mechanisms in toxic disasters

In the aftermath of a toxic disaster, three groups of illness determinants play a role: the biological effect of the exposure itself, the stressful experience of the population response measures (countermeasures) and the response measures themselves. This contribution deals with the health effects that are determined by the stressful experience of the exposure itself or by ensuing response measures such as evacuation.

Box 5.1 lists the possible mechanisms by which health problems among the population may be linked to an ecological accident. The most straightforward and feared link is a direct negative influence of the toxic substance on human physiology.

Box 5.1. **Possible links between health problems and toxic disasters**

- physical effects of the exposure
- psychological effects of the exposure ("stress")
- physical and psychological effects of the response measures
- interaction between these effects
- chance (attribution).

Because the disaster itself is a traumatic life event it may also induce a stress reaction. Typical of the psychological impact of toxic disasters is the stress-related response to a perceived direct threat to one's own health. Other factors that contribute to the psychological impact are the feeling of loss of control over one's life and the uncertainty of what will follow.

As important as the direct physical or psychological impact of these events are, secondary health consequences that occur in the disaster response period also require attention. These may be physical effects, such as traffic accidents during evacuation or nutritional deficiencies resulting from dietary restrictions in contaminated areas, or psychological effects. The latter are typically seen in the negative psychological consequences of evacuation, a fact that unfortunately is rarely taken into account in evacuation decisions. The risk of inducing mental health problems by evacuation should be one of the factors weighed against the risk of other potential harm in decisions to evacuate.

Another element of countermeasures that can profoundly affect health outcomes is the way information is disseminated. In the immediate aftermath of a toxic disaster, authorities may be preoccupied with trying to prevent panic and social unrest. For this reason they tend to take a reassuring stance, trying to minimise the severity of the event, sometimes even falsely so.

Direct and indirect physical, psychological and social mechanisms can interact in complicated ways to amplify health effects.

A final but nevertheless important way in which health problems may be linked to toxic disasters is attribution. In this case health problems present in any population but not causally related to the event are erroneously attributed to exposure to a hazardous substance. This type of association is likely to cause considerable debate and societal unrest.

The stressful experience of toxic disasters

Six major elements of the stressful experience have been identified, which determine the stress response following a toxic disaster.

Uncertainty – It usually take a while before the contaminant is identified and exact information can be provided concerning exposure levels and risk for health. As long as people are not aware of the exposure, no stress response occurs. A factor contributing to the uncertainty is the lack of undisputed knowledge about the effects of the exposure. Another important is that failure to adequately manage and communicate risk thus contributing to uncertainty. In the long run, this uncertainty tends to remain, because of the low biodegradability of many toxic substances, for example, radionuclides or dioxins, and the long period of latency of some health effects, which may became manifest only in future generations. Because of the protracted nature of the threat, toxic disasters have been called "diluted disasters" (Bertazzi, 1989).

Housing and job insecurity following toxic disasters is related to both the actual and the perceived danger of the situation. The loss of jobs or property and the uncertainty as to whether one can ever return safely leave deep scars in the human soul. The Seveso accident was an example of an area becoming temporarily uninhabitable because of the concerns over ground contamination, as dioxin is extremely resistant to degradation. Evacuation from the contaminated site and fear of contamination of homes and premises are important sources of stress. Loss of value of property may be an additional stress factor, especially in western countries. More often than not there are considerable controversies between experts and laymen about the actual safety of the living place. Public behaviour is much more likely to be determined by the public perception of risks and hazards than by experts' opinion.

Social rejection – Stigma may be attached to survivors. Victims of toxic disasters may be subjected to discrimination as though they were carriers of some mysterious and noxious agent. Social rejection and discrimination of evacuees and inhabitants from contaminated regions have been reported following toxicological events, for example after the Seveso accident (Bertazzi, 1989), the Love Canal crisis (Edelstein and Wandersman, 1987; Fowlkess and Miller, 1992) and in victims exposed to asbestos and pesticides (Cuthberston and Nigg, 1987).

Media siege – The media play an important role, not only in transmitting the news about a toxicological event, but also in shaping the issues of debate and in determining public perception of the event.

Cultural pressure – Survivors of toxic disaster become the target of conflicting public pressures and messages about how to behave, what to believe and what to expect. An example is the advisability for pregnant women to have an abortion after the toxic disaster. In the Seveso accident no clear public health guidance could be given but many women sought abortion despite conflict with Italian custom and Roman Catholic beliefs.

Inadequate medical follow-up and compensation – Disasters can undoubtedly bring the latent tensions of a society to the surface. Examples are the inadequate treatment and delay in compensation for survivors of the Bhopal accident which continues to dog the life of survivors. At Bhopal, the eruption of these forces sustained a chronic disaster making near impossible the recovery and rehabilitation of the more than half a million people involved. Delays and arguments over litigation and settlements present additional difficulties.

Massive evacuation during chemical accidents

A review of the public health impact of chemical incidents should not overlook cases of massive evacuation. At Bhopal, up to half the population – 500 000 persons – temporarily self-evacuated from the city as a result of the acute episode. Two weeks later during the official deactivation of chemicals in the plant, a quarter of the population of approximately one million self-evacuated. In Mississauga, Canada in 1979 a large-scale official evacuation was ordered following a train derailment and a fire in a tanker car containing 90 tons of chlorine. Within 24 hours, 90% of the population at risk – about 220 000 people – had removed from the area without death or injury. Three hospitals and a nursing home were evacuated. Rapid evacuation of such a large number of people to relative safety is impressive, but it may not necessarily be possible in congested cities in other parts of the world.

Are natural and human-made disasters different in terms of stress-related health outcomes?

The features of natural disasters and technological catastrophes are summarised and contrasted in Table 5.1. An extensive review by Rubonis and Bickman (1991) showed that the main predictor for stress after a disaster is the number of (immediate) deaths. These authors were unable to show a difference between natural and human-made (technological) disasters in terms of stress-related health outcomes. Despite this, there is reason to assume that ecological and toxic disasters nevertheless constitute a distinct type of disaster in terms of their dynamics. The individual and community response where hazardous materials are released is quite different from the response to non-toxic events, whether natural or technological (Havenaar and van den Brink, 1997; Havenaar and Bromet, 2002). The main difference is the amount of social unrest toxic disasters tend to create. Natural disasters may have positive as well as negative effects: however devastating they might be, in some cases they also have a tendency to strengthen social ties and collective healing tendencies in the community. Ecologically "clean" disasters, such as a collapsing dam or a major train crash where no dangerous substance is released, are similar in this respect. Toxic disasters by contrast appear to have a greater propensity to bring about negative psychological and societal effects, such as public discord and relentless debates about the nature and extent of the damage or about who is to blame.

Table 5.1. **Summary of characteristics of natural disasters and technological catastrophes**

	Natural disasters	Technological catastrophes
Course of events	Sudden Usually, there is an identifiable clear low point. Conditions tend to improve with passage of time.	Sudden or diffuse There may be a clear low point, but particularly in "toxic" disasters, this is not so. Conditions do not necessarily improve in foreseeable time.
Visible damage	Usually disfigure the environment. May destroy homes, businesses; disrupt power, sanitation and the availability of drinking water.	Some (e.g. dam breaks) involve visible destruction. Other (e.g. TMI, Love Canal) do not. May cause invisible damage manifested as exposure-related health problems.
Predictability	Though point of impact cannot always be specified, there is a level of predictability because: (a) occurrence rates for an area can be obtained from past experience and (b) forecasts can provide some warning.	Not predictable; failures are usually sudden and leave little time for evacuation.
Perception of control	Natural disasters are not generally viewed as controllable. Their occurrence highlights a lack of control over the elements.	Technology is normally under human control. Therefore, mishaps are likely to be perceived as loss of control.
Extent of events	Usually limited to direct victims of the disaster.	Loss of confidence and credibility may engender effects in people not directly victimised.
Persistence of effects	Effects appear to be relatively short lived. Loss of property or loved ones. However, chronic effects may be experienced.	May be either acute or chronic, but appear to be likely to cause long-term (chronic) consequences for many, particularly when toxic substances are involved.
Effects on community	Tendency to form a "therapeutic community" (low conflict; consensus about causative agents, level of damage, priorities for remedial action).	Tendency to form a "non-therapeutic" community (high conflict, uncertainty about causative agents, level of damage, future risk and necessary countermeasures).

Adapted from Baum, A., R. Fleming and L.M. Davidson, 1983.

Lessons learnt from the public health perspective to enhance quality of future interventions

The quality and timeliness of information and its presentation are crucial: Environmental catastrophes are unfortunately not uncommon occurrences, and furthermore a toxic disaster may evolve from what seems to be an environmentally limited human-made or natural catastrophe. Regardless of the realities of a situation, once information emerges that hazardous substances have been released into the environment during an accident, the aftermath is likely to turn "toxic" in the psychological and social senses. The interpretation of subsequent events tends to be dominated by this information, especially when the information is inconsistent or contradictory, as frequently happens. In short, an information disaster may follow from what started as a concrete physical catastrophe. The analysis of many ecological accidents has demonstrated that the quality and timeliness of information and its presentation are crucial in determining outcome.

Debate about how to disentangle the physical and psychological sequelae: Toxic disasters are typically followed in both the short term and the long run by a complex web of psychological and physical health consequences. In many cases, the psychological consequences outweigh the physical ones. In practically all cases, there is a debate about the causality and interdependency of the physical and psychological sequelae.

