An Illusion of Safety

Challenges of Nuclear Weapon Detonations for United Nations Humanitarian Coordination and Response

UNIDIR/2014/6

An Illusion of Safety

Challenges of Nuclear Weapon Detonations for United Nations Humanitarian Coordination and Response

John Borrie and Tim Caughley

UNIDIR
United Nations Institute for Disarmament Research
Geneva, Switzerland

UNITED NATIONS

New York and Geneva, 2014

The United Nations Institute for Disarmament Research (UNIDIR)—an autonomous institute within the United Nations—conducts research on disarmament and security. UNIDIR is based in Geneva, Switzerland, the centre for bilateral and multilateral disarmament and non-proliferation negotiations, and home of the Conference on Disarmament. The Institute explores current issues pertaining to the variety of existing and future armaments, as well as global diplomacy and local tensions and conflicts. Working with researchers, diplomats, government officials, NGOs and other institutions since 1980, UNIDIR acts as a bridge between the research community and governments. UNIDIR's activities are funded by contributions from governments and donor foundations.

www.unidir.org

About the cover

Satellite image of Mexico City courtesy of the U.S. Geological Survey.

Note

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The views expressed in this publication are the sole responsibility of the individual authors. They do not necessarily reflect the views or opinions of the United Nations, UNIDIR, its staff members or sponsors.

UNIDIR/2014/6

Copyright © United Nations, 2014
All rights reserved

UNITED NATIONS PUBLICATIONS
Sales No. GV.E.14.0.1
ISBN 978-92-9045-203-4
eISBN 978-92-1-056894-4

CONTENTS

List of boxes and figures

Boxes

Figures

FOREWORD

Why should United Nations humanitarian and development agencies and their partners be interested in developing approaches to how to respond to nuclear weapon detonations? It could be argued that there are much more immediate and pressing humanitarian and development issues on which to focus. As well, the possibility of a nuclear weapon being detonated in a highly populated area, either by accident or design, is widely assumed to be low.

The answer to this question has three parts, and it begins with the core mission of the United Nations. Every day, the United Nations is on the front line of efforts to empower people around the globe, and to help nations become more resilient to crisis. To this end, United Nations agencies, funds, and programmes and partner organizations assist millions of people affected by disasters or armed conflict each year.

This is a massive task. The conflict in Syria alone has left 9.3 million people in need of aid. 6.5 million of these are displaced within Syria, and more than 2.3 million people have left the country as refugees. The Syrian conflict has also borne witness to chemical weapon use in highly populated areas. It has shown that weapons of mass destruction generate particular humanitarian challenges, including for the delivery of assistance, and for the safety of humanitarian staff. In addition it has demonstrated the longer term impact which these weapons can have on prospects for human development.

In the aftermath of a nuclear detonation, United Nations and other humanitarian organizations could well be called upon to assist victims and governments of affected states.

The United Nations system has relevant experience in dealing with the consequences of civil nuclear accidents, including those of the 1986 Chernobyl and 2011 Fukushima Daiichi power-plant disasters. Recent related reports by the Secretary-General, UNDP, and OCHA have underlined the immediate and longer-term human consequences of radiation-related emergencies, and the difference which a well-coordinated United Nations system makes in addressing those effects. Giving prior thought to the practical challenges such situations create could help to improve our future responses, including in humanitarian coordination and early recovery activities.

Nuclear weapon detonations, however, are different from civil nuclear emergencies in important respects. Even a single, low-yield nuclear explosive device would cause vast physical destruction. Alongside blast and heat, intense and harmful ionizing radiation is created within the zone of a nuclear bomb's direct effects. A nuclear weapon detonation in a highly populated area would be a humanitarian disaster. Moreover, it could blow large amounts of radioactively contaminated material into the atmosphere, which would travel long distances and endanger human health far from 'ground zero'.

Renewed attention is being paid to the humanitarian impacts and risks of nuclear weapon detonations, including in recent international conferences in which United Nations humanitarian and development agencies participated, along with the Red Cross and Red Crescent Movement, academic experts, civil society, and Member States. UNIDIR's study, undertaken in cooperation with OCHA and UNDP, examines the finding of one of those conferences, held in Oslo, Norway, in March 2013, that: 'It is unlikely that any state or international body could address the immediate humanitarian emergency caused by a nuclear weapon detonation in an adequate manner and provide sufficient assistance to those affected. Moreover, it might not be possible to establish such capacities, even if it were attempted.'

Alongside this, recent research suggests we should not be so sanguine about the low probability of nuclear weapon detonations. Low probability, yet high consequence events add up to tangible risk. Indeed, this awareness of the nature of risk is a reason why the humanitarian system exists in the first place. This is the second part of the answer to the question of why we should be interested in the consequences of nuclear weapon detonations, and in a study of this kind.

The third part of the answer relates to what the International Committee of the Red Cross has described as the need for a 'reality check' by humanitarian agencies. This reality check has two aspects. The first is illustrated in the UNIDIR study's title. To continue believing that current planning is sufficient for coordinating a meaningful humanitarian response to one nuclear weapon detonation's consequences, let alone many, would be to believe in an illusion of safety. The study argues that a clearer, self-directed evaluation of the humanitarian system's capacities, in relation to the nature and magnitude of the challenges of responding to a nuclear weapon detonation event in a populated area, would be a desirable step. It is set against the unfortunate reality that in view of the consequences of many kinds of nuclear weapon detonation events, we might only be considering how to respond, at best, in a less inadequate way. Yet the response would be no less valuable because of that.

The second aspect of a reality check is related to that: recognizing that the United Nations-coordinated humanitarian system has many immediate priorities and faces constraints of various kinds, are there nonetheless feasible steps it could take to prepare itself better to respond to a nuclear weapon detonation? This study suggests that there are, including through internal United Nations decision-making, risk assessment procedures, and the practical coordination of delivery of assistance. Prior evaluation and planning would underline the very real practical limits on what is possible to assist the victims, and the significant (perhaps excessive) risks to humanitarian staff in many scenarios. Attention to such issues and procedures, however, has the potential to reduce the overall level of suffering and harm in the event of a nuclear weapon detonation – resulting, for example, from nuclear fallout or displacement – even if there is not much the humanitarian system could do in the immediate aftermath. Such assessment and planning need not be burdensome for the system, but would be consistent with meeting the United Nations' wider humanitarian responsibilities.

We welcome UNIDIR's study. Recent humanitarian disasters of various kinds indicate that it is not a wasted effort to consider how to respond to low-probability yet high-consequence events before they occur. Some of these events are, moreover, preventable by eliminating the source of risk. To this end the United Nations has long supported the achievement of a world free of nuclear weapons. Clearly we must all, including within the humanitarian and development communities, redouble our efforts to bring that about. Indeed, in addition to its specific findings, this study reminds us all that until we achieve a world free of nuclear weapons, they will continue to pose the risk of catastrophic consequences for humanity – whatever the United Nations and its humanitarian partners endeavour to do to pick up the pieces.

Helen Clark
Administrator, United Nations
Development Programme

Valerie Amos
United Nations Emergency Relief Coordinator and
Under Secretary-General for Humanitarian Affairs

ABOUT THE AUTHORS

John Borrie is a Senior Researcher and Policy Adviser at UNIDIR. Since 2004, Borrie has led several UNIDIR projects. Since early 2013 his research (with Tim Caughley) has focused on issues around the humanitarian impact of nuclear weapons. Borrie has a PhD from the University of Bradford in the United Kingdom, and a BA (Hons) from the University of Canterbury in New Zealand. He is an Associate Fellow at the Royal Institute of International Affairs in London (Chatham House). Prior to joining UNIDIR, Borrie worked on weapons issues at the International Committee of the Red Cross and before that was Deputy Head of Mission for Disarmament in Geneva with the New Zealand government (1999–2002).

Tim Caughley is a Resident Senior Fellow at UNIDIR, and manages its project on the humanitarian impact of nuclear weapons. Prior to that he was the Director of the United Nations Office of Disarmament Affairs in Geneva from 2006 to 2009 and, concurrently, the Deputy Secretary-General of the Conference on Disarmament. From 2002 to 2006, Caughley was New Zealand's Permanent Representative to the United Nations at Geneva and Ambassador for Disarmament. From 1998 to 2002 he was the New Zealand Ministry of Foreign Affairs and Trade's international legal adviser.

ACKNOWLEDGEMENTS

This study is the second phase of a UNIDIR project on humanitarian impacts of nuclear weapons that initially began its work in January 2013. This second phase of project work, commencing in August 2013 and working toward this study, would not have been possible without the generous support of the governments of Norway and Ireland. At the Ministry of Foreign Affairs of Norway we would like to thank, in particular, Sten Arne Rosnes and Per-Øyvind Landemoen. Ambassador Steffen Kongstad, Kjersti Nordskog Nes, and Stein-Ivar Lothe Eide at the Norwegian Permanent Mission in Geneva were unflaggingly supportive. Our thanks also go to Gerard Keown, Breifne O'Reilly, and Michael Hurley, at the Department of Foreign Affairs and Trade of Ireland and to Irish Aid in Dublin, as well as to Ambassador Patricia O'Brien, and to Robert Jackson, at Ireland's Permanent Mission to the United Nations in Geneva.

We are grateful to all of those experts who were generous with their time and their advice to us. Our study's advisory group, which met twice over the course of the research, was notable in this regard. Dr. Simon Bagshaw of OCHA and Sara Sekkenes of UNDP chaired this group ably, which was also attended by Neil Buhne (UNDP), Dr. Zhanat Carr (WHO), Dr. Robin Coupland (ICRC), Elin Enger (Norwegian Defence Research Establishment), Professor Sir Andy Haines (London School of Hygiene and Tropical Medicine), Martin Krottmayer (IFRC), Dr. Patricia Lewis (Chatham House), Joy Muller (IFRC), Rene Nijenhuis (UN OCHA/UNEP Environmental Emergencies Section), and Dr. Pavel Podvig (UNIDIR). Some of these experts were among those who reviewed drafts of our study, and we thank all of those who took the time to do this, although we alone are responsible for any errors.

Others gave us the benefit of their views and expertise. While not all of them can be named here, they included Derrin Culp (National Center for Disaster Preparedness at Columbia University Mailman School of Public Health), Steve Donnelly (ICRC), Gregor Malich (formerly ICRC), and Elena Sokova (Vienna Center for Disarmament and Non-Proliferation). Within the United Nations system, we interviewed or received information from staff in DSS, OCHA, ODA, OPCW, WHO, UNDP, and UNISDR, as well as the CTBTO and the IAEA. We thank them for their candour and, in some cases, their comments on our report drafts. Special thanks go to Richard Moyes who granted us permission to republish tables and diagrams from a recent case study produced by the British not-for-profit Article 36 on the direct humanitarian impacts from a single nuclear weapon detonation on Manchester. Christoph Wirz from the Swiss Federal Office for Civil Protection's Spiez Laboratory graciously allowed us to draw from a presentation he gave at a Swiss Foreign Ministry conference in Bern in August 2013. Thanks also to Shelley Bulling for her advice on matters related to radiation protection, especially in improving appendix 2.

In February 2014 we were offered the opportunity to present preliminary findings from our research to an international audience in meetings held in Nayarit, Mexico. For the opportunity to exchange thoughts with the International Red Cross and Red Crescent Movement, we thank Peter Herby and the Norwegian Red Cross, Mexican Red Cross, and Lou Maresca of the ICRC. We are also grateful to the government of Mexico, and in particular Tonie Jaquez and Paola Ramirez of the Mexican Ministry of Foreign Affairs, for allowing us to present at the Nayarit Conference on the humanitarian impact of nuclear weapons.

As can be seen from the content of this study, producing it required the management and processing of a large number of sources of different kinds. In this respect, we wish to acknowledge the contributions of Carla Bellota and Rachel Forman at the United Nations Library/Archives, who helped us set up a database system, and to populate it with useful information early in our work. Within UNIDIR, Anita Blétry, Theresa Hitchens, Jason Powers, Isabelle Roger, Tae Takahashi, and Kerstin Vignard were unfailingly helpful throughout the project. The Institute thanks its core funders, who provide the foundation for all of the Institute's activities.

Madeleine Barbru, our project's assistant researcher, deserves special mention. She made an invaluable contribution to the study, both in terms of her substantive input and wrangling its data and us. We feel very fortunate to have had her as a member of our team, and wish her the best in her future endeavours.

Last, and by no means least, we wish to acknowledge the vital contribution that the United Nations-coordinated humanitarian system, and especially those staff in the field, make to the lives of vulnerable people around the world, every single day. Their work is difficult and often

dangerous. We hope that they never have to respond to the humanitarian consequences of a nuclear weapon detonation event in a populated area. However, until such time as these weapons can be eliminated, we hope the study you are reading prompts plans for keeping humanitarian personnel safer, and enhancing their efforts to help the victims if the “unthinkable” happens.

John Borrie and Tim Caughley, July 2014

EXECUTIVE SUMMARY

This study examines one of the conclusions of an international conference on the humanitarian impacts of nuclear weapon detonations held in Oslo, Norway, in March 2013 that "It is unlikely that any state or international body could address the immediate humanitarian emergency caused by a nuclear weapon detonation in an adequate manner and provide sufficient assistance to those affected. Moreover, it might not be possible to establish such capacities, even if it were attempted".

- The UNIDIR study describes the current humanitarian system, and considers challenges for its activation and operation in the face of a range of plausible, illustrative nuclear weapon detonation scenarios.
- As a scoping exercise the study identifies specific issues that warrant further policy and operational attention in order to enhance civilian protection from nuclear weapons.
- It suggests steps the humanitarian system could take to better plan for such eventualities, and it reinforces the importance of preventing nuclear weapons ever being used again in populated areas—whether deliberately or accidentally.

Even if the probability of a nuclear weapon detonation event is viewed as low compared with other sudden-onset disasters (as some believe), it remains a real one. There has been a certain degree of international focus on scenarios involving a single nuclear detonation in an urban area by a non-state armed group. The possibility also cannot be excluded of state use of single or multiple nuclear weapons, whether deliberately or inadvertently. While it is thought that terrorist groups possess no nuclear weapons, there are more than 17,000 in the arsenals of nine states, and growing evidence of accidents, mishaps, and near misses since their invention.

Nuclear weapon detonation events could occur in populated or remote areas, with differing implications in terms of harm to human life, infrastructure, and the environment. The consequences of even one nuclear weapon exploded in or near a population centre would be sufficiently disastrous that the United Nations-coordinated humanitarian system could be called upon to assist the victims.

UNIDIR's study indicates that this would present a range of serious practical and policy challenges: these problems range from the particular characteristics of nuclear detonation events such as prompt radiation and radioactive fallout, large numbers of injured people with multiple trauma, serious burn injuries, and radiation-related illness, to widespread fear and disruption, and a low current level of awareness and planning for response. Related to this last point, there are inadequate specific procedures and systems appropriate to nuclear weapon detonation events as these differ from civil nuclear accidents in significant ways. Protection of humanitarian personnel is highlighted as a particular issue of concern.

The study's main findings are as follows:

1. The current level of awareness within the humanitarian system is generally low about the specificities of nuclear weapon detonation events or its ability to respond to them.
2. For the United Nations to offer or be called on to coordinate humanitarian assistance suggests an event is already beyond the capacity of the state or states affected to respond effectively to assist the victims. Moreover, as a rule it would depend upon an affected state requesting it, or appropriate international decision-making to be enacted if its government was incapacitated.
3. The United Nations is unlikely to be able to offer much humanitarian assistance in the immediate aftermath of a nuclear weapon detonation event, and it would take time for the humanitarian system to deploy.
4. At present there are a number of foreseeable challenges to prompt and effective use of the humanitarian cluster system in the context of a nuclear weapon detonation event.
5. Threat or fear of further nuclear weapon detonation events could vastly complicate decision-making about the nature and scale of humanitarian coordination and response, let alone its delivery.
6. Prevention is the best approach to the possibility of nuclear weapon detonation events. However, it is incumbent upon those humanitarian actors in a position to do so, such as the United Nations, to plan for the likely challenges of "lower end" nuclear

weapon detonation events even if such a response is palliative. Such planning would, in reality, also reinforce the need for action to reduce the risk of nuclear detonations happening in the first place.

We suggest that the humanitarian system consider the following:

1. Giving focused attention to the issue in the Inter-Agency Standing Committee (IASC);
2. Assigning responsibility to a new or existing IASC task team, and inviting the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE) to participate in the task team's work;
3. Studying and simulating varied nuclear weapon detonation scenarios with a view to humanitarian response;
4. Including representative nuclear detonation scenarios in future revisions of humanitarian procedures for large, complex, sudden-onset disasters; and
5. Reviewing current capacities and plans.

States and the Secretary-General could consider:

1. Prompting relevant humanitarian agencies and specialized agencies such as the IAEA, WHO, and CTBTO to clarify their mandates, policies, roles, and capabilities with a view to responding to nuclear weapon detonations;
2. Accounting for how inter-state decision-making processes could impinge on timely activation of humanitarian coordination and response efforts in the event of nuclear detonation; and
3. Examining how eliminating the risk of nuclear weapon use can be better pursued through practical measures. While nuclear weapons exist the risk of their detonation does too, whether caused deliberately or inadvertently.

Humanitarianism marks the broader mission of the United Nations, which since its inception has taken a strong stand in favour of nuclear disarmament. The initiation of specific planning for how to respond to a nuclear weapon detonation event would appear to be logical and consistent with both these aims. The development of necessary understandings about decision-making and a protocol for planning can be based on existing humanitarian coordination practices and need not entail a lot of resources. The rapid mounting of a well-coordinated response will have an impact in reducing the level of human suffering, even if it may not assist those directly affected in the immediate aftermath.

Nevertheless, the study also reinforces previous findings, such as those of the World Health Organization in the 1980s, that the only really effective response to the public health effects of the use of nuclear weapons is preventing that use. Greater attention to the immense challenges of preparedness and response to nuclear weapon detonation events in populated areas complements focus on the continued risks posed by nuclear weapons.

INTRODUCTION

What would be the humanitarian consequences of nuclear weapon detonations in populated areas? How would the United Nations humanitarian system respond in supporting the efforts of the state(s) concerned to meet the protection and assistance needs of the affected population, if such events were to occur? Are there particular kinds of challenges the United Nations would face that are distinct to nuclear detonations?

These questions are the subject of this UNIDIR study, which examines their implications for the United Nations-coordinated humanitarian system. The United Nations humanitarian system, led by the Emergency Relief Coordinator (ERC), includes a mosaic of actors of which United Nations agencies and their capacities are only a part (we describe the humanitarian system in part one). It is a formidable task to keep all of these entities working together across a multitude of different humanitarian emergencies that all require resource and policy attention, and entail some measure of hazard for personnel working in the field. There are many constraints on humanitarian operations, including of political, financial, security-related, and practical kinds, which limit available options at any given time.

Clearly responding to even a single nuclear weapon explosion in an urban area would be a mammoth task, and the great damage done by its effects in the moment of detonation means any humanitarian assistance would come after much harm is already done. In fact, an international conference on the humanitarian impacts of nuclear weapons held in March 2013 found that:

> it is unlikely that any state or international body could address the immediate humanitarian emergency caused by a nuclear weapon detonation in an adequate manner and provide sufficient assistance to those affected. Moreover, it might not be possible to establish such capacities, even if it were attempted.[1]

UNIDIR has produced this study to further investigate that finding in cooperation with the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) and the United Nations Development Programme's Bureau for Crisis Prevention and Recovery (UNDP BCPR). Although the findings are of UNIDIR researchers alone, it is hoped that the study will prompt further engagement by relevant policymakers both related to the humanitarian system and more broadly, for instance in the domains of disarmament, development, and public health. As a scoping study, our assessment is an attempt to establish some context, and take first steps towards identifying risks associated with nuclear weapon detonation events in terms of humanitarian impact, although it cannot be considered a systematic treatment or evaluation of those risks.[2] In view of the seriousness of the consequences of nuclear weapon detonation events and the likely humanitarian need arising from them, we feel that further and sustained policy engagement is needed. As we shall see, while a certain amount of thinking has occurred at the national level in terms of emergency response and within the United Nations in related domains such as responding to nuclear and radiological accidents or terrorist attacks, the issues have not yet been tackled head on.

Structure of the study

This study consists of five parts, each of which is briefly outlined below. Some of the issues the study deals with are complex, although we have been at pains to make it as accessible as possible to policy practitioners such as humanitarian agency personnel and diplomats. The study assumes no special knowledge on the part of the reader, and explains from the beginning nuclear weapons and their effects, and implications for response. Where we felt certain topics deserved more attention but digressed from the flow of discussion in the body of the study we created thematic boxes, and there are also a number of figures. One of the less intuitive phenomena when thinking about the consequences of nuclear weapon detonations is radiation, and there would seem to the non-specialist reader to be a plethora of terms and units of measurement of different

1 E. Barth Eide, "Chair's summary: Humanitarian Impact of Nuclear Weapons", 5 March 2013, www.regjeringen.no/en/archive/Stoltenbergs-2nd-Government/Ministry-of-Foreign-Affairs/taler-og-artikler-2013/nuclear_summary.html?id=716343.

2 See European Commission, *Commission Staff Working Paper: Risk Assessment and Mapping Guidelines for Disaster Management*, document SEC(2010) 1626, 2010, p. 20, http://ec.europa.eu/echo/civil_protection/civil/pdfdocs/prevention/COMM_PDF_SEC_2010_1626_F_staff_working_document_en.pdf.

kinds. We have kept reference to these matters to a minimum, but try to concisely explain those we did use in an appendix. The other appendix goes into more detail about the humanitarian cluster system than we felt we had space for in the study.

The first part of the study explains the context for it, and introduces its terms of reference. It sets out how the research was carried out, and some of the issues involved. In addition, some key terms and concepts are described.

Part two of the study describes what happens in a nuclear weapon detonation. It encompasses the physical processes involved and the resulting effects (such as blast, thermal radiation, and prompt radiation. In due course significant amounts of radioactive fallout can also occur). It looks at the kinds of direct consequences for people and infrastructure in terms of harm and destruction, as well as the societal disruptions that could result from nuclear detonations in populated areas such as mass human displacement, economic and developmental problems, and psychosocial harm. Of course, an important point is that the humanitarian consequences of one or more nuclear detonations will vary due to factors like their explosive yield, the number detonated, and the context in which these explosions occur. Correspondingly, this part also outlines a representative set of plausible detonation scenarios in order to consider whether there is a recognizable pattern of harm, and where effects differ in their consequences, due to the implications it may have for humanitarian coordination and response planning and activity.

Part three surveys current systems and capabilities in the United Nations system relevant to planning for or responding to the humanitarian consequences of the detonation of nuclear weapons. To date, this system seems to have given the challenges of responding to the humanitarian consequences of nuclear weapon detonation scenarios little sustained attention. Nevertheless, some thought has recently been given to its contribution to international response to major nuclear emergencies, especially in the wake of the 2011 Fukushima nuclear accident although there are some major differences between radiological accidents and the detonation of nuclear weapons. This section encompasses discussion of whether certain aspects of response to nuclear accidents are relevant to nuclear weapon detonation events. By nuclear detonation event we refer to a single event in which one or more nuclear weapons are detonated in a place or continuous area. By multiple events we mean more than one event in which one or more nuclear weapons are detonated.

The fourth part of the study explores what might happen in terms of decision-making and humanitarian mobilization processes in the United Nations following the type of nuclear weapon detonations outlined in our scenarios in part two. It suggests some of the specific types of challenges the United Nations would face if one or more nuclear detonation events occurred. These challenges will vary to some extent, especially since, as mentioned above, it is difficult to precisely predict what a nuclear detonation event (or multiple events) would look like.

Based on our analysis, there are foreseeable challenges. There are the logistical and operational challenges one might expect, and it is noted that the humanitarian coordination system has experience in the context of sudden-onset, large-scale disasters of many kinds. Nonetheless, there has not been systematic thinking about the full ramifications of nuclear weapon detonation events in populated areas (such as decontamination needs, radioactive fallout, and public fear of radiation). Nor has there been careful thought given to the political and organizational obstacles to effective response, such as constraints on agency mandates, roles and responsibilities, and lack of familiarity with radiation-related issues in field agencies that could impede humanitarian coordination and response efforts.

A real question is whether any response would be "adequate" in humanitarian terms. In the concluding part of the study we come back to the statements United Nations agencies have recently made on this point and how and to what degree the study confirms the Oslo conference's finding that any response would be inadequate. It also considers, if so, the question of what if anything could be done to change this. The study offers our research findings in that regard, including some suggestions about what could come next.

The study's most important finding is perhaps not surprising; that the only really effective response in humanitarian and public health terms is preventing the threat of detonation of nuclear weapons through their elimination. Humanitarian coordination and assistance in the case of nuclear weapon detonation events—whether at the local, regional, national, or international level—will be a matter of picking up the pieces after vast physical destruction and human harm has already been inflicted. Consistent with this, we nevertheless suggest that there are internal assessments the

United Nations system could undertake that would conceivably reduce the overall human harm from such an event's after-effects, and perhaps avert a "systemic failure" of the kind the Secretary-General has noted in certain past humanitarian contexts.[3] These steps need not be costly or onerous even for a system with many more pressing humanitarian and developmental priorities. Moreover, the undertaking would be consistent with the Organization's commitment to the peoples and purposes of the United Nations.

About risk

Although we touch upon the issue of the question of the risk of nuclear weapon detonation events in populated areas in outlining potential challenges to the validity of this study (in part one), the issue requires discussion at the outset. Risk in basic terms is the probability of an event multiplied by its consequences.[4] Thus even an event that is very unlikely to occur at any given moment could still be of significant risk in view of its severe consequences. Nuclear weapon detonation events in populated areas fall into this category of high risk (low probability, high consequence) events.

For the purposes of this study we assume the risk of a nuclear weapon detonation event to be greater than zero, and therefore a matter worth taking seriously and planning for in view of the potentially catastrophic consequences. We do not take a view on whether a multiple nuclear weapon detonation event is less likely than a multiple one, except to note this: many nuclear weapon delivery systems remain on high alert, and contain several independently targetable warheads. For this reason even an isolated accident or other mishap could result in multiple nuclear weapon detonations. Alternatively, a failure of nuclear deterrence could result in multiple nuclear strikes.

People draw differing conclusions from the lack of nuclear weapon detonation events in populated areas since the use of nuclear bombs on Hiroshima and Nagasaki in 1945. (There have, of course, been more than 2,000 nuclear tests.[5]) Some infer that, because of such an event's absence, there is little to worry about. Others—and we would place ourselves in this category—are less sanguine. Unlikely events do happen, whether severe earthquakes and tsunamis, financial crashes, vanishing aircraft, or large asteroid strikes. Add to the mix tightly coupled technological systems in which simple failures can lead to complex and potentially catastrophic problems, the pathological aspects of organizational cultures, as well as human error, and you get the picture. It is not hard to think of examples: they include nuclear reactor accidents at the Three Mile Island, Chernobyl, and Fukushima plants (the latter following a severe earthquake and tsunami), the loss of two NASA space shuttles in flight, the failure of safety valves in the *Deepwater Horizon* causing the Gulf of Mexico oil spill in 2010, and the crash of Air France flight 447 in the Atlantic ocean in 2009 with the loss of 228 lives. Even if it is assumed that the systems of control for nuclear weapons really can ensure that the risk of a detonation event is extremely low in ordinary circumstances, as some nuclear weapon possessor states claim, these systems are not immune to the same sorts of low probability–high impact failures.

There are real limits to safety.[6] Indeed, as the picture of accidents, crises, and near-use events involving nuclear weapons in state arsenals during the Cold War becomes clearer, there were many instances in which detonation events almost occurred. In just one example, a United States Air Force bomber was forced to jettison two 4 megaton nuclear bombs over Goldsboro, North Carolina, in 1961—one of these began the detonation process, which was prevented only by a single low-voltage switch after all other systems failed. The detonation of a nuclear weapon 260 times more powerful than the Hiroshima bomb would, as investigative journalist Eric Schlosser observed, have "changed literally the course of history".[7] What is important to appreciate is that

3 Ban Ki-Moon, *Renewing Our Commitment to the Peoples and Purposes of the United Nations*, 21 November 2013, www.undg.org/docs/13405/SG%27s%20commitment%20statement%20Final%20(English).pdf.

4 See European Commission, *Risk Assessment and Mapping Guidelines for Disaster Management*, 2010, pp. 15–16. This is also discussed in P.M. Lewis et al., *Too Close for Comfort: Cases of Near Nuclear Use and Options for Policy*, Chatham House, 2014, pp. 4–5, especially note 13. The authors draw on work that argues risk is not a number, rather it is a curve or set of curves representing multiple scenarios.

5 Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization, "History of nuclear testing", www.ctbto.org/nuclear-testing/history-of-nuclear-testing/world-overview/.

6 For research on United States nuclear weapons safety during the Cold War, see S.D. Sagan, *The Limits of Safety: Organizations, Accidents, and Nuclear Weapons*, 1993. For the United Kingdom, see N. Ritchie, *Nuclear Risk: The British Case*, Article 36, 2014, www.article36.org/wp-content/uploads/2013/06/Nuclear-risk-paper.pdf.

7 British Broadcasting Corporation, "US plane in 1961 nuclear 'near miss'", 21 September 2013, www.bbc.com/news/world-us-canada-24183879.

these issues were not just products of the larger numbers of nuclear weapons at that time, but of the fallibility of complex and tightly coupled technological systems in which accidents are inevitable.[8]

A recent study by Chatham House assessed that "in the last few years, there is evidence that the perceived nuclear risk calculation is shifting upwards again", citing five reasons for this:

1. Since the Cold War's end and the relaxation of tensions, the number of nuclear weapons possessors has increased and newcomers are in regions of high tension, notably South and North-East Asia;
2. Nuclear weapons possessor states continue to depend on these weapons for their security, despite the end of the Cold War;
3. The threat of nuclear terrorism, which is assessed very differently across countries and experts, adds to the overall nuclear risk;
4. It is likely that the probability of nuclear use or accident has hitherto been underestimated and thus needs to be corrected; and
5. The consequences of use are being revised upwards in the light of new information and analysis.[9]

Alongside this, we have observed in the course of our own research two opposing tendencies, neither of which is necessarily conducive to engagement with regard to considering humanitarian response. At one end of the continuum is the view that the existence of nuclear weapons is a necessary, enduring feature of the international system. The consequences of a nuclear war are clearly so catastrophic that these arms will never be used—their awfulness both contributes to restraint, and strengthens nuclear deterrence.[10] The only real risk to watch out for is acquisition by "terrorists". At the other end of the continuum, those concerned about the risks of nuclear weapons might be tempted to view efforts to better understand the challenges to humanitarian response of such detonations as simply futile and possibly dangerous. There is the associated view that planning any humanitarian "safety net" could contribute to undermining a perceived taboo against use—to making a nuclear conflict seem less risky to wage.

We are sensitive to both these concerns, although we do not share them. It stands to reason that in considering the possibility of nuclear weapon detonation events, especially those involving the explosion of multiple weapons, any capacity for offering a meaningful level of assistance to many of the victims would be utterly overwhelmed. It should not necessarily lead to nuclear fatalism that there are no scenarios in which United Nations-coordinated humanitarian response would make a difference to assisting victims. Moreover, an absence of engagement with these questions creates an illusion of safety. Yet in view of the continued nuclear risk of various kinds mentioned above, the humanitarian system may not have the luxury of failing to plan for how it would respond to a nuclear weapon detonation event much longer, whether that failure is by choice or omission. And it cannot be emphasized enough that both humanitarian staff and those requiring assistance could pay dearly for such a failure.