Health effects from disasters are far more than the sum of their physical or psychological health effects, including post-traumatic stress disorder. Medically unexplained symptoms or syndromes may be the most prominent negative health outcome. These may be accompanied by a marked shift in illness behaviours, perceived health care needs (e.g. demand for check-ups or examinations), and health care utilisation that can overtax the public health system. Better understanding of the occurrence and persistence of these phenomena will come from the social sciences and not just from epidemiology or laboratory research-based methods.

Need to move beyond a purely professional or organisational approach and include a "consumers' perspective". Perception of the individual and community risk inherent in the disaster plays a central role. This means that personal narratives deserve careful attention by professionals. Lay perspectives, being so central to the perception of the threat as well as the valuation of the response, have to be taken seriously.

Prevention, assessment and management of health problems are linked to the preparedness, early intervention and long-term intervention phases of a disaster. During each phase, both physical and psychological mechanisms will be at work simultaneously. The situation is made more complex by the many different parties that are involved: the victims of exposures, rescue workers, health care professionals, news reporters, representatives of different agencies and government authorities, and finally the public at large. All of these groups will have their own views of what has happened and will have implicit expectations of what should be done next. The impact of disasters (by definition) exceeds the level of the individual and involves processes at group and societal levels.

Havenaar et al. (2002) summarise the lessons learnt for each phase of the disaster separately (i.e. preparedness, immediate response, and long-term response), taking into account the different points of views of victims, professionals, authorities and the general public. An overview of these lessons is presented in Table 5.2.

Table 5.2. **Overview of public health lessons learnt from ecological and toxic disasters**

Preparedness phase	
Preparing the public	**The perception of what has happened is the central link in the chain of events following a toxic exposure** *Preparing people for what they might expect is of utmost importance*. Examples of good practices are the distribution of information leaflets about the chemical facilities and emergency procedures in the neighbourhood, involving the public in the preparation and conduction of emergency drills. *Educating the news people how to act responsible in order to protect their own and the public's mental health* is an issue that deserves attention. As the media plays the most visible, if not the most influential role, in relation to general public preparedness there is a need to inform them about the risk to themselves and the population, as well as the risk their very messages can carry.
Preparing the professionals	**There are many national and local opportunities for enhancing preparedness for ecological accidents** They range from preparing multiagency disasters plans to organising sampling frames and reference data in areas where such events are likely to occur. Unfortunately the funding for such preventive data collection is limited. *Prepare the rescue teams* who are first to enter the contaminated grounds and facilities. A common occurrence in toxic disasters is that emergency workers rushing in after the disaster became victims of the toxic agent themselves. Preparation should include instruction on safety procedures in such cases, but also information on what team members can expect in terms of psychological traumatisation and the best way to cope with this. *Disaster teams should include professionals from the mental health field*. They can give insight to team members and also contribute to designing studies to shed light on the subsequent psychological and public health consequences of these events. It is important that rescue workers and mental health teams be educated beforehand on how best to contribute to early interventions to preclude the worsening of undetected effects. *Helping the helpers* must be facilitated in community crisis situations when setting up mental health delivery systems. *Medical doctors, especially those working in primary care and emergency medicine*, should be targeted in the preparedness phase. These professionals can play a role in either suppressing or amplifying the signals of concern of the population. Training physicians in behavioural medicine and models of stress and health is essential if they are to deal skilfully with the psychological concerns of the exposed population.
Organisational aspects of preparedness	*Exercises involving police, fire departments and health care institutions*. Contingency plans exist involving these actors, however these plans exist mainly on the paper and most of them are not equipped to deal with major toxicological accidents or attacks.
Immediate response phase	
Immediate impact on those directly involved	**Professions versus peers/family support** *The immediate need for practical and emotional support is readily observable in every disaster situation*. However, there is still debate among mental health specialist whether immediate support (i.e. emotional debriefing programmes) is indeed helpful. People might prefer support from peers and family members.
Role of professionals in early phase	**Population facing physical and psychological issues** *Take environmental measures* (i.e. soil and air samples) *and biophysical measures* in the immediate phase is of utmost importance. Long-term storage of such samples is advice (to understand health effects at later phases). *New forms of psychological and pharmacotherapeutic treatments are available for survivors of trauma*, specially originated in Westerns countries. Nonetheless, Western-style trauma treatments may have questionably validity in non-Western countries such as Japan or Africa. Use training materials and professional services for disasters form international organisations (WHO, Red Cross, etc.).

Table 5.2. **Overview of public health lessons learnt from ecological and toxic disasters** *(cont'd)*

Immediate response phase	
What the authorities should do	*Establish a central information centre in the wake of a toxic disaster*, preferably keeping it open for some time. A straightforward approach involving timely and accurate information seems to be the best way to handle this type of crisis, although examples of successful information management are few and far between. *Include mental effects and not only physical effects in the health registries or other form of monitoring usually set up in the aftermath of toxic disasters*. *Raise awareness on the negative effects of such registries which might foster victim mentality leading to medicalisation and iatrogenic health problems as well to false expectations*. To avoid this, it is very important to know the health effects to look for and to have a clear focus on specific outcomes.
Long-term response	
Living with long-term effects of toxic disaster	*Sociodemographic pessimism*. A worst-case scenario of a toxic disaster is the decline in population size through emigration and decreased numbers of deaths and widespread illness and decline in well-being throughout the affected population. Once this stage is reached, it may be nearly impossible to mount adequate countermeasures. *Social stigma can be one of the most negative long-term consequences*. This stigmatisation has never been reported after natural disasters. Unfortunately very little is known about the mechanism that perpetuates it. For young people this may mean being les eligible as a marriage partner and living with a constant concern about the health of their children and of future generations.
Long-term professional response	**The contradictory long-term findings about mental health mirror the chaos that ensues from the very beginning of these events** Demonstrating casualty is often complicated partly because of the many methodological pitfalls involved in this type of investigation. A related problem is how to translate uncertain or contradictory research finding to people who have been exposed and who are worried about the risks. The research difficulties inherent in proving casualty should not lull concerned health care professionals into apathy or complacency about continuing to follow-up on exposed populations.
Maintaining the attention of official agencies	*Long-term information centre*. In the immediate phase, government agencies tend to become flexible and generous in providing solutions and adapting rules and regulations to the extraordinary circumstance. After a year or so, however, they tend to revert to business as usual. They are not prepared to deal with long-term consequences, such as the financial problems that are the result of unemployment due to the direct or indirect effects of the disaster (e.g. decline in tourism in areas hit by an oil spill, or in agricultural production, in areas that are no longer considered safe to grow food. An information centre that can continue to inform the public about newly emerging facts related to the exposure, can also serve as communication medium to inform authorities about new problems arising in the affected communities. *The media also plays an important role* in keeping agency officials and health professionals arising in the affected communities.

Adapted from Havenaar et al., 2002.

Concluding remarks

Despite the enormous psychological and social cost of toxic disasters, until recently, there has been a tendency not to take into account the mental health axis in assessing the adverse effects of these disasters.

The public health perspective shows us how each phase of a disaster and each player in disease onset (host, agent, environment) intertwine. Underneath it all is perception – by the sufferers, the health care providers, the government agency officials and the media – and it is these perceptions that drive the magnitude, persistence, evolution, and even the risk and protective factors that are identified after major ecological catastrophes. We need a comprehensive, longitudinal, long-term approach that combines physical and mental health evaluations to further our understanding of the consequences and the relative effectiveness of different interventions as these tragedies occur. Building resilience will be the key challenge for disaster recovery.

It is imperative that we learn more about the variables that promote health and protect against adverse mental health outcomes after disasters. Such knowledge can then be used in the formulation of potentially successful interventions. New interventions should be careful to take cultural factors into account. They should maximise the ability of people to cope with stressful circumstances and to make sense out of what is happening to them. It is a well-known observation that disasters and periods of extreme collective strain can sometimes strengthen social cohesiveness and thus enhance the resilience of its members. Elucidation of the optimal type and quantity of supportive interventions will be one of the main challenges.

The World Health Organization (WHO) definition of health encompasses physical, mental and social well-being. Future studies of toxic disasters will have optimal translational value by fully embracing all three features of the WHO definition of health. They might best conceptualise health as "physical + mental", and consider the combined exposure to both toxic substances (radiation in the case of a nuclear disaster) and stress when evaluating the public health consequences of these catastrophes.

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Chapter 6. US NRC review of emergency planning and responses to non-nuclear events within the United States

by P.A. Milligan[1]

Emergency planning for nuclear power plants (NPPs) in the United States has always included evacuation as a primary protective action. Events since 2001, such as massive hurricanes, the terrorist attacks on the United States on 11 September, large wildfires, and an increasing population in the areas around NPPs has had many people asking whether an evacuation exercise could be successful if an accident happened?

Radiological-related evacuations are a very rare occurrence in the United States. Only one radiological-related evacuation was ordered and that was the recommendation to evacuate pregnant women and children from an area out to 8.3 km (5 miles) around the Three Mile Island unit 2 reactor during the accident at that facility in 1979. As a result of this accident, NPP emergency planning requirements, including evacuation planning, were significantly enhanced.

However, to evaluate the efficacy of evacuations as an effective protective action, other types of disasters and accidents where evacuations were ordered needed to be evaluated. Researchers discovered that public emergency evacuations in response to natural disasters and hazardous material accidents occur rather frequently in the United States. An overview of evacuations shows that emergency evacuations of at least 100 people occur more than once a week, and major evacuations of more than 1 000 people generally occur more than three times per month in the United States (NUREG/CR-6864).