---

8 See C. Perrow, *Normal Accidents: Living with High Risk Technologies*, 1984. For a useful online presentation see M.A. Greenfield, "Normal accident theory", Conference on the Changing Face of NASA and Aerospace, 17 November 1998, www.hq.nasa.gov/office/codeq/accident/accident.pdf.

9 P.M. Lewis et al., *Too Close for Comfort: Cases of Near Nuclear Use and Options for Policy*, Chatham House, 2014, pp. 4–5.

10 See, for example, B. Tertrais, *In Defense of Deterrence: The Relevance, Morality and Cost-Effectiveness of Nuclear Weapons*, IFRI Security Studies Centre, 2011.

PART 1: CONTEXT FOR THE STUDY

Definition of terms

As was clear from some of their statements at the March 2013 Oslo conference on the humanitarian impacts of nuclear weapons, beyond acknowledging the difficulties of response to assist populations in need and their lack of preparedness or capacity to respond adequately, United Nations agencies have not given the matter much studied thought. Regardless, though, of whether or not the international humanitarian system is able to respond effectively to nuclear weapon detonations in populated areas, the United Nations and other humanitarian actors such as the Red Cross and Red Crescent Movement may still be called upon for help.[11]

Correspondingly, this study is undertaken with a view to better understanding the nature of the challenges the United Nations would face. It is a scoping exercise, and is not intended as a blueprint for "solving" the challenges facing humanitarian response to nuclear weapon detonations in populated areas. As will be seen, there are important reasons why this is unlikely to be possible in most cases. Rather, this study tries to map out the current state of capability and preparedness, and to think through the implications for the international system as it stands. It also underlines the need for every effort to be undertaken to ensure that nuclear weapons are never used again.

Nuclear detonations

This study deals with nuclear detonations in the sense of weapons designed to derive their destructive power from the splitting (fission) or joining (fusion) of atoms. This is explained in part two of the study.

As defined, the scope of the study excludes nuclear reactor accidents of all types including reactor fires, meltdowns and explosions, as these are fundamentally different from nuclear weapon detonations. (A nuclear reactor is a device in which a controlled chain reaction of neutrons happens.[12]) A civil nuclear reactor can explode, but it will not give rise to a nuclear explosion, and so is vastly less powerful in effect than a fission or thermonuclear weapon.[13]

This study also excludes radiological dispersion devices (or "dirty bombs") from consideration, although these are sometimes conflated with nuclear weapons. A dirty bomb explosion is not a nuclear weapon detonation, and can only directly affect a relatively small area. A radiological dispersion device:

> is a bomb that combines conventional explosives, such as dynamite, with radioactive materials in the form of powder or tiny pellets packed around the explosive material. The idea behind a dirty bomb is to spread radioactive material into some populated area. This could contaminate buildings and the local environment, and expose people to radiation emanating from the radioactive material. Persons could be externally (skin) contaminated or internally contaminated with radioactive materials through inhalation, ingestion, or through wounds.[14]

The study also excludes conventional explosive weapon detonations, and chemical and biological weapon use. This is important because often literature published on emergency response to so-called weapons of mass destruction brackets nuclear, radiological, biological, and chemical weapons together. These are very different in their characteristics and effects.

In practice, the only way in which a nuclear explosion would occur is through the detonation of a nuclear explosive device, which, since the end of the era of "peaceful nuclear explosions" when large underground cavities were created for gas storage by nuclear explosions, would entail the deliberate or accidental use of a nuclear weapon.

Nuclear accidents and events

In this study, a distinction is made between nuclear "events", "accidents", and the term "nuclear weapon detonation event" that we use widely. Nuclear events and nuclear accidents are defined in the International Atomic

11 D. Loye and R. Coupland, "Who will assist the victims of use of nuclear, radiological, biological or chemical weapons—and how?", *International Review of the Red Cross*, vol. 89, no. 866, 2007.

12 A fuller, plain-language description can be found in R.A. Muller, *Physics and Technology for Future Presidents: An Introduction to the Essential Physics Every World Leader Needs to Know*, 2010, p. 177.

13 WHO, *Health Protection Guidance in the Event of a Nuclear Weapons Explosion*, 2003, footnote 1. www.who.int/ionizing_radiation/en/WHORAD_InfoSheet_Nuclear_weapons21Feb.pdf?ua=1.

14 WHO, *Radiological Dispersion Device (Dirty Bomb)*, 2003, http://helid.digicollection.org/pdf/s13473e/s13473e.pdf.

Energy Agency's Safety Glossary and reflect understandings in the international system primarily about civil nuclear incidents. For example, the IAEA Safety Glossary describes an event as:

> any occurrence unintended by the operator, including operating error, equipment failure or other mishap, and deliberate action on the part of others, the consequences or potential consequences of which are not negligible from the point of view of protection or safety.[15]

Although this definition adequately covers events in civil nuclear activities, it does not include deliberate events caused by actions of operators, such as could be the case for nuclear weapon detonations. "Event" can also mean different things, depending on whether it is in the context of analysis and reporting, or of safety standards (where it may mean the same as "accident").[16]

Meanwhile, the IAEA defines a nuclear accident as:

> any accident involving facilities or activities from which a release of radioactive material occurs or is likely to occur and which has resulted or may result in an international transboundary release that could be of radiological safety significance for another State.[17]

This definition is inadequate for the purposes of this study because the characteristic effects of nuclear detonations, even if accidental, may not be transboundary, and are not limited to radiation release. The primary effects of nuclear weapons are blast and heat, which would have enormously destructive impacts on human life, fauna, and flora, and infrastructure over a wide area.

By a "nuclear weapon detonation event" or "nuclear detonation event" we refer to a single event in which one or more nuclear weapons are detonated in a place or continuous area. By multiple nuclear weapon detonation events we mean more than one event in each of which one or more nuclear weapons are detonated.

The United Nations "system"

By United Nations "system" it is meant the organization itself, its subsidiary organs, United Nations funds and programmes administered separately, the specialized agencies, and affiliated organizations.[18] For the purposes of this study, it includes related organizations such as the IAEA, the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), the World Health Organization (WHO), and the Organisation for Prohibition of Chemical Weapons (OPCW), each of which have relationship agreements with the United Nations.

When "international system" is used it has a broader meaning, encompassing states and inter-governmental entities, including humanitarian organizations such as the International Committee of the Red Cross (ICRC).

"Humanitarian system" as used here refers primarily to entities involved in the provision or coordination of humanitarian relief activities, including relevant parts of the United Nations system and humanitarian non-governmental organizations (NGOs).

International assistance

As a concept, the meaning of providing international assistance varies depending on the forum and context in which it is discussed. When assistance is referred to within and between United Nations entities mandated with non-humanitarian decision-making and coordination responsibilities such as the IAEA or OPCW, it most often means assistance to states. This follows the principle that states bear the primary responsibility for the safety and security of their inhabitants.

When assistance is discussed in a humanitarian context, it by default means assistance to victims. While the state maintains the primary responsibility for meeting the needs of the affected population, humanitarian organizations have a role in supporting states in meeting that responsibility, which may in some circumstances include direct provision of services and assistance to victims.[19] The United Nations General Assembly has established a set of guiding principles in that respect. Of particular importance to this study are the following:

- "Humanitarian assistance must be provided in accordance with the principles of humanity, neutrality and impartiality"; and

15 IAEA, *IAEA Safety Glossary: Terminology Used in Nuclear Safety and Radiation Protection, 2007 Edition*, 2007, p. 73.
16 Ibid., pp. 73–74.
17 Ibid., p. 12.
18 A chart representing the United Nations system can be found online at www.un.org/en/aboutun/structure/pdfs/UN%20system%20chart_11x17_color_2013.pdf.
19 Conversation with OCHA official, 22 May 2014.

- “The sovereignty, territorial integrity and national unity of States must be fully respected in accordance with the Charter of the United Nations. In this context, humanitarian assistance should be provided with the consent of the affected country and in principle on the basis of an appeal by the affected country”.[20]

The term “humanitarian”, stemming from humanitarianism, is challenging to define, especially as various interests and agendas arguably influence it in meaning. A dedication to human welfare is embedded in the term.[21] But the exact meaning of the term humanitarian becomes clear only when contextualized.

Although descriptions vary, “humanitarian assistance” as described by OCHA seeks to “save lives and alleviate suffering of a crisis-affected population”, and can come in the form of direct assistance, indirect support, or assistance with infrastructure.[22] Humanitarian assistance also implies that international actors are delivering the support.[23] Certain states are better prepared for disasters and have easier access to resources than others, and the former might be able to deal with the humanitarian consequences of certain nuclear weapon detonation events without seeking assistance from outside their borders. However, it is widely seen as more likely that international assistance would be required to deliver humanitarian relief and coordinate aspects of disaster response following such an event, particularly if in or near a population centre. In this study, humanitarian assistance is therefore understood as that provided by the international humanitarian system.

For the purpose of analysing the ability of the humanitarian system to respond to nuclear weapon detonation events, the main focus in this study is on the short- to medium-term humanitarian impacts. However, nuclear weapon detonation events could produce lengthy states of disaster.[24] In the emergency phase, relief will be necessary for some time, and concurrent early recovery plans and activities will be vital for future reconstruction and rehabilitation. The line between complementary activities of early recovery and development would therefore be indistinct in the aftermath of such an event. It means that actors such as UNDP and the United Nations Environment Programme (UNEP) are also relevant when we talk about humanitarian assistance.

Humanitarian definitions

Concepts used by the humanitarian system to describe events and responses to them warrant mention here. Natural and man-made occurrences of a scale that make them non-manageable to single states are commonly referred to as disasters. A disaster is “a serious disruption of the functioning of society, causing widespread human, material or environmental losses which exceed the ability of affected society to cope using only its own resources”.[25] States would, of course, vary in their capacities for response, but a nuclear weapon detonation event is likely to be a disaster, especially if detonations are multiple or occur in highly populated areas. Disasters usually have an emergency component to them—“a sudden and usually unforeseen event that calls for immediate measures to minimize its adverse consequences”.[26]

“Emergency preparedness” is considered to be:

> the knowledge and capacity developed by governments, recovery organizations, communities and individuals to anticipate, respond to and recover from the impact of potential, imminent or current hazard

20 General Assembly, *Strengthening of the Coordination of Humanitarian Emergency Assistance of the United Nations*, UN document A/RES/46/182, 19 December 1991, annex, paras. 2–3.

21 See for instance WHO, “Definitions: emergencies”, www.who.int/hac/about/definitions/en/index.html?utm_source=feedblitz&utm_medium=FeedBlitzEmail&utm_content=565123&utm_campaign=0.

22 As defined in OCHA, *Glossary of Humanitarian Terms: In Relation to the Protection of Civilians in Armed Conflict*, 2003, p. 13, http://un-interpreters.org/glossaries/ocha%20glossary.pdf.

23 Environmental Emergencies Section (Joint UNEP/OCHA) of the UN Office for the Coordination of Humanitarian Affairs, *Linking Humanitarian and Nuclear Response Systems: A Study by the Office for the Coordination of Humanitarian Affairs*, 2013, p. 8, https://ochanet.unocha.org/p/Documents/Linking%20Humanitarian%20and%20Nuclear%20Response%20Systems.pdf.

24 This is evident from research into the nuclear bombings of Hiroshima and Nagasaki. See for example The Committee for the Compilation of Materials on Damage Caused by the Atomic Bombings in Hiroshima and Nagasaki, *Hiroshima and Nagasaki: The Physical, Medical, and Social Effects of the Atomic Bombings*, 1981; and *The United States Strategic Bombing Survey: The Effects of the Atomic Bombings of Hiroshima and Nagasaki*, 1946.

25 United Nations Department of Humanitarian Affairs, *Internationally Agreed Glossary of Basic Terms Related to Disaster Management*, UN document DHA/93/36, 1992 (modified 2000).

26 Ibid.

events, or emergency situations that call for a humanitarian response.[27]

Although "crisis" can be defined as a more complex or endemic situation that may or may not encompass a disaster,[28] the terms disaster and crisis are sometimes used interchangeably within the humanitarian system.[29] The use of either term therefore does not necessarily bear on the intensity and structure of the response mechanisms activated. This can be seen in the similarly planned responses by the humanitarian cluster approach to the 2012–2013 Typhoon Bopha disaster[30] and the 2013–2014 Syrian Arab Republic crisis.[31] Following this practice, this study uses the terms disaster and crisis interchangeably.

The United Nations defines disaster response as comprising rehabilitation and reconstruction, in addition to immediate relief.[32] Emergency relief is the prompt survival assistance to the victims, initiated on short notice, and with a limited time span.[33] Rehabilitation and reconstruction are the activities needed to restore everyday life as it was before the disaster, integrating also the necessary improvements to resilience to try to prevent similar disasters from happening again.[34]

As will be outlined later in part one, numerous states have referred in recent statements to their concerns about the catastrophic humanitarian consequences of the detonation of nuclear weapons. Although, in the humanitarian system, the term "catastrophe" is used for advocacy reasons,[35] with certain exceptions it is not used in trying to quantify complete response needs, as it is not sufficiently precise.[36] However, the broader concept of catastrophe is still relevant to this study. A catastrophe can be understood as "a momentous tragic event ranging from extreme misfortune to utter overthrow or ruin; a violent and sudden change in a feature of the earth".[37] Such occurrences have a low or unknown probability of taking place, but the consequences would be sudden and overwhelming.[38] Framed in terms of current international debate about the dangers of nuclear weapons, this could aptly describe at least some kinds of nuclear weapon detonation event.

Contextual overview

Concerns about the effects and implications of nuclear weapon detonations in populated areas and efforts to understand them are certainly not new. This section provides a contextual overview. For reasons of space, it is not a comprehensive account of expressions of humanitarian concern or of studies on the consequences of nuclear weapon use.

Scientists from the United States' Manhattan project inaugurated the nuclear weapons age with the so-called Trinity test of a nuclear weapon in the New Mexico desert in mid-July 1945. The detonation of nuclear weapons by the United

27 OCHA, "Preparedness", www.unocha.org/what-we-do/coordination/preparedness/overview.

28 WHO uses this definition of a crisis: "a situation that is perceived as difficult. Its greatest value is that it implies the possibility of an insidious process that cannot be defined in time, and that even spatially can recognize different layers/levels of intensity. A crisis may not be evident, and it demands analysis to be recognized. Conceptually, it can cover both preparedness and response ('crisis management')", in WHO, "Definitions: emergencies", www.who.int/hac/about/definitions/en/index.html?utm_source=feedblitz&utm_medium=FeedBlitzEmail&utm_content=565123&utm_campaign=0; Disasters are included in OCHA's description of crisis: "Many of the risks that lead to humanitarian crises are well known—disasters, conflict, and the harsh, day-to-day realities of poverty, hunger and fragility", in OCHA, *World Humanitarian Data and Trends 2013*, 2013, p. 2.

29 An example of interchangeable terms can be seen in OCHA, *Addendum. Philippines: Typhoon Haiyan Action Plan*, 23 November 2013, https://docs.unocha.org/sites/dms/CAP/2013_Philippines_Typhoon_Haiyan_Action_Plan.pdf.

30 Typhoon Bopha is referred to as a disaster in OCHA, *Philippines (Mindanao) Humanitarian Action Plan 2013: Typhoon Bopha/Pablo Response—An Action Plan for Recovery*, January 2013.

31 The situation there in 2013–2014 is referred to as a crisis in OCHA, *2014 Syrian Arab Republic Humanitarian Assistance Response Plan (SHARP)*, 2013.

32 United Nations Department of Humanitarian Affairs, *Internationally Agreed Glossary of Basic Terms Related to Disaster Management*, UN document DHA/93/36, 1992 (modified 2000).

33 ReliefWeb, *Glossary of Humanitarian Terms*, 2008, p. 25, www.who.int/hac/about/reliefweb-aug2008.pdf?ua=1.

34 United Nations Department of Humanitarian Affairs, *Internationally Agreed Glossary of Basic Terms Related to Disaster Management*, United Nations document DHA/93/36, 1992 (modified 2000).

35 WHO, "Definitions: emergencies", www.who.int/hac/about/definitions/en/index.html?utm_source=feedblitz&utm_medium=FeedBlitzEmail&utm_content=565123&utm_campaign=0.

36 Food security appears to be the only domain within the humanitarian system for which catastrophe classification is based on set criteria, with response measures adopted accordingly. For an example of this, please see Food and Agriculture Organization of the United Nations, *The Integrated Food Security Phase Classification Technical Manual Version 2.0*, 2012, www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/IPC-Manual-2-Interactive.pdf.

37 See the Merriam-Webster Dictionary, www.merriam-webster.com/dictionary/catastrophe.

38 R.A. Posner, *Catastrophe: Risk and Response*, 2006, p. 6.

States military ensued over the cities of Hiroshima and Nagasaki in Japan the following month and their massive blast and heat effects caused the majority of death and injury in the attacks. Novel forms of harm to human health accompanied them. By this time, several United States government institutions were engaged in research into the harmful effects of radiation on the human body.[39] Although such radiological effects had been known of as early as 1941, these were not a primary consideration in decisions about whether and how to use nuclear weapons in Japan in the Manhattan project's briefing for American policymakers at the highest political and military levels in 1945.[40]

Reports emerging from Japan after the bombings of very large numbers of people with what were symptoms of radiation sickness were at first downplayed by United States authorities.[41] When the United States military occupied Japan after the end of hostilities and made its own inquiries the evidence became clearer that the nuclear bombs dropped on Japan were still making people sick and killing them even months after the detonations occurred. For example, a United States strategic bombing analysis concluded on the basis of surveys in 1945 that radiation sickness, alongside blast and heat effects, was a significant cause of health problems and death (see box 3 in part 2). Survivors' testimonies and various medical and scientific studies conducted since have contributed to awareness of the considerable long-term impacts of the detonation of nuclear weapons in populated areas.[42]

Concerns about the consequences of nuclear weapon detonations during the Cold War were mainly focused on scenarios involving general nuclear war between the United States, Soviet Union, and their respective allies. From the 1950s it was typically assumed that nuclear and thermonuclear weapons would be used to attack both specifically military targets and important economic and industrial targets—many of them located within or adjacent to areas of civilian concentration. There would be little or no warning of attack for civilian populations, and military planning in both the United States and the Soviet Union envisaged some target areas being struck multiple times in a nuclear attack, which would further compound the harm and destruction. This kind of planning in the United States and Soviet Union also encompassed the development of detailed assessments of the consequences of nuclear attack on both their own and the adversary's territory and population.[43] This was because at stake were perceived military and political survivability, residual war making potential after an attack, and the enemy's capacity for retaliatory nuclear response. At the time, these analyses were usually highly classified and in many cases remained so for decades.

Public anxieties about the Cold War nuclear arms race, including the consequences of nuclear weapon testing, spurred on disarmament movements in many countries that frequently underlined the humanitarian consequences of a global nuclear conflict.[44] Such anxieties also led to a variety of publicly available studies being produced that looked at various aspects of what could be expected to happen in a nuclear war including the short- and long-term medical and public health impacts, and the effect on the environment such as the atmospheric climate and capacity for continued food production.[45] These

39 See E.P. Wigner and H.D. Smyth, "Radioactive poison", 10 December 1941, as outlined by H.D. Smyth, *Atomic Energy for Military Purposes*, 1945, p. 65. Institutions involved in research on the biological effects of radiation on the human body were the Health Division of the Metallurgical Laboratory at the University of Chicago, the Berkeley Radiological Laboratory, the Massachusetts Institute of Technology, and the University of Rochester.

40 S.L. Malloy, "'A "very pleasant way to die': radiation effects and the decision to use the atomic bomb against Japan", *Diplomatic History*, vol. 36, no. 3, 2012, p. 543.

41 See for instance F. Bugnion, "The International Committee of the Red Cross and nuclear weapons: from Hiroshima to the dawn of the 21st century", *International Review of the Red Cross*, vol. 87, no. 859, 2005. See also: "Memorandum of telephone conversation between General Groves and Lt. Col. Rea, Oak Ridge Hospital, 9.00 a.m., 25 August 1945", www2.gwu.edu/~nsarchiv/NSAEBB/NSAEBB162/76.pdf.

42 See for instance The Committee for the Compilation of Materials on Damage Caused by the Atomic Bombings in Hiroshima and Nagasaki, *Hiroshima and Nagasaki: The Physical, Medical, and Social Effects of the Atomic Bombings*, 1981; and Nanao Kameda, *One Day in Hiroshima: An Oral History*, International Physicians for the Prevention of Nuclear War, 2007.

43 E. Schlosser, *Command and Control*, 2013.

44 L.S. Wittner, *Confronting the Bomb: A Short History of the World Nuclear Disarmament Movement*, 2009.

45 For instance see United States National Research Council, *Report of the Committee to Study the Long-Term Worldwide Effects of Multiple Nuclear-Weapons Detonations*, 1975; R.U. Ayres, *Environmental Effects of Nuclear Weapons*, Hudson Institute, 1965; E.S. Batten, *The Effects of Nuclear War on the Weather and Climate*, RAND Corporation, 1966; United Nations Secretary-General, *Study on the Climatic and Other Global Effects of Nuclear War*, UN document A/43/351, 1989; Congress of the United States Office of Technology Assessment, *The Effects of Nuclear War*, 1979.

studies varied in their purposes, methodologies, and aspects of their conclusions. Some were connected to disarmament aims, while other studies—such as those produced by national scientific academies—focused solely on assessing the evidence for a range of impacts. What many had in common was that they assumed hundreds or thousands of nuclear and thermonuclear weapons would be detonated, predominantly in populated areas in the northern hemisphere, and they concluded that this would have severe disruptive effects on human society and the environment.[46]

After a period of political thaw between the United States and Soviet Union in the 1970s, relations between the superpowers underwent a renewed freeze in the 1980s. The nuclear arms race escalated. This period saw a new wave of research reports investigating the likely consequences for human society and the environment of a nuclear war between the United States and Soviet Union and their respective allies. Many of these reports, while couched in cautious language, pointed to alarming consequences on a par with mass extinction events in the Earth's distant past, for instance due to massive volcanic activity or a large asteroid impact.[47] Again, this research tended to focus on large-scale nuclear war and its consequences.

What does not appear to have been seriously investigated was the contribution international organizations could be expected to make to humanitarian coordination and response to help the victims of nuclear attack. This is perhaps understandable in view of the apocalyptic consequences it was widely assumed that a large-scale nuclear war would have. Reports produced by WHO experts in the 1980s on the effects of nuclear war on health and health services were unequivocal in this regard. These were produced in response to a World Health Assembly resolution asking the WHO's Director-General to create a committee to study "the contribution WHO could make to implementation of the United Nations resolutions on strengthening peace, detente, and disarmament and preventing thermonuclear conflict".[48] In a revised and updated 1987 version three years after its first release, the WHO report's authors were careful to skirt around the political dimensions of the nuclear arms race. Their findings merit quoting at length:

1. Nuclear weapons have now been amassed throughout the world to an estimated total of some 15,000 megatons and the quantity continues to increase. The destructive power of these bombs is such that if only 1% of them were utilized on urban areas, more people could be killed in a few hours than during the whole of the Second World War.
2. In addition to the immediate effects of blast and heat, the radiation and fallout of nuclear explosions have devastating effects in both the short and long term. …
5. After a major nuclear war famine and diseases would be widespread and social, communication and economic systems around the world would be disrupted.
6. It is obvious that the health services in the world could not alleviate the situation in any significant way.
7. Therefore the only approach to the treatment of health effects of nuclear war is primary prevention, that is, the prevention of nuclear war.[49]

After the Cold War ended, the 1990s were witness to significant reductions in the sizes of the nuclear arsenals of the United States and the former Soviet Union from the purported 15,000 megatons quoted above. As the relationship between the former adversaries appeared to improve, public fears faded about the likelihood and consequences of nuclear war. What was less widely realized was that many of the remaining weapons in their nuclear arsenals remained on alert—ready to launch at a moment's notice—as they still are today. "Russia and the United States continue to maintain hundreds of nuclear weapons capable of striking the other side, and to have at least some of these nuclear forces at Cold

46 For instance see United States National Research Council, *Report of the Committee to Study the Effects on the Atmosphere of a Major Nuclear Exchange*, 1985.

47 These included The Scientific Committee on Problems of the Environment, *Environmental Consequences of Nuclear War*, 1985–1986; P.J. Crutzen and J.W. Birks, "The atmosphere after a nuclear war: twilight at noon", *Ambio*, vol. 11, no. 2–3, 1982; O.B. Toon et al., "Evolution of an impact-generated dust cloud and its effects on the atmosphere", *Geological Society of America Special Papers*, vol. 190, pp. 187–200, 1982: C. Covey, S.H. Schneider, and S.L. Thompson, "Global atmospheric effects of massive smoke injections from a nuclear war: results from general circulation model simulations", *Nature*, vol. 308, no. 5954, 1984.

48 WHO, *Effects of Nuclear War on Health and Health Services*, 1987, p. 1.

49 Ibid., p. 5.

War levels of alert, that is, ready to fire within a few minutes of receiving an order to do so".[50]

In 2001, the National Resources Defense Council (NRDC), a United States NGO, produced a study entitled *The US Nuclear War Plan: A Time for Change*, which tried to refocus attention on this state of affairs. This detailed report provided an open, independent assessment of the United States nuclear war plan (called the SIOP or Single Integrated Operational Plan) and argued that it was a Cold War relic in need of major reform. In addition, the report's authors sought:

- To introduce a human context into the debate about nuclear strategies and alternative nuclear force structures[; and]
- To inject some basic honesty into the nuclear debate by providing data that reveals how a counterforce attack could kill almost as many millions of people as a counter-value attack[.][51]

The NRDC report's authors developed an open-source computerized nuclear war simulation application cross-matched with declassified data in order to try to model the effects of nuclear attacks of different kinds based on targeting strategies in the SIOP nuclear war plan. RAND Corporation analysts had pioneered such models decades before, but the results were not generally shared publicly.[52] NRDC's two simulations of nuclear attacks on the Russian Federation—a major "counterforce" attack against Russian nuclear forces and a "counter-value" strike using a "minimal arsenal" to inflict severe damage on Russian cities—generated notable results. It confirmed that a counterforce attack would be devastating in terms of harm to the Russian population (and, of course, would prompt major nuclear retaliation against the United States by the Russian Federation). But a "minimal arsenal" strike simulation indicated that an attack using just a single Trident nuclear missile submarine could result in 30 to 45 million casualties in Russian cities. The NRDC concluded that either option would be massive overkill, arguing "There is no such thing as a surgical nuclear strike; nuclear weapons are simply weapons of mass destruction, and their effects are complex, unpredictable, and ultimately uncontrollable".[53]

Thus, in effect, the NRDC report found that there could be an immense level of humanitarian harm from detonation of a much smaller number of nuclear weapons than the scenarios receiving the most attention during the Cold War. Beside the United States Navy, the United Kingdom operates Trident nuclear missile submarines, and France and the Russian Federation possess their own types. China has an arsenal of land-based long-range ballistic nuclear missiles and is poised to launch a fleet of nuclear-armed ballistic missile submarines. Moreover, Israel is long thought to possess an undeclared nuclear arsenal, and during the later 1990s India and Pakistan emerged as nuclear-armed powers.[54] Despite the smaller-sized nuclear arsenals of these states (compared with the United States and the Russian Federation), the NRDC report also showed the capacity to inflict a level of immediate humanitarian harm in

50 EastWest Institute, *Reframing Nuclear De-Alert: Decreasing the Operational Readiness of U.S. and Russian Arsenals*, 2009, p. iii.

51 NRDC, *The U.S. Nuclear War Plan: A Time for Change*, 2001, p. 2.

52 E. Schlosser, *Command and Control*, 2013, pp. 353–354.

53 NRDC, "Exposing the U.S. nuclear war plan", 17 June 2001, www.nrdc.org/nuclear/nwarplan.asp.

54 The United States Navy has 14 ballistic missile submarines equipped with Trident II missiles, and an estimated 1,152 warheads for this purpose. The United Kingdom possesses four ballistic missile submarines with Trident II missiles, and leases 58 of these missiles from the United States under a "mingled asset ownership" agreement. The United Kingdom has an estimated 160 operational warheads for its missiles. France has a fleet of four nuclear-powered submarines equipped with submarine-launched ballistic missiles with a capacity of approximately 300 nuclear warheads. France is in the process of upgrading its submarines to be able to carry the new "Oceanic Nuclear Warhead" with a yield up to 150kt. The Russian Federation currently possesses 10 nuclear-powered ballistic missile submarines for launch of ballistic missiles. It has 624 warheads allocated to this use. There are an estimated 144 Chinese land-based nuclear long-range ballistic missiles. Israel's arsenal is believed to consist of approximately 80 nuclear weapons, for delivery by aircraft and medium-range ballistic missile. India's arsenal is estimated at 90–110 nuclear weapons, deliverable by land-based ballistic missile and aircraft. Pakistan is estimated to possess 100–120 nuclear weapons for delivery by land-based ballistic missile and aircraft. See Stockholm International Peace Research Institute, *SIPRI Yearbook 2013: Armaments, Disarmament and International Security*, 2013, pp. 286–320.

the millions of casualties was within the means of some, if not all, of them.[55]

Soon after the NRDC report was published, Al Qaeda operatives attacked the Twin Towers in New York and the Pentagon in Washington, D.C., followed a few years later by further attacks including in Madrid, London, and Mumbai. The willingness of extremist groups to commit mass atrocities—apparently by any means at their disposal—led to a redoubled level of international focus on preventing so-called weapons of mass destruction from falling into the wrong hands. There was also a great expansion of expert literature at this time on the consequences of the detonation of an improvised nuclear device (IND) in the 0.1kt to 15kt yield range in a built-up urban area. This was a scenario now treated as a plausible (and worst-case) type of terrorist attack, particularly in Western countries. It was easy to see why—states could be deterred from using nuclear weapons it was widely thought, but non-state armed groups with apocalyptic aims and without territory or civilian populations raised alarming prospects. Published analyses turned away from attention to large-scale nuclear war scenarios of either the counterforce or counter-value variety (which in any case had been declining) to an almost single-minded focus on prevention and response to lower-yield single bomb scenarios.[56]

After the 11 September 2001 attacks, many states assigned high priority, attention, and significant resources to defeating and dealing with the consequences of terrorism. A 10kt IND detonation in a large metropolitan area became one of the 15 scenarios the United States government uses for local, state, and federal emergency response planning.[57] Perhaps unsurprisingly, the United States was where the most extensive national literature on this subject developed, although it was often limited in scope to the lone urban IND type of scenario above. Aspects modelled or studied included protection from the direct physical effects in terms of human harm, physical destruction and disruption,[58] guidance for local emergency responders,[59] implications for surviving medical facilities and procedures for triage, decontamination, and

55 See for instance P. Webber, "The climatic impacts and humanitarian problems from the use of the UK's nuclear weapons", *Scientists for Global Responsibility Newsletter*, 2013, www.sgr.org.uk/sites/sgr.org.uk/files/SGR_climatic_impacts_Trident_Feb2013.pdf; C.E. Dallas et al., "Nuclear war between Israel and Iran: lethality beyond the pale", *Conflict and Health*, vol. 7, no. 10, 2013; L. Forrow et al., "Projected US casualties and destruction of US medical services from attacks by Russian nuclear forces", *Medicine & Global Survival*, vol. 7, no. 2, 2002; H.M. Kristensen, R.S. Norris, and M.G. McKinzie, "Simulated U.S. and Chinese nuclear strikes", in *Chinese Nuclear Forces and U.S. Nuclear War Planning*, The Federation of American Scientists and NRDC, 2006; N. Wilson, "Regional nuclear war in South Asia: effects on surrounding countries", *Medicine & Global Survival*, vol. 6, no. 1, 1999.