The US Nuclear Regulatory Commission (NRC) undertook two research studies to examine the efficiency and effectiveness of public evacuations in response to natural disasters, technological hazards and malevolent acts. The first study, published as NUREG/CR-6864, identified a universe of 230 evacuation incidents where at least 1 000 people were evacuated, and that occurred between 1 January 1990 and 30 June 2003. These evacuations generally proceeded safely and effectively, even when managed by local emergency response officials with little or no practical evacuation experience or planning. NUREG/CR-6864 was published in January 2005 and supported the assumptions of safety and efficacy of evacuations. However, later that year the Gulf Coast of the United States was hit by a devastating hurricane season which appeared to challenge many assumptions about emergency preparedness and planning and the safety and efficacy of evacuations. It was apparent following this hurricane season that the NRC needed to review the assumptions and conclusions from its prior evacuation study.[2]

The NRC expanded the scope of the first evacuation study to include a review of emergency plans and planning elements in addition to evacuation and to focus on much larger populations and geographic areas. Eleven major incidents were identified for study,

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2. At the time of writing this report, the 2017 Atlantic hurricane season was proving to be particularly severe, requiring large-scale evacuations across many countries in the region. Further lessons will certainly be drawn from these experiences.

which included approximately 10 million people. None of the evacuations were related to NPPs. The results of this study were published in October 2008 as NUREG/CR-6981. These two studies are discussed below.

NUREG/CR-6864 "Identification and Analysis of Factors Affecting Emergency Evacuations"

This study examined the efficiency and effectiveness of public evacuations of 1 000 or more people in response to natural disasters, technological hazards and malevolent acts, occurring in the United States between 1 January 1990 and 30 June 2003. A universe of 230 evacuation incidents was identified and a subset of 50 incidents was selected for case study analysis. Case study selection was based on a profiling and ranking scheme designed to identify evacuation incidents of sufficient complexity to challenge the local and regional emergency response capabilities. Case study analysis included completion of a detailed question survey for each incident. Advanced statistical methods, including regression analyses and correlation analyses, were used to identify factors contributing to evacuation efficiency. The regression analyses identified that community familiarity with alerting methods, and door-to-door notification were statistically significant for a more efficient evacuation. In addition, interviewees stated that the following contributed to the efficiency and effectiveness of their evacuation: a high level of co-operation among agencies, use of multiple forms of emergency communications, community familiarity with alerting methods, community co-operation and well-trained emergency responders. All 50 evacuation cases studied succeeded in safely evacuating people from the area, saved lives, and reduced the potential number of injuries from the hazard.

This study revealed that large-scale evacuations in the United States, whether pre-planned or ad hoc, are very effective and successfully save lives and reduce the potential number of injuries associated with the hazard. The local responders typically initiate the evacuations and expand them to include regional or federal agencies as the size of the evacuation dictates. An overwhelming factor cited as contributing to evacuation success was a high level of co-ordination and co-operation among agencies and an effective command structure (e.g. the command structure was well understood, agencies worked well together, and emergency responders were empowered to make decisions). Those interviewed during for this report stated that they thought training and exercises had contributed to the effectiveness of their evacuations. All 50 of the communities questioned for this study had provided training to emergency response personnel, and 40% had tested their plan in a full-scale field exercise. Shadow evacuations (people evacuating outside of the designated evacuation area) had no significant impact on traffic or congregate care centre capacity or on the efficiency of the evacuation. Public awareness of the hazard, of evacuation procedures, and especially of alerting methods was often cited as contributing to the efficiency and effectiveness of an evacuation. Co-operation from evacuees was repeatedly cited as contributing to safe, efficient and effective evacuations.

Emergency communication issues were reported in 28% of the cases studied. This usually involved radios that were not on the same frequency. Radios were used in 92% of the cases studied. However, multiple forms of emergency communication were used in 40% of the cases, which often compensated for the radio communications failures.

The following factors were statistically significant for a less efficient evacuation: traffic accidents, number of deaths from the hazard, number of injuries caused by the evacuation, people spontaneously evacuating before being told to do so, people refusing to evacuate, and looting or vandalism. Traffic issues, such as traffic congestion, were reported in 28% of the evacuation cases studied. However, traffic accidents occurred in only 8% of the cases. Finally, some type of citizen misbehaviour was reported in 24% of the cases; however, this was generally limited to a small portion of the population. In addition, looting and vandalism was reported in only 10% of the evacuation cases.

Nearly a third of the 50 evacuations studied had no issues associated with them, such as communication failures or traffic issues, and nearly three-quarters of the cases encountered one or none of these types of issues. Only one case, the East Bay Hills Fire near Berkeley, California in 1991, involved deaths during the evacuation. In this particular instance, special circumstances, including steep hills and narrow roads, combined with poor visibility due to the wildfire, were directly responsible for the deaths and injuries that occurred during the evacuation. However, the East Bay Hills Fire evacuation overwhelmingly saved lives that would have otherwise been lost.

The evacuation research also identified that many communities are actively engaged in activities to improve their emergency response capabilities, including modernising communication systems, developing transportation analyses and assessments to improve traffic flow, improving local education awareness, and developing interagency and cross-boundary co-ordination plans.

NUREG/CR-6981 "Assessment of Emergency Response Planning and Implementation for Large Scale Evacuations"

In the summer of 2005, Hurricanes Katrina, Rita and Wilma made landfall in the United States testing the emergency preparedness community to the fullest extent. These hurricanes challenged the conclusions of the prior study; many people died despite extensive emergency planning; buses sat unused and flooded, over a hundred people died on the roadways during the evacuation. These were not sudden and unannounced storms. Weather forecasters, the general public as well as the emergency response community watched for days as Hurricane Katrina et al. marched across the Atlantic Ocean and headed for the Gulf Coast targeting cities such as New Orleans, Houston and Galveston over a period of several weeks. In many communities plans were appropriately implemented and several million people made their way to safety. However in cities such as New Orleans, emergency response to the storm was not successful and about a thousand people died as a result of this storm. Three weeks later during the evacuation of Houston during Hurricane Rita, 130 people died. What went wrong? The NRC was very interested in the issues that presented serious challenges and also those that contributed to the successes during these evacuations. While the populations impacted by hurricanes are significantly larger than the populations impacted by an NPP accident, the NRC felt that much could be learnt by examining these evacuations along with others that had occurred since the last study.

In addition to these hurricane cases, the NRC identified eight further large-scale evacuations that were not considered in its prior study. The evacuations included a total of five hurricanes, the 2007 California wildfire and five additional evacuations. A qualitative rather than quantitative approach was taken in the selection of the five additional evacuations with emphasis on incidents that were large scale and had some unique attribute associated with the evacuation. For example, the Hawaii earthquake was selected because the evacuation included primarily special facilities. In 8 of the 11 incidents, the hazard or response encroached upon NPP emergency planning zones (EPZs) affecting a total of 14 EPZs. The NRC was also interested in understanding the relationship between the planning done for NPPs and its use in these events. This report examines emergency planning for these non-nuclear events and compares them to the emergency planning undertaken for NPP communities.

The emergency response for these large-scale incidents was very broad, so only a few important emergency planning elements were selected for detailed assessment. Elements were selected that were expected to provide insights and lessons learnt which may be of benefit to the NRC and/or the Federal Emergency Management Agency (FEMA) emergency preparedness programme for NPPs. Seven emergency response elements were identified for review. These elements are: i) training; ii) public education; iii) communication with the public; iv) communication with emergency response; v) evacuation; vi) special needs; and vii) shelters. Unlike the prior evacuation study (NUREG/CR-6864) with its emphasis on quantitative analysis the analysis of these incidents was primarily qualitative. These seven elements from these non-nuclear emergency plans are compared to similar NRC requirements for emergency preparedness and planning and both are discussed in the paragraphs below.

For the assessment of planning elements, emergency response plans at the state and/or local level were reviewed for each incident, and where possible the plans that were in place at the time of the incident were reviewed rather than updated plans. It was evident from this review that emergency response planning was generally well documented in identifying objectives and the resources required to meet response needs, although there were areas for improvement.

Training, the first of the seven emergency response elements to be reviewed, was found to be very effective. Training is an essential element of emergency response planning and was included in all of the emergency response plans reviewed. Training is a broad activity that encompasses items such as continuing education, online training courses and formal classroom and field training. Training also includes table-top exercises, drills and full-scale exercises. Generally it was found that training of emergency response personnel is routine, thorough and practical for emergency responders.

Responders interviewed for this study stated that a very important element of training was the conduct of exercises. Most of the plans reviewed called for at least one large-scale exercise each year. The NRC requirements to establish a training programme and conduct drills and exercises to validate the training are well integrated within the regulatory framework. Training and the conduct of periodic exercises are addressed in 10 CFR 50.47, and Appendix E to Part 50 requires that provisions for the training programme be described and off-site plans be exercised biennially. NUREG-0654/FEMA-REP-1, Rev. 1 provides guidance for the implementation of 10 CFR 50.47 and includes detail on types of exercises and drills, including communications drills, fire drills, and medical emergency, radiological monitoring and health physics drills, and radiological emergency response training (NRC, 1980).

The second element examined was public education. Overall it was considered to be effective in emergency response planning. Most of the plans reviewed referenced public outreach efforts of some kind ranging from distributing information at libraries to mailing brochures to all residents. Some plans included use of televised emergency awareness messages. In the areas where there are annual hazards such as the hurricanes in the Gulf Coast states and in fire- and flood-prone areas education programmes are typically well-defined and include public awareness presentations to local civic groups, schools and businesses. Seasonal hazards such as hurricanes, floods and wildfires differ in educational awareness needs from technological hazards such as chemical fires. The Atlantic and Gulf Coast states are subjected to a hurricane season from 1 June through 30 November each year and typically have educational awareness programmes to inform the public before and during the season. Technological hazards, however, may have no warning and frequently occur in areas where residents may be unaware of the potential hazards. Response officials in many cases have established local emergency planning committees to provide a forum for emergency management agencies, responders, industry and the public to work together to understand the chemical hazards within their communities and to develop emergency plans in case of accidental releases.

Public education within NPP EPZs is required by NRC regulation (10 CFR 50.47[b] [7]). The regulation requires that information on how the public would be notified and their expected actions be made available to the public on a periodic basis. Appendix E to Part 50 requires informing the public and transients at least annually and requires that information provided to the public be addressed in implementing procedures. In order to determine the effectiveness of this focused public education effort for EPZ populations the NRC undertook an assessment which included focus groups and telephone surveys. The results indicated a very high level of education and understanding of the radiological hazard among members of the public, awareness of how they will be notified and a good understanding of their expected actions (NRC, 2007).The third element reviewed in this study, communications with the public, was judged to be effective. Communication protocols had been established to inform residents of a hazard, warn them of potential response actions, and advise them when to take protective action. All plans identified the need for communication with the public during an evacuation. However, not all plans described the potential methods or resources necessary to communicate with the public during various stages of the incident. Many plans did not address communicating details on available transportation modes and any restrictions upon the evacuees, such as what they may bring with them if they were evacuating by buses or trains and not private automobiles. In addition many plans did not consider the need to convey information in multiple languages.

The NRC regulatory requirements of 10 CFR 50.47 specify that procedures be in place to notify the public. The regulation requires that a means to provide instruction to the EPZ population be established and that content of the messages be established. NRC/FEMA guidance requires consideration of multiple languages for emergency communication and public education.

When NPP conditions are such that an emergency classification is necessary regulations require that off-site authorities are notified of the event and whether public protective actions are warranted. The NPP licensee must have the capability to notify the state and local agencies within 15 minutes of an incident. The state and local officials must have the capability to then notify the public within 15 minutes of their receipt of notification, if urgent. These notification requirements and guidance have driven the development of comprehensive communications systems and plans that are routinely tested and exercised.

A common problem found across emergency response planning is the effectiveness of communications with the public in areas not impacted by the evacuation to ensure that they understand the prescribed protective actions do not include them and they need not take protective measures or evacuate unnecessarily which could impede the flow of the disaster-impacted evacuees.

Communication with emergency responders was the fourth element to be reviewed. It was rated very effective based on the resources, planning and infrastructure dedicated to and used in response activities. Emergency response professionals are frequently required to overcome issues with communications and routinely demonstrate that through training and ingenuity, they have the ability to overcome these issues. Emergency response agencies have aggressively updated their communications systems over the last several years.

The NRC requirements established in 10 CFR 50.47 include identifying staffing, resources and procedures needed to communicate with emergency response agencies. Within this regulation are requirements that procedures be in place, provisions exist for prompt communication with response organisations, and adequate facilities and equipment are available. Arrangements for requesting and accommodating state and local staff must also be in place. Each of these requirements is tested in periodic exercises, also required in 10 CFR 50.47.

The fifth element reviewed was evacuation. Overall it was rated to be effective, but areas for improvements were identified. Plans in areas impacted by seasonal events such as hurricanes had predetermined evacuation strategies while evacuations as a result of technological hazards were typically ad hoc and routes were determined in real time and influenced by wind direction. Development of a range of protective actions, which includes evacuation, is required by NRC regulation (10 CFR 50.47). Appendix E to Part 50 requires a description of protective measures taken within the EPZ, including evacuation, identification of officials responsible for ordering an evacuation, and a description of the alerting and activating of response agencies. Appendix E requires consideration of the permanent and transient population groups and an analysis of the time to evacuate. Guidance has been developed on the evacuation decision process and includes discussion on identification of evacuation routes and assessment of population, including special needs facilities, distribution by evacuation area and projected traffic capacities (NRC, 1980). In addition, NPP licensees are required to conduct an evacuation time-estimate study which must be updated as population changes or at least every ten years (Appendix E to 10 CFR 50).

The lessons learnt from the investigation of evacuations revealed that implementation of evacuation planning improves with practice. Traffic control is simulated in exercises, including NPP exercises, but is not always deployed in the field. An enhancement that may be beneficial in evacuation planning would be more detailed assessment of traffic management, particularly where extensive traffic control may be planned. This may involve table-top exercises or field drills that include locating the traffic control devices, transporting them to designated locations and installing these devices when appropriate. Drills of this nature may help assure that the resources and time periods included in the planning for traffic control are appropriately understood.

Special needs was the sixth element in the review. The review of this planning element included the subcategories of special needs facilities and special needs individuals. Overall this element was found to be lacking in sufficient detail in most plans and both subcategories were rated as marginally effective at the time of this study. Although NRC regulations 10 CFR 50.47 and Appendix E do not specifically identify requirements for special populations, the broadly worded requirements are applicable to all segments of the population within the EPZ without exception.

Special needs facilities include hospitals, nursing homes, prisons, schools and other facilities where additional time may be necessary to evacuate the persons at these facilities. In developing their evacuation plans, special needs facilities face unique issues and must decide whether the risks of evacuating populations such as, for example, seriously ill and frail individuals or incarcerated individuals are greater than the risk of not evacuating. The facilities are responsible for evacuation planning of their facilities but co-ordination among evacuation plans with state and local authorities as well as other facilities is necessary to assure resources will be available during a large-scale evacuation. NRC guidance provides that plans include means for protecting special needs individuals whose mobility may be impaired as a result of such factors as institutional or other confinement. In addition a separate evacuation-time estimate of special needs facilities must be performed and means of transport must be described.

Special needs individuals were defined in this study as any individuals who are unable to comply with an evacuation order without assistance from outside the home. This included people who are elderly, those with disabilities or medical conditions, people with limited English proficiency, people with hearing and sight impairment, people without access to private vehicles within the definition, individuals who are impoverished, chemically dependent, and those with emotional or mental disabilities. The definition may need to be expanded further to include households where minor children are left alone at home after school until the parent or caregiver arrives. Although the basic definition of special needs covers all of the groups mentioned, it was found that emergency response personnel do not universally understand or consider all of these groups during planning or response.

As an example, Hurricane Katrina made landfall near the end of the month when many lower-income families could not afford to evacuate. Traditionally this group was not considered as having special needs, but it is now recognised that additional planning is needed to support evacuation of this group. In addition some individuals do not realise that they have special needs. This is particularly true of the elderly individuals who may believe they are able to evacuate, but some of whom should not attempt a multi-hour evacuation without assistance. While emergency plans for NPP EPZs require consideration of special needs facilities and individuals challenges remain to ensure that all special needs individuals are accommodated.

NRC guidance states that when developing evacuation-time estimates special attention must be given to those households not having automobiles. This includes an estimate of the time to evacuate the segment of the public dependent on public transportation. The regulations and guidance documents require planning for special needs individuals under the broad requirement that all segments of the population be included in planning.

Shelter facilities were the seventh element reviewed for this study. The assessment of shelter facilities as addressed in emergency response planning was rated effective. Shelter facilities were discussed in all of the emergency response plans reviewed. A review was conducted of types of shelters planned (e.g. general, special needs, last resort), under what conditions shelters were expected to be opened, and whether or not sufficient capacity was planned. While overall the review was positive there was a consistent lack of adequate planning for pets, limited planning for special needs individuals, and lack of adequate space for very large evacuations. The NRC guidance is limited to provisions that the location of the shelters be situated at least 8 km (5 miles) outside the EPZ and that a means to register evacuees be available.

Conclusions

Emergency preparedness for NPPs is regulated by the NRC in 10 CFR 50.47 and Appendix E to 10 CFR Part 50. These regulations include requirements that address and mitigate many of the difficulties experienced in the large-scale evacuations assessed in the described studies. The NRC bases its licensing decisions, in part, on its assessment of on-site capabilities and on a review of FEMA's assessment of off-site capabilities. These on-site and off-site capabilities for NPPs include comprehensive co-ordination of resources, dedicated support services, warning and notification systems, and frequent and thorough cross-jurisdictional training and exercises. Decision processes are established and tested; communication resources are planned, implemented, and tested; and infrastructure is assessed to understand the potential impacts during an evacuation.

The review of NRC/FEMA emergency preparedness regulatory, programmatic and guidance material demonstrated that criteria, plans and procedures are already in place to address the issues that were experienced in the large-scale evacuations studied. These regulatory requirements and guidance are well established, and some of the applicable lessons learnt from this study were captured in the NRC 2011 Emergency Preparedness rule change while others were captured in NRC/FEMA guidance documents.

These studies support evacuation as an effective protective measure that saves lives, even when it is ad hoc or without predetermined evacuation planning. The studies also support the NRC's confidence that its emergency preparedness and planning regulations, guidance and programmes are robust and serve to protect public health and safety in the unlikely event of a severe NPP accident.