56 Examples of such literature are C. Meade and R.C. Molander, *Considering the Effects of a Catastrophic Terrorist Attack*, The RAND Center for Terrorism Risk Management Policy, 2006; G.C. Benjamin, "Medical preparedness and response to nuclear terrorism", *The Bridge: Linking Engineering and Society*, vol. 40, no. 2, 2010; L.M. Wein, Y. Choi, and S. Denuit, "Analyzing evacuation versus shelter-in-place strategies after a terrorist nuclear detonation", *Risk Analysis*, vol. 30, no. 9, 2010; A.R. Knebel et al., "Allocation of scarce resources after a nuclear detonation: setting the context", *Disaster Medicine and Public Health Preparedness*, vol. 5, supplement S1, 2011; I.E. Redlener et al., *Regional Health and Public Health Preparedness for Nuclear Terrorism: Optimizing Survival in a Low Probability/High Consequence Disaster*, National Center for Disaster Preparedness, Columbia University Mailman School of Public Health, 2010; A.B. Carter, M.M. May, and W.J. Perry, *The Day After: Action in the 24 Hours Following a Nuclear Blast in an American City*, report based on a workshop hosted by The Preventive Defence Project, Harvard and Stanford Universities, 2007.

57 United States Department of Homeland Security, *National Planning Scenarios*, 2006, www.llis.dhs.gov/sites/default/files/NPS-LLIS.pdf.

58 Examples include L.E. Davis et al., *Individual Preparedness and Response to Chemical, Radiological, Nuclear, and Biological Terrorist Attacks*, Monograph Reports no. MR-1731/1-SF, RAND Corporation, 2003, appendix A; United States Department of Health and Human Services, "Nuclear detonation: weapons, improvised nuclear devices", 2014, www.remm.nlm.gov/nuclearexplosion.htm#ind.

59 For instance see R.E. Goans, *Medical Management of Radiological Casualties*, online 3rd ed., AFFRI Special Publication no. 10-1, Armed Forces Radiobiology Research Institute, 2010; Nuclear Detonation Response Communications Working Group, *Nuclear Detonation Preparedness: Communicating in the Immediate Aftermath*, www.remm.nlm.gov/NuclearDetonationPreparedness.pdf; National Security Staff Interagency Policy Coordination Subcommittee for Preparedness and Response to Radiological and Nuclear Threats, *Planning Guidance for Response to a Nuclear Detonation*, 2nd ed., 2010, www.epa.gov/radiation/docs/er/planning-guidance-for-response-to-nuclear-detonation-2-edition-final.pdf. It should be noted that this last source emphasizes the need for responders to think outside of the low-yield terrorist scenario as well, and it therefore models different yield scenarios.

treatment of survivors,[60] predicting the behaviour of populations affected by or adjacent to an IND detonation zone,[61] impacts of disruption and mass human displacement,[62] and even the decontamination and care of domestic animals.[63] Some of the studies used computer-based models to integrate geospatial and demographic data to develop specific localized assessments.

Virtually all of these studies emphasized the immense practical challenges of delivering assistance to the victims following a nuclear detonation in an urban area. United States government experts concluded that "by far, the greatest factor impacting the reduction of the effects of the detonation on the general population will remain the speed and appropriateness of the decisions that are made and the effectiveness of the dissemination of this information".[64] In this respect, they also observed it would probably not be feasible for the federal government to be able to offer significant amounts of on-the-ground assistance for at least 24 hours[65] after such a detonation in view of factors such as the logistical demands, a country on heightened security alert (because of the possibility of further detonations), and anticipated problems with damage to and gridlock within the transportation and communication systems in and around the affected zone.

Several studies found that what the population in the zone affected did after a nuclear detonation would be important in determining overall levels of casualties. It was concluded that essentially nothing could be done for people unfortunate enough to be in the innermost zone of severe destruction and prompt radiation. But getting people to take shelter deep down or in the innermost parts of stout, major structures such as thick concrete buildings for a few hours could spare them a lethal dose of radiation if they were far enough away from the hypocentre (or "ground zero"). While "duck and cover" policies had become widely derided during the Cold War, some experts have argued recently that it could save many lives in the event of a single nuclear detonation.[66]

Bell and Dallas have produced some of the most illuminating studies about immediate medical consequences of nuclear attacks. Using models based on geospatial data, they examined the vulnerability of American populations and urban health care systems to nuclear detonations. Notably, their studies were not limited to lower-yield nuclear detonations, but included scenarios

60 Examples of such literature include P. Murrain-Hill et al., "Medical response to a nuclear detonation: creating a playbook for state and local planners and responders", *Disaster Medicine and Public Health Preparedness*, vol. 5, supplement 1, 2011; J.L. Hick et al., "Health care system planning for and response to a nuclear detonation", *Disaster Medicine and Public Health Preparedness*, vol. 5, supplement 1, 2011; A.L. Di Carlo et al., "Radiation injury after a nuclear detonation: medical consequences and the need for scarce resources allocation", *Disaster Medicine and Public Health Preparedness*, vol. 5, supplement 1, 2011; C.N. Coleman et al., "Triage and treatment tools for use in a scarce resources-crisis standards of care setting after a nuclear detonation", *Disaster Medicine and Public Health Preparedness*, vol. 5, supplement 1, 2011; R. Casagrande et al., "Using the model of resource and time-based triage (MORTT) to guide scarce resource allocation in the aftermath of a nuclear detonation", *Disaster Medicine and Public Health Preparedness*, vol. 5, supplement 1, 2011; J.J. Caro et al., "Resource allocation after a nuclear detonation incident: unaltered standards of ethical decision making", *Disaster Medicine and Public Health Preparedness*, vol. 5, supplement 1, 2011.

61 For example see S.M. Becker, "Emergency communication and information issues in terrorist events involving radioactive materials", *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science*, vol. 2, no. 3, 2004; D. Dodgen et al., "Social, psychological, and behavioral responses to a nuclear detonation in a US city: implications for health care planning and delivery", *Disaster Medicine and Public Health Preparedness*, vol. 5, supplement 1, 2011.

62 For instance, see I. Redlener, D.M. Abramson, and D. Culp, *Day 30: The Impact of Mass Evacuations on Host Communities Following Nuclear Terrorism*, Institute of Medicine of the National Academies, 2013; M. Meit et al., "Rural and suburban population surge following detonation of an improvised nuclear device: a new model to estimate impact", *Disaster Medicine and Public Health Preparedness*, vol. 5, supplement 1, 2011.

63 See chp. 5 in National Security Staff Interagency Policy Coordination Subcommittee for Preparedness and Response to Radiological and Nuclear Threats, *Planning Guidance for Response to a Nuclear Detonation*, 2nd ed., 2010, www.epa.gov/radiation/docs/er/planning-guidance-for-response-to-nuclear-detonation-2-edition-final.pdf.

64 United States Department of Homeland Security, *National Planning Scenarios*, 2006, pp. 1–6, www.llis.dhs.gov/sites/default/files/NPS-LLIS.pdf.

65 According to the United States federal government, it is unlikely that full-scale federal resources could be expected at the scene of a nuclear weapon detonation event in the first 72 hours. However, some federal response capabilities would likely be available after 24 hours. See National Security Staff Interagency Policy Coordination Subcommittee for Preparedness and Response to Radiological and Nuclear Threats, *Planning Guidance for Response to a Nuclear Detonation*, 2nd ed., 2010, p. 11, www.epa.gov/radiation/docs/er/planning-guidance-for-response-to-nuclear-detonation-2-edition-final.pdf.

66 W.J. Broad, "New advice for nuclear strike: don't flee, get inside", *New York Times*, 15 December 2010.

such as much larger 550kt detonations in Los Angeles and Houston.[67] In another study looking at nuclear detonations in Washington, D.C., New York, Atlanta, and Chicago, Bell and Dallas concluded that as well as tens or even hundreds of thousands of burn casualties from thermal radiation (who would probably overwhelm surviving and operational medical facilities), fallout radiation plumes in the hours and days after a detonation would knock out of action many of those hospitals not already physically damaged by blast or fire.[68] These fallout plumes could also change in their strength and direction over time, further complicating response efforts and posing a threat to emergency responders and survivors. In 20kt scenarios, the blast area of high mortality lies within the ring of high mortality from prompt radiation. In contrast, in the 550kt scenarios, the total number of people affected by thermal injuries is 30 per cent greater than for blast-related injuries because the thermal radiation zone is much larger.[69] This serves to underline that the effects of nuclear detonations do not simply scale-up in a linear fashion according to yield, but that their signatures change—with corresponding implications for the types of medical assistance required for victims.

In other words, no two nuclear detonations in populated areas will precisely be the same in their effects. There are many variables, as will be discussed in part two. This is significant, because it suggests the profile of types of challenge to assisting the victims following a nuclear detonation could differ in important respects between United States cities (on which many of the recent studies have focused) and other places. For instance, many of those studies assumed an average urban population density of 10,000 people per square kilometre or less.[70] However, it is much higher in some major cities in other parts of the world—Hong Kong, for example, has an average population density of 25,200 per square kilometre.[71] It means that a nuclear detonation of a given yield will directly impact a much greater number of people in Hong Kong than, say, Denver. Infrastructure and emergency services are not necessarily equivalent either. The upshot is that while the great expansion in literature looking at preparation and response to IND detonations in United States and, to a lesser extent, some other Western cities has improved experts' understanding of the kind of aftermath to be expected, it also underlines the vast challenges to effective humanitarian response. And indirectly, it also reveals those consequences are much less deeply explored for some other parts of the world, although they are certain to be at least as harmful. This has implications for humanitarian actors, as disparities in the nature and scale of consequences would affect contingency planning.

As Bell and Dallas's work discussed above indicates, not all studies of the consequences of nuclear weapon detonations are confined to single IND detonations. Notably, Robock, Toon, and others have published scientific studies on the consequences of regional-scale nuclear conflicts, especially on the climate, using quantitative models.[72] Their analyses were largely based on scenarios involving war between India and Pakistan, using 50 nuclear weapons each on the others' cities. These studies found that the consequences in terms of the immediate death, destruction, and disruption would be massive, with dramatic consequences for the climate (due to large amounts of particulate debris being carried into the atmosphere from burning cities) depressing global crop production for at

67 C.E. Dallas and W.C. Bell, "Prediction modelling to determine the adequacy of medical response to urban nuclear attack", *Disaster Medicine and Public Health Preparedness*, vol. 1, no. 2, 2007.

68 W.C. Bell and C.E. Dallas, "Vulnerability of populations and the urban health care systems to nuclear weapon attack—examples from four American cities", *International Journal of Health Geographics*, vol. 6, no. 5, 2007.

69 We also observe this in our examination of the effects of a hypothetical nuclear detonation of differing yields (1kt, 20kt, and 500kt) in Geneva, Switzerland, discussed in part two.

70 See for instance L.E. Davis et al., *Individual Preparedness and Response to Chemical, Radiological, Nuclear, and Biological Terrorist Attacks*, Monograph Reports no. MR-1731/1-SF, RAND Corporation, 2003, appendix A. Some studies do not specify the population density, such as W.C. Bell and C.E. Dallas, "Vulnerability of populations and the urban health care systems to nuclear weapon attack—examples from four American cities", *International Journal of Health Geographics*, vol. 6, no. 5, 2007.

71 United Nations Human Settlements Programme, *State of the World's Cities 2012/2013: Prosperity of Cities*, 2013, p. 38. Figures quoted are from 2008.

72 A. Robock et al., "Climatic consequences of regional nuclear conflicts", *Atmospheric Chemistry and Physics*, vol. 7, 2007, pp. 2003–2012. Their work also found that individual nuclear detonations in cities could generate many more fatalities and much more smoke than previously thought; see O.B. Toon et al., "Atmospheric effects and societal consequences of regional scale nuclear conflicts and acts of individual nuclear terrorism", *Atmospheric Chemistry and Physics*, vol. 7, 2007, pp. 1973–2002.

least a decade. They suggested this might have many negative follow-on effects such as mass starvation, especially among the world's poorest, as food prices would rise in view of increased scarcity, along with increased political and economic instability. This work became the basis for reports by the NGO International Physicians for the Prevention of Nuclear War (IPPNW), the most recent of which estimated as many as two billion deaths would result, and linking this to the need for prevention through the elimination of nuclear weapons.[73]

Recently, other studies have explored (or in some cases revisited) the consequences of nuclear weapon detonation events in other places and scenarios than in major metropolitan areas in the United States. For instance, the British NGO Article 36 produced a policy-oriented case study of the direct impacts from a single 100kt nuclear weapon detonation on Manchester in the United Kingdom to "reinforce a basic understanding of the scale of humanitarian consequences that would result from any use of nuclear weapons".[74] Another study by Bell and Dallas modelled the impacts of nuclear conflict between Israel and the Islamic Republic of Iran, the authors stressing the "utterly unacceptable outcomes for either nation".[75] Other studies have sought to examine the longer-term consequences of nuclear weapon detonations, not only on survivors injured or displaced by the attacks, but on the communities to which they have relocated.[76] As mentioned in this study's introduction, there have also been new studies detailing a litany of accidents and near misses involving nuclear weapons going back as far as the dawn of the nuclear weapon age, hazards which persist, and which have brought the world exceedingly close to nuclear weapon detonation events.[77]

The political context

On 5 April 2009, United States President Barack Obama delivered a speech in Prague that stressed the serious harm that would result from the detonation of even one nuclear weapon in an urban area:

> One nuclear weapon exploded in one city—be it New York or Moscow, Islamabad or Mumbai, Tokyo or Tel Aviv, Paris or Prague—could kill hundreds of thousands of people. And no matter where it happens, there is no end to what the consequences might be—for our global safety, our security, our society, our economy, to our ultimate survival.[78]

Obama's speech stressed the risk of nuclear terrorism. But it also featured his concerns about the large size of the United States and Russian nuclear arsenals and of nuclear proliferation in the context of his declared commitment to a world eventually rid of nuclear weapons.[79] In tone it represented a departure from the non-proliferation-centric rhetoric of his predecessor, George W. Bush, although it too continued to make a direct link between the spread (that is, wider possession) of nuclear weapons with the possibility of their detonation without seeming to apply this to existing possessors like his own country, for instance due to accident or misperception. Nevertheless, as it garnered worldwide media attention, Obama's speech put the issue of the continued existence of nuclear weapon arsenals back in the public eye.

The speech also fed into the dynamics of the Nuclear Non-Proliferation Treaty's five-year review cycle, which culminated in 2010 in an outcome document adopted by the regime's 189 states parties. The NPT Review Conference expressed "deep concern at the continued risk for humanity represented by the possibility that these weapons

73 I. Helfand, *Nuclear Famine: Two Billion People at Risk? Global Impacts of Limited Nuclear War on Agriculture, Food Supplies, and Human Nutrition*, 2nd ed., IPNNW, 2013.

74 R. Moyes et al., *Humanitarian Consequences: Short Case Study of the Direct Humanitarian Impacts from a Single Nuclear Weapon Detonation on Manchester, UK*, Article 36, 2013, p. 1, www.article36.org/wp-content/uploads/2013/02/ManchesterDetonation.pdf.

75 C.E. Dallas et al., "Nuclear war between Israel and Iran: lethality beyond the pale", *Conflict and Health*, vol. 7, no. 10, 2013.

76 See M. Meit et al., "Rural and suburban population surge following detonation of an improvised nuclear device: a new model to estimate impact", *Disaster Medicine and Public Health Preparedness*, vol. 5, supplement 1, 2011. See also I. Redlener, D.M. Abramson, and D. Culp, *Day 30: The Impact of Mass Evacuations on Host Communities Following Nuclear Terrorism*, Institute of Medicine of the National Academies, 2013.

77 For instance, see E. Schlosser, *Command and Control*, 2013; and P.M. Lewis et al., *Too Close for Comfort: Cases of Near Nuclear Use and Options for Policy*, Chatham House, 2014.

78 See www.whitehouse.gov/the_press_office/Remarks-By-President-Barack-Obama-In-Prague-As-Delivered.

79 President Obama said that "Today, the Cold War has disappeared but thousands of those weapons have not. In a strange turn of history, the threat of global nuclear war has gone down, but the risk of a nuclear attack has gone up".

could be used and the catastrophic humanitarian consequences that would result from the use of nuclear weapons".[80] This was the first time such language had been included in an NPT review meeting final document, and it was to prove a springboard for a number of initiatives inspired by concerns about the humanitarian consequences of nuclear weapon use in succeeding years. These initiatives included joint statements of various kinds by like-minded groups of states in the United Nations General Assembly First Committee and the current round of NPT preparatory meetings.[81] Humanitarian perspectives also achieved prominence in an open-ended working group of the General Assembly[82] that met in Geneva during 2013 to deliberate on nuclear disarmament, and a High-Level Meeting[83] held in New York in September of that year.

In late 2012, Norway announced it would host an international conference to consider the humanitarian impacts of nuclear weapon detonations in Oslo on 4–5 March 2013.[84] It was apparent that this made the five NPT nuclear weapon states (China, France, the Russian Federation, the United Kingdom, and the United States) uncomfortable, and they chose not to attend. (The five claimed it detracted from the NPT and their "step-by-step" approach to nuclear disarmament—despite the 2010 NPT final document element on humanitarian consequences.) However, 128 other states, including India and Pakistan, did attend—along with United Nations humanitarian and development agencies, the Red Cross and Red Crescent Movement (RCRC), invited experts, and representatives of civil society. The discussions at this two-day meeting were introductory in nature, and followed expert presentations on a range of subjects.

During the conference in Oslo, Mexico announced its intention to host a second international conference on the subject, building on the central findings of the first event.[85] This took place in Nayarit on 13–14 February 2014, and yet again the five nuclear-weapon states that are members of the NPT chose not to attend, but the overall attendance was greater than in Oslo.[86] There were testimonies from victims of the two nuclear weapon attacks on Japan during the Second World War and expert presentations regarding risk and consequences of maintaining nuclear weapons. UNIDIR presented some preliminary findings of this study. Austria announced that it would hold a third conference on humanitarian impacts of nuclear weapons in late 2014.[87]

The United Nations context

Alongside the RCRC, a number of United Nations field agencies and individual experts were invited to participate in the Oslo and Nayarit conferences and, in several cases, to present views on emergency preparedness, humanitarian coordination, and response. These included OCHA, UNDP, WHO, the United Nations High Commissioner for Refugees (UNHCR), the World Food Programme (WFP), and the International Organization for Migration (IOM). Thus, certain staff from these entities were prompted to reflect on the question of adequacy of a United Nations coordinated response to a nuclear weapon detonation event, perhaps for the first time.

Evidently, such scenarios would generate considerable humanitarian need. This would almost certainly require the services and expertise

80 2010 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, *Final Document*, UN document NPT/CONF.2010/50 (Vol. I)*, 2010, part I, p. 19.

81 For an overview and analysis, see J. Borrie and T. Caughley (eds.), *Viewing Nuclear Weapons Through a Humanitarian Lens*, UNIDIR, 2013.

82 Please see General Assembly, *Report of the Open-Ended Working Group to Develop Proposals to Take Forward Multilateral Nuclear Disarmament Negotiations for the Achievement and Maintenance of a World Without Nuclear Weapons*, advance copy, 3 September 2013, www.unog.ch/80256EDD006B8954/(httpAssets)/4FAE74F4CDAC78A2C1257BDB00543192/$file/A_AC.281_2+Final+Report+Original+English.pdf.

83 For his comments see United Nations, "United Nations Secretary-General, at High-Level Meeting on nuclear disarmament, says new binding legal commitments, expanded cooperation vital for ending proliferation", UN document SG/SM/15335, 26 September 2013.

84 Norway, *United Nations General Assembly 67th Session First Committee General Debate Statement by H.E. Mr. Geir O. Pedersen, Ambassador/Permanent Representative*, New York, 12 October 2012, p. 3, www.reachingcriticalwill.org/images/documents/Disarmament-fora/1com/1com12/statements/12Oct_Norway.pdf.

85 See "Conference: Humanitarian Impact of Nuclear weapons", www.regjeringen.no/en/dep/ud/selected-topics/humanitarian-efforts/humimpact_2013.html?id=708603.

86 One hundred and forty-six states were represented, alongside delegations from the United Nations, the RCRC, and a number of civil society organizations and individual, invited experts.

87 *Second Conference on the Humanitarian Impact of Nuclear Weapons: Nayarit, Mexico, 13–14 February, 2014: Chair's Summary*, www.sre.gob.mx/en/index.php/humanimpact-nayarit-2014.

of all United Nations humanitarian agencies and beyond, including such organizations as the ICRC and the entire RCRC as well as a range of humanitarian NGOs as implementing partners, on which United Nations agencies depend. It would also almost certainly have implications for each of the main sectors of humanitarian response—health, logistics, nutrition, protection, shelter, water, sanitation and hygiene, camp coordination and camp management, early recovery, education, emergency telecommunications, and food security.[88] The reactions of United Nations agencies resulted in the Oslo conference chairperson's summary report element quoted earlier: an adequate humanitarian response was "unlikely", and it might not even be possible to establish such capacities. This conclusion was echoed in the chair's summary of the Nayarit conference.

The Red Cross and Red Crescent Movement

In contrast to United Nations field agencies, elements of the RCRC have been systematically contemplating the challenges of a nuclear weapon detonation event in a populated area for some time. Conclusions to which we will return later in this study include the "near impossibility" of bringing effective humanitarian assistance to the victims of an event such as the detonation of a nuclear weapon in a populated area and the necessity of preventing the use of such armaments. In similar vein, the ICRC has anticipated particular challenges for the United Nations system's ability to respond to or coordinate assistance.[89] In September 2013, for example, the ICRC's Vice-President pointedly asked the following question at a high-level international meeting on nuclear disarmament in New York:

> Who will assist the victims of a nuclear weapon detonation, and how? … The ICRC's assessment, which it conducted between 2006 and 2009, concluded that the means to assist a substantial proportion of the survivors, while adequately protecting those delivering aid, is not currently available at the national level in most countries, and is not feasible at the international level. Unfortunately, there has been no significant progress internationally since the ICRC first reached this conclusion several years ago.[90]

We discuss the ICRC's assessment further in part three.

Study methodology

Understanding the nature of the challenges the United Nations would face after a nuclear weapon detonation event entails investigating the following questions—questions that are reflected in the structure of this study:

- What would happen if a nuclear weapon detonation event occurred, including the particular consequences it would generate that would require humanitarian response?
- What experience and points of reference can the United Nations system draw upon, and what mandates, capabilities, and systems does it have in place for coordination and response relevant to nuclear weapon detonation events?
- Bearing in mind the answers to the questions above, what could or would the United Nations system do?

Methods and elements of the study

There are three major research elements in the study:

1. *Systems review and process tracing*. Methods include document study, research interviews with relevant policymakers, and mapping of pertinent relationships within the international system with a view to assessing overall capacity.
2. *Analysis of the impacts of a plausible set of nuclear weapon detonation events*, both in terms of the direct effects and the kinds of issues these create for United Nations humanitarian coordination and response. The study's researchers selected scenarios based on careful reading of the relevant literature and input from an advisory group of experts.
3. *Historical and political analysis*, for instance to consider "similar" historical occurrences such as previous nuclear weapon detonation events in populated areas, natural disaster preparation and response planning, and major nuclear accidents. We carried out an extensive literature review, and collected,

88 Please see figure 9 on page 56 as well as appendix 1 for more information about the humanitarian cluster approach.
89 G. Malich et al., "A proposal for field-level medical assistance in an international humanitarian response to chemical, biological, radiological or nuclear events", *Emergency Medicine*, vol. 30, 2013, pp. 804–808.
90 *Statement of the ICRC to the High-level Meeting of the United Nations General Assembly on Nuclear Disarmament by Christine Beerli, Vice-President*, New York, 26 September 2013, www.un.org/en/ga/68/meetings/nucleardisarmament/pdf/ICRC_en.pdf.

analysed, and shared this information within the project in a database.

Potential challenges to validity

There are two types of research validity—internal and external. Internal validity means the research design is capable of detecting the causal relationships described in the hypotheses at the beginning of this section. Equally, the research design should not create "false positives" in the sense of asserting causal relationships where none in fact exist.

The study uses a variety of qualitative methods such as document analysis, process tracing, and interviewing (with respondents chosen by means of non-random "snowball" sampling). These methods are relatively straightforward, and have been used in previous UNIDIR research projects. We are reasonably confident the study meets an acceptable standard of internal validity, although it should be noted that this is an exploratory, scoping study, and is not intended to be exhaustive.

One element of the study—the description and analysis based on computer models of a range of plausible nuclear weapon detonation events—uses some quantitative methods. These models appear to be widely recognized as useful tools for indicating the types of consequences possible from nuclear weapon detonations, although these also have various limitations. Minor errors in one or more of the scenarios should not threaten the overall validity of the study, especially since these are primarily illustrative in nature.

However, one issue of concern to internal validity is that the illustrative scenarios chosen for description and analysis be plausible. The term plausibility is used advisedly here. This study is not directly concerned with trying to settle the question of how probable (or improbable) it is that nuclear weapon detonation events will occur, or whether one type of cause (e.g. accident) is more likely than another. There is considerable work to be done in this domain. It is unclear to us in this regard what the base assumptions are for current predictions about nuclear weapon detonation events being "highly unlikely", "unthinkable", or even for that matter "just a matter of time". It is a separate focus from the one in this study—though work that we hope takes place, and soon. For the purposes of this study, it is simply assumed that the probability of a nuclear weapon detonation event is greater than zero.

In terms of external validity, an important question concerns to what extent the findings of the study are anticipated to be able to be extrapolated. In other words, how useful do we expect its findings to be over time, or across other contexts? Some literature on dealing with the consequences of chemical, biological, radiological, and nuclear (CBRN) weapon attacks purports to deal with nuclear weapon detonations when in fact this is not really the case. For that, among other reasons, the study focuses only on nuclear detonations without claiming its relevance to humanitarian coordination and response to the use of other weapons. Nor is the study concerned directly with the characteristics of response and coordination capacities of states. Although these are referred to, for instance in order to contrast them with United Nations capacities—or to show the dependence of the latter on the former—assessing these is not the purpose of the study. It is also important to recall that the study is not intended to present a blueprint to "solve the problem" of challenges to United Nations coordination and response to nuclear weapon detonations.

Summary

This part has set out the basic terms and understandings this study uses, and has discussed some of literature relevant to considering nuclear weapon detonation events of various kinds. It is clear that since their invention, certain nuclear weapon detonation scenarios have taken greater prominence than others. Fears of large-scale thermonuclear war dominated during the Cold War, and shifted after 2001 to concern about the consequences of the detonation of a "terrorist"-acquired nuclear weapon in an urban area should they ever acquire one—although state-held arsenals of nuclear weapons have not gone away, and the number of possessors has in fact increased. Some work has been done on analysing other scenarios including the consequences of regional nuclear wars and detonations of differing yields in several cities. This underlines that there is a spectrum of possibilities when considering the challenges for the United Nations coordinated humanitarian system. The next part explores the effects of nuclear weapons, and what this could mean in specific terms for humanitarian response in differing scenarios.

PART 2: NUCLEAR WEAPON DETONATIONS

This section explains what happens in a nuclear weapon detonation, and describes its effects. An appreciation of these features is important to understanding the challenges involved in assessing and responding to nuclear weapon detonations.

At the outset, it is important to recognize that while it is straightforward to generically describe the characteristics and effects of nuclear weapon detonations, many factors will affect the nature and extent of their humanitarian consequences. Factors include (but are not limited to) explosive yield, altitude of burst, the location in which the nuclear detonation (or detonations) occurs and corresponding topography, population density, meteorological conditions, and time of day. Several specific scenarios in which nuclear weapon detonations could occur will be examined with a view to understand where there might be differences.

Nuclear versus conventional weapon explosions

Like nuclear weapons, many "conventional" explosive weapons fulfil their military functions by detonating to produce blast, heat, and other destructive effects that radiate from a central point faster than the speed of sound (so-called "high-explosive" weapons).[91] However, there are some important differences:

1. Nuclear explosions can be many thousands (or millions) of times more powerful than the largest conventional explosions.
2. For the release of a given amount of energy, the mass of a nuclear explosive is much less than that of a conventional explosive and so payloads on missiles are lighter and they can travel further.
3. Temperatures reached in a nuclear explosion are much higher, and a large proportion of the energy is emitted in the form of heat, generally referred to as "thermal radiation". This thermal radiation and the blast wave are generally much greater than from detonation of any "conventional" weapons.
4. Nuclear explosions are accompanied by immediate and harmful rays, called initial or prompt nuclear radiation, that are highly penetrating.
5. The substances remaining after a nuclear explosion are radioactive, emitting harmful radiation over an extended period of time. This is known as residual nuclear radiation or residual radioactivity and when it is deposited from the air is called fallout.[92]

Why nuclear explosions are different

An explosion occurs when a great deal of stored energy is suddenly converted to heat in a confined space. This is true whether it is from a conventional, chemical explosive such as TNT (trinitrotoluene), or a nuclear weapon. "In a conventional explosion, the energy released arises from chemical reactions; these involve a rearrangement among the atoms, e.g., of hydrogen, carbon, oxygen, and nitrogen, present in the chemical high-explosive material".[93] In contrast, in a nuclear explosion the energy the explosion produces results from the formation of different atomic nuclei by the redistribution of the protons and neutrons within the interacting nuclei. "The forces between the protons and neutrons within atomic nuclei are tremendously greater than those between the atoms; consequently, nuclear energy is of a much higher order of magnitude than conventional (or chemical) energy when equal masses are considered".[94]

For most atoms, the enormous energy inside the nucleus cannot be released easily. However, in the

91 "High explosives are defined by their ability to 'detonate'. Detonation is the sustained propagation of a supersonic shockwave through an energetic material". This is significant, as the destructive properties of supersonic shock waves are generally far greater than those moving at less than the speed of sound (deflagration). See C. King (ed.), *Jane's Explosive Ordnance Disposal, 2009–2010*, Jane's Information Group, 2008, p. 3.

92 S. Glasstone and P.J. Dolan, *The Effects of Nuclear Weapons*, 3rd ed., United States Department of Defense and the Energy Research and Development Administration, 1977, pp. 1–2.

93 Ibid., p. 4.

94 In ibid., Glasstone and Dolan note that "What is sometimes referred to as atomic energy is thus actually nuclear energy, since it results from particular nuclear interactions. It is for the same reason, too, that atomic weapons are preferably called 'nuclear weapons'".

case of the isotope[95] of uranium known as U-235 the energy can be released through a process called nuclear fission.[96] The amount of energy in U-235 is 30 million times that of the energy found in TNT. "The sudden liberation of energy causes a considerable increase of temperature and pressure, so that all the materials present are converted into hot, compressed gases. Since these gases are at very high temperatures, they expand rapidly and thus initiate a pressure wave, called a 'shock wave,' in the surrounding medium—air, water, or earth".[97] (This is also true for nuclear weapons using another form of fissile material, plutonium-239, explored below.)