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Chapter 7. **Integrating lessons learnt from nuclear and non-nuclear events in national emergency plans: Japan's experience**[1]

Introduction

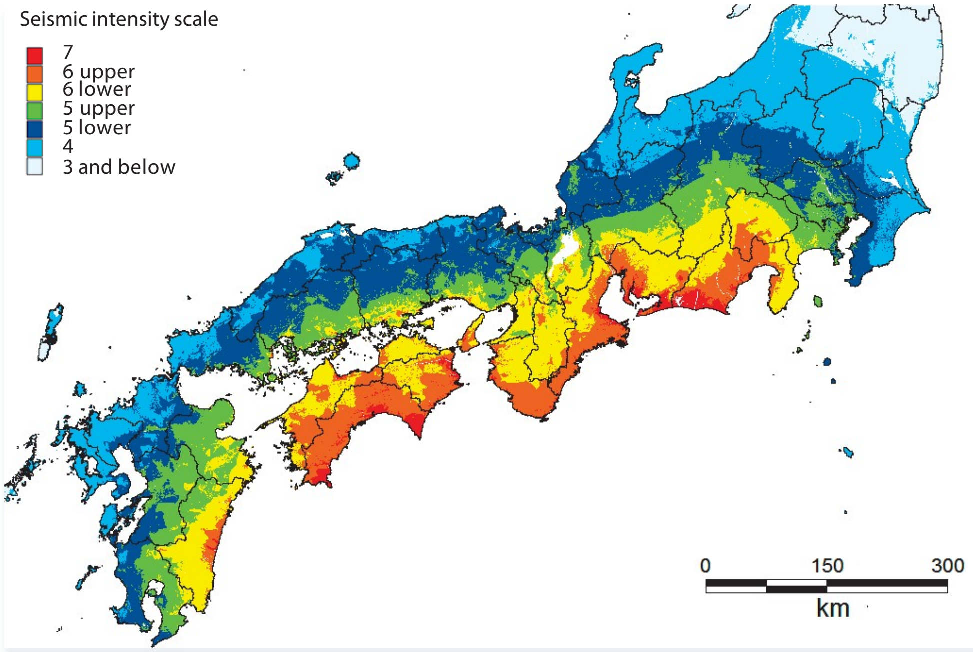
Japan has extensive experience with preparing for and responding to disasters and it has drawn many lessons from this experience. The white paper on "Disaster Management in Japan" is a report designated by law to be drawn up and reported annually to the ordinary session of the Diet pursuant to the Disaster Countermeasures Basic Act. The white paper was first published in 1963. In 2016, the 53rd edition dated 2015 was issued. Ms Margareta Wahlstrom, the Special Representative of the United Nations for Disaster Risk Reduction assessed this publication as follows: "The White Paper on Disaster Management is one of Japan's most noteworthy initiatives. Few countries publish such comprehensive reports on a regular basis. Other countries can learn from Japan's example and adapt this model to their own needs." In this spirit, the Cabinet Office of Japan shared the official information which is contained in this chapter. The main sources are "Disaster Management in Japan 2015" and the associated booklet "Disaster Management in Japan".

Japan: A country prone to natural disasters

Because of its natural conditions, Japan is prone to virtually every type of natural disaster. Japan is located in the Circum-Pacific Mobile Belt where seismic and volcanic activities occur constantly (see Figures 7.1 and 7.2). Although the country covers only 0.25% of the land area on the planet, the number of earthquakes and active volcanoes is quite high. In addition, because of geographical, topographical and meteorological conditions, the country is subject to frequent natural disasters such as typhoons, torrential rains and heavy snowfalls, as well as sediment disasters (Figure 7.3) and tsunami.

1. This chapter was produced by Olvido Guzmán of the NEA based on publications of the Cabinet Office of Japan.

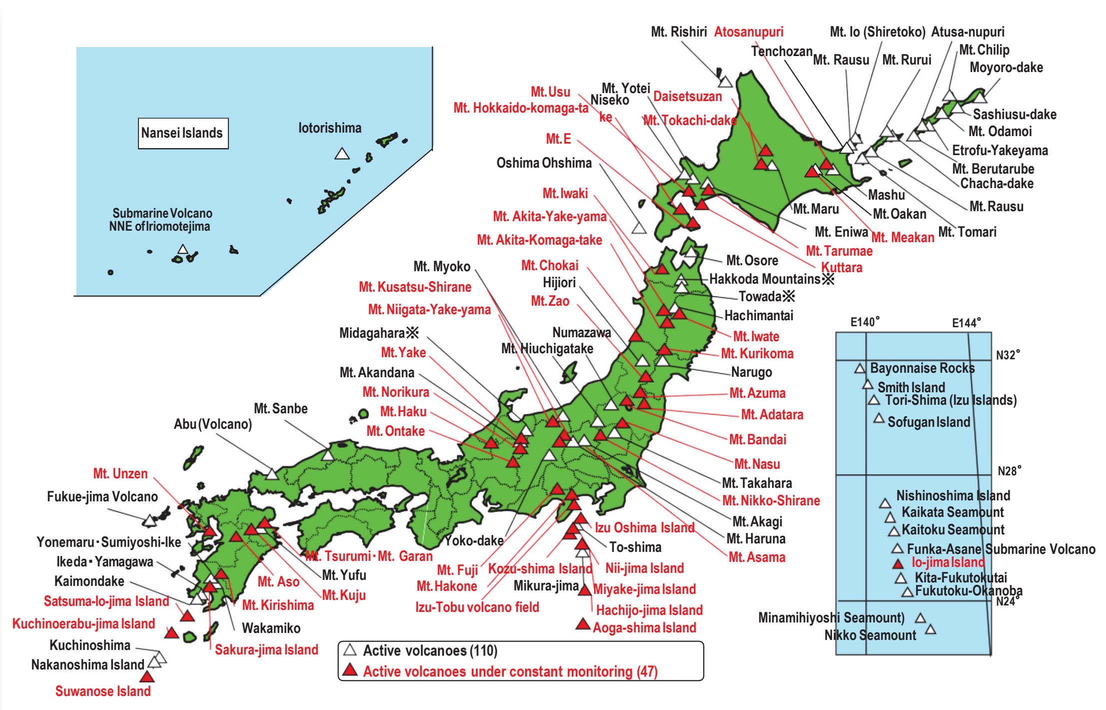
Figure 7.1. **Map of maximum seismic intensity distribution in Japan**



* The results of multiple cases were combined to show the maximum intensity in a given area.

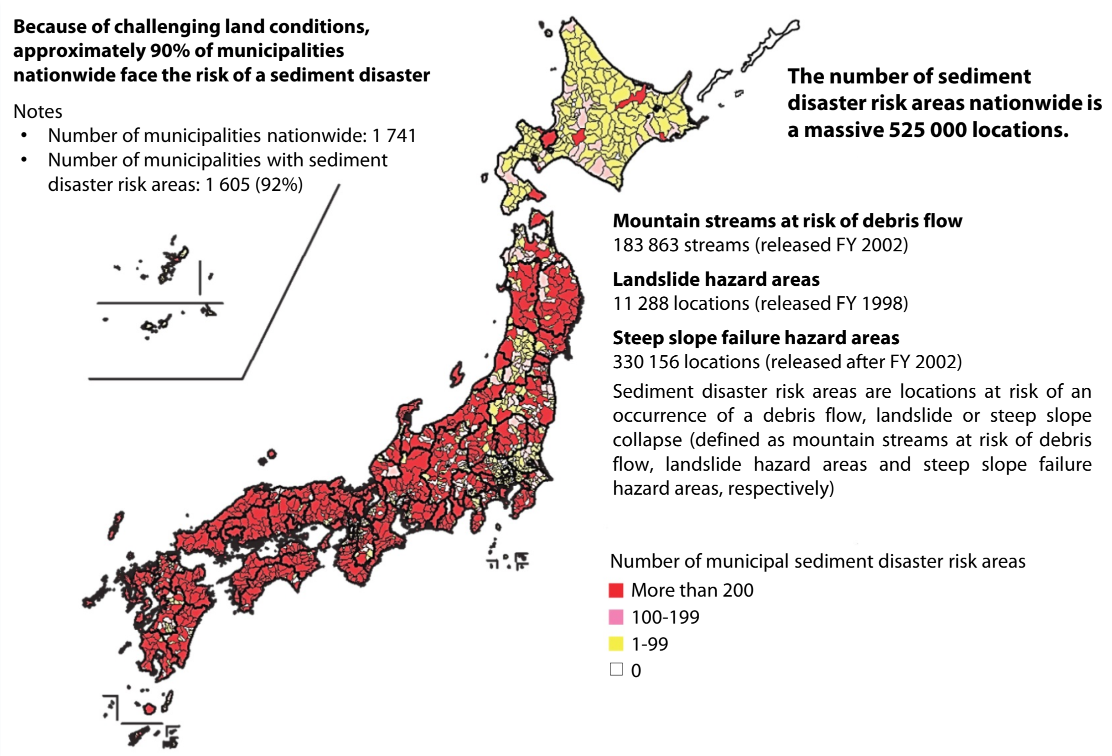
Source: Committee for Modeling a Nankai Trough Megaquake, Cabinet Office.

Figure 7.2. **Distribution of active volcanoes in Japan**



Source: Created by the Cabinet Office from the Japan Meteorological Agency website.

Figure 7.3. **Sediment disaster risk areas by municipality**



Source: Ministry of Land, Infrastructure, Transport and Tourism, as of 31 March 2015.

Evolution of disaster management laws and systems in Japan

Disasters in Japan have triggered the introduction over time of disaster management systems and regulations integrating lessons learnt from those disasters. The turning point for strengthening the disaster management system came in response to the immense damage caused by the Typhoon Ise-wan in 1959, and led to the enactment of the Disaster Countermeasures Basic Act in 1961, which formulates a comprehensive and strategic disaster management system. This was followed by the formulation of the first Basic Disaster Management Plan based on the Disaster Countermeasures Basic Act in June 1963. Thereafter, the disaster management system has been continuously reviewed and revised to integrate the lessons learnt from large-scale disaster regardless of its nature, natural or human-made. Table 7.1 presents the progress on disaster management laws and systems since 1945 which have led to today's disaster management system in Japan.

A comprehensive disaster management system

Japan's legislation for disaster management including the Disaster Countermeasures Basic Act addresses all of the disaster phases: prevention, mitigation, preparedness, emergency response, recovery and reconstruction. Roles and responsibilities among the national and local governments are clearly defined and it is stipulated that the relevant entities of the public and private sectors are to co-operate in implementing various disaster countermeasures. The Disaster Countermeasures Basic Act has constantly been reviewed and amended since its first enactment. Lessons learnt from the Great East Japan Earthquake of 2011 were reflected in enhanced provisions concerning support activities mutually carried out by local governments (2012) and measures for ensuring smooth and safe evacuation of residents and improving protection of affected people (2013). In 2014, provisions were added for strengthening measures against unattended cars in order to promptly clear them from the roads for emergency vehicles. Table 7.2 reviews the adaptations in disaster risk reduction (DRR) measures which were carried out by government following the latest large-scale disasters in Japan.

Table 7.1. **Progress on disaster management laws and systems since 1945**

Disasters that triggered law/system introduction	Disaster management law	Explanation
1940s 1945: Typhoon Ida (Makurazaki) 1946: The Nankai Earthquake 1947: Typhoon Kathleen 1948: The Fukui Earthquake	1947: The Disaster Relief Act 1949: The Flood Control Act	
1950s 1959: Typhoon Vera (Isewan)	1950: The Building Standards Act	
1960s 1961: Heavy Snowfalls 1964: The 1964 Niigata Earthquake 1967: Torrential Rains in Uetsu	1960: Soil Conservation and Flood Control Urgent Measures Act 1961: Disaster Countermeasures Basic Act 1962 Central Disaster Management Council established 1963 Basic Disaster Management Plan 1962: Act on Special Financial Support to Deal with Extremely Severe Disasters; Act on Special Measures for Heavy Snowfall Areas 1966: Act on Earthquake Insurance	Establishment of fundamental disaster prevention laws • Clear assignment of federal responsibilities • Development of cumulative and organised disaster prevention structures, etc.
1970s 1973: Mt. Sakurajima Eruption Mt. Asama Eruption 1976: The Seismological Society of Japan publishes reports on a possible Tokai Earthquake 1978: The 1978 Miyagi Earthquake	1973: Act on Provision of Disaster Condolence Grant; Act on Evacuation Facilities in Areas Surrounding Active Volcanoes (Act on Special Measures for Active Volcanoes, 1978) 1978: Act on Special Measures Concerning Countermeasures for Large-Scale Earthquakes	
1980s	1980: Act on Special Financial Measures for Urgent Earthquake Countermeasure Improvement Projects in Areas for Intensified Measures 1981: Amendment of Order for Enforcement of the Building Standard Law	• Induction of current earthquake engineering laws, etc.
1990s 1995: The Southern Hyogo Earthquake (The Great Hanshin-Awaji Earthquake) 1999: Torrential Rains in Hiroshima Tokaimura Nuclear Accident (The JCO Nuclear Accident)	1995: Act on Special Measures for Earthquake Disaster Countermeasures Act on Promotion of the Earthquake-proof Retrofit of Buildings Amendment of Disaster Countermeasures Basic Act 1996: Act on Special Measures for the Preservation of Rights and Interests of the Victims of Specified Disasters 1997: Act on Promotion of Disaster Resilience Improvement in Densely Inhabited Areas 1998: Act on Support for Reconstructing Livelihoods of Disaster Victims 1999: Act on Special Measures Concerning Nuclear Emergency Preparedness	• Establishment of disaster management mechanisms based on volunteer groups and private organisations, loosening of requirements for the establishment of a Central Disaster Management Council led by the Prime Minister, the codification of disaster relief requests for the JSDF, etc.

Table 7.1. **Progress on disaster management laws and systems since 1945** *(cont'd)*

Disasters that triggered law/system introduction	Disaster management law	Explanation
2000s 2000: Torrential Rains in the Tokai Region	2000: Act on the Promotion of Sediment Disaster Countermeasures for Sediment Disaster Prone Areas 2001: Amendment of the Flood Control Act 2002: Act on Special Measures for Promotion of Tohnankai and Nankai Earthquake Disaster Management 2003: Specified Urban River Inundation Countermeasures Act	• More rivers were added to flood alert lists, announcement of expected inundation areas. • Expansion of list of designated rivers in expected inundation area.
2004: Torrential Rains in Niigata, Fukushima The 2004 Niigata Chuetsu Earthquake	2004: Act on Special Measures for Promotion of Disaster Management for Trench-type Earthquakes in the Vicinity of the Japan and Chishima Trenches 2005: Amendment of the Flood Control Act; Amendment of the Act on the Promotion of Sediment Disaster; Countermeasures in Sediment Disaster Prone Areas; Amendment of the Act on the Promotion of the Seismic Reinforcement and Retrofitting of Buildings 2006: Amendment of the Act on the Regulation of Residential Land Development	• Increased efforts in public education through use of Sediment Disaster Hazard Maps. • Establishment of basic national directives and regional earthquake-proof retrofit plans, and promotion of organised earthquake-proofing.
2011: The 2011 Tohoku (The Great East Japan Earthquake)	2011: Act on the Promotion of Tsunami Countermeasures; Act on Development of Areas Resilient to Tsunami Disasters 2012: Amendment of Disaster Countermeasures Basic Act; Act for Establishment of the Nuclear Regulation Authority	First Amendment (2012) • Regional response for large-scale disasters. • Incorporated lessons from the disaster, improvements to disaster management education, and improvements to regional disaster management capabilities through participation of diverse entities in implementation.
	2013: Amendment of Disaster Countermeasures Basic Act Act on Reconstruction from Large-Scale Disasters;	Second Amendment (2013) • Improvement of support for affected people. • Improvements to rapid response capabilities in the event of a large-scale and regional disaster. • Smooth and safe evacuation of residents. • Improvements in disaster countermeasures in daily life.
	Amendment of the Act on the Promotion of the Seismic Reinforcement and Retrofitting of Buildings;	• Establishment of obligatory earthquake-proofing examinations and publication of test results for large buildings in need of emergency safety checks.
	Amendment of the Flood Control Act and River Act;	• Participation of diverse entities including river management organisations in flood control activities, acquisition of appropriate maintenance and management needs in river management facilities, etc.
	Act on Special Measures for Land and Building Leases in Areas Affected by Large-scale Disasters; Amendment of the Act on Special Measures for the Promotion of Nankai Trough Earthquake Disaster Management (Amendment of the Act on Special Measures for the Promotion of Tonankai and Nankai Earthquake Disaster Management); Act on Special Measures against Tokyo Inland Earthquake	• Designation of Nankai Trough Earthquake Disaster Countermeasure Promotion Areas, promotion of earthquake disaster management for the Nankai Trough Earthquake through the creation of a Basic Plan. • Designation of Areas for Urgent Implementation of Measures against a Tokyo Inland Earthquake and promotion of earthquake management through the creation of a Basic Plan.
2014: Heavy Snowfall	2014: Amendment of Disaster Countermeasures Basic Act;	• Establishment of laws regarding abandoned vehicles in opening up transportation routes for emergency vehicles in large-scale disasters.
Hiroshima Landslide Disaster	Amendment of Act on the Promotion of Sediment Disaster Countermeasures for Sediment Disaster Prone Areas	• Clear definitions of sediment disaster-prone areas (publication of basic investigations), provision of information necessary for issuing evacuation alerts.

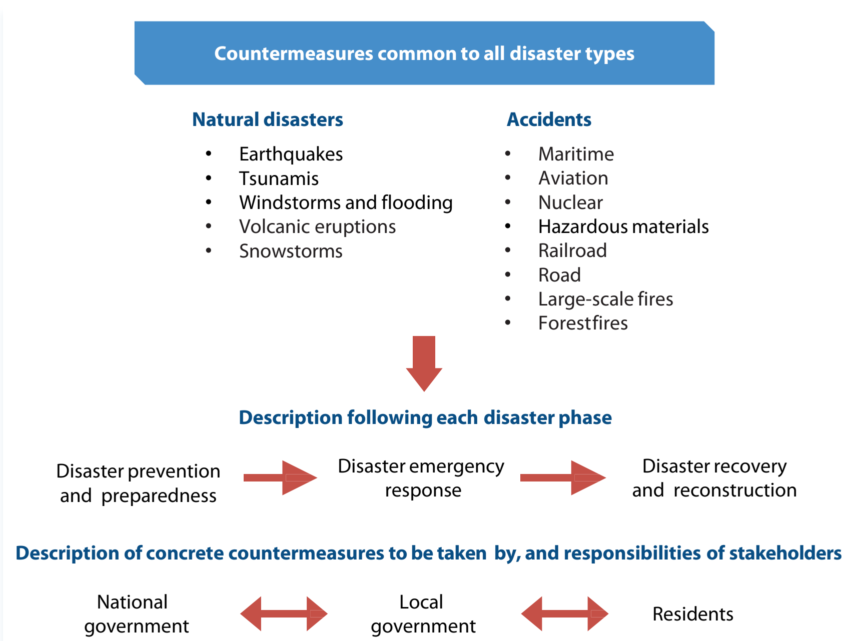
Source: Cabinet Office of Japan.