How a nuclear chain reaction occurs

Nuclear fission is the splitting of an atomic nucleus that results in the release of energy mainly in the form of high-energy photons (gamma rays), smaller nuclei, and neutrons. Atomic nuclei of plutonium and certain uranium isotopes can be split to yield significant amounts of energy by using neutrons to initiate the fragmentation (certain other elements such as thorium, americium, and neptunium can also be split in this way). The fission yields neutrons that can then be harnessed to initiate further fission and, in the right conditions, a chain reaction can thus ensue. A chain reaction requires enough fissile material to ensure that emitted neutrons hit other nuclei, rather than passing between nuclei and escaping. This is called "critical mass". A chain reaction can either be sustained for a slow, steady release of useable energy (which is the basis for nuclear power production reactors) or contained for a short period of time until it explodes releasing uncontrollable enormous amounts of energy—the basis of the nuclear fission bomb. All nuclear weapons in today's arsenals have a fission component made of highly enriched uranium or plutonium, or a mixture of both.

Acquiring enough fissile material for a critical mass is challenging. U-235 exists in very tiny amounts in nature. It has to be separated from a much more common isotope of uranium (U-238) and concentrated (enriched) and processed into a quantity large enough to make a nuclear weapon. Natural uranium is about 0.7 per cent U-235. Uranium that contains 20 per cent or more of U-235 is known as highly enriched uranium (HEU), and weapons-grade uranium usually contains at least 90 per cent of this isotope. Uranium enriched for use in most civil nuclear reactors is enriched to between 3 and 20 per cent (low-enriched uranium, or LEU). The amount of HEU needed to make a nuclear fission weapon depends on the enrichment level of the HEU and the sophistication of the weapon.[98]

All isotopes of plutonium are fissionable. Plutonium is produced in nuclear reactors. It can, in principle, be extracted from used reactor fuel for use in nuclear weapons. Pu-239 emits more neutrons in fission reactions than U-235 does—typically, three neutrons are released per stage in Pu-239 fission rather than two as in the case of U-235. This means that a Pu-239 chain reaction requires significantly fewer generations in a chain reaction than U-235 to achieve a nuclear explosion because of the greater number of neutrons released.[99] This has practical implications: less fissile material is required for critical mass in a Pu-239 bomb. Nuclear weapon designers use various techniques to decrease the required amount of fissile material further, for instance by using neutron reflectors, and thus

95 An isotope is "one of two or more atoms of the same element that have the same number of protons in their nucleus but different numbers of neutrons. Isotopes have the same atomic number but different mass numbers". An isotope of an element is denoted here by indicating its mass number (the number following the name or symbol of the element, e.g. uranium-233 or Pu-239). See IAEA, *IAEA Safeguards Glossary*, 2001, p. 30.

96 See R.A. Muller, *Physics and Technology for Future Presidents: An Introduction to the Essential Physics Every World Leader Needs to Know*, 2010, pp. 2–14.

97 S. Glasstone and P.J. Dolan, *The Effects of Nuclear Weapons*, 3rd ed., United States Department of Defense and the Energy Research and Development Administration, 1977, p. 1.

98 According to the IAEA, a significant quantity is "the approximate quantity of nuclear material in respect of which, taking into account any conversion process involved, the possibility of manufacturing a nuclear explosive device cannot be excluded" is set at 8kg of plutonium, 25kg of U-235 in highly enriched uranium, and 75kg of U-235 in natural or low-enriched uranium. See IAEA, *IAEA Safeguards Glossary*, 2001, p. 23. However, it has been observed that the "significant quantity" concept is sometimes abused; for more detail see F. Dalnoki-Veress, J. Lewis, and M. Pomper, "Significant Quantities Rant", *Arms Control Wonk*, 1 March 2012, http://lewis.armscontrolwonk.com/archive/5028/significantly-wrong-about-significant-quantities.

99 See R.A. Muller, *Physics and Technology for Future Presidents: An Introduction to the Essential Physics Every World Leader Needs to Know*, 2010, p. 155.

further decrease the weight for payload delivery on missiles.[100]

Types of nuclear weapons

Two basic nuclear weapon designs are the "gun" and "implosion" types. The nuclear bomb that destroyed Hiroshima on 6 August 1945 was a gun type. This type only works with HEU. Its detonation involves firing one or more shaped pieces of U-235 at a shaped U-235 target. This brings together enough fissile material to create a critical mass that can sustain a chain reaction and, if contained for long enough, result in a nuclear explosion. The Hiroshima bomb was physically large, at 4 tons in weight, and created an explosion equivalent to approximately 13,000 tons (or 13 kilotons) of TNT.

Box 1: How large is a kiloton?

Two terms commonly used in the context of the explosive yields of nuclear weapons and other high-energy events are kilotons and megatons. This is because nuclear explosions rapidly release an immense amount of energy relative to chemical explosives. The terms stem from the concept of TNT equivalent, a method of quantifying the energy released in explosions. The "ton of TNT" is a unit of energy equal to 4.184 gigajoules (1 gigacalorie), which is approximately the amount of energy released in the detonation of a ton of TNT, a chemical explosive. A megaton of TNT is a unit of energy equal to 4.184 petajoules.

To put this into perspective, figure 1 below assumes one truck can carry 40 tons of TNT. Later in this study two 1kt nuclear groundburst detonation scenarios are described: each is thus the explosive equivalent of 25 40-ton truckloads of TNT explosive. Estimates of the explosive yield of the nuclear weapon dropped on Nagasaki in 1945 range between 18kt and 20kt—the equivalent of between 450 and 500 40-ton truckloads of TNT. Yet the bomb contained less plutonium than would fit in a coffee cup (see image).[101]

Figure 1: Equivalents of kilotons of TNT

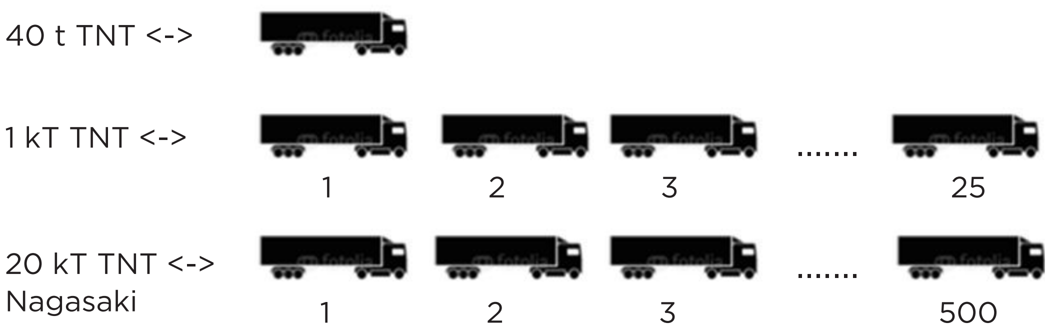

Diagram and image courtesy of Christoph Wirz, Swiss Federal Office for Civil Protection, Spiez Laboratory.

100 Neutron reflectors are atomic structures (for example carbon or steel) surrounding the fissile material. These have high capacity to reflect neutrons instead of absorbing them. Neutrons of the fissile material therefore collide with neutrons of the reflecting matter and are sent back towards the core to fission again, hereby increasing the efficiency of the chain reaction. In a nuclear bomb, the reflecting material also helps to contain the fissile material as a critical mass for longer than would have been possible without such a solid shell.

101 C. Wirz, "What are the physical effects of a nuclear explosion?", presentation to the Swiss Ministry of Foreign Affairs Ambassadors' Conference, Bern, 20 August 2013. See also C. Wirz and E. Egger, "Use of nuclear and radiological weapons by terrorists?", *International Review of the Red Cross*, vol. 87, no. 859, 2005.

The nuclear bomb that destroyed Nagasaki on 9 August 1945 was of a different type, called an implosion nuclear weapon, which creates a detonation by compressing a subcritical sphere of fissile material (it could be Pu-239 or U-235) to create a super-critical mass. This is more efficient than a gun-type design as it requires far less fissile material.[102] However, implosion-type nuclear weapons are more difficult to design, engineer, and build than gun types.

In addition there are nuclear weapons known as boosted fission weapons and thermonuclear weapons, both of which include a nuclear fusion component in addition to the fission component. Fusion is the process of fusing together very light nuclei such as the elements hydrogen, helium, and lithium. When these light nuclear elements fuse together they form other elements and release enormous amounts of energy. Nuclear fusion is the process that fuels the energy emitted by stars such as the sun. In order to achieve the conditions needed for nuclear fusion, large temperatures and pressures have to be created, and this is done through the initial fission reaction.

In boosted fission weapons, fusion materials are introduced to the process and the fusion reactions serve to boost the explosive yield of the fission weapon. This involves adding a small container of a material such as tritium/deuterium gas[103] to increase the energy of a fission bomb by releasing more neutrons in the heat of the explosion, and thus making the chain reaction in the fission bomb more complete. It is called boosted fission since the fusion of deuterium and tritium is being used to produce neutrons to increase the efficiency of the use of fissile material rather than for energy production as in a thermonuclear weapon.

Thermonuclear weapons (or hydrogen bombs) were invented a few years after the Second World War ended. In a thermonuclear weapon, the explosion takes place in two stages, first the fission and then—through a focusing lens effect—a nuclear fusion second stage. This can create explosions of much greater yield than fission weapons of the kinds discussed above:

> First, the explosion of a fission bomb creates an intense heat. Second, this heat causes the deuterium and tritium to reach energies that are sufficient to overcome their natural repulsion to each other (the nuclei of both are positively charged) and fuse. Third, this fusion releases energy and neutrons; the high-energy neutrons cause fission in a uranium container (made of U-238) that surrounds everything else, and that releases even more energy.[104]

So far, this section has described how nuclear weapons work in basic terms, and their main variants. Although these types vary in their mechanisms, what is important is that these have common characteristics in terms of their consequences.

What happens in a nuclear explosion?[105]

During the Cold War, the states developing nuclear weapons tested them on the surface, in the air at low, medium, and high altitude, underground, and underwater in order to study the characteristics and effects of their explosions. Because this study is concerned with the humanitarian challenges of responding to nuclear weapon detonation events in populated areas, it focuses on the characteristics of their use on the surface and in the air.

At the moment of detonation of a nuclear weapon a huge fireball is created virtually instantaneously. This is because the fission of uranium or plutonium, or the fusion of hydrogen isotopes in a nuclear weapon, leads to the liberation of a large amount of energy extremely rapidly within a limited quantity of matter. It means that heat is produced: the temperature in the centre of a nuclear fireball can briefly be as hot as the surface of the sun (compared with a mere few thousand degrees in conventional high-explosive detonations). Tremendous pressures are also produced, since all of the materials in the weapon are immediately converted into gaseous form. Large amounts of energy are radiated, including as X-rays, heat, and light.

102 See box 4.1 in *Report of the International Commission on Nuclear Non-Proliferation and Disarmament: Eliminating Nuclear Threats—a Practical Agenda for Global Policymakers*, 2009, p. 41.

103 Hydrogen has several different isotopes (see appendix). The most common isotope of hydrogen (protium, or hydrogen-1) has a single proton in its nucleus. The nucleus of deuterium (or hydrogen-2) contains one proton and one neutron. Tritium (or hydrogen-3) contains one proton and two neutrons in its nucleus.

104 See R.A. Muller, *Physics and Technology for Future Presidents: An Introduction to the Essential Physics Every World Leader Needs to Know*, 2010, p. 172.

105 Some of this section is drawn from S. Glasstone and P.J. Dolan, *The Effects of Nuclear Weapons*, 3rd ed., United States Department of Defense and the Energy Research and Development Administration, 1977, pp. 26–41.

A radioactive cloud is also created. While the fireball is still luminous, its interior temperature is so high that all of the weapon materials are an extremely hot mixture of gases, including the radioactive fission products, and uranium (or plutonium, depending on the type of nuclear weapon) that escaped fission. As the fireball increases in size and cools, the gases condense to eventually form solid particles that are rising up in the air as a cloud, which is highly radioactive due to the presence of the fission products. As the fireball cloud rises, its outside is cooled as it radiates heat into the surrounding air. It also changes shape from being roughly spherical to a toroid (or doughnut) shape and, as it ascends, there are violent, internal circulatory motions within it. (This is the mushroom cloud image so many people are familiar with, which has become synonymous with the destructive power of nuclear weapons.) How high the radioactive cloud rises depends on the heat energy of the weapon, and upon atmospheric conditions such as moisture content in the air.[106]

The rising radioactive cloud sucks in the air below. Depending on the height of burst of the nuclear weapon and the nature of the terrain below it, the strong updraft with inflowing winds produced in the immediate vicinity will suck up what is left of people, animals, trees, cars, buildings, dirt, and debris into the radioactive cloud. The particles of the matter carried into the cloud mix with the vaporized fission products, which then condense on them to form highly radioactive particles. At first the rising mass of weapon residues carries the particles upward, but over time they begin to fall slowly due to gravity, at rates depending on their size—larger particles will fall closer to the hypocentre and sooner.

The consequences of these processes for human harm are discussed in the next section. Of the many variables that affect the signature of a nuclear explosion, the explosive yield of the nuclear weapon is an obvious one, but another is the altitude of burst:

- *Surfaceburst* (or *groundburst*) nuclear explosions occur on or near the Earth's surface. In other words, some part of the fireball touches the ground. In addition to making a crater, some of the rock, soil, and other material (including the living) is vaporized and taken into the fireball because of its intense heat. Additional material will be melted, either completely or on its surface, and the strong afterwinds described above cause large amounts of dirt, dust, and other particles to be sucked up as the fireball rises. Consequently, the radioactive cloud is laden with rather heavy debris particles that will sooner rather than later fall as radioactive fallout. (It is fallout, with its associated radioactivity decaying over a long period of time, which is the main source of residual nuclear radiation.)
- *Airburst* nuclear explosions occur at an altitude at which the nuclear fireball does not touch the Earth's surface. The Hiroshima and Nagasaki bombs were airbursts in that each was detonated at a height of several hundred metres. In principle, airburst nuclear detonations create less radioactive fallout (because the radioactive particles created as the fireball cools off in this case are relatively light and tend to stay in the atmosphere dispersing over a much larger area and losing most of their radioactivity before they fall). However, airbursts can cause prompt harm and destruction over a broader area.

Effects

The detonation of a nuclear weapon releases a massive amount of destructive energy, which manifests itself in the following ways:

- *Flash*—a nuclear explosion causes a very bright flash, which can damage eyesight and cause blindness.
- *Thermal radiation (heat)*—the electromagnetic radiation of short wavelengths emitted from a nuclear weapon detonation is absorbed in the surrounding air and heats it to millions of degrees, which constitutes the fireball. The ultraviolet, visible, and infrared radiation from the fireball travelling at the speed of light within the first minute (or less) is the thermal radiation (including the flash, mentioned above). This is extremely damaging to physical objects and living things—the high temperatures it creates are even enough to make buildings or normally non-flammable materials burst into flame if close enough

106 The maximum altitude mushroom clouds tend to ascend to before flattening out is the altitude of the boundary between the troposphere and the stratosphere. This boundary varies with the seasons, but is typically around 7.5km from the ground in areas close to the poles, and around 17 km from the ground in equatorial areas. See ibid., p. 31.

to the hypocentre. People may suffer terrible burns depending on their distance from the point of detonation and whether they have any shelter. In addition to the prompt thermal radiation, many fires will be started and fanned by the winds caused by the nuclear detonation. These effects are discussed later in this part.

- *Blast wave*—a fraction of a second after a nuclear explosion, a high-pressure wave develops and moves outward from the fireball, behaving like a moving wall. The effects of this shock front can be amplified by reflection from the surface of the Earth (the "Mach effect"). The blast wave creates immense overpressure, that is, pressure in excess of the normal atmospheric value. Strong transient winds are associated with the blast wave's passage, which may have peak velocities of several hundred kilometres per hour. Depending on distance from the hypocentre, the blast effects of a nuclear weapon detonation result in:

  > various categories of trauma related injuries, including primary injuries (such as tympanic membrane destruction in the ears due to the overpressure wave), secondary injuries (such as eye injuries and cuts on exposed limbs from wind-blown glass and other debris), tertiary injuries (trauma injuries resulting from the actual impact of a flying human body against structures, or from the tumbling of the body) and quaternary injuries (severe trauma resulting from building collapse).[107]

- *Prompt nuclear radiation*—the large amount of ionizing radiation emitted from the fireball can cause acute illness and death to living things. Radiation is a general term for a travelling particle or wave. Ionizing radiation is harmful to human health because it is energetic enough to cause atoms and molecules to gain or lose electrons, and thus can kill cells or cause mutation to DNA. (See appendix for explanation.) Even if not killed immediately, many people may suffer the effects of acute radiation syndrome (see box 2).[108]

Box 2: Acute Radiation Syndrome

Acute Radiation Syndrome (ARS) is a serious illness that occurs when most or all of the human body receives a high dose of radiation, usually over a short period of time. Many survivors of the Hiroshima and Nagasaki bombings and some fire fighters who first responded to the Chernobyl nuclear power plant accident in 1986 became ill with ARS. The first symptoms are typically nausea, vomiting, and diarrhoea, beginning within minutes to days after exposure. A person may seem to subsequently recover and look and feel healthy for a short period of time, after which they become sick again, with loss of appetite, fatigue, fever, nausea, vomiting, diarrhoea, and possibly even seizure and coma. This seriously ill stage may last from a few hours up to several months. Other symptoms include skin damage and hair loss. The chances of survival for people with ARS decrease with increasing radiation doses. Most people who do not recover from ARS will die within several months, in most cases due the destruction of their bone marrow. Treatment may take from several weeks to as long as two years, and may include blood transfusions, antibiotics, and the use of blood stimulating agents or, if these fail, bone marrow transplants in specialized medical units. Obviously, a medical response system overwhelmed by large numbers of people with ARS and other forms of injury from a nuclear weapon detonation event will struggle to offer such intensive treatment,[109] particularly as it may be difficult to ascertain to what level of radiation a person was exposed.[110]

107 C.E. Dallas et al., "Nuclear war between Israel and Iran: lethality beyond the pale", *Conflict and Health*, vol. 7, no. 10, 2013, p. 12.

108 See A.B. Wolbarst et al., "Medical response to a major radiologic emergency: a primer for medical and public health practitioners", *Radiology*, vol. 254, no. 3, 2010.

109 See Centers for Disease Control and Prevention, *Acute Radiation Syndrome (ARS): A Fact Sheet for the Public*, www.bt.cdc.gov/radiation/ars.asp; see also I. Helfand et al., *The U.S. and Nuclear Terrorism: Still Dangerously Unprepared*, Physicians for Social Responsibility, 2006, p. 23, www.psr.org/resources/the-us-and-nuclear-terrorism.html.

110 "Radiation exposure would complicate this dilemma enormously, because the initial symptoms of radiation sickness—namely vomiting and bloody diarrhea—are almost the same regardless of what dose of radiation has been absorbed. At very high doses, those exposed would die in a matter of days from radiation-induced encephalopathy, preceded by delirium, seizures and coma. At lesser levels, persons may survive the initial symptoms, only to die within weeks of hemorrhage or infection due to bone marrow suppression. Some, who might have been saved with simple intravenous fluid therapy, would die of dehydration and shock. It will be almost impossible to know for sure who might survive, if given medical support, and who will die no matter what is done for them"; see C. Cassel "An epistemology of nuclear weapons effects", *The Western Journal of Medicine*, vol. 138, no. 2, 1983, p. 216.

- *Fallout*—as explained above, fallout is the process by which radioactively contaminated particles and water droplets gradually fall to the ground following a nuclear explosion (it is also the name applied to the particles themselves). Its extent and nature can vary widely, and is determined by a combination of circumstances associated with the yield and design of the nuclear weapon, the height of the explosion, the nature of the surface beneath the point of burst, and the meteorological conditions. In general, heavier particles fall closer to the hypocentre of the explosion and more quickly than lighter particles. Fallout might spread for hundreds and even thousands of kilometres from the hypocentre.
- *Electromagnetic pulse (EMP)*—nuclear detonations produce intense electric and magnetic fields that under certain conditions may extend considerable distances depending on the yield and altitude of detonation.[111] The close-in region near the detonation point is highly ionized and large electric currents flow. If a nuclear weapon is exploded at very high altitudes (between 20km and 40km), the gamma rays interact to produce high-energy free electrons that are trapped in the Earth's magnetic field—creating a powerful electromagnetic field called an EMP. The High-Altitude EMP (HAEMP) is capable of simultaneously short-circuiting a wide range of electronic equipment including satellites, communications equipment, airplanes, power stations, computers, radios, and radar across huge swathes of land, sea, and air. Lower-altitude nuclear detonations can produce a "Source Region" EMP (SREMP) that can affect military or civilian electronic and communication systems close to the detonation point (about 3km to 8km[112]). SREMP effects are only significant if the electronic systems survive the primary damage-causing mechanisms of blast, shock, and thermal pulse. Taken with the destructive effects of the blast and thermal pulse outlined above, SREMP effects of lower-altitude nuclear detonations could compound inoperability of critical societal infrastructure and challenges for emergency response services. For example, electronic systems such as medical devices, air traffic control systems, and aircraft instruments within the zone of EMP effect would be affected. In addition a high-altitude detonation at the same time as a ground of lower-altitude burst would likely have far greater EMP effects and create very difficult conditions for communication and response for humanitarian organizations.

The explosive and prompt radiation effects of a nuclear weapon emanate from the point of detonation. The large energy released means this zone is very wide as compared with conventional explosive weapons, even for the smallest of existing nuclear weapons (see figure 2 on the next page).

In the zone closest to the point of detonation (zone 1) there will be complete destruction. In zone 2, surrounding zone 1 (and thus further away from the point of detonation), the level of destruction is severe. In consecutive zones further from the point of detonation the level of damage decreases. The area of these zones will depend on factors such as the weapon yield. Figures 2 and 3, reproduced from a study by British NGO Article 36, summarize the fire and blast effects for a 100kt nuclear weapon detonated at 850m over the city of Manchester in the United Kingdom. In addition, prompt radiation released from the explosion would severely affect people within a radius of approximately 2km from the detonation point. Alone this would result in 50–90 per cent mortality. However, the blast and thermal effects of the detonation would already kill many of these victims.[113]

111 S. Glasstone and P.J. Dolan, *The Effects of Nuclear Weapons*, 3rd ed., United States Department of Defense and the Energy Research and Development Administration, 1977, pp. 520–521.
112 Federation of American Scientists, *Nuclear Weapon EMP Effects*, 1998, www.fas.org/nuke/intro/nuke/emp.htm.
113 R. Moyes et al., *Humanitarian Consequences: Short Case Study of the Direct Humanitarian Impacts from a Single Nuclear Weapon Detonation on Manchester UK*, Article 36, 2013, p. 14, www.article36.org/wp-content/uploads/2013/02/ManchesterDetonation.pdf.

Figure 2: Impact zones in a 100kt airburst detonation at 850m over Manchester

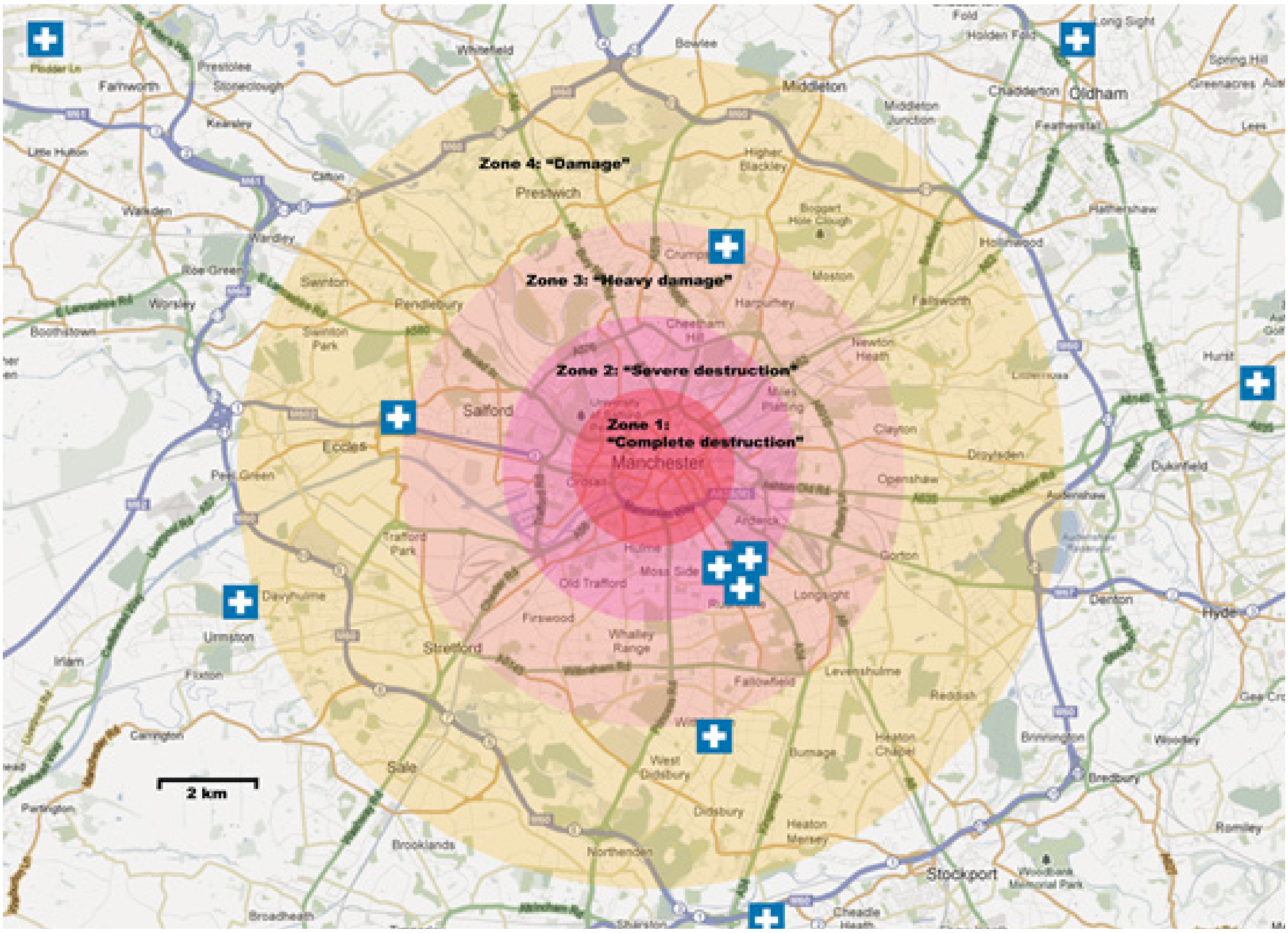

Figure courtesy of Article 36.[114]

114 Ibid., p. 8.

Figure 3: Summary of fire and blast effect zones for 100kt airburst over Manchester[115]

Zone	Blast pressure (pounds per square inch)[116]	Approximate distance from ground zero	Fire damage	Blast damage
Zone 1 "Complete destruction"	>12psi	<1.26km	Steel surfaces melt, concrete surfaces explode, glass windows melt.	Bridges and multi-storey buildings destroyed. Cars and lorries blown long distances.
		1.26–1.8km	Aluminium window frames melt, car metal melts.	Multi-storey concrete buildings destroyed or near collapse.
Zone 2 "Severe destruction"	5–12psi	1.8–3km	Severe fire. Wood, roofing burst into flames.	Unreinforced brick or timber-frame houses destroyed. Multi-storey concrete buildings severely damaged.
Zone 3 "Heavy damage"	2–5psi	3–4km	Upholstery, canvas, clothing burst into flames. Painted surfaces explode.	Unreinforced brick or timber-frame houses damaged beyond repair. Telephone lines blown down.
		4–5km	Severe 3rd degree burns. People flash-blinded by reflected light.	Timber-frame houses damaged beyond repair. Brick houses damaged but repairable.
Zone 4 "Damage"	1–2psi	5–7km	Severe 2nd degree burns. People flash-blinded by reflected light.	Trees blown down. Brick and timber-frame houses damaged but repairable.
		7–8km	1st degree burns.	Windows and doors blown in. Interior partitions cracked.
Zone 5	<1psi	>8km		

Table courtesy of Article 36.[117]

115 Original source material from S. Glasstone and P.J. Dolan, *The Effects of Nuclear Weapons*, 3rd ed., United States Department of Defense and the Energy Research and Development Administration, 1977. The summaries for damage within those zones are taken from O. Greene et al., *London After The Bomb, What a Nuclear Attack Really Means*, 1982. These are estimates based on several United States bomb tests. In reality blast radii may easily vary by 10 per cent. There could be several reasons for this, such as topography (hills, valleys), or the bomb does not detonate at the chosen altitude. Also, explosive yield may be higher or lower than designed or the weapon may malfunction. Blast distances vary proportionally to the cube root of the blast power; ibid., pp. 102–103.

116 Pressure is force per unit of area applied in a direction perpendicular to the surface of an object. Pressures stated are assumed to be relative to atmospheric pressure, and not to a vacuum. Although superseded by International System of Units measurements, in this study the older unit of pounds per square inch is quoted from a number of sources. The SI unit of pressure is the newton per square metre, called the pascal (Pa). Everyday pressures are often stated in kilopascals (kPa = 1000 Pa). 1 psi is equal to 6.89476 kPa.

117 R. Moyes et al., *Humanitarian Consequences: Short Case Study of the Direct Humanitarian Impacts from a Single Nuclear Weapon Detonation on Manchester UK*, Article 36, 2013, p. 7, www.article36.org/wp-content/uploads/2013/02/ManchesterDetonation.pdf.

Types of consequences

To summarize so far, there is the direct harm and injury in the moments following a nuclear detonation due to blast, thermal, and prompt radiation effects. Infrastructure within the zone of effect will be destroyed, disabled, or damaged, and people there killed or injured unless they are effectively sheltered. Thermal radiation effects will also start many fires, which cause more casualties and destruction. Radioactive fallout can create a health hazard in the days, weeks, and possibly months following detonation, including in places far from the point of detonation because radioactive particles can be borne aloft and carried long distances. What would this mean for a population centre?

Death and destruction

Because of its vast zone of destructive effect, any nuclear weapon detonation in a population centre such as a city would result in large-scale loss of life and injury, even taking into account factors such as time of day, the strength of buildings and topography. In addition to the types of blast effects described earlier, mass fires and burns from the thermal radiation would be major sources of death and injury, although the severity would depend to a certain extent on factors such as weather. It has been noted, for instance, that in the case of a groundburst nuclear weapon in a city, cloudy conditions supplemented by strong thermal winds and blast damage could greatly increase the probability of local fires starting and spreading.[118] Blindness from the flash would result for many people looking in the direction of the nuclear weapon at the time of detonation.

The bombing of Hiroshima and Nagasaki in 1945 with what were fairly low-yield nuclear weapons by modern standards each resulted in tens of thousands of deaths directly attributable to their immediate effects (see box 3). For various reasons, the destructive effects of larger weapons do not scale up directly, but these would nevertheless generally increase the greater the explosive yield.[119] Article 36's estimate of casualties based on detonation of a 100kt warhead over Manchester illustrated in figures 2 and 3, for instance, suggests blast and thermal effects would kill more than 81,000 people and leave more than 212,000 injured.[120]

118 Ibid., p. 7.
119 Ibid., p. 20.
120 Ibid., p. 9.

Box 3: Casualties from the Hiroshima and Nagasaki bombs

There is still debate about the exact number of casualties from the detonation of nuclear weapons over Hiroshima and Nagasaki in August 1945. A year after the bombings, fieldwork carried out for the United States Strategic Bombing Survey, quoted below, underlined the difficulty in arriving at estimates:

> The most striking result of the atomic bombs was the great number of casualties. The exact number of dead and injured will never be known because of the confusion after the explosions. Persons unaccounted for might have been burned beyond recognition in the falling buildings, disposed of in one of the mass cremations of the first week of recovery, or driven out of the city to die or recover without any record remaining. No sure count of even the previous populations existed. Because of the decline in activity in the two port cities, the constant threat of incendiary raids, and the formal evacuation programs of the Government, an unknown number of the inhabitants had either drifted away from the cities or been removed according to plan. In this uncertain situation, estimates of casualties have generally ranged between 100,000 and 180,000 for Hiroshima, and between 50,000 and 100,000 for Nagasaki. The Survey believes the dead at Hiroshima to have been between 70,000 and 80,000, with an equal number injured; at Nagasaki over 35,000 dead and somewhat more than that injured seems the most plausible estimate.
>
> Most of the immediate casualties did not differ from those caused by incendiary or high-explosive raids. The outstanding difference was the presence of radiation effects, which became unmistakable about a week after the bombing. At the time of impact, however, the causes of death and injury were flash burns, secondary effects of blast and falling debris, and burns from blazing buildings.

No records are available that give the relative importance of the various types of injury, especially for those who died immediately after the explosion. Indeed, many of these people undoubtedly died several times over, theoretically, since each was subjected to several injuries, any one of which would have been fatal. The Hiroshima prefectural health department placed the proportion of deaths from burns (flash or flame) at 60 percent, from falling debris at 30 percent, and from other injuries at 10 percent; it is generally agreed that burns caused at least 50 percent of the initial casualties. Of those who died later, an increasing proportion succumbed to radiation effects.

The seriousness of these radiation effects may be measured by the fact that 95 percent of the traced survivors of the immediate explosion who were within 3,000 feet suffered from radiation disease. Colonel Stafford Warren, in his testimony before the Senate Committee on Atomic Energy, estimated that radiation was responsible for 7 to 8 percent of the total deaths in the two cities. Most medical investigators who spent some time in the areas feel that this estimate is far too low; it is generally felt that no less than 15 to 20 percent of the deaths were from radiation. In addition, there were an equal number who were casualties but survived, as well as uncounted thousands who probably were affected by the gamma rays but not enough to produce definite illness.[121]

Devastation to a population centre would be extensive across a wide area due to the explosive power of the nuclear weapon detonation. Buildings, bridges, and other structures would probably collapse in the more severely affected zones, and suffer damage further away from the hypocentre. This level of damage could vary considerably due to factors such as topography—structural damage to Hiroshima from nuclear attack was approximately three times greater than that in Nagasaki.[122] Electrical power distribution and communications infrastructure would be damaged or disrupted, cell towers and power poles would be knocked over and disconnected, electrical substations destroyed or damaged. Roads, tunnels, and railway systems would probably be impassable.

Depending on their construction, hospitals and medical clinics within the two or three innermost zones of the detonation would be destroyed or damaged to the extent that these became inoperable, and medical and nursing staff would be killed or injured. In the Hiroshima bombing, for example, 90 per cent of the doctors and nurses were killed or injured by the explosion, as were more than 80 per cent of the city's pharmacists.[123] Due to EMP effects, electricity and any connected backup sources could be lost, and most equipment using a plug to access power probably rendered inoperable, which would have consequences for hospital machines of various kinds. In addition, radioactive fallout plumes following the detonation could render physically undamaged health infrastructure unusable as well. A study of the effects of nuclear attacks on major cities in the United States indicated that fallout plumes following prevailing winds would have a drastic impact on the availability of hospital services further afield than the directly physically damaged zone for this reason.[124]

The same study noted that the signature of the detonation of nuclear weapons (e.g. yield, altitude of detonation) would heavily impact the kind of medical response needed:

> The thermal impacts of a nuclear explosion are always large but scale much faster than blast with larger yield detonations. Thermal radiation decays as the inverse square of the distance from the detonation, while blast decays as the inverse cube of the distance. … For large weapon sizes (>100Kt), significant thermal

121 Quoted from The United States Strategic Bombing Survey, *The Effects of the Atomic Bombings of Hiroshima and Nagasaki*, 1946, p. 16.

122 Of approximately 76,000 buildings before the detonation of a nuclear weapon, 62.9 per cent were completely destroyed or burned in Hiroshima, 5 per cent were completely destroyed, and 24 per cent were damaged to a lesser degree. In Nagasaki, 22.7 per cent of approximately 51,000 buildings were completely destroyed or burned, and 2.6 per cent were damaged to a lesser degree. See table 4.1 in The Committee for the Compilation of Materials on Damage Caused by the Atomic Bombings in Hiroshima and Nagasaki, *Hiroshima and Nagasaki: The Physical, Medical, and Social Effects of the Atomic Bombings*, 1981, p. 57. This source quotes Hiroshima and Nagasaki city almanacs.

123 See ibid., p. 379, table 10.18 (number of medical personnel killed or injured in Hiroshima).

124 See W.C. Bell and C.E. Dallas, "Vulnerability of populations and the urban health care systems to nuclear weapon attack—examples from four American cities", *International Journal of Health Geographics*, vol. 6, no. 5, 2007.

> effects extend to much greater radii than substantial blast effects.[125]

In other words a greater proportion of burn victims (due to flash burns from the nuclear detonation and to fires started in its aftermath) could be anticipated after detonations with larger nuclear explosive yields than smaller ones. Burn victims require a lot of medical resources to treat,[126] and treatment facilities for this patient group exist to a very limited degree. In the United States for example, there are only an estimated 1,500 burn beds, and a maximum of 150 of these are potentially empty at any one time.[127] Combined with the fact that many of these victims would have other trauma, including crush or fragmentation injuries and possibly ARS—even assuming they could reach a functioning medical emergency room alive—the prognosis for successful treatment of such compound injuries would in most cases probably be bleak. An IAEA manual described the radiation, blast, and thermal injuries from a nuclear weapon detonation event as catastrophic in scale: "Medical resources will be quickly overwhelmed as most survivors will have significant traumatic injuries and thermal burns. The impact of radiation exposure will be secondary to medical management of conventional trauma".[128] In regard to radiation exposure and the difficult ethical choices this would raise for responders, an article by physicians involved in the treatment of ARS victims from the 1986 Chernobyl disaster put it succinctly:

> There is, unfortunately, little to say regarding victims exposed to more than 12 to 15 gray of ionizing radiation. These people are likely to die, and medical resources need to be focused on victims with a reasonable likelihood of survival.[129]

Some of the most serious impacts of the physical devastation wrought by a nuclear detonation event in a population centre would be the ensuing impact on emergency response and public health infrastructure. Long experience of the impacts of use of conventional explosive weapons in populated areas in areas of conflict around the world has shown the challenges this creates for diverse but related activities such as fire services, sanitation, and water delivery infrastructure due to damage to sewers and sewage treatment plants, water reservoirs, and pipes. In the particular case of nuclear weapon detonations in populated areas:

> fire-fighting facilities were almost totally destroyed in Hiroshima and Nagasaki. In Hiroshima, 70 per cent of the facilities were destroyed, and 80 per cent of the firemen suffered from the disaster. … Even when both facilities and firemen escaped disaster, blocked roads interfered with fire-fighting activity. In Nagasaki, firemen from other districts could not get within 2 kilometres of the hypocentre. One of the reasons for the expansion of fire was that water pipes were broken, causing loss of water pressure and water supply. The water pipes on the ground were cut off when structures collapsed or were melted by fire, while most underground pipes were damaged by irregular movements of the earth.[130]

Without a reliable source of water and means of delivery, including potable water for drinking and sanitation facilities, the incidence and spread of infectious disease of various kinds is raised. Combined with the radiation effects of nuclear weapon detonations, this holds particular risk for the young,[131] the very old, and those with weakened immune resistance due to

125 Ibid., p. 6.

126 See, for instance, R. Casagrande et al., "Using the model of resource and time-based triage (MORTT) to guide scarce resource allocation in the aftermath of a nuclear detonation", *Disaster Medicine and Public Health Preparedness*, vol. 5, supplement 1, 2011; R. Kearns, J. Holmes 4th, and B. Cairns, "Burn disaster preparedness and the southern region of the United States", *Southern Medical Journal*, vol. 106, no. 1, 2013. Hospitalization periods for burn victims tend to be long, as seen in the table on p. 365 of C.M. Ryan et al., "Objective estimates of the probability of death from burn injuries", *The New England Journal of Medicine*, vol. 338, no. 6, 1998.

127 W.C. Bell and C.E. Dallas, "Vulnerability of populations and the urban health care systems to nuclear weapon attack—examples from four American cities", *International Journal of Health Geographics*, vol. 6, no. 5, 2007, p. 19.

128 IAEA, *Generic Procedures for Medical Response During a Nuclear and Radiological Emergency*, 2005, p. 192, www-pub.iaea.org/MTCD/publications/PDF/EPR-MEDICAL-2005_web.pdf.

129 R.P. Gale and A. Baranov, "If the unlikely becomes likely: medical response to nuclear accidents", *Bulletin of the Atomic Scientists*, vol. 67, no. 2, 2011, p. 15. See appendix 2 of this study for an explanation of the gray as a unit of measurement.

130 The Committee for the Compilation of Materials on Damage Caused by the Atomic Bombings in Hiroshima and Nagasaki, *Hiroshima and Nagasaki: The Physical, Medical, and Social Effects of the Atomic Bombings*, 1981, pp. 56–57.

131 Committee on Environmental Health, "Radiation disasters and children", *Pediatrics*, vol. 111, no. 6, 2003.

injuries (such as ARS).[132] In addition to ARS and epidemic disease, fatalities due to complications from compound injuries could be anticipated to continue for some time. In the longer term, medical studies from the Hiroshima and Nagasaki bombings, as well as nuclear weapons testing, indicate increased rates of cancer and other medical problems for those exposed.[133]

Response and disruption costs

It is impossible to estimate the financial costs of a nuclear weapon detonation event in a highly populated area. However, a comparison with the costs of the Al-Qaida attacks of 11 September 2001, which killed some 3,000 people, helps to put its immensity in perspective. A survey the *International Herald Tribune* conducted of estimates a decade after the event put the overall economic cost of those attacks (which, used passenger jets as bombs) at USD 3.3 trillion.[134] Of that, the toll and physical damage amounted to USD 55 billion, and the economic impact cost USD 123 billion.[135] Detonation of even one low-yield nuclear weapon in New York could be more destructive than those attacks, and kill and injure more people as discussed further below. And, of course, the detonation of nuclear weapons in multiple places would be much worse.

In addition to those costs directly related to the destruction nuclear weapon detonations cause, there are those related to the economic disruption created. A nuclear weapon detonation event would, depending on its extent and location, have a cascade of effects on national, regional, and global infrastructure and systems.[136] Such an event in an important strategic location such as a capital city could decapitate political decision-making in a country, including for civil defence and emergency response. Destruction of important financial service centres would have major implications for global markets and create additional economic volatility. And of course such an event would be extremely expensive for the insurance and reinsurance industries.

There could also be major implications for global supply chains. It is a cliché that the world is becoming more interconnected, but one manifestation of this is the increasingly complex and interdependent supply chains for many materials and services. The earthquake and tsunami in Japan in 2011, for instance, affected the supply of Japanese vehicles, automobile parts, and electronic components across the globe for months. Floods in Thailand the same year disrupted supply of many items from rice to computer hard drives. Disruptions to food supplies would be most concerning, both in the shorter and longer term. It has been noted, for instance, that in recent decades the average amount of global food reserves in number of days has fallen below 100 days.[137] And, as mentioned in the first part of this study, several studies have underlined serious impacts from scenarios such as a regional nuclear war in South Asia for global climate and food production capacity for a decade or more afterward, with the poorest of the world's population most vulnerable to food hoarding practices and resultant starvation.[138]

There are also those costs related to the reaction a nuclear detonation event provokes. This includes the response costs, both in the immediate and longer term, of humanitarian assistance, if it is requested from the international community (the United States government did not request such assistance following the 11 September 2001 attacks). These humanitarian response costs, which we are not able to estimate, would have to be met somehow by states and could be very large and even unprecedented depending on the nature of the event.

---

132 Haines observed that in the medium term radiation exposure causes immunosuppression and decreased resistance to infection. See A. Haines, "Nuclear weapons: catastrophic impacts on health", presentation at the Conference on Humanitarian Impact of Nuclear Weapons, Oslo, 4 March 2013, www.regjeringen.no/upload/UD/Vedlegg/Hum/hum_haines.pdf.

133 See The Committee for the Compilation of Materials on Damage Caused by the Atomic Bombings in Hiroshima and Nagasaki, *Hiroshima and Nagasaki: The Physical, Medical, and Social Effects of the Atomic Bombings*, 1981.

134 A. Cox, "A 9/11 tally: $3.3 trillion—costs to the United States stretch far beyond the damage of the attacks", *International Herald Tribune*, 10–11 September 2011.

135 Homeland security-related costs were estimated, in addition, at USD 589 billion, and war funding and related costs at USD 1.649 trillion. See D.E. Sanger, "Grim decade's huge cost", *International Herald Tribune*, 10–11 September 2011.

136 See L.J. Dumas and T.D. Nelson, "Estimating the economic consequences of a nuclear weapons explosion: critical factors", in B. Fihn (ed.), *Unspeakable Suffering—the Humanitarian Impact of Nuclear Weapons, Reaching Critical Will*, 2013, pp. 50–51.

137 See I. Helfand, "Nuclear famine: a billion people at risk", in ibid., p. 42.

138 See A. Robock and O.B. Toon, "Self-assured destruction: the climate impacts of nuclear war", *Bulletin of the Atomic Scientists*, vol. 68, no. 5, 2012.

One of the most significant and immediate costs and sources of lasting disruption from a nuclear weapon detonation is likely to be in terms of displacement of people from their homes and local environments, with all of its downstream consequences in terms of human misery and economic loss. A large numbers of survivors will have nothing left to their names but rubble, and will require shelter, food, clean water, and medical attention for a considerable period of time. Rebuilding of communities—if it is possible due to the extent of the immediate devastation and residual radioactivity—will be a lengthy process, which means there will be need for provision of services such as education and temporary health infrastructure. In some cases, it will be more feasible to relocate communities or their remnants than to attempt reconstruction in their original location (the fate, for instance, of some indigenous communities after fallout from nuclear testing in the Pacific during the early Cold War.) Thus, the consequences of a nuclear weapon detonation event may raise migration issues as well as challenges of dealing with temporary displacement.

The trauma of a nuclear weapon detonation event and the feelings of profound dislocation and powerlessness it engenders among an affected population can have serious and even multi-generational effects, including for psychosocial health and for livelihood prospects. These have been carefully documented in Japan in the case of the Hiroshima and Nagasaki bombings—they include the breakdown of community and families, loss of general prospects (due in part to loss of wealth), the stigma attached to victims affecting their ability to find a job or marry, the orphaning of children and the elderly (the orphaned elderly, "whether or not they themselves were A-bomb victims, lost their spouses and children and thus were completely without anyone on who to depend"[139]). This was not just the case in Japan. A recent report of the United Nations Secretary-General summarized the long-term international efforts to mitigate and minimize the consequences of the 1986 Chernobyl nuclear power plant disaster (see box 11 in part 3). Even nearly 30 years after that radiological disaster, "the Chernobyl-affected areas continue to face numerous socioeconomic challenges, such as the lack of economic opportunities and stigma associated with Chernobyl and the effects of radiation. Young people and skilled workers tend to move away, investors shun the region, and joblessness is high".[140]

One recent study is worth quoting at length on the overall costs and disruption of a nuclear weapon detonation event:

> Whether it is the result of an accident, a terrorist attack, or a military strike, the explosion of a single nuclear weapon on the territory of any nation would impose economic costs at least equivalent to, and most likely well beyond, the costs of a major natural disaster. Our past experience with large-scale natural and human-induced disasters tells us by analogy that the resulting economic costs depend strongly on the population density and the nature and extent of economic activities carried out in the zone surrounding the site of the explosion. In a key urban area, the costs of the immediate destruction and longer-term economic disruption inside and potentially far outside of that area could easily run into tens of billions—and possibly as high as hundreds of billions—of dollars.
>
> Were this disaster to be the result of a deliberate attack, it is not difficult to imagine that extraordinary pressure would be generated for the government of the country struck to take some form of strong action in response. The additional economic costs imposed by that action would almost certainly be high, and should it degenerate into all-out war between two nuclear-armed rivals, the costs would be virtually incalculable.[141]

Moreover, responding to the impacts of a nuclear weapon detonation would likely divert attention and resources away from existing global priorities, including development, as enshrined in the Millennium Development goals or after 2015 the Sustainable Development Goals. Acheson has argued, for instance, that the "humanitarian consequences of the use of nuclear weapons would have a particularly devastating impact on poor and vulnerable communities in both the immediate aftermath of the incident and the long-

139 The Committee for the Compilation of Materials on Damage Caused by the Atomic Bombings in Hiroshima and Nagasaki, *Hiroshima and Nagasaki: The Physical, Medical, and Social Effects of the Atomic Bombings*, 1981, p. 444.

140 United Nations, *Optimizing the International Effort to Study, Mitigate and Minimize the Consequences of the Chernobyl Disaster: Report of the Secretary-General*, UN document A/68/498, 3 October 2013, p. 3.

141 L.J. Dumas and T.D. Nelson, "Estimating the economic consequences of a nuclear weapons explosion: critical factors", in B. Fihn (ed.), *Unspeakable Suffering—the Humanitarian Impact of Nuclear Weapons*, Reaching Critical Will, 2013, p. 55.

term".[142] UNDP, for its part, has stated concern that a nuclear weapons detonation event:

> has the potential to cause massive human fatalities, major economic disruption, and global food shortages through environmental effects and infrastructural destruction. So while there may be some uncertainties among scientists in their predictions on the scale and nature of the effects, we know that the consequences will be severe, that they will hamper human development and that our ability to address these consequences will be inadequate.[143]

Challenges for humanitarian response

So far, the generic impacts of the detonation of nuclear weapons have been discussed. While such detonations point to the likelihood of very serious humanitarian consequences, especially if used in densely populated areas, there are many different variables. Therefore it is helpful to move from the general to particular illustrative scenarios in order to unpack challenges to humanitarian response and how these might vary. To that end, in this section, seven scenarios are discussed in which a nuclear weapon detonation event occurs. Several points are important for the reader to bear in mind:

- This study is intended to help policymakers understand the kinds of challenges posed for humanitarian coordination and response systems as they stand, rather than how the humanitarian system should respond to a nuclear weapon detonation event.
- The selection of these scenarios reflects input from a number of experts including this project's advisory group, scenarios sometimes discussed in the contemporary policy literature, and those that we observe tend to be raised when nuclear weapon effects arise in public discourse, for instance in the media. Brief descriptions of the nuclear weapon detonation event are for the purposes of backstory only. By choosing these scenarios we are not implying that these are more or less likely than other nuclear weapon detonation events, nor do we mean to single out particular states beyond mentioning them for the purposes of illustration. What interests us most is not how the nuclear weapon detonation event necessarily came about, but the kinds of humanitarian challenges the humanitarian system could foreseeably expect to face.
- This small set of scenarios is by no means the sum total of potential nuclear weapon detonation event scenarios—it is simply a set drawn up on the basis of these scenarios being plausible. In other words, taken individually and as a set, the scenarios are indicative of the kinds of nuclear weapon detonation events humanitarian responders might see.
- Six of the seven scenarios entail the detonation of a single nuclear weapon. This is for practical reasons rather than because single nuclear weapon detonation events are necessarily more likely. (Indeed, in view of the tightly coupled nature of nuclear weapon control systems and the fact that many weapon delivery vehicles such as missiles and bombers can carry multiple nuclear weapons it should certainly not be taken as given.) One reason is that single detonation events are more straightforward to assess in terms of their consequences. Second, if a single nuclear weapon detonation would pose severe humanitarian response and coordination challenges for the United Nations, then it can be inferred that the use of multiple weapons would be correspondingly worse.
- In order to try to minimize repetition, not all of the seven scenarios go into the same level of detail.

Three scenarios: single nuclear detonations in rural areas

Let us now turn to three scenarios in which a single nuclear weapon is detonated in a sparsely populated area either at ground level or in an airburst. We equate a sparsely populated area here with a rural area, although we recognize it is not synonymous in all cases. (There are rural areas of intensive cultivation, for instance such as rice paddies, which might have significant numbers of people present.)

The scenarios we considered in our research were:

- Detonation of a low-yield (1kt) nuclear weapon at ground level. This might be carried out, for instance, by a state

142 R. Acheson, "Wide consequences—impact on development", in B. Fihn (ed.), *Unspeakable Suffering—The Humanitarian Impact of Nuclear Weapons*, Reaching Critical Will, 2013, p. 65.

143 S. Sekkenes, *UNDP Statement on the Challenges of a Nuclear Weapon Detonation to National, Regional and Global Economic Growth and Sustainable Development at the Second Conference on the Humanitarian Impact of Nuclear Weapons*, Nayarit, Mexico, 13–14 February 2014, www.sre.gob.mx/en/images/stories/cih/undp.pdf.

possessing high-accuracy targeting in order to destroy a hardened facility in a comparatively isolated area. In this scenario, an isolated nuclear blast occurs in a remote region of China where (for the purposes or our scenario) an intercontinental ballistic missile silo or a command centre is located.

- Detonation of a 20kt nuclear weapon by a state seeking to destroy unhardened targets such as buildings, armoured vehicles, missile launchers, aircraft, and runways over an area such as a military base,[144] or military formations in the field. Such a scenario could arise, for instance, as a consequence of escalation of a military conflict in which nuclear weapons are used to destroy concentrations of conventional military forces. This scenario has the weapon detonated at an altitude of 500m at a randomly selected point in rural Pakistan. This airburst would produce much less fallout than a groundburst detonation of equivalent nuclear explosive yield.
- Detonation of a 500kt nuclear weapon. Plausible scenarios include a strike against hardened missile silos (or multiple silos), or an accident with a silo-based missile. In these respects, it is notable that China, the Russian Federation, and the United States all maintain land-based intercontinental ballistic missile forces in rural areas of their territories.[145] In the case of the United States, Schlosser noted that although there have not yet been inadvertent nuclear detonations involving silo-based missiles, there have been serious accidents involving the destruction of missiles and silos that point to the possibility of catastrophic failure resulting in a nuclear detonation event. Similarly, fires on the runway or air crashes involving the destruction of United States bombers carrying thermonuclear weapons have occurred on several occasions.[146] In this illustrative scenario, a detonation occurs close to a possible missile site in the south of the Russian Federation.

What, if any, particular challenges for humanitarian coordination and response could be foreseen in these scenarios? Some have supposed that the harm to civilian populations is unlikely to be large scale in view of the projected low population densities of such areas, thus limiting the number of people who would be caught within zones affected by blast, thermal radiation, and prompt radiation. However, this view has to be set against several observations. The first observation is that nuclear weapons detonated at ground level (or just beneath it) could cause seismic waves that collapse or cause less severe structural damage to buildings in the vicinity.[147]

The second observation is that casualties could be expected to occur due to ionizing radiation from local radioactive fallout in each of the groundburst rural scenarios outlined above. (Significant radioactive fallout appears less likely in the airburst scenario.[148]) This fallout would pose significant hazard to people in the first few hours after the detonation event in the areas surrounding the nuclear detonation, which would leave little time for their evacuation before harm to their health occurred. Local authorities would have to act quickly, or risk hundreds or thousands of people made sick (or worse) from fallout if they are present. Provision would have to be made for their care, including monitoring for symptoms of radiation-related illness and treatment, which might require international help. Crops and animals would probably have to be left, and those remaining would be unsafe for sale or consumption—leading to economic losses for local, affected communities down the line.

In the two groundburst scenarios, radioactive fallout could spread for hundreds or even thousands of kilometres contingent on wind strength or factors such as precipitation. Depending on the terrain, wind direction, and the proximity of higher-population areas such as towns and cities, fallout could blow over areas in

144 Of course, military bases often attract a non-military population—something not factored in here.

145 See http://nuclearforces.org/unidir. See also, H.M. Kristensen, R.S. Norris, and M.G. McKinzie, “Chapter 4: simulated U.S. and Chinese nuclear strikes”, in *Chinese Nuclear Forces and U.S. Nuclear War Planning*, Federation of American Scientists and NRDC, 2006.

146 E. Schlosser, *Command and Control*, 2013.

147 R.W. Nelson, “Low-yield earth-penetrating nuclear weapons”, *Science and Global Security*, vol. 10, 2002, p. 18. This vicinity is not likely to be very large in the case of a 1kt detonation compared to larger nuclear weapons. However, Nelson argued that the physics of destroying buried structures means that, whatever the policy discourse around “mini-nukes”, in reality larger-yield nuclear weapons are likely to be required to destroy deeply buried or protected targets.

148 See figures 3 and 4 on p. 6 of the appendix to K.A. Lieber and D.G. Press, “The nukes we need: preserving the American deterrent”, *Foreign Affairs*, vol. 88, no. 6, 2009.

which large populations require evacuation and emergency shelter, food, water, and medical care. Wind direction and speed is not consistent, and so changes in these factors during the hours, days, and weeks following the detonation event could exacerbate these consequences by blowing over different areas at differing times, which would add to the challenges for humanitarian actors in establishing safe environments for displaced populations and protecting their own staff from exposure. Thus, a challenge for the humanitarian system would be in ensuring a reliable and timely system for fallout tracking that translated such data into actionable guidance in near real time on the ground, as a component of humanitarian coordination.

A third observation is that it cannot be assumed that detonation of a nuclear weapon in a rural area would not have serious humanitarian consequences. This is due to the scale of the explosion, particularly of a high-yield weapon. For example, although the south-eastern area of the Russian Federation bordering Kazakhstan in the 500kt groundburst scenario is scarcely populated, up to several thousand people could be affected by the prompt radiation, blast, and thermal effects because of the large yield of the detonation. The number of people who would need guidance, assistance, and possibly evacuation due to nuclear fallout, which could be lofted thousands of kilometres, would be in addition to this. It is difficult to estimate the consequences for other populated areas and agriculture, but it could include a zone encompassing parts of the Russian Federation, Kazakhstan, Turkmenistan, and Uzbekistan. As agriculture constitutes a high proportion of the employment of those in the area, the regional economy would probably suffer significantly.

Of course, it is important to recall that the scenarios discussed refer to single nuclear weapon detonations. Scenarios in which multiple nuclear detonations occurred, whether due to deliberate or inadvertent use, would see greater consequences, including in the level of radioactive fallout if groundbursts. Moreover, detonations in military-designated areas (whether shown to be deliberate or inadvertent) might result in reluctance by authorities in the state on whose territory the detonation occurred to permit humanitarian assistance from outside or place particular constraints upon it, which could create additional challenges for helping those affected.

Three scenarios: single nuclear detonations in urban areas

If it is possible to conceive of situations in which the immediate consequences of a single nuclear weapon in a rural area do cause an immediate humanitarian crisis, in contrast a nuclear weapon of even low yield (1kt) detonated in an urban area would have major consequences. The scale of physical destruction, casualties, and disruption to services, as well as delayed effects such as radioactive fallout, would create extreme stress on and damage to critical societal infrastructure. Local emergency response assets and medical facilities, if not destroyed or rendered non-functional by the detonation, would be inadequate to the scale of the task of assisting all of the victims. Yet assistance from further afield nationally would be likely to take days to arrive in significant amounts, at a minimum—even in countries in which considerable thought has been given to the challenges of responding to the consequences of such an event.[149] Moreover, a nuclear detonation event in a major urban centre such as a national capital could conceivably decapitate central emergency response authority. This would exacerbate the challenges for humanitarian coordination and responders.

Assistance would (if requested from the humanitarian system, that is) probably not arrive "on the ground" in the immediate aftermath of a nuclear weapon detonation event. Mechanisms for rapid international disaster relief functions such as urban search and rescue exist for natural events such as earthquakes,[150] but residual radiation and the political context in which a nuclear weapon detonation event might occur suggest their

149 See, for example, Executive Office of the United States President, *Interagency Policy Coordination Subcommittee for Preparedness and Response to Radiological and Nuclear Threats Planning Guidance for Response to a Nuclear Detonation*, Federal Emergency Management Authority, 2010, p. 11, www.epa.gov/radiation/docs/er/planning-guidance-for-response-to-nuclear-detonation-2-edition-final.pdf.

150 United Nations Disaster Assessment and Coordination (UNDAC) is part of the international emergency response system for sudden-onset emergencies. UNDAC teams can deploy at short notice (12–48 hours) anywhere in the world. They are provided free of charge to the disaster-affected country, and deployed upon the request of the United Nations Resident or Humanitarian Coordinator or the affected government (see www.unocha.org/what-we-do/coordination-tools/undac/overview). UNDAC may coordinate urban search and rescue teams provided from the International Search and Rescue Advisory Group, a network of disaster-prone and disaster-responding countries and organizations dedicated to urban search and rescue and operational field coordination.

applicability would be in some doubt. Currently, most such teams are not trained or equipped for radiological environments. It would, moreover, be very difficult to function wearing hot, heavy, and bulky radiation protection gear let alone provide meaningful assistance. Arriving in a timely manner to assist could also be a considerable challenge—safety concerns and the objections of insurers may be issues, not to mention the question of where vessels with relief personnel and supplies could disembark without hazard since airports, ports, and roads could be damaged.

Meanwhile, most specialized CBRN military units are optimized for force protection rather than humanitarian assistance. There would likely be soul-searching by governments about the wisdom or efficacy of sending their teams into hazardous post-nuclear weapon detonation environments, probably resulting in marked reluctance to do so. Moreover, a major fear in the aftermath of a nuclear weapon detonation event could be: will there be more? Concern about further nuclear weapon detonation events might make states not directly affected even more reluctant to commit their limited, relevant response assets. Taken together, these factors mean it may be hard to take much for granted about the automaticity of humanitarian assistance as the dust settles after a nuclear weapon detonation event.

Fire and debris are two major problems that would arise in terms of emergency and later humanitarian response to the consequences of a nuclear weapon detonation in any urban area. Many fires would be caused by the intense thermal radiation from the nuclear weapon detonation. Experience from the Hiroshima and Nagasaki bombings shows such fires are likely to spread unless checked by emergency services. These fires could kill and injure many additional people, and add considerably to the destruction. Yet the huge amount of debris created by the blast and the afterwinds from a nuclear detonation would likely block transport arteries, including roads, throughout the zones of complete and severe destruction, and of heavy damage. Roads would be at least partially blocked in zones of lighter damage. This would impede surviving fire fighters in responding to fires, or in repairing crucial infrastructure such as water mains.

A few of the humanitarian personnel we spoke to in research for this study suggested that these effects are analogous to major natural disasters such as earthquakes or tsunamis. It is true that an urban area following a nuclear weapon detonation might partially resemble a natural disaster. Major differences are that nuclear detonations also release massive amounts of radiation, and can lead to radioactive fallout, which has major consequences for effective response. A nuclear detonation event would also differ from a civil radiological emergency like a reactor meltdown for this reason, in addition to the great physical destruction over a wide area caused instantaneously by the blast and thermal radiation. Moreover, fear of radiation among the surviving population (and possibly of further nuclear weapon detonations) might result in behaviours that significantly impede humanitarian assistance in ways that differ from other sudden onset major disasters.