Table 7.2. **Areas recently addressed by government efforts in disaster risk reduction**

Disaster management systems and disaster preparedness	• government's approach to crisis-management organisation; • efforts in human resource development and disaster management drills; • implementation of disaster risk reduction (DRR) education in communities; • construction of business continuity systems across sectors; • communicating lessons learnt from disasters.
Disaster response and preparedness	• evacuation directive decision making and communication; • designated emergency evacuation sites and evacuation shelters; • measures for handling abandoned or stranded vehicles; • measures to assist stranded persons; • inspections for controlling the outbreak of electrical fires during large-scale earthquakes.
Initiatives to support disaster victims	• development and promotion of a victim's registry; • disaster relief act, disbursement of condolence grant to disaster-affected people.
Promotion of DRR activities in co-ordination with various stakeholders	• initiatives to develop an environment for DRR volunteers; • strengthening the DRR capacity of communities; • awareness raising and knowledge dissemination on disaster reduction; • promotion of disaster reduction activities of corporations.
Recovery and reconstruction measures	• investigating measures to secure housing for victims; • act on support for livelihood recovery of disaster-affected people.
Efforts to promote national resilience	• designation of "Disaster Preparedness Day" (1 September), "Disaster Preparedness Week", and "Tsunami Preparedness Day" (5 November); • act on promotion of disaster resilience.

Figure 7.4 presents the current structure of Japan's Basic Disaster Management Plan and Figure 7.5 presents the outline of the latest amendment to the plan in January 2014.

Figure 7.4. **Structure of Japan's basic disaster management plan**



Source: Cabinet Office of Japan.

Figure 7.5. **Outline of amendment of basic disaster management plan (January 2014)**

Background

Amendment of Disaster Countermeasures Basic Act (June 2013)	Enactment of Act on Reconstruction from Large-Scale Disasters (June 2013)	Deliberation by Nuclear Regulation Authority

Main amendments

Strengthening countermeasures against large-scale disasters

1. Clarification of the disaster management basic principles

- Definition of the ideas on "disaster risk reduction" to minimise damage and recover quickly
- Promotion of disaster countermeasures with a joint effort by the national government, local governments, private sectors and citizens

2. Improvement of immediate response to large-scale disasters affecting over wide areas

- Developing Basic Guidelines to promote disaster response measures and maintaining national economic order by concerted effort by whole government in time of Declaration of Disaster Emergency Situation
- Enhancement of support system by national government's efforts including providing assistance and coverage of emergency response efforts for affected local governments when their administrative functions are paralysed

3. Ensuring smooth and safe evacuation of residents

- Ensuring safety of residents in time of emergency by designation of Designated Emergency Evacuation Places
- Appropriate evacuation guiding and improvement of safety confirmation system by making and utilising the lists of People Requiring Assistance in Evacuation, such as elderly and disabled people

4. Improvement of measures for protecting affected people

- Improving environment of shelters for affected people to stay for certain period of time by designating Designated Shelters
- Issuing certificate for affected people to receive appropriate support depending on the extent of damage
- Supporting affected people comprehensively and efficiently by developing database of affected people

5. Strengthening disaster preparedness in normal time

- Promotion of concluding partnership agreements between national/local governments and private companies that engage emergency response
- Promotion of disaster prevention activities in residential district by developing District Disaster Management Plans and joint implementation of disaster prevention drills with residents and private sectors

6. Smooth and quick reconstruction from large-scale disasters

- Clarification of the basic principles of reconstruction, respecting residents' opinions and supporting independent activities of local governments by the national government
- Promotion and comprehensive co-ordination of measures implemented by the reconstruction headquarters established by the national government
- Systematic reconstruction based on municipalities' reconstruction plans

Improvement of policies for response to nuclear disaster

1. Implementation of protection measures in the priority area that performs nuclear disaster

- Implementation of protective measures such as sheltering and evacuation in Precautionary action zone (PAZ) and urgent protective action planning zone (UPZ)

2. Setting emergency levels

- According to the situation on nuclear facilities, levels of emergency that Alert, Site Area Emergency and General Emergency will be set and measures including residents protection and radiological monitoring will be stipulated

3. Defining operational intervention level (OIL)

- Defining the operational intervention level according to results of radiological monitoring and implement emergency response measures such as evacuation and temporary relocation

4. Reviewing emergency monitoring system

- Establishment of emergency monitoring centre by the national government, local governments and nuclear businesses co-operatively and implementation of emergency monitoring

5. Developing the system of preventive taking of stable iodine tablet

- Developing the system of taking stable iodine in emergency and required measures of distributing in advance

Reviewing the structure of the act

1. Organising common countermeasures against various disasters

- Newly develop "Chapter 2: Common Matters in Various Disasters" summarising the common matters in various disasters in the beginning of the chapters of "Countermeasures on Each Disaster"

2. Reviewing matters to be emphasised in disaster management operation plans and local disaster management plans

- Clarifying the matters to be particularly emphasised and summarise them in the Chapter 1 based on the recent deliberation on disaster countermeasures after the Great East Japan Earthquake

3. Review based on the lessons learnt from recent disasters

- Defining the standards of issuing evacuation advisory and establishing measures to provide evacuation guidance for travellers from foreign countries

Source: Cabinet Office of Japan.

Integrating lessons learnt from evacuation and sheltering

Revision of the Guidelines for Producing a Decision and Dissemination Manual for Evacuation Advisories and Orders (April 2014)

The Cabinet Office revised the Guidelines for Producing a Decision and Dissemination Manual for Evacuation Advisories and Orders in April 2014 given the use of new information, such as Sediment Disaster Alert Information, and based on the lessons learnt from disasters like the landslide disaster that occurred on Izu Oshima Island in October 2013. They recommended that municipalities issue evacuation advisories, orders, and other directives without fear that they might be unnecessary, and had planned to disseminate the guidelines through explanatory meetings organised for prefectures and municipalities. However, following the sediment disaster that occurred in Hiroshima City in August 2014, and based on reports that the timing of evacuation directives had been an issue, in September of that year the Cabinet Office and the Fire and Disaster Management Agency requested that all local governments in Japan re-examine their decision-making criteria for the issuance of evacuation directives for sediment disasters. On the other hand there are actual examples of governments issuing evacuation directives based on the decision-making criteria established in these Guidelines and of damage having been reduced as a result. In the case of the sediment disaster that occurred in Tanba City, Hyogo Prefecture also in August 2014, the disaster occurred around midnight. The city issued its evacuation advisory earlier, before the disaster had occurred, and thus was able to minimise the number of human casualties. Thus, the Cabinet Office plans to continue disseminating the Guidelines in co-ordination with relevant institutions.

Figure 7.6 lays out the conceptual and practical process of revision of guidelines, highlighting the responsiveness to actual experience and providing key definitions.

"Natural disaster/evacuation card"

The guidelines propose a system whereby a "natural disaster/evacuation card" is installed at every address and building. This card would help ensure that residents know the appropriate actions to take when an evacuation directive is announced for various types of natural disasters (e.g. where to go if there is a need to evacuate, and what information to pay attention to in the case of an evacuation). Going forward, there are plans to improve DRR awareness of residents through initiatives aimed at disseminating general knowledge of the guidelines as well as the "disaster/ evacuation card".

Designated emergency evacuation sites and evacuation shelters

When the Great East Japan Earthquake struck in March 2011, a clear distinction was not necessarily made between "evacuation sites" to which people could flee to escape the dangers of the imminent disaster and "evacuation shelters" or places of refuge where they could stay for a specific period and live as evacuees following the disaster. Furthermore, the evacuation sites were not designated according to the type of natural disaster for which they were intended. Thus, some people fled to evacuation sites immediately after the earthquake only to have these facilities destroyed by the tsunami. This was one cause of damage escalation.

Figure 7.6. **Guidelines for producing a decision and dissemination manual for evacuation advisories and orders**

Timeline

March 2005 Formulation of the old guidelines

Sep.2005	Sediment disaster alert information launched	Jun.2013	Revision of Disaster Countermeasures Basic Act (e.g. provisions guaranteeing seamless and safe evacuation of residents)
Sep.2006	Revision of designated river flood forecasts		
Mar.2011	The Great East Japan Earthquake	Aug.2013	Emergency warning is launched

Revisions based on new systems, lessons from past disasters

Key changes

Concept of "evacuation" reconsidered

- "Evacuation" redefined as behaviours engaged in to protect oneself from natural disasters
- Evacuation understood not only to mean going to an evacuation area as before; remaining home and ensuring one's safety is now also recognised as a kind of "evacuation behaviour"
  → "evacuation by fleeing" and "securing one's safety at home"
- Demonstrated the concept that there are areas where life-threatening phenomena may occur, where evacuation by fleeing is necessary, depending on the type of disaster
- Principle is established for municipalities to issue evacuation advisories/orders early, without concern that evacuation may not be necessary
  → if evacuation is necessary during the night or early in the morning, issue "evacuation preparation information"

Criteria for issuance of evacuation advisories/orders are clearly defined

- Decision criteria for evacuation advisories/orders are set out as precisely and clearly as possible, and information to be taken into account in decision making is concretely defined

Example of evacuation advisory issuance criteria	Reference information
Flood: River water lever reaches flood risk water level Sediment disaster: Issue sediment disaster alert information Storm surge: Issue storm surge warning (For tsunamis: Give all evacuation orders when alert is issued)	Meteorological information: disaster risk reduction information system (Japan Meteorological Agency [JMA]) Water level of rivers: river disaster risk reduction information (Ministry of Land, Infrastructure, Transport and Tourism [MLIT])

- Support partners have been clarified for the definition of criteria for issuing evacuation advisories/orders and the analysis of DRR meteorological information when the DRR system has been activated
- JMA Regional Headquarters and Local Meteorological Offices, MLIT River Offices, prefectural Land Development Offices, etc.