Can we estimate casualties? Yes, but studies even of the effects of single nuclear weapon detonations in highly populated areas vary widely in their estimates of immediate casualties, and these often use differing methodologies in their simulations.[151] For example, a RAND Corporation study of a scenario on which a 1kt nuclear weapon in a truck is detonated in the middle of a United States city with a population of 1 million to 5 million people without many skyscrapers suggests around 20,000 casualties, of which 10,000 would be fatalities.[152] It is not clear whether the model used to calculate those effects took into account casualties due to subsequent fires caused by the detonation.[153] And subsequent casualties, say from radioactive fallout or secondary consequences such as lack of food, water, or shelter, or disease must be considered separately, at least in part because they depend on how well organized the humanitarian response is. Nevertheless, figure 4

151 Some recent studies include R. Moyes et al., *Humanitarian Consequences: Short Case Study of the Direct Humanitarian Impacts from a Single Nuclear Weapon Detonation on Manchester, UK*, Article 36, 2013, www.article36.org/wp-content/uploads/2013/02/ManchesterDetonation.pdf; D. Lalanne, *Et si une bombe nucléaire explosait sur Lyon*, Observatoire des armaments, 2013; W. van der Zeijeden and S. Snyder, *The Rotterdam Blast: The Immediate Humanitarian Consequences of a 12-kiloton Nuclear Explosion*, Pax Netherlands, 2014. In addition, the publications mentioned in part one of this study help to illustrate this point.

152 L.E. Davis et al., *Individual Preparedness and Response to Chemical, Radiological, Nuclear, and Biological Terrorist Attacks*, Monograph Reports no. MR-1731/1-SF, RAND Corporation, 2003, appendix A, pp. 95–98.

153 For a discussion of the evolution of United States models to calculate nuclear weapon effects, see L. Eden, *Whole World on Fire: Organizations, Knowledge, and Nuclear Weapons Devastation*, 2004.

offers a rough indication of the magnitude of immediate casualty numbers.

Figure 4: Immediate casualty numbers

Description	Range of immediate casualties
1kt groundburst in urban area	Tens of thousands
20kt airburst in urban area	Tens of thousands to more than one hundred thousand
500kt airburst in urban area	Hundreds of thousands

How much worse would a 20kt or 500kt nuclear weapon detonation in an urban area be in humanitarian terms than a 1kt detonation of the kind mentioned above? We compared the effects of a single nuclear weapon detonation of differing yields if it had its hypocentre at the Palais des Nations, the European home of the United Nations in Geneva, Switzerland. To do so we used Nukemap, a nuclear weapons effect simulator for Google Earth (see box 4). These results are listed in figure 7.

Box 4: Alex Wellerstein's Nukemap

This study draws on a range of scenarios from differing sources to explore the humanitarian effects of nuclear weapon detonations. In this section we used a publicly available online tool developed by an American nuclear historian, Alex Wellerstein, to estimate the effects of nuclear weapons of varying yields. These hypothetical nuclear weapons were detonated at or above the Palais des Nations in Geneva. Nukemap estimates prompt effects of single nuclear detonations. Resulting fallout is also estimated using a scaling model. There are other methods to estimate the effects of nuclear weapon detonations, but we chose to use Nukemap because it is easy to use, and Wellerstein is transparent about his methods and sources of data. The tool is available at http://nuclearsecrecy.com/nukemap.

Wellerstein is upfront about the limitations of using Nukemap to estimate effects: "in choosing a model I went with one that could relatively straightforwardly be implemented given the data I have available, and was backed by at least one serious source. So I thoroughly encourage you to take these numbers with a grain of salt—they [merely] give some indication of how many people live in reasonably close proximity to the selected ground zero".[154] In view of that, although in figure 6 the reader will see that Nukemap estimates deliver precise numbers, these should be read as notional only, especially as there are limitations in the models used to produce them such as a lack of precise topography modelling, including how built-up the area is. One obvious variable that is not handled within Nukemap is the time of day the detonation occurs: in many urban areas the population density ebbs and flow significantly over any given 24-hour period. It should also be noted that Nukemap's casualty estimates do not include those from fallout. And fallout measurements themselves are calculated using a scaling model, which is very approximate. Rad levels cited are 1 hour after the detonation.

A 1kt nuclear weapon groundburst detonation

A 1kt nuclear weapon detonation, according to Nukemap, would create a fireball 160m across, and create blast overpressure sufficient to level most of the 80-year-old Palais des Nations complex and damage buildings around it in the international organization district (see figure 5). More than 6,000 people would be immediately killed or injured depending on the time of day. Anyone within 500m of the detonation, if not killed outright by the blast, would receive 3rd degree burns as well as a lethal dose of radiation (5000 rem).[155] Anyone within almost one kilometre (840m) of the hypocentre would receive a dose of radiation sufficient to cause radiation sickness, which without immediate medical treatment would more likely than not result in death within days or weeks. Moreover, radioactive fallout from the detonation would create a plume blowing out from the location of the blast. Fortunately for the rest of Geneva, in the simulated blast the wind takes the plume out over Lake Leman rather than across the rest of the city. But this plume would drift up the lake and over Yvoire, a French village, at the rate of exposure of 1 rad per hour in the hours following the detonation. Anyone between the Palais grounds and the lake, however, (for instance, in the Geneva botanical gardens, at the World Trade Organization, or in the World Meteorological Organization building) soon after the detonation, could receive up to 1000 rad per hour, which would quickly be fatal.

154 See http://nuclearsecrecy.com/nukemap/faq/.
155 See appendix 2.

Figure 5: Zone of direct effect of a 1kt groundburst nuclear detonation in the vicinity of the Palais des Nations

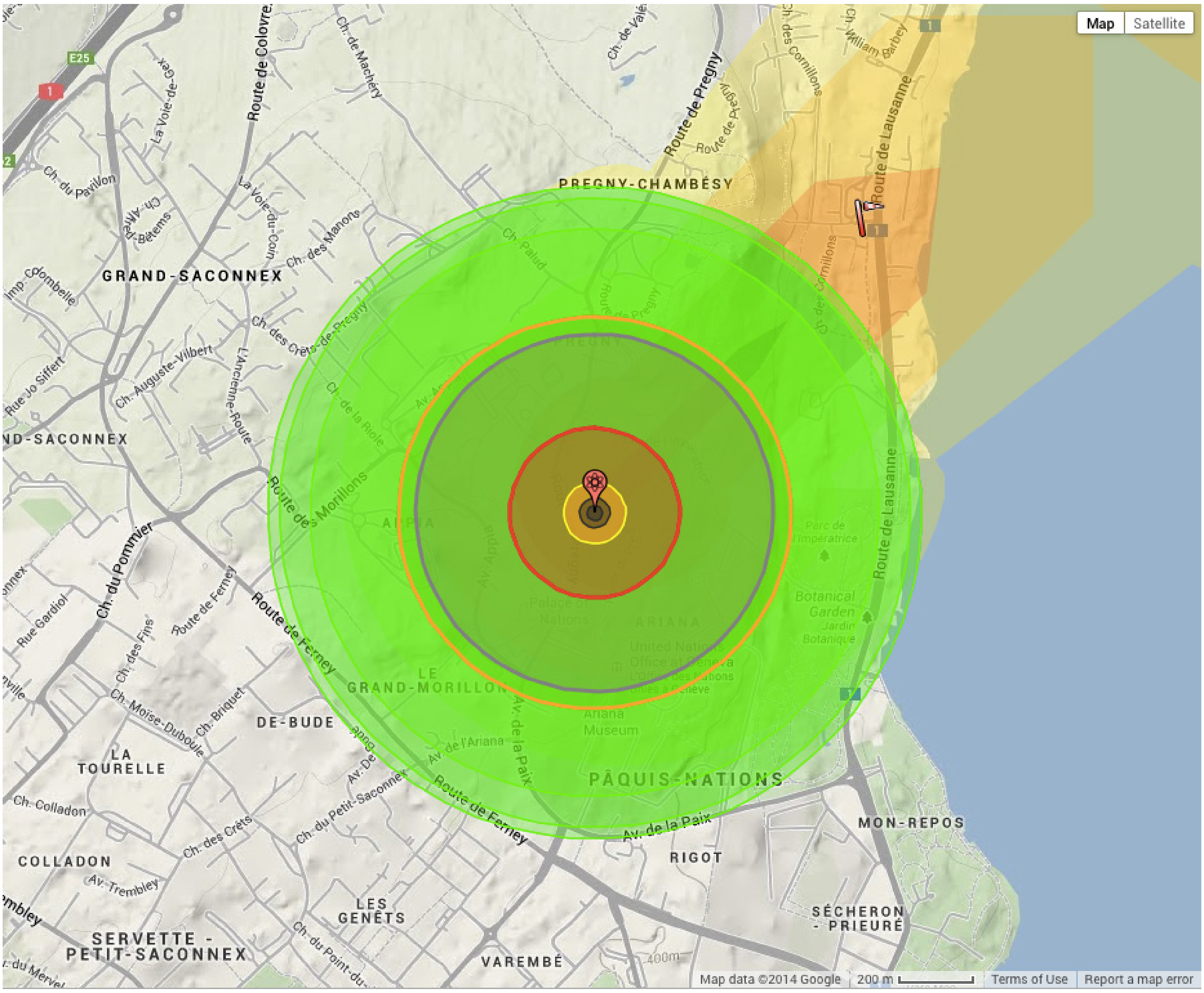

Image courtesy of Alex Wellerstein (Nukemap) and Google Maps. The orange zone illustrates the size of the fireball. The next zone is the 3rd degree burn thermal radiation radius. The green zone illustrates an area exceeding 500 rem. Intermediate lines represent fallout contours. The zone in the top-right of the map is the fallout plume.

20kt nuclear weapon detonation (groundburst and airburst)

Compare this with a roughly Nagasaki-sized detonation (20kt) 500m above the Palais des Nations. Nukemap estimates this could cause almost 26,000 deaths, and more than 73,000 injured people. The nuclear fireball, 400m across, would destroy most residential buildings within 1.75km. Anyone within 2.2km caught in the open would receive 3rd degree burns. In contrast to the 1kt detonation scenario, this zone of thermal radiation is now larger than the high-blast overpressure zone (5psi or above) or zone of prompt, lethal radiation. Very large numbers of people would lie injured with terrible burns all over their bodies, blinded and some with injuries from being hit by debris, or flung against unyielding surfaces. Multiple fires would start, and the remains of buildings in Geneva's densely packed neighbourhoods would permit these to spread quickly if unchecked by fire fighters. Geneva's airport—not far from the Palais—would be at least temporarily knocked out of action, and Geneva's railway and road links to the rest of Switzerland would be damaged. However, because the detonation was an airburst, there would probably not be immediately life-threatening radioactive fallout to contend with.

Unfortunately, the world has already experienced two nuclear airburst attacks on urban areas—on Hiroshima and Nagasaki. These detonations illustrate that effects can differ significantly in terms of immediate casualties although both bombs resulted in many tens of thousands, with longer-term deaths and illness significantly higher (see box 3 earlier in part two). However, though the "Fat Man" nuclear bomb dropped on Nagasaki (18–20kt) had a larger explosive yield, Hiroshima's flatter terrain resulted in more deaths and injuries from the "Little Boy" weapon, which had a yield estimated at around 13kt. This illustrates the importance of terrain effects.

If one compares a 20kt Geneva airburst with a 20kt groundburst detonation in the same location, it also underlines the importance of altitude of burst as a variable. The immediate death and injury from a 20kt groundburst at the Palais would be considerably less (around half the estimated number of fatalities and injuries of the airburst). The 20psi and 5psi blast radii are also smaller. However, in the case of a groundburst more radioactive debris would be deposited in the vicinity of the explosion, so the radiation doses would be higher. Assuming a moderate prevailing wind again blew fallout over Lake Leman rather than the city of Geneva, it would be considerably larger than in a 1kt detonation—the 1 rad per hour exposure plume being several kilometres wide and reaching a maximum extent of around 125km, spreading fallout over much of Western Switzerland.

500kt airburst detonation

Despite being an airburst, a 500kt detonation at 500m of altitude above the Palais would also create fallout due to its high yield.[156] (In fact, the resulting airborne fireball would actually touch the ground because of its diameter.) Its 1 rad exposure fallout plume would extend 30km further than a 20kt ground burst would under the same conditions. Moreover, it would create a 100 rad per hour plume north-east for more than 50km, over the lake, the sizeable French town of Thonon-les-Bains, and beyond to Lausanne, a Swiss city of approximately 125,000 inhabitants. However, these hazards would be dwarfed by the direct consequences of the detonation (see figure 6), which would directly affect more than 540,000 people in and around Geneva. More than 144,000 would be killed, and at least 177,000 injured according to Nukemap's estimate. Metropolitan Geneva (on both sides of the river Rhône) would be largely destroyed, including at least 6 hospitals, 112 schools, and 36 places of worship. Bridges across the Rhône in the city centre would be rendered impassable. The airport would be heavily damaged, and the highway on both the Swiss and French sides of the border blocked with damaged and abandoned vehicles. Many fires would spread, both through the remains of urban areas and leafy suburbs, unhindered by Geneva fire-fighters because most of them would be dead, or if not, probably stranded by roads made impassable by debris. Any survivors between the airport and the lake would likely have received a prompt radiation dose in excess of 500 rem, which without medical treatment can be expected to cause between 50–90 per cent mortality from acute effects alone, even assuming an absence of other trauma such as burns or other wounds.

156 Nukemap estimates this fallout to be equivalent to a 40kt surface burst.

Figure 6: Zone of direct effect of a 500kt airburst nuclear detonation in the vicinity of the Palais des Nations

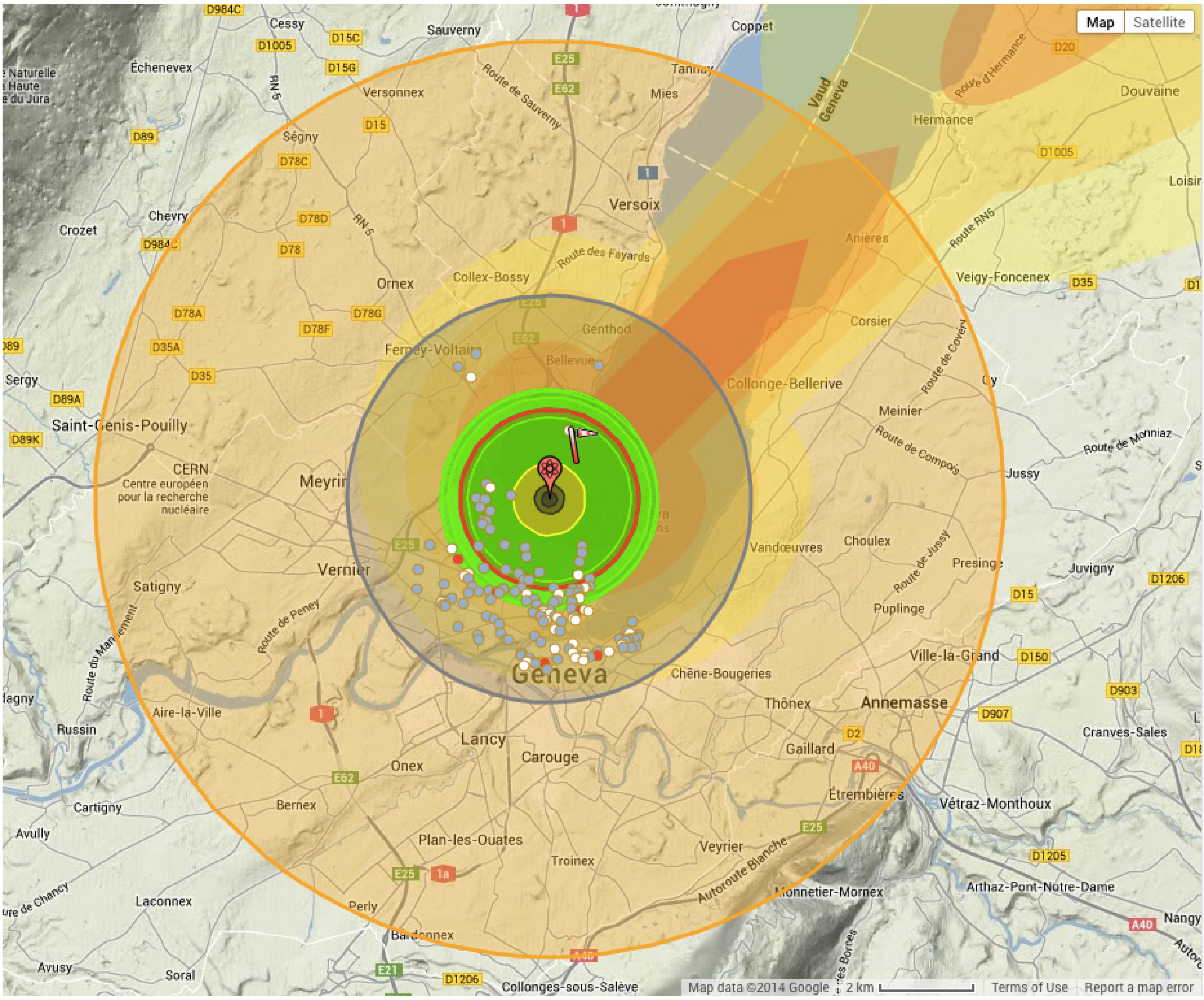

Image courtesy of Alex Wellerstein (Nukemap) and Google Maps. The yellow zone illustrates the size of the fireball. The green zone illustrates an area exceeding 500 rem. Intermediate lines represent fallout contours. The outer orange zone is the 3rd degree burn thermal radiation radius. The zone in the top-right of the map is the fallout plume.

The sheer magnitude of the humanitarian need following a nuclear weapon detonation of the sort described above would be massive, especially in the 20kt and 500kt scenarios. Tens or hundreds of thousands of injured and sick people would require immediate assistance, and would be largely dependent on their own efforts to reach help. Many of those people would subsequently die due to the effects of radiation, as well as multiple trauma, without intensive and specialized medical assistance. The geography of the Geneva region would mean that any humanitarian response of the scale needed would, by necessity, be international in view of the proximity of France and (a little further away) Italy as direct primary transport links to the rest of Switzerland would be disrupted, and Swiss assistance might have to pass through zones of radioactive fallout to reach Geneva. The inhabitants of Geneva would find themselves dependent upon their French and Italian neighbours for emergency shelter, food, and medical care.[157]

157 It is also notable that Geneva, as the centre of operations for much of the international humanitarian system, would be effectively decapitated. For instance, the ICRC's headquarters are across the road from the Palais des Nations, and both complexes of buildings would be totally destroyed in the 20kt and 500kt scenarios, and heavily damaged in the 1kt scenario. The headquarters of UNHCR is only a few hundred metres from the Palais des Nations.

Figure 7: Notional estimates of effects of a nuclear detonation at the Palais des Nations in Geneva in four scenarios

	1kt groundburst	20kt groundburst	20kt airburst	500kt airburst
Estimated fatalities	1,530	13,150	25,990	144,640
Estimated injuries	4,690	42,680	73,050	177,690
People within 1psi range in given 24-hour period	20,001	123,525	224,153	542,995
Effects radius				
Fireball radius	80m	260m	200m	730m
Airblast radius (20psi)	220m	590m	760m	1,820m
Airblast radius (5psi)	460m	1,240m	1,720m	4,140m
Range of 3rd degree burns from thermal radiation	0.5km	1.91km	2.21km	9.31km
Radiation radius[158]				
5000 rem[159]	0.51km	0.97km	0.83km	1.67km
1000 rem	0.73km	1.27km	1.17km	2.07km
600 rem	0.81km	1.37km	1.27km	2.19km
500 rem	0.84km	1.41km	1.31km	2.24km
Fallout max distance (15mph/24.14km)				
1 rad per hour	47.7km	123km	Minimal	153km
10 rad per hour	27.5km	80.km	Minimal	102km
100 rad per hour	7.36km	37.4km	Minimal	52.2km
1000 rad per hour	0.7km	5.99km	Minimal	7.51km

The source for this table is Nukemap by Alex Wellerstein. All numerical figures are notional, for instance not taking into account factors such as variations in population density due to time of day.

Geneva has been used here as a convenient example. Many of the analyses publicly available today focus on broadly similar urban areas in population density and types of building construction of those found in Europe and North America. (North American studies often use 10,000 inhabitants per square kilometre as an assumption. Geneva's is a little higher than this at 11,816.3 inhabitants per square kilometre in 2013.[160]) The population density of cities in other parts of the world is often much higher, however, and some have less resilient national transportation links and emergency response infrastructure, along with lower standards of building construction, which could impede humanitarian access.[161]

It stands to reason that the higher the population density of an urban area the more people will be directly impacted by the effects of a nuclear weapon detonation in that location. Mumbai, for instance, has a reported population density of around 23,000 people per square kilometre, which means more than twice as many people might be killed and injured immediately by a

158 See appendix 2 for explanation of radiation terminology and units.

159 According to the United States Nuclear Regulatory Commission, the dose of radiation expected to cause death to 50 per cent of an exposed population within 30 days (LD 50/30, with "LD" meaning lethal dose) is typically in the range of 400–450 rem (4 to 5 sieverts) received over a very short period. See www.nrc.gov/reading-rm/basic-ref/glossary/lethal-dose-ld.html. However, serious medical effects occur at much lower levels than this.

160 See http://www.media-stat.admin.ch/maps/profile/profile.html?226.6621.en.geoRefStandard.

161 O.B. Toon et al., "Consequences of regional-scale nuclear conflicts", *Science*, vol. 315, 2007, pp. 1224–1225.

nuclear detonation of a given yield as in Geneva.[162] Moreover, it has been observed that official Indian census figures tend to significantly undercount, and there are areas of Mumbai where population density is much higher than 23,000 per square kilometre.[163] A nuclear detonation during the day would also catch many commuters from other cities not counted in census data. Consequently, Ramana has argued that:

> The explosion of a Hiroshima-sized (15kt) nuclear weapon over Bombay would result in 150,000 to 800,000 deaths within a few weeks from the combined effects of blast, burn, and radiation. A weapon with a yield of 150 kilotons could cause between 2,000,000 and 6,000,000 deaths. The use of nuclear weapons over any densely populated city in South Asia would result in similar casualty figures. Fallout-related cancers and other illnesses would increase the casualty totals over time. Treatment of blast, burn, and radiation injuries in a region with relatively few physicians and hospital facilities would be compromised further by the devastation of medical and transportation infrastructures.[164]

Beside population density, the varying nature of infrastructure of urban areas is also a variable that should be considered. While the centres of metropolises in many developing countries increasingly resemble those of major cities such as New York, this is usually not the case for the majority of their sprawling land area in which flimsily built shantytowns and substandard buildings may be the norm, and heating and cooking uses wood or natural gas cylinders prone to combustion in the event of a nuclear detonation. Factors such as these suggest that casualties from a nuclear weapon detonation event in urban areas in developing parts of the world could be even higher than in a city such as Geneva, and the challenges of coordinating humanitarian response and access more difficult.

It is clear from the discussion above that the consequences of even a single nuclear weapon detonation in a highly populated area would have profound humanitarian consequences. By the time international assistance begins to arrive, the immediate effects of the nuclear weapon would already have caused massive death, injury, and destruction. Some of those who survived the detonation would die for want of rescue or medical attention. Fallout and mass human displacement would be major issues to contend with, as would longer-term medical care—much of it unavoidably palliative—as survivors of the detonation die of the effects of multiple trauma, ARS, and later elevated levels of cancer and other problems. Psychosocial issues such as depression and post-traumatic stress disorder will affect a significant number of people.

It is conceivable that some states could feasibly handle these issues without international assistance in the case of a 1kt urban detonation, and perhaps even a 20kt detonation. Most states could not—let alone manage the human costs of a 500kt nuclear weapon detonation unassisted. This is underlined by a study by United States experts who modelled urban population movement into surrounding areas after an IND detonation in Manhattan, New York. Among its findings, the study suggested that, following such an event, suburban and rural communities could be overwhelmed by evacuees from the centre city, and that just providing basic services would stretch local communities to their limits and beyond.[165] Some of the same experts also noted that despite such a scenario being one of the 15 national disaster scenarios planned for by the United States federal government, the scale and scope of the effort and resources required to respond to a nuclear detonation remain largely beyond the capacity of any local jurisdiction or region.[166]

The study mentioned above highlighted two other points that are especially relevant to the United Nations system, in our view. The first is the urgency of educating and communicating with the public about radiation hazards. Not only might this mitigate panic and hysteria and encourage people to act to protect themselves to the extent possible under the circumstances, it anticipates the ways in which a mass exodus

162 Although it must be noted that there is a range of factors that would influence this ratio including whether the blast occurred in a location among tall, solid buildings (which would partially block the wider effects of the blast and thermal radiation), weather, and time of day.

163 M.V. Ramana, "Effects of a nuclear blast over Bombay", in B. Fihn (ed.), *Unspeakable Suffering—The Humanitarian Impact of Nuclear Weapons*, Reaching Critical Will, 2013, p. 96.

164 Ibid., p. 94.

165 See M. Meit et al., "Rural and suburban population surge following detonation of an improvised nuclear device: a new model to estimate impact", *Disaster Medicine and Public Health Preparedness*, vol. 5, supplement 1, 2011.

166 I. Redlener, D.M. Abramson, and D. Culp, *Day 30: The Impact of Mass Evacuations on Host Communities Following Nuclear Terrorism*, Institute of Medicine of the National Academies, 2013, p. 18.

could disrupt or even cripple rescue and response efforts. Second, there is a need for policymakers to think about the possibly unprecedented kinds of political and bureaucratic decisions that would need to be taken—and quickly.

Scenario: a regional nuclear war in South Asia

In view of the challenges a single nuclear weapon detonation in a highly populated area would pose, it appears unlikely that any state could handle the consequences for its population of the detonation of nuclear weapons in multiple urban areas within its own capacities and resources. Yet it is also difficult to see how the humanitarian system could offer adequate assistance on the ground in light of the scale of need and its immediacy, the risk of further use of nuclear weapons, the hazards to humanitarian personnel (including the risk of further use), and the likely destruction of infrastructure such as ports, airports, roads, and rail links necessary for delivering significant quantities of practical aid.

The scale of the humanitarian challenge is underlined by studies of hypothetical regional war scenarios in geopolitically tense areas of the world such as the Middle East and South Asia. These studies indicate millions of immediate deaths and the obliteration of many cities as a result of regional conflicts using one hundred nuclear weapons or less[167]—let alone a large-scale nuclear war in which those thousands still remaining in the American and Russian arsenals are used.[168] Aspects of such studies are inevitably speculative to some degree, despite their use of sophisticated computational models, but they are notable here because they serve to highlight additional challenges nuclear conflict would create for the humanitarian system. In particular, Robock, Toon, and others have modelled the consequences of a nuclear conflict between India and Pakistan in which each uses 50 15kt weapons, predominantly against the others' urban areas:

> such an exchange between India and Pakistan could produce about 21 million fatalities—about half as many as occurred globally during World War II. The direct effects of thermal radiation and nuclear blasts, as well as gamma-ray and neutron radiation within the first few minutes of the blast, would cause most casualties. Extensive damage to infrastructure, contamination by long-lived radionuclides, and psychological trauma would likely result in the indefinite abandonment of large areas leading to severe economic and social repercussions.[169]

Since we have already described the direct effects of nuclear weapon detonations in urban areas, it is to considering some broader repercussions that we now turn.

Displacement

Multiplied 50 or 100 times, the consequences of a single Hiroshima or Nagasaki-scale nuclear detonation in an urban area would be by far the largest sudden-onset disaster in recorded history in humanitarian terms. Although to our knowledge it has not been carefully estimated, the scale of human displacement from a regional nuclear conflict—both people forced to flee areas affected by the detonations and those compelled to move because of fallout, fear of radiation or further nuclear strikes, or for other reasons—would also be on a massive scale. Even assuming that the number of those displaced was only the same as the total number of short-term fatalities in the study cited above (a conservative estimate), this would create 21 million displaced people. To put this in the context of existing global displacement figures, in 2013 there were estimated to be 33.3 million internally displaced persons globally,[170] and 10.4 million refugees of concern to UNHCR.[171] Thus, a nuclear conflict of the kind described above would add at least a third to this total number overnight.

In the immediate term, people would most likely flee from cities into the surrounding countryside.

167 For example, see C.E. Dallas et al., "Nuclear war between Israel and Iran: lethality beyond the pale", *Conflict and Health*, vol. 7, no. 10, 2013.

168 See O.B. Toon, A. Robock, and R.P. Turco, "Environmental consequences of nuclear war", *Physics Today*, vol. 61, no. 12, 2008, pp. 37–38. That study estimated 4,400 nuclear detonations assuming 100kt weapons (based on limits in the Strategic Offensive Reductions Treaty, which "would generate 770 million casualties and 180 Tg of soot". Other studies include the firing of nuclear-armed missiles from a single British Trident submarine; see P. Webber, *The Climatic Impacts and Humanitarian Problems from the Use of the UK's Nuclear Weapons*, Scientists for Global Responsibility, 2008, www.sgr.org.uk/sites/sgr.org.uk/files/SGR_climatic_impacts_Trident_Feb2013.pdf.

169 O.B. Toon et al., "Consequences of regional-scale nuclear conflicts", *Science*, vol. 315, 2007, p. 1224.

170 See Internal Displacement Monitoring Centre, *Global Figures: Conflict and Violence-Induced Displacement*, www.internal-displacement.org/global-figures.

171 UNHCR, *Figures at a Glance*, www.unhcr.org/pages/49c3646c11.html.

Unless adequate humanitarian assistance such as emergency shelter, medical care, food, sanitation, clean water, and security could be provided quickly, those displaced would be compelled to move on as local resources became depleted. Others in coastal or river areas might take to the water in whatever vessels were at hand, and attempt to cross to safety to other places, including to other countries in the region.

Fear of radiation should not be underestimated as a driver for people to take flight from their home locales, even if in reality the effects happen to be slight or non-existent there.[172] The invisible nature of radiation, concern about its long-term impacts on the human body, and suspicion of official statements in the aftermath of a nuclear weapon detonation event may lead people to take matters into their own hands. A challenge for authorities at all levels will be in establishing a level of credibility and trust among affected (or potentially affected) populations in order to influence their behaviour in ways that maximize their safety and do not compound problems such as displacement or the further inundation of medical facilities with the "worried well".[173]

Nuclear war-induced climate change

Modelling of an India–Pakistan regional war scenario using climate change models indicated that 100 15kt airbursts in urban areas could produce so much soot from burning cities that it would have significant effects on the climate.[174] While it was understood during the Cold War that a large-scale nuclear war between the two superpowers could create a "nuclear winter", it was not appreciated until these studies were conducted that the use of as little as 0.03 per cent of the global nuclear arsenal could cause comparable effects. Work by Robock and others indicates that globally temperatures would fall below those of the Little Ice Age of the fourteenth to nineteenth centuries because of the light blocked from reaching the planet's surface.