Concepts behind municipal DRR systems are presented

- Examples are given of basic concepts relating to the transition stage of municipal DRR systems
  Examples of DRR meteorological information and DRR systems (for sediment disasters)
  Heavy rain advisory: System for posting communications personnel and monitoring the weather
  Heavy rain warning: System for ensuring that governors and mayors get to work and decide when to issue evacuation orders
  Sediment disaster warning information: All disaster response personnel go to work

Proposal for mechanism to increase resident awareness of evacuation behaviours

- Proposed a framework for increasing residents' awareness of the disaster risks they face at home, and what steps to take to evacuate if an evacuation advisory/order is issued
  → Disaster evacuation info card (card placed in every building that specifies which disasters necessitate evacuation and the relevant methods of evacuation)

Future plans

- ☐ Since co-ordination with DRR institutions is necessary for municipalities to investigate criteria for issuing evacuation advisories/orders, a revision with a target of one to two years will be requested
- ☐ Guidelines will be revised as conditions require

Source: Cabinet Office of Japan.

Given this, revisions were made in June 2013 to the Disaster Countermeasures Basic Act establishing new provisions distinguishing "designated emergency evacuation sites" and "designated evacuation shelters". These are outlined below.

- *Designated emergency evacuation sites*: A designated emergency evacuation site is a place where residents can flee to when a tsunami, flood or other natural disaster is imminent. The purpose of these sites is to guarantee the immediate safety of residents. Under the Disaster Countermeasures Basic Act, municipal mayors must make an overall assessment of the maintenance conditions, configuration, geological features and other attributes of DRR facilities. When necessary, mayors must designate facilities or locations that meet certain criteria as designated emergency evacuation sites, so as to ensure efficient and rapid evacuations in the event of a natural disaster.
- *Designated evacuation shelters*: A designated evacuation shelter is a facility, such as a school or community centre, where residents who have fled as a result of the dangers of a natural disaster may stay for as long as is necessary until the dangers of that natural disaster have receded. The purpose of these facilities is to offer temporary shelter for residents who are unable to return home because of the natural disaster. Shelters are designated by the municipal government. At the time of the Great East Japan Earthquake, when many victims were forced to live as evacuees for long periods, authorities observed the mental and physical functional decline of victims as well as the outbreak and worsening of various diseases. Many persons requiring special care experienced problems with the physical elements of the structures or struggled in their relations with other evacuees, leaving them no choice but to return to live at home. The June 2013 partial revision to the Disaster Countermeasures Basic Act took account of these lessons. It provides for sure access to an appropriate facility where victims could stay in the event of a disaster, and provides a system for the designation of evacuation shelters by municipal mayors in Article 49-7.
- *Welfare evacuation shelters:* Furthermore, a system for designating some evacuation shelters as welfare evacuation shelters was stipulated in Article 20-6-1-5 of the Enforcement Order of the revised act.

In 2014 a survey was conducted to promote initiatives to manage the evacuation shelters and welfare evacuation shelters operated by the municipalities. This was posted online and was circulated among the prefectures and municipalities.

Measures for support to disaster-affected people

- *Measures for residents in need of assistance in evacuation:* In 2006, the Cabinet Office released and disseminated to municipalities the Guidelines for Evacuation Support of People Requiring Assistance during a Disaster. High mortality rates were seen for aged and disabled groups in the Great East Japan Earthquake in 2011, while there was sacrifice on a broad scale by those who provided support such as firefighters and social workers. With these lessons, the Disaster Countermeasures Basic Act was amended in 2013 to stipulate that head of each municipality be assigned the responsibilities of establishing a list of residents who need assistance in evacuation at the time of disaster. The 2006 guidelines were revised in their entirety and incorporate specific procedures for establishing that list.
- *Securing good living environment at the evacuation centres*: The Great East Japan Earthquake was accompanied by many difficulties: affected people suffered health impacts; aged people were forced to stay home because they could not adapt themselves to the evacuation shelters in some cases; relief supplies were not provided sufficiently to home evacuees in many cases; and there were reported

problems in provision of information, relief supplies, and services for wide-area evacuees who evacuated to other prefectures or municipalities. In order to address these challenges, the 2013 revision of the Disaster Countermeasures Basic Act added provisions to oblige administration to make efforts to improve living environment of the evacuees at the evacuation centre. Articles 86-6 and 86-7 outline the matters that local governments must take into consideration in the development of the living environments at designated evacuation shelters including supply of food, clothes, medicines, and other basic living needs as well as health and medical services. Guidelines for Ensuring Satisfactory Living Conditions at Evacuation Shelters were formulated and published in August 2013, as a reference tool to promote efforts in mainly municipal management of evacuation shelters under both emergency and non-emergency conditions.

Concluding remarks

"Even if we cannot eliminate the occurrence of natural hazards, we are confident that it is possible to mitigate disaster impacts using both the instinct to survive and the wisdom with which human beings are naturally equipped. In English, the Japanese terms bousai or gensai are translated as 'disaster risk reduction', abbreviated DRR … an important precept in Japan: 'DRR is our DNA'. Based on the view that disaster countermeasures are never 'costs', but rather investments in the future, the Government of Japan is wholeheartedly committed to achieving safe and secure living. We therefore intend to proactively request that all citizens of Japan maintain a reasonable awareness of natural threats, be well prepared in advance for the hazards they face, refuse to react to false alarms, and take actions to protect themselves from disasters."

– Eriko Yamatani, Minister of State for Disaster Management, Japan (July 2015)

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Chapter 8. **Conclusions**

Emergency preparedness and response (EPR) for nuclear power plants (NPPs) in OECD countries is well-defined and well-practised. A comparison between nuclear power plant EPR and the events described in the present report reveals no gaps in NPP EPR planning. However, reviewing the responses to accidents in other hazardous industries and events, such as weather-related natural disasters, enables planners to learn from those responses and enhance their own programmes where appropriate.

While there are unique aspects to radiological/nuclear EPR, most of the aspects of planning are very similar to planning in an all-hazards framework. For example, protective actions need to be taken for NPP accidents as well as chemical accidents and natural disasters. These can be the same types of protective actions (i.e. evacuation). Review of evacuations in many non-nuclear events can reveal lessons learnt that can enhance the effectiveness of similar protective actions around NPPs. The need for rapid and accurate information is similar for both nuclear and non-nuclear events. Analysis of communication strategies employed during non-nuclear events enables NPP EPR planners to employ up-to-date communications strategies that can result in more effective messaging to the public or between response organisations.

This report shows the similarity in EPR planning across all sectors, and identifies lessons learnt and good practices. Incorporation of these lessons learnt and good practices into the nuclear field builds strong emergency preparedness and response, as well as national resiliency. The IAEA and the OECD recognise the importance of a strong and unified response and urge the inclusion of radiological emergency preparedness to the event possible in greater comprehensive all-hazards emergency planning.

The contributions to this report support the value of such an all-hazards approach to EPR. Lessons from a multidisciplinary perspective in fields other than nuclear energy can be used by countries, as appropriate, to enhance their already robust nuclear emergency preparedness and response systems.

This report can also be a valuable tool for OECD countries in implementing the OECD Council Recommendation on the Governance of Critical Risk that members establish and promote a comprehensive, all-hazards and transboundary approach to country risk governance to serve as the foundation for enhancing national resilience and responsiveness.

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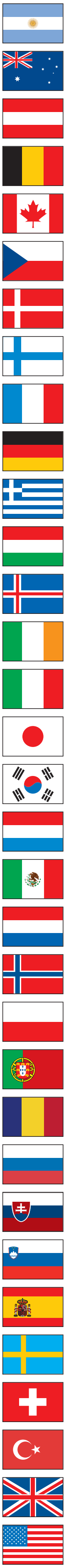

Towards an All-Hazards Approach to Emergency Preparedness and Response: Lessons Learnt from Non-Nuclear Events

The field of emergency management is broad, complex and dynamic. In the post-Fukushima context, emergency preparedness and response (EPR) in the nuclear sector is more than ever being seen as part of a broader framework. The OECD has recommended that its members "establish and promote a comprehensive, all-hazards and transboundary approach to country risk governance to serve as the foundation for enhancing national resilience and responsiveness". In order to achieve such an all-hazards approach to emergency management, a major step in the process will be to consider experiences from the emergency management of hazards emanating from a variety of sectors.

The NEA Working Party on Nuclear Emergency Matters (WPNEM) joined forces with the OECD Working Group on Chemical Accidents (WGCA), the OECD Public Governance and Territorial Development Directorate's High-Level Risk Forum (HLRF) and the European Commission's Joint Research Centre (JRC) to collaborate on this report, which demonstrates similarities between emergency planning and preparedness across sectors, and identifies lessons learnt and good practices in diverse areas for the benefit of the international community. A set of expert contributions, enriched with a broad range of national experiences, are presented in the report to take into account expertise gathered from the emergency management of hazards other than those emanating from the nuclear sector in an effort to support and foster an all-hazards approach to EPR.

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