The effect of this temperature fall would be shortened growing seasons throughout the world for a decade or more after such a conflict. Moreover, there would be major ozone depletion in the atmosphere, allowing more ultraviolet radiation to reach the surface, which would have effects on human health as well as the environment.[175] Recent studies indicate that agricultural production in parts of the United States and China would decline by about 20 per cent for four years, and by 10 per cent for a decade.[176]

Yet the world is not well prepared in terms of its current food reserves. Although stocks appear to have increased slightly since it was reported in 2012, in most countries reserves of staple foods such as grains have fallen below 80 days of consumption on average.[177] Past famines historically indicate that the effects of food shortages are likely to be most seriously felt by the poorest, and hence most vulnerable, people as food becomes scarcer and prices rise. This led IPPNW to observe that:

> The 925 million people in the world who are chronically malnourished have a baseline consumption of 1,750 calories or less per day. Even a 10% decline in their food consumption would put this entire group at risk. In addition, the anticipated suspension of exports [in the case of a nuclear war] from grain growing countries would threaten the food supplies of several hundred million additional people who have adequate nutrition today, but who live in countries that are highly dependent on food imports.[178]

IPPNW argued that, based on recent academic studies, the number of people threatened by nuclear-war induced famine would be well over one billion—a number they later revised

172 See, for example, D. Ropeik, "Fear vs. radiation: the mismatch", *The New York Times*, 21 October 2013; J.J. Caro et al., "Resource allocation after a nuclear detonation incident: unaltered standards of ethical decision making", *Disaster Medicine and Public Health Preparedness*, vol. 5, supplement 1, 2011, p. S47.

173 A.B. Wolbarst et al., "Medical response to a major radiologic emergency: a primer for medical and public health practitioners", *Radiology*, vol. 254, no. 3, 2010, p. 671.

174 A. Robock and O.B. Toon "Self-assured destruction: the climate impacts of nuclear war", *Bulletin of the Atomic Scientists*, vol. 68, no. 5, 2012.

175 M.J. Mills et al., "Massive global ozone loss predicted following regional nuclear conflict", *Proceedings of the National Academy of Sciences*, vol. 105, no. 14, 2008.

176 See L. Xia and A. Robock, "Impacts of a nuclear war in South Asia on rice production in mainland China", *Climatic Change*, vol. 116, 2013, pp. 357–372, and M. Özdoğan, A. Robock, and C.J. Kucharik, "Impacts of a nuclear war in South Asia on soybean and maize production in the midwest United States", *Climatic Change*, vol. 116, 2013, pp. 373–387.

177 J. Vidal, "UN warms of looming worldwide food crisis in 2013", *The Guardian*, 13 October 2012.

178 I. Helfand, *Nuclear Famine: A Billion People at Risk: Global Impacts of Limited Nuclear War on Agriculture, Food Supplies, and Human Nutrition*, IPNNW and Physicians for Social Responsibility, 2012, p. 1.

upward to two billion.[179] Such a situation would create immense pressure both on states and a humanitarian system that already struggles to provide sufficient food aid to a small fraction of those currently classed as hungry. Today, in contrast, on average the WFP provides food assistance to 100 million people per year.[180]

Other disruptions

In an earlier section we discussed the kinds of disruptions to global infrastructure, markets, and other systems that might be foreseen from even the detonation of a single nuclear weapon. A conflict in which tens of millions of people are killed or injured, millions more lose members of their family, their homes, jobs, and most of their material possessions and are forced to relocate to possibly unknown parts, and trillions of dollars of destruction are wrought is going to have global consequences in addition to those mentioned above. These could include:

- economic disruption, including to financial markets and logistical supply chains in areas such as agriculture and manufacturing;
- loss of wealth on a scale that has macroeconomic impacts;
- increased market volatility, loss of investor confidence, and potential for political turmoil (especially if further use of nuclear weapons is thought likely);
- further military conflict stemming from the use of nuclear weapons;
- long-term impacts on public health from the effects of nuclear detonations—this includes not only directly impacted populations and those affected by fallout, but those elsewhere as climate induced effects such as increased ultraviolet radiation and long-lived elements of nuclear fallout take their toll; and
- diversion of resources from global development and poverty reduction to meet emergency needs from other programmes, with negative consequences for prospects of the most vulnerable people.

Summary

This part of the study has explained what happens in a nuclear weapon detonation, and the characteristic effects of nuclear weapons. It has illuminated the kinds of challenges involved in assessing and responding to such events in humanitarian terms, even if these challenges are difficult to quantify. Although many factors affect the nature and extent of the humanitarian consequences of nuclear weapon detonations it is clear that population density is a key factor, and in that sense not all such events would be catastrophic in their immediate effects if these were targeted to avoid civilians. Nevertheless, how radioactive fallout from groundburst detonations and large airburst detonations will spread is difficult to predict, and has harmful effects on human health. Several specific scenarios explored indicate that any use of a nuclear weapon in a highly populated area such as a city or even an intensely cultivated rural area would have major humanitarian consequences. These consequences are summarized in figure 8, which is organized according to the categories of the United Nations humanitarian cluster system.

Given the scale of the human harm and physical destruction caused at the moment of detonation, any coordinated humanitarian response to ameliorate suffering and harm will be inadequate by definition. However, the discussions in this part suggest that among the roles it might play, the United Nations system could assist in facilitating information exchange (for instance, data about the location of a detonation, and the spread of fallout), acting as a trustworthy and accurate source of information for the public, and in coordinating international responses to the large-scale human displacement likely as an outcome of some scenarios, building on its current capacities. This is discussed further later in the study.

179 I. Helfand, *Nuclear Famine: Two Billion People At Risk? Global Impacts of Limited Nuclear War on Agriculture, Food Supplies, and Human Nutrition*, 2nd ed., IPNNW and Physicians for Social Responsibility, 2013.

180 WFP, “About: WFP in numbers”, http://www.wfp.org/wfp-numbers.

Figure 8: Some of the foreseeable humanitarian challenges from a single nuclear detonation in an urban area

Cluster	Indicative description of consequences
Health	Within the 5psi+ zone of blast, most people are killed or suffer horrific life-changing injuries. Hospitals in the blast zone and fallout zones are rendered unusable. Surviving local hospitals overwhelmed by large numbers of casualties with complex trauma. Risk of fire to medical facilities. Wider support needed, e.g. for burn treatment, trauma centres. Decontamination challenges. Psychosocial challenges include widespread anxiety and confusion. Significant long-lasting effects can include depression and post-traumatic stress disorder. Large numbers of fatalities stress mortuary services.
Emergency shelter	Shelter is a major issue for the displaced in 20kt and above detonations. Exposure to elements will increase mortality, especially among the injured and those with ARS. Number of displaced people from inner blast zones probably limited by lethality of blast there, but significant numbers of people displaced from outer blast damaged zones or areas affected by fallout. Scale of self-displacement more broadly from panic/anxiety difficult to predict. Sufficient availability of suitable shelter materials is an issue.
Camp coordination and management	Tens or hundreds of thousands of people require medium- to long-term accommodation and service delivery depending on area affected. Those displaced from all but outermost blast zones likely to be displaced permanently as there will be nothing to return to. Those displaced by local fallout concerns may be able to return home within weeks pending appropriate decontamination. But such resources may not be available, and they may fear doing so. Issues for communities hosting the displaced and likelihood of resentment in view of resource degradation, crime, lack of opportunity, etc. Many displaced may move to less-affected areas to stay with friends and relatives, not in camp settings where they can be more easily identified and assisted.
Nutrition	Food in fallout affected area unsafe to eat. Food must come from outside.
Sanitation, water, and hygiene	Water, sanitation infrastructure damaged across blast area, which causes wider disruption to services. Air contaminated by radioactive airborne fallout particles, which may affect water supplies across a wide area. Large numbers of corpses, many buried under debris. Risk of disease, effects on sanitation. Massive amounts of radioactive debris—severe disruption to trash collection services.

Logistics	Roads outside blast zone leading to it are impassable because of abandoned vehicles. Inside blast zone roads, rail links, and tunnels are impassable because of debris. Bridges may be destroyed or heavily damaged. Surviving infrastructure requires inspection to ensure it is safe for vehicles. Sea port and airport infrastructure within blast or thermal radiation zones may be destroyed or heavily damaged. Those within fallout-affected areas may be unsafe to use.
Food security	Food services and delivery unlikely inside 10 rem[181] zone. Panic causes people to stockpile (or loot) food. Distribution of food may be hampered by physical damage to ports, airports, roads, rail lines and yards etc. Availability of food stocks.
Protection	Many families suffer loss of family members (including breadwinners). Large numbers of people are especially vulnerable: there will be many separated families, unaccompanied children, older persons, disabled, people with mental health issues requiring protection services—not only in the context of camp coordination and management but in the opening stages of crisis after detonation. Heightened risk of sexual violence in emergency shelters. Loss of essential documentation that may be needed to access assistance. Family tracing, especially for children, will be a major challenge with no trace left of some victims. Health services will be advised not to separate families as this will be resisted and could cause (further) loss of confidence in authorities.
Emergency telecommunications	Depending on the height and conditions of the detonation, EMP could knock out electrical power, telecommunications and permanently damage most electronic equipment on mains supply or battery backups within the blast region. Portable electronics fare better, but mobile network infrastructure possibly disrupted in affected area for unknown duration. For UN coordinated response, physical damage to telecommunications infrastructure will likely be a greater problem than EMP unless there is a second high altitude detonation creating wide-area EMP damage
Education	All educational infrastructure within 2psi ring heavily damaged or destroyed. Losses to educators and student populations within this ring. Displaced population will require educational services.
Early recovery	Electrical power likely to be restored within +/- 7 days in 1kt scenarios Major damage and disruption likely to most types of critical infrastructure within city. Contamination of fallout zone may require relocation of population and physical decontamination for up to 10 years (at massive financial cost). Hiroshima and Nagasaki aftermath saw collapse of social organizations and functions. Loss of experienced personnel and wealth led to business closures. Traumatized population unable to resume normal life or city functions.

181 See appendix 2 for explanation of rem and related terms.

PART 3: WHAT SYSTEMS AND CAPABILITIES DOES THE UNITED NATIONS HAVE TO RESPOND TO THE HUMANITARIAN CONSEQUENCES OF A NUCLEAR WEAPON DETONATION?

No part of the United Nations system has been explicitly tasked with preparing for how to assist the victims of a nuclear weapon detonation event. (As will be discussed in part four, the General Assembly did ask the United Nations to study how it would offer assistance to Member States in the context of a terrorist nuclear attack.) The IAEA, as will be described shortly, has been closely involved in responding to accidents involving civil nuclear facilities and in planning to prevent or mitigate such occurrences. However, in response to our question about whether the IAEA regards a nuclear emergency as encompassing nuclear weapon detonation events, the Agency responded that "the IAEA has no mandate for coverage of such events".[182]

Nevertheless, if faced with a situation in which a nuclear weapon detonation event occurred in a populated area, the United Nations could scarcely stand idly by. Irrespective of the event's circumstances, public and media pressure—in addition to that from states—to mount a humanitarian and political response would swiftly manifest itself. (This will be explored in part four.) The Secretary-General would probably immediately seek advice within the United Nations system as to its capacity and capability for response. Moreover, the General Assembly and the Security Council[183] would likely be convened.

Organizing relief whatever the circumstances goes to the heart of what the United Nations Secretary-General recently characterized as the Organization's "responsibilities to protect people".[184] The Secretary-General's speech of 22 November 2013 on renewing commitment to the peoples and purposes of the United Nations acknowledged past "systemic failure" in its collective response to protect people, for instance in the Rwanda genocide. He concluded that the United Nations system can and must improve how it reacts to impending catastrophes. This begins with acknowledgement of the problem and a series of steps that would strengthen United Nations action.

Also of relevance is a recent OCHA report on managing the risk of humanitarian crises, which called for a shift in the way that humanitarian and development actors operate.[185] It encourages the humanitarian system—including donors—to move away from responding to crises in a purely reactive manner and to instead adopt an approach that anticipates and prevents crisis through effective risk management. The report recognizes that humanitarian actors are being asked to do more, and at a greater cost, than ever before. Consequently, there is a need for greater investment in risk mitigation and crisis management, which existing structures are not equipped to provide. Humanitarian, development, and government actors, the report argues, must work together to identify risks and align planning cycles, increase aid effectiveness, build the resilience of affected populations, and, to a greater extent, focus on preventing disasters than at present.

Two important humanitarian considerations come immediately into play where nuclear weapon detonation events are concerned. The first is that strengthened United Nations action in the domains of preparedness and response capacity could save lives even if there is nothing that it can do to alleviate the suffering from the immediate effects of a nuclear weapon detonation event. The second consideration is that as time passes after such an event, scope for relief response will grow; this relief activity will have to evolve in lockstep with those needs in order to be most effective. The more prepared the United Nations system is in terms of the necessary decision-making process, the quicker, better,

182 Written communication from senior IAEA official, 9 December 2013.

183 The Security Council under resolution 984 of 1995 affirmed its readiness, in response to a request from a non-nuclear-weapon state that was the victim of nuclear weapon aggression, to consider what measures were needed by way of "medical, scientific or humanitarian assistance" in the event of such an act of aggression. Similarly, in its resolution 255 of 1968, the Security Council had welcomed the intention expressed by nuclear-weapon states that they would provide or support immediate assistance, in accordance with the Charter, to any non-nuclear-weapon NPT state party "that is a victim of an act or an object of a threat of aggression in which nuclear weapons are used".

184 Ban Ki-Moon, "Renewing our commitment to the peoples and purposes of the United Nations", 22 November 2013, www.un.org/apps/news/infocus/sgspeeches/statments_full.asp?statID=2068.

185 OCHA Policy Development and Studies Branch, *Saving Lives Today and Tomorrow: Managing the Risk of Humanitarian Crises*, 2014.

and more adaptable the response is likely to be. United Nations agencies were—and continue to be—involved in monitoring the effects of civil nuclear reactor accidents at Chernobyl and Fukushima. Moreover, in the Chernobyl case, a number of United Nations agencies have for decades helped with responding to the consequences for the local population (as described in boxes 10 and 11 later in this part). While those disasters lacked the explosive power of a nuclear detonation, the discharge of radiation presented numerous challenges to humanitarian actors. As such, although quite different from nuclear weapon detonations, those accidents offer a convenient starting point for building a picture of preparedness and response planning by the United Nations system for radiological incidents. And, such an explanation helps to place in perspective the challenges of mitigating the wider impacts of a nuclear detonation.

United Nations and related preparedness and response systems: a survey of agencies with relevant technical expertise

IAEA

The Fukushima Daiichi nuclear accident (see box 5) resulted in several examinations of the international emergency framework for responding to nuclear accidents and nuclear emergencies. The first of the studies was one of a number of concrete steps on nuclear safety proposed by the United Nations Secretary-General on 19 April 2011 at the Kiev Summit on the Safe and Innovative use of Nuclear Energy. The United Nations System-wide Study on the Implications of the Accident at the Fukushima Daiichi Nuclear Power Plant (referred to here as the United Nations System-wide Study)[186] was tabled at a High-level Meeting on Nuclear Safety and Security convened by the Secretary-General on 22 September 2011. It contains three sections. Two sections primarily concentrate on nuclear safety and security and bear closely on the work and role of the IAEA. The study observes that the Agency, as an independent intergovernmental, science and technology-based organization in the United Nations system, "serves as the global focal point for nuclear cooperation".[187] The IAEA's central role in nuclear safety and security is set out in its statute and enshrined in decisions and resolutions of its policymaking organs. The purpose of nuclear safety and security is described in the study as being to protect people and the environment from the harmful effects of ionizing radiation.

Box 5: The Fukushima Daiichi nuclear accident

On 11 March 2011 an earthquake of 8.9 magnitude and resulting tsunami caused severe damage to the Fukushima Daiichi nuclear power plant in east Japan. A 15-metre tsunami disabled the power supply and cooling of three of the Fukushima Daiichi reactors. All three cores largely melted in the first three days after the tsunami. The accident was rated 7, the maximum level on the International Nuclear Events Scale (INES) for danger of radiation doses to people,[188] due to high radioactive releases over days 4 to 6. A nuclear emergency was declared, and the Fukushima Prefecture issued an evacuation order for people within 2km of the plant. On 12 March the evacuation zone was extended to 20km. More than 100,000 people were evacuated from their homes for their health and safety. Although three employees were killed directly by the earthquake and tsunami, there were to date no deaths or cases of radiation sickness among the general population from the nuclear accident.[189] However, the official report of The Fukushima Nuclear Accident Independent Investigation Commission found that 167 workers were exposed to large amounts of radiation (100 millisieverts or more)[190] in dealing with the accident. As some negative health effects of radiation can take years to manifest themselves, these high dosages received by some creates the possibility of consequent deaths later on. The commission also found that many people received unnecessary exposure to radiation. For instance, due to lack of sufficient monitoring and evacuation planning, some residents were not promptly evacuated from high dosage areas and others were evacuated to areas of higher radiation. For some, the moves resulted in increased "stress and health risks—including deaths among seriously ill patients".[191]

186 *United Nations System-wide Study on the Implications of the Accident at the Fukushima Daiichi Nuclear Power Plant*, UN document SG/HLM/2011/1, 16 August 2011.
187 Ibid., p. 15, para. 72.
188 IAEA, "INES: The International Nuclear and Radiological Event Scale", www-ns.iaea.org/tech-areas/emergency/ines.asp.
189 World Nuclear Association, "Fukushima accident", www.world-nuclear.org/info/Safety-and-Security/Safety-of-Plants/Fukushima-Accident/.
190 See appendix 2 for an explanation of sieverts and related units.
191 The National Diet of Japan, *The Official Report of The Fukushima Nuclear Accident Independent Investigation Commission*, 2012, p. 19.

The third section of the study is of particular relevance. It focuses on response to nuclear accidents and addresses the adequacy of disaster preparedness measures, cooperation among international organizations, and the development of new monitoring and scientific capabilities. The study notes that the established system for nuclear and radiological emergencies is based on the central coordinating role of the IAEA, and the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE) established following the Chernobyl disaster. IACRNE is chaired by the IAEA and comprises representatives of organizations from within and outside the United Nations system. Under IACRNE's terms of reference,[192] any international intergovernmental organization that has a role with respect to preparedness for or response to radiation emergencies is eligible for membership in this committee, subject to its approval.[193]

The scope of the preparedness and response activities IACRNE covers derives from two treaties adopted by the General Conference of the IAEA in 1986. These are the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of Nuclear Accident or Radiological Emergency. The former sets out an international framework for cooperation among parties and with the IAEA to facilitate prompt assistance and support in the event of nuclear accidents or radiological emergencies. The latter treaty establishes a notification system for nuclear accidents that have the potential for international transboundary release of significance for the radiological safety of another state. United Nations core agencies, the WHO, the Food and Agriculture Organization of the United Nations (FAO), and World Meteorological Organization (WMO) are party to both agreements, along with the European Atomic Energy Community (EURATOM).

Ratifications of the treaties number 117 and 111 respectively. As to states not party to the two IAEA conventions, the Agency has invited those states to use the arrangements described in the Joint Radiation Emergency Management Plan of the International Organizations (JPLAN) when providing relevant information about nuclear or radiological emergencies so as to minimize transnational radiological consequences and to facilitate the prompt provision of information and assistance. Because of its importance, the JPLAN is discussed further below.

The IAEA from time to time also reminds non-party states of their obligations under general international law (notably the responsibility of states for internationally wrongful acts). Of relevance, too, are the "guiding principles" of emergency humanitarian assistance developed by the United Nations General Assembly in 1991.[194] Principle 4 provides that each state has the responsibility "first and foremost" to take care of the victims of natural disasters and other emergencies occurring on its territory. The affected state has the primary role in the initiation, organization, coordination, and implementation of humanitarian assistance within its territory. Principle 5 recognizes that the "magnitude and duration" of the emergency in question may be beyond the response capacity of the affected state and that international cooperation will be required for which the United Nations has a "central and unique" leadership and coordinating role.

WHO

Beyond the IAEA conventions, the International Health Regulations (IHR) concluded in 2005 under WHO auspices are also legally binding measures of relevance. The IHR provide a framework for the coordination and management of events that may constitute a public health emergency of international concern. In light of their comprehensive purpose and scope, and the expansive definitions of "disease", "event", and "public health risk", the IHR are very broad in their application, and also include risks and events of radiological origin. The regulations are significant

192 See annex E of IAEA, *Joint Radiation Emergency Management Plan of the International Organizations*, 2013.

193 The members are IACRNE are CTBTO, the Food and Agriculture Organization of the United Nations (FAO), IAEA, OCHA, WHO, the World Meteorological Organization (WMO), the European Commission, the European Police Office (EUROPOL), the International Civil Aviation Organization (ICAO), the International Maritime Organization (IMO), the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the International Criminal Police Organization (INTERPOL), the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA), the Pan American Health Organization (PAHO), UNEP, and the United Nations Office for Outer Space Affairs (UNOOSA); see www-ns.iaea.org/tech-areas/emergency/iacrna/login.asp. In addition, UNDP has applied to become a member, and the International Federation of Red Cross and Red Crescent Societies (IFRC) is a corresponding member (observer).

194 General Assembly, *Strengthening of the Coordination of Humanitarian Emergency Assistance of the United Nations*, UN document A/RES/46/182, 19 December 1991.

because in contrast to the IAEA conventions mentioned above they are binding on 196 states across the globe, including all member states of the WHO. Each member state is required to notify the WHO of all events that may constitute a public health emergency of international concern within its territory. If the notification received by the WHO involves the competency of the IAEA (for instance, a radiological event), the WHO is required to notify the Agency immediately.

All IHR parties are required to develop and maintain a broad range of core public health capacities for surveillance and emergency preparedness and response throughout their national territory as well as at designated international ports, airports, and border crossings. Consistent with the broad scope of the IHR, these requirements apply to public health risks of radiation, as well as to those of a biological or chemical origin. All states parties are required to have national IHR focal points available at all times for IHR-related communications with the WHO, including public health emergencies of international concern as determined by the WHO's Director-General based on considerations specified in the IHR.[195]

As noted in part one, the 1987 findings of WHO experts on the "devastating" effects of the use of nuclear weapons in conflict in both the short and the long term, and the inability of health services to alleviate the situation in any meaningful way, led to an emphasis in that report on primary prevention—the prevention of nuclear war. In the aftermath of the terrorists attacks of 11 September 2001, the World Health Assembly (WHA) adopted a resolution on 18 May 2002 entitled "Global public health response to natural occurrence, accidental release or deliberate use of biological and chemical agents or radioactive material that affect health".[196] The WHA urged member states to treat any deliberate use of "biological and chemical agents and radionuclear attack" as a global public health threat, and to respond to such a threat in other countries by sharing expertise, supplies, and resources in order rapidly to contain the event and mitigate its effects.[197]

The WHA also requested the WHO Director-General to examine the possible development of new tools, within the mandate of WHO, including modelling of possible scenarios for and global public health responsiveness to accidental release or deliberate use of "biological, chemical agents and radionuclear material".[198] It should be noted that in materials published since 2002 (e.g., the JPLAN) the terms "radiological" and "radioactive" are used instead of "radionuclear". Current IAEA and WHO usage favours the expressions "radiological and nuclear emergency" (sometimes abbreviated to "radiation emergency") and "radioactive material".

Box 6: Role of the WHO

The WHO is a full party to the Early Notification and Assistance Conventions. As such, the Organization is competent to act as the directing and coordinating authority in international public health matters covered by the conventions, and to provide assistance upon the request or acceptance of governments without prejudice to the national competence of individual member states. With regard to its obligations as a party to the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, the WHO:

- has undertaken to co-operate … to facilitate prompt assistance in the event of a nuclear accident or radiological emergency to minimize its consequences and to protect life … from the effects of radioactive releases;
- shall promptly decide and notify a requesting State Party, directly or through the IAEA, whether it is in a position to render the assistance requested, and if so, the scope and terms of the assistance that it might render; and
- shall, within the limits of its capabilities, identify and notify the IAEA of experts, equipment and materials which could be made available for the provision of assistance to other States Parties in the event of a nuclear accident or radiological emergency as well as the terms, especially financial, under which such assistance could be provided.[199]

195 WHO, *International Health Regulations*, 2nd ed., 2005, art. 12, http://whqlibdoc.who.int/publications/2008/9789241580410_eng.pdf?ua=1.
196 WHA, *Global Public Health Response to Natural Occurrence, Accidental Release or Deliberate Use of Biological and Chemical Agents or Radionuclear Material that Affect Health*, 18 May 2002, http://apps.who.int/gb/archive/pdf_files/WHA55/ewha5516.pdf.
197 Ibid., p. 2.
198 Ibid., p. 1
199 See IAEA, *Joint Radiation Emergency Management Plan of the International Organizations*, 2013, appendix B, p. 44.

The WHO is a member both of IACRNE and the Inter-Agency Standing Committee (IASC). The WHA resolutions of 2002 envisage a WHO response to terrorist attacks using radiological material rather than the detonation of a nuclear weapon. Nevertheless, WHO experts we spoke with in research for this study considered it axiomatic, given the WHO's mission and the ethos of the medical profession of "utmost respect for human life from its beginning" (in the modern meaning of the Hippocratic Oath), that in the immediate aftermath of a nuclear detonation the WHO would want to attend to and mitigate casualties to the greatest extent possible. They saw obstacles to this, however. An immediate challenge for the WHO (along with other humanitarian actors) would be the risks of exposing their staff to radiological and other contamination in the course of lending assistance, and the lack of specific emergency scenario planning or exercising to help in risk assessment.[200]

IACRNE and the JPLAN

To return to the role of IACRNE, it should be noted that while the IAEA Early Notification and Assistance Conventions serve to frame the scope of that committee, the primary tool of its activities is the JPLAN, the Emergency Preparedness and Response Joint Radiation Emergency Management Plan of 2013.[201] IACRNE member organizations jointly "sponsor" the JPLAN. The JPLAN document details the inter-agency framework for radiation emergency preparedness and response, provides a practical mechanism for coordination and clarifies the roles and capabilities of the participating international organizations. Maintenance of the plan is one of IACRNE's primary functions. The JPLAN document's introduction explains that its function is not to prescribe arrangements among the participating organizations, but to articulate a common understanding of how each organization should act during a response and in making preparedness arrangements. That is, nothing in the JPLAN is intended to cut across the individual mandates of international organizations involved (or the responsibilities of states). This is significant—as we have seen in the case of the WHO with its broad public health remit. However, the IAEA has counselled all international organizations, irrespective of whether they are members of IACRNE, to consider the JPLAN's arrangements in formulating their own emergency management plans.

The latest edition of the JPLAN (dated 1 July 2013) reflects lessons learned from the Fukushima Daiichi nuclear accident. The framework for international cooperation represented by the JPLAN is not, however, the only IAEA vehicle of relevance. At the level of states, there is also the International Action Plan for Strengthening the International Preparedness and Response System for Nuclear and Radiological Emergencies, which was in effect from 2004 to 2009 (referred to here as the 2004 plan). The objective of that plan was to strengthen the preparedness and response capacity of states, thus complementing cooperation activities among international organizations. It reflected concerns at the national level about the possible malicious use of radioactive material, and about possible attacks on nuclear installations. The 2004 plan also recognized that there is a large number of radioactive sources in use or being transported for which the international emergency preparedness and response system was less developed than for nuclear installations.

In June 2011, shortly after the final report of the 2004 plan was issued, a new, more comprehensive action plan emerged at the state level. It followed a Ministerial Conference on Nuclear Safety convened by the IAEA with the objective of paving the way for an "enhanced post-Fukushima global nuclear safety framework" in the words of its Director-General Yukiya Amano.[202] The Ministerial Declaration resulting from that meeting sought to strengthen nuclear safety, emergency preparedness, and radiation protection for people and the environment worldwide. The declaration requested the Director-General to draft an Action Plan on Nuclear Safety (the 2011 plan). The 2011 plan enumerated a programme of work to strengthen the global nuclear safety framework (see box 7).

200 The WHO chairs the United Nations Medical Directors Working Group, composed of, but not limited to, medical directors of the United Nations and specialized agencies, which routinely meets about once per year.

201 IAEA Incident and Emergency Centre, *Joint Radiation Emergency Management Plan of the International Organizations*, 2013, p. ii, www-pub.iaea.org/MTCD/Publications/PDF/EPRJplan2013_web.pdf.

202 IAEA, *Director General Yukiya Amano's Concluding Statement to the IAEA Ministerial Conference on Nuclear Safety*, 24 June 2011, www.iaea.org/newscenter/statements/2011/amsp2011n014.html.

Box 7: Actions following the 2011 Action Plan[203] on Nuclear Safety

The 2011 plan has resulted in the following actions:

- opening in Fukushima the Capacity Building Centre of the IAEA's Response and Assistance Network (RANET). The Centre is used for organizing training activities to enhance nuclear emergency preparedness and response capacity at the regional and international level, establishing the Emergency Preparedness and Response Expert Group comprising 16 senior experts from all regions globally to provide advice on strategies to strengthen and sustain sound international preparedness for nuclear and radiological emergencies;
- initiating RANET review missions and encouraging all RANET National Assistance Coordinators to identify their availability to host RANET review missions in their countries;
- finalizing the 2013 edition of the JPLAN; and
- strengthening the IAEA Secretariat's responsiveness to nuclear and radiological incidents and emergencies by updating and improving training and coordination capabilities and by scrutinizing its internal capabilities for assessment of possible radiological consequences and prognosis of likely emergency progression.

Leaving aside issues of mandate, these examples of the depth of preparedness planning for civilian nuclear accidents undertaken under IAEA leadership are offered here for two reasons. First, any scoping exercise to develop capacities for preparing for a nuclear detonation, to the extent that it is judged feasible to do so, could usefully draw on the IAEA's depth of expertise in the civil arena.[204] Second, these arrangements provide a measure of the organizational complexity commensurate with confronting the challenges to the international community's ability to respond to a civil nuclear event,[205] let alone the impacts of nuclear weapon detonation events.

UNSCEAR

The General Assembly established the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) in 1995 in response to international concerns about the effects of radiation on human health and the environment. UNSCEAR is a committee of scientists drawn from 27 countries designated by the General Assembly. The committee receives and collates radiological information provided by states, and reports on observed levels of ionizing radiation and radioactivity and their impacts. UNSCEAR is a member of IACRNE. UNSCEAR's secretariat is functionally linked to UNEP. The JPLAN notes that if an event occurred that involved significant numbers of serious radioactive overexposures or widespread contamination of people, water, commodities, or surface, or is of significant concern to the General Assembly or the public, the UNSCEAR secretariat would liaise with the IAEA, WHO, or UNEP as appropriate. The purpose of this coordination would be to review the levels, effects, and risks of exposure for reporting to the General Assembly and for public release.

CTBTO

The Preparatory Commission for the CTBTO administers an international monitoring system to monitor the planet for signs of nuclear explosions. The system, which to date has established over 280 monitoring stations around the world, measures shock waves, sound waves, and radioactive particles in the atmosphere. The objective of the system is to ensure that no nuclear explosion goes undetected. Seismic data would provide the first indication of an explosion (as is the case with nuclear tests conducted by the Democratic People's Republic of Korea since 2006). The CTBTO's Executive Secretary would thereupon alert counterparts in specialized agencies of the United Nations system. Moreover, the utility of its global monitoring system has already been noted and is capable of providing data for other uses. According to the Stockholm International Peace Research Institute, following the 26 December 2004 earthquake and tsunami in Asia, "the CTBTO was mandated to provide

203 IAEA, *Action Plan on Nuclear Safety*, 13 September 2011, www.iaea.org/newscenter/focus/actionplan/reports/actionplanns130911.pdf.

204 The communiqué of The Hague Nuclear Security Summit 2014 (paragraph 13) attached great importance to the IAEA's support for national efforts to improve nuclear security and encouraged states to utilize the IAEA Nuclear Security Series of publications; see www.nss2014.com/sites/default/files/documents/the_hague_nuclear_security_summit_communique_final.pdf.

205 See also the compendium of IAEA materials related to emergency preparedness and response contained in IAEA Incident and Emergency Centre, *Joint Radiation Emergency Management Plan of the International Organizations*, 2013, appendix D, www-pub.iaea.org/MTCD/Publications/PDF/EPRJplan2013_web.pdf.

data from its seismic and hydroacoustic stations to tsunami warning centres to enhance the ability of potentially tsunami-generating earthquakes. In 2011 this information was also provided to the IAEA nuclear emergency centre to warn nuclear power plant operators against tsunami-generating earthquakes".[206] The CTBTO is a member of IACRNE and of the JPLAN. To date, no systematic process exists for analysing CTBTO data about nuclear explosions or radioactive fallout and disseminating it to United Nations humanitarian agencies.[207]

WMO

The WMO is the authority in the United Nations system on the state and behaviour of the Earth's atmosphere, its interaction with the oceans, the climate it produces, and the resulting distribution of water resources. WMO also contributes to reducing the impacts of human-induced disasters (such as those associated with chemical and nuclear accidents), forest fire, and volcanic ash. It is a member of IACRNE and the JPLAN. The organization is a full party to the Early Notification and Assistance Conventions under which it cooperates with the IAEA to facilitate prompt forecasting and other technical assistance in the event of a nuclear accident or radiological emergency, in order to minimize the consequences of radioactive releases into the environment and protect life from the effects. The WMO has established standing operational procedures to allow for urgent requests for assistance by state parties, coordinated with their respective national meteorological services, or through the IAEA. WMO also has a network of Regional Specialized Meteorological Centres that function around-the-clock to provide assistance to any requesting country, or the IAEA.

Humanitarian relief agencies and mechanisms within the United Nations system

Mention has already been made of the 2011 United Nations system-wide study on the implications of the accident at the Fukushima Daiichi nuclear power plant. That study recognized that effective local, national, regional, and global preparedness and response cooperation capabilities and arrangements were essential to minimize the impacts of nuclear and radiological incidents and emergencies and to mitigate and respond to disasters caused by natural hazards. Drawing on the Fukushima Daiichi event, the study observed that:

> disasters can have sequential and collateral impacts that we have yet to imagine and plan for, not only for nuclear facilities but also for industrial complexes, weapons storage depots and major infrastructure such as hydroelectric dams, bridges and highways. Those considerations must motivate new efforts for integrated and innovative planning for preparedness and response.[208]

Given the scale of disasters such as Fukushima Daiichi, this observation implies an overlap between nuclear emergency response organizations and mechanisms on the one hand and their equivalents in the humanitarian field on the other. While the system-wide study noted that established procedures for dealing with nuclear and radiological emergencies were based on the central coordinating roles of IAEA and IACRNE, the Secretary-General acknowledged at the 2011 High-level Meeting that there was a need to establish a closer link between the nuclear response system and the humanitarian coordination system in case of nuclear accidents. He asked the Emergency Relief Coordinator and Chair of the IASC to study ways to enhance the capacity of the organizations of the IASC in this regard.

ERC and IASC

The IASC is the primary mechanism in the international community for coordination of humanitarian assistance in the aftermath of natural disasters, conflict-related emergencies, global food crises, and pandemics. As well as nine United Nations agencies (OCHA, UNDP, the United Nations' Children's Fund, UNHCR, WFP, FAO, WHO, the United Nations Human Settlements Programme, and the United Nations Population Fund), the IASC includes humanitarian organizations (as standing invitees) such as the ICRC, the International Federation of the Red

206 T. Rauf, "From ending nuclear testing to detecting tsunamis and missing aircraft: the wider applications of the Nuclear-Test-Ban Treaty", *SIPRI Expert Comment*, 15 April 2014, www.sipri.org/media/expert-comments/rauf_apr2014.

207 Discussion with CTBTO official, 12 December 2013.

208 *United Nations System-wide Study on the Implications of the Accident at the Fukushima Daiichi Nuclear Power Plant*, UN document SG/HLM/2011/1, 16 August 2011, para. 120.

Cross and Red Crescent Societies (IFRC), the IOM, the World Bank, and three consortiums of NGOs. The IASC was established in June 1992 by a United Nations General Assembly resolution,[209] with the specific aim of strengthening humanitarian assistance. (A subsequent resolution[210] affirmed the Standing Committee's role as the primary mechanism for inter-agency coordination of humanitarian assistance.) Participants use the forum to agree on system-wide policies to improve responsiveness, while respecting organizations' individual mandates in the same way IACRNE and the JPLAN do.

As noted in part one, the Emergency Relief Coordinator (ERC), who is also the United Nations Under-Secretary-General for Humanitarian Affairs, leads the IASC. The ERC is responsible for the oversight of all emergencies that require United Nations humanitarian assistance, and acts as the central focal point for governmental, intergovernmental, and non-governmental relief activities. In a country affected by a disaster or conflict, the affected state has the primary role in the initiation, organization, coordination, and implementation of humanitarian assistance within its territory. Nevertheless, the ERC normally appoints a Humanitarian Coordinator to ensure response efforts are well organized.[211] Supported by OCHA, the Humanitarian Coordinator works with governments and communities affected by a humanitarian disaster, and relevant international and non-governmental organizations.

The IASC created a Sub-Working Group on Preparedness in 2001 with the aim of strengthening and promoting inter-agency preparedness, contingency planning, and early warning processes across the IASC community of humanitarian actors. This Sub-Working Group sets out to promote collaboration in emergency preparedness among humanitarian actors, to support effective and timely humanitarian response.

Cluster approach

Generally speaking, the humanitarian cluster approach (or simply cluster approach) is the mechanism used to coordinate the international response to humanitarian emergencies.[212] The approach encompasses 11 thematic clusters designated by the IASC, as seen in figure 9. Depending on the situation, the Humanitarian Coordinator may decide to activate all clusters or only those that are considered most relevant. In addition to these clusters there are six cross-cutting issues to be incorporated into any humanitarian response involving one or more clusters. These are accountability to affected people, age, environment, gender, HIV/AIDS, and mental health/psychosocial support.[213]

Each cluster is headed by a cluster lead agency at both the global and country level. The cluster lead agency at the country level is responsible for coordinating the operational response by a broad range of United Nations and non-United Nations humanitarian actors in its sector of concern and reports to the Humanitarian Coordinator. The global- and country-level lead agencies are not necessarily the same. In the figure below, it is the global cluster lead agencies that appear.

---

209 General Assembly, *Strengthening of the Coordination of Humanitarian Emergency Assistance of the United Nations*, UN document A/RES/46/182, 19 December 1991.

210 General Assembly, *Strengthening of the Coordination of Humanitarian Emergency Assistance of the United Nations*, UN document A/RES/47/168, 22 December 1992.

211 See www.unocha.org/about-us/headofOCHA.

212 IASC defines major new emergencies as "any situation where humanitarian needs are of a sufficiently large scale and complexity that significant external assistance and resources are required, and where a multi-sectoral response is needed with the engagement of a wide range of international humanitarian actors". See. IASC, *Operational Guidance on Designating Sector/Cluster Leads in Major New Emergencies*, 2007, www2.wpro.who.int/internet/files/eha/toolkit/web/Technical%20References/Cluster%20Approach/IASC%20Operational%20Guidance%20in%20New%20Emergencies.pdf.

213 For more info on these please see OCHA, *Cross-Cutting Issues*, www.humanitarianresponse.info/cross-cutting-issues.

Figure 9: The humanitarian cluster approach

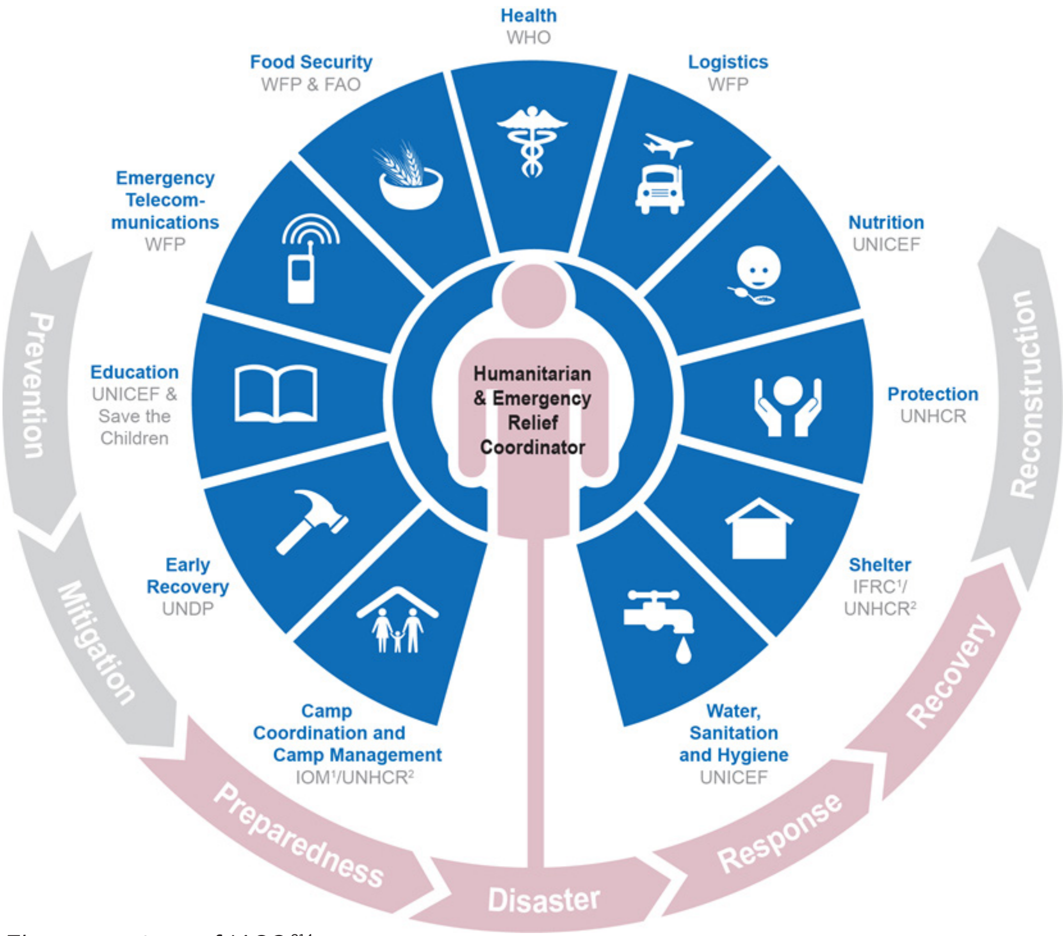

Figure courtesy of IASC.[214]

The clusters are activated if humanitarian need is great and there is insufficient capacity for coordination within national resources alone.[215] The international coordination provided is a temporary arrangement, and the clusters are deactivated when national coordinating mechanisms are able to assume control of the situation. The cluster approach is designed only to respond to the emergency and early recovery phases of the disaster,[216] attention to early recovery from the beginning being important in order to facilitate the longer-term rehabilitation and reconstruction.[217]

The IASC Principals have agreed that major sudden-onset humanitarian crises triggered by natural disasters or conflict requiring system-wide mobilization are to be subject to a "humanitarian system-wide emergency activation", known as "Level 3" or L3, to ensure a more effective response to the humanitarian needs of affected populations. This exceptional measure will only be applied in those circumstances where the gravity

214 IASC, *Reference Module for Cluster Coordination at the Country Level*, 2013, https://clusters.humanitarianresponse.info/system/files/documents/files/iasc-coordination-reference%20module-en_0.pdf.

215 OCHA, "Activate and deactive clusters", https://clusters.humanitarianresponse.info/activate-and-deactive-clusters.

216 In Level 3 activation, an early recovery cluster will be established as part of the wide activation. In situations where Level 3 activation is not justified, early recovery should be an integrated part of the response of all clusters. Early Recovery Networks are often established to address "the multi-dimensional nature of early recovery by bringing together early recovery focal points from each of the clusters/sectors to work together on the integration, mainstreaming and coordination of early recovery issues and activities across all clusters/sectors". If this network does not have the capacity to completely fill the gaps, an Early Recovery Cluster may be established as well. See IASC, *Reference Module for Cluster Coordination at the Country Level*, 2013, p. 10, https://clusters.humanitarianresponse.info/system/files/documents/files/iasc-coordination-reference%20module-en_0.pdf.

217 Early recovery is described in appendix 1. See also OCHA, "About early recovery", http://er.humanitarianresponse.info.

justifies mobilization beyond normally expected levels. The procedure activates mechanisms and tools to ensure that the system delivers effectively and can monitor its performance.[218] There are five specific criteria for evaluating the need for L3 activation: "scale, complexity, urgency, capacity, and reputational risk".[219] An independent review is hence made in each situation, following a procedure established by IASC:[220]

1. A Multi-Cluster Initial Rapid Assessment (MIRA)[221] is initiated almost immediately after the situation is known.
2. The ERC receives a compiled assessment from OCHA, based largely on MIRA data, within 18 hours.
3. The ERC seeks contact with national authorities at the highest possible level to discuss a potential Level 3 activation.
4. The Inter-Agency Emergency Directors network is activated, and discussions result in a set of proposals on how to proceed. This is passed on to the ERC.
5. The ERC convenes the IASC Principals to review the initial assessment, and presents them with the recommendations of the network on a "no objections" basis. The Principals have a norm for reaching consensus with the ERC, but the final decision lies with the ERC.
6. The ERC notifies parts of the United Nations system[222] on possible Level 3 activation.
7. The final decision on activation is taken by the ERC within 48 hours of the onset situation, although effort is made to activate as soon as possible. Involved parties are notified on activation.
8. Within 72 hours of the onset situation, MIRA produces its first output, the Situation Analysis. This evaluates the humanitarian situation based on available first and secondary data, forming the basis for planning and funding appeals.[223]

The ERC will announce the activation via e-mail to all IASC Principals (i.e. heads of agencies). The ERC will also issue a note for the Secretary-General's attention and a note to the Humanitarian Country Team via its Humanitarian Coordinator. The ERC will also contact the national authorities at the highest level to explain the decision and its implications.

Based on the scenarios described in part two of this study, a nuclear weapon detonation event with mass casualties would in principle justify the triggering of a Level 3 activation.

OCHA

Although OCHA's assistance was not specific to the Fukushima Daiichi nuclear power plant accident, it was one of the United Nations agencies that responded to the overall crisis following the earthquake and tsunami in March 2011.[224] The system-wide study requested by the United Nations Secretary-General in the wake of the Fukushima Daiichi nuclear accident examined the international emergency response framework in case of nuclear accidents. It found the need for "an inclusive and consolidated response system" and that "The different response mechanisms should be linked and mainstreamed,

218 IASC, *Humanitarian System-Wide Emergency Activation: Definition and Procedures*, document PR/1204/4078/7, 13 April 2012, p. 1, www.refworld.org/cgi-bin/texis/vtx/rwmain?page=topic&tocid=4565c22535&toid= 4a8e57802 &publisher=IASC&type=THEMREPORT&coi=&docid=512deb632&skip=0.

219 For more elaboration on these criteria see ibid., annex A.

220 This outline is limited to the procedures for activation of Level 3, but procedures for process review and deactivation are also important parts of the complete Level 3 response. A full review of the arrangement can be found in ibid.

221 More information on MIRA and the assessment process can be found in IASC, *Multi-Cluster/Sector Initial Rapid Assessment*, 2012, https://docs.unocha.org/sites/dms/Documents/mira_final_version2012.pdf.

222 The United Nations Secretary-General, the lead United Nations Department (either the Department of Peace Keeping Operations or Department of Political Affairs), and the chair of the United Nations Development Group are notified. See https://assessments.humanitarianresponse.info/psd.

223 For more information see OCHA, "Preliminary scenario definition and humanitarian needs overview", https://assessments.humanitarianresponse.info/psd.

224 The United Nations deployed a Disaster Assessment and Coordination (UNDAC) team in the immediate aftermath of the earthquake and tsunami whose activities were subsequently assumed by OCHA. UNDAC teams are designed to help governments of disaster-affected countries during the first phase of a sudden-onset emergency. UNDAC also assists in the coordination of incoming international relief at national level or at the site of the emergency. Other United Nations support included the provision of logistical support and mobile warehouses by WFP and support from UNICEF to relief activities carried out by the national UNICEF Committee. FAO provided technical support and policy advice on the dissemination of information on food monitoring and food restrictions, the consideration of agricultural counter-measures and remediation strategies. WHO was involved in risk communication and the provision of technical information to the media and states.

and an appropriate governance framework for coordination should be developed".[225] Acknowledging the need to establish a closer link between the nuclear response system and the humanitarian coordination system in case of nuclear accidents, the Secretary-General asked the ERC, as IASC Chair, to study ways to enhance the capacity of IASC organizations in this regard. The resulting study, undertaken by OCHA, was released in March 2013.[226]

Although the March 2013 OCHA study was limited in scope to emergencies involving civilian uses of nuclear power, it nonetheless considered the fact that nuclear accidents can result from "security-related threats" and not only from problems with the functioning of nuclear reactors. In this regard, the study noted two possible scenarios.[227] The first scenario is the deliberate "preventive" bombing of nuclear facilities that are suspected of being used for the production, assembly, or testing of nuclear weapons. The study described the second scenario as "simply the 'unthinkable'—a nuclear detonation". The study considered that:

> Rather than from an act of war, this would more likely result from the loss of control of a warhead on the part of a country with military nuclear capability, or from a terrorist act. The consequences of such event would be of such magnitude (and its likelihood so limited) that it is considered outside the scope of this study.[228]

What the study did not explore—or really acknowledge—was a third possible scenario: that of a nuclear weapon detonation as a result of deliberate, hostile intent by a state or states. Yet, as was observed, "That these concerns have faded from memory and have receded in the policy discourse probably speaks more to more immediate-seeming preoccupations than because the risk of nuclear weapons detonations has become negligible".[229] The recent unfolding of an international discourse enquiring into the impacts and sources of risk of nuclear weapons indicates both that there is renewed concern, and the risk of nuclear weapon detonation events is not necessarily as negligible as assumed.

The OCHA study examined the relationship between nuclear accidents and humanitarian crises to identify the operational implications for international humanitarian partners of responding to nuclear accidents. The study also outlined the arrangements for inter-agency coordination for responding to nuclear emergencies and the headquarters and field-level coordination mechanisms of the humanitarian community. It concludes with recommendations for enhancing the capacities of humanitarian and nuclear emergency response mechanisms.

The recommendations of the OCHA study do not therefore embrace non-civilian nuclear accidents. Nonetheless, several of them are of relevance here. One recommendation was that, given the importance of the human dimension in nuclear emergencies, and the key role of humanitarian organizations therein, the IASC Working Group should invite the IAEA to take part in a special session at which the human dimension of nuclear emergencies and other aspects of the humanitarian-nuclear emergencies interface are discussed.

Another recommendation of the OCHA study was for the development of risk and crisis assessments by the United Nations Department of Safety and Security (DSS) (see box 8). These assessments would include explanations of terms, safety levels, United Nations response mechanisms, and guidance on what to do in the case of a radiological emergency. Standard operating procedures for use in environments affected by radiological release should, the study argued, be developed by security and medical services to provide guidance on safe access for staff and how to extract them safely in emergency situations.

225 *United Nations System-wide Study on the Implications of the Accident at the Fukushima Daiichi Nuclear Power Plant*, UN document SG/HLM/2011/1, 16 August 2011, para. 127.

226 See Environmental Emergencies Section (Joint UNEP/OCHA) of the UN Office for the Coordination of Humanitarian Affairs, *Linking Humanitarian and Nuclear Response Systems: A Study by the Office for the Coordination of Humanitarian Affairs*, 2013, https://ochanet.unocha.org/p/Documents/Linking%20Humanitarian%20and%20Nuclear%20Response%20Systems.pdf.

227 Ibid., p. 12.

228 Ibid.

229 S. Bagshaw, "Responding to the detonation of nuclear weapons: A United Nations humanitarian perspective", in J. Borrie and T. Caughley (eds.), *Viewing Nuclear Weapons Through a Humanitarian Lens*, UNIDIR, 2013, p. 125. Much of this sub-section is based on Bagshaw's article.

Box 8: DSS

The United Nations Department of Safety and Security is responsible for ensuring the maximum security of staff and enabling the safest and most efficient conduct of the programmes and activities of the United Nations system. The DSS has established a "coordinated security threat and risk assessment mechanism within the framework of a common, system-wide methodology" that is contained in a the Security Policy Manual. The Manual supersedes the previous Field Security Handbook including the Handbook's annex T on operations in a nuclear, biological, or chemical warfare environment. Annex T had provided that in such an environment United Nations organizations, with a few exceptions such as the IAEA and the OPCW, would not undertake or continue operations. The new manual is more nuanced and rests on the mechanism for threat and risk assessment to which reference has just been made. In essence, whether risk is acceptable at any level lower than "unacceptable" becomes a question of programme priority as determined by senior managers listed in the mechanism. This refinement in effect reflects the need to properly balance the protection of United Nations staff with the reality that the international community will have certain expectations of the United Nations system in the dire circumstances of a nuclear, biological, or chemical event. Given the seriousness of a nuclear weapon detonation event requiring United Nations coordinated humanitarian assistance, it seems likely that a determination of unacceptable risk would ultimately be made by the Secretary-General himself.

The Under-Secretary-General for Safety and Security of DSS chairs an Inter-Agency Security Management Network (IASMN), established to support the High-Level Committee on Management in a comprehensive review of the United Nations security management system. The IASMN is comprised of senior managers from United Nations organizations who have oversight of security. It may call upon specialized agencies to provide expertise and advice on specific issues related to staff safety, for example, advice from the OPCW on issues related to chemical threats.

Of particular relevance to our study is the Operational Preparedness Group (OPG) on CBRN, co-chaired by OCHA and WFP. Other OPG members are the United Nations Children's Fund (UNICEF) and the WHO. The UNHCR and the IFRC are observers. The OPG's focus is on harmonizing operational preparedness and response procedures for CBRN events, as they relate to humanitarian action, including planning for remote operations as needed. The group was formed in October 2013 against the background of the situation in the Middle East which, as well as putting pressure on humanitarian actors operational on the ground to protect and prepare themselves for a potential CBRN incident, presents challenge for preparing to assist affected populations. The OPG's terms of reference note that CBRN preparedness begins with staff safety and security, and may include the continuation of humanitarian activities through alternative means and the management of knock-on effects, such as the large-scale displacement of populations.[230] The terms of reference explicitly accept that action may also include recognizing and publicizing the fact that humanitarian organizations will not be likely to be able to respond in any effective way to any CBRN incident of magnitude, other than to protect staff and respond to secondary consequences.

Other relevant mechanisms with which OCHA is centrally involved include:

- United Nations Disaster Assessment and Coordination (UNDAC). UNDAC is part of the international emergency response system for sudden-onset emergencies. Created in 1993, UNDAC is designed to help the United Nations and governments of disaster-affected countries during the first phase of a sudden-onset emergency. UNDAC also assists in the coordination of incoming international relief at the national level including at the site of the emergency.
- Joint UNEP/OCHA Environment Unit (JEU), housed within OCHA's Emergency Services Branch. The JEU helps member states to prepare for and respond to environmental emergencies arising typically in the wake of a conflict or natural disaster. By pairing UNEP's technical expertise with OCHA's humanitarian response coordination structure, the JEU ensures an integrated approach in responding to environmental emergencies.
- United Nations Humanitarian Civil–Military Coordination. OCHA's Geneva-based Civil–Military Coordination Section is the focal point in the United Nations system for humanitarian civil–military coordination to support OCHA's overall efforts in humanitarian operations with

230 Operational Preparedness Group on CBRN, "Terms of reference", draft, 2 October 2013, www.humanitarianresponse.info/system/files/documents/files/CBRN_OpPrepGroup_TOR-2013_10.pdf.

> a military presence, where OCHA leads the establishment and management of interaction with military actors. The Civil–Military Coordination Section advises the international community on needs related to mobilizing foreign military assets in support of relief operations or humanitarian assistance to ensure that local and international humanitarian organizations can operate in the same space without detriment to the civilian character of humanitarian assistance.

UNDP

The OCHA system-wide study instigated in the aftermath of the Fukushima Daiichi nuclear accident also drew on the Chernobyl experience, as did the 2011 Secretary-General's report. The OCHA study highlighted the extensive experience of UNDP in assisting affected countries with recovery in the aftermath of the Chernobyl accident. Even now, UNDP (together with other humanitarian organizations such as the IFRC) is still actively engaged in helping mitigate the consequences of that event, the key details of which are briefly recalled in box 9.

Box 9: The Chernobyl nuclear disaster

On 26 April 1986, a sudden surge of power during a reactor systems test destroyed one unit of the nuclear power station at Chernobyl, Ukraine. The accident and the fire that followed released massive amounts of radioactive material into the environment. After the accident, officials closed off the area within 30km of the plant, except for persons with official business at the plant and those people evaluating and dealing with the consequences of the accident and operating the undamaged reactors—115,000 people were evacuated from the most heavily contaminated areas in 1986, and another 220,000 people in subsequent years. The Chernobyl accident's severe radiation effects killed 28 of the site's 600 workers in the first four months after the event. Another 106 workers received doses high enough to cause ARS. Chernobyl clean-up activities eventually required the efforts of about 500,000 workers.[231]

Initially, the United Nations system treated the Chernobyl accident as a humanitarian disaster. Until 2004, OCHA was the United Nations lead agency. That year UNDP assumed the lead agency role in recognition of longer-term developmental considerations having taken on greater prominence, for instance the restoration of community self-reliance and self-sufficiency and the creation of new economic opportunities. It was thus logical that the OCHA study should recommend that UNDP join IACRNE (of which OCHA is already a member) to "ensure that the human dimension of nuclear accidents is taken into consideration in early recovery efforts".[232] UNDP formally submitted a membership request to IACRNE in January 2014.

The United Nations Secretary-General's latest report on Chernobyl was tabled in the General Assembly on 3 October 2013.[233] The report recorded the activities undertaken by the United Nations system to promote recovery from the Chernobyl disaster including UNDP's role in coordinating inter-agency efforts on the implementation of the Decade of Recovery and Sustainable Development of the Affected Regions (2006–2016). The report also emphasized the importance of ongoing inter-agency cooperation. It noted UNDP commitment to giving a stronger voice to the human dimension of preparedness for and recovery from nuclear emergencies at the United Nations level and to incorporating that knowledge and experience into UNDP developmental programming worldwide.

Drawing on lessons learned from 28 years of sustained response to the Chernobyl accident,[234] the Secretary-General's report makes a broader point about coordination in the United Nations system. The effectiveness of coordination mechanisms among organizations involved in recovery efforts, according to their distinct mandates, is seen as critical in meeting humanitarian needs. The report notes (with prescience) that:

> programmatic developmental approaches that address the unique human dimensions of nuclear disasters may serve as a guide

231 UNSCEAR, *Sources and Effects of Ionizing Radiation*, vol. II, 2008, pp. 47, 58, 107, 119, www.unscear.org/docs/reports/2008/11-80076_Report_2008_Annex_D.pdf.

232 United Nations, *Optimizing the International Effort to Study, Mitigate and Minimize the Consequences of the Chernobyl Disaster: Report of the Secretary-General*, UN document A/68/498, 3 October 2013, pp. 15–16.

233 Ibid., p. 22.

234 UNDP (Regional Bureau for Europe and the CIS), *Knowledge Product: Recovery from Chernobyl and Other Nuclear Emergencies: Experiences and Lessons Learnt*, 2013, http://chernobyl.undp.org/english/docs/knowledge_product.docx.

> in dealing with similar emergencies in the future. By the end of the third decade following the Chernobyl accident, it would be important to properly document and codify the solutions so that they can be applied and replicated in other nuclear disaster situations worldwide.[235]

In the meantime, UNDP continues to lead the dialogue with organizations in the United Nations system and member states on the future of inter-agency cooperation in respect of the human consequences of the Chernobyl accident. Box 10 provides several relevant insights into that cooperation.

Box 10: Learning from the human consequences of Chernobyl

A 2002 report UNDP and UNICEF commissioned with the support of OCHA and WHO reviewed the human consequences of the Chernobyl nuclear accident. It observed that many of the initiatives taken in response to that calamity "have potential application in other parts of the world where rural communities have been subjected to destructive shocks, whether technological in origin or resulting from war, civil disturbance, or economic change".[236] A later UNDP publication dated April 2013 on "Recovery from Chernobyl and other nuclear emergences: experiences and lessons learnt" codified the experience gained from responding to the humanitarian and developmental challenges that emerge in the aftermath of civilian nuclear disasters—recovery efforts that are specific to nuclear fallout. As well as the Chernobyl accident, the study focused on communities near the sites of nuclear tests in Semipalatinsk, Kazakhstan, and uranium tailings in Central Asia.[237]

FAO

Under its constitution, the FAO has statutory functions that are relevant in preparing for, responding to, and providing assistance in the event of a nuclear or radiological incident or emergency. The organization is a full party to the Early Notification and Assistance Conventions and as such, is within its constitutional mandate to monitor and evaluate the world food security situation. The FAO also has the competency to assess the qualitative and quantitative effects of all contaminants including radionuclides on food supplies, and to advise governments on measures to be taken to minimize radionuclides appearing in agricultural, fisheries, and forestry products entering national and international trade. The FAO is a member both of IACRNE and the IASC and along with the WFP leads the food security element of the humanitarian cluster system. Under a joint initiative with the WHO, the FAO has established the International Food Safety Authorities Network (INFOSAN) of 177 member states to promote the rapid exchange of information during food safety-related events and of helping countries strengthen their capacity to manage food safety risks including contamination from radiation releases. The FAO has a strategic partnership with the IAEA.

UNHCR

The Office of the United Nations High Commissioner for Refugees is mandated to lead and coordinate international action to protect refugees and resolve refugee problems worldwide. Its roles and responsibilities under the cluster system are described in appendix 1. UNHCR is experienced in dealing with sudden-onset emergencies requiring immediate response such as outbreaks of fighting causing people to flee their homes. Providing fleeing civilians with emergency help is often the first step towards their long-term protection and rehabilitation. To prepare for and respond to an emergency, UNHCR formed a roster of trained personnel with a wide range of key skills that are ready for deployment anywhere in the world at short notice. It also created emergency stockpiles of non-food aid items in Copenhagen and Dubai to supplement local aid supplies in areas of need. UNHCR believes that it has the capacity to respond to a new emergency impacting up to 500,000 people.[238]

---

235 United Nations, *Optimizing the International Effort to Study, Mitigate and Minimize the Consequences of the Chernobyl Disaster: Report of the Secretary-General*, UN document A/68/498, 3 October 2013, p. 17, para. 76.

236 UNDP, UNICEF, OCHA, and WHO, *The Human Consequences of the Chernobyl Nuclear Accident: A Strategy for Recovery*, 2002, p. 2, http://chernobyl.undp.org/english/docs/strategy_for_recovery.pdf.

237 UNDP (Regional Bureau for Europe and the CIS), *Knowledge Product: Recovery from Chernobyl and Other Nuclear Emergencies: Experiences and Lessons Learnt*, 2013, http://chernobyl.undp.org/english/docs/knowledge_product.docx.

238 UNHCR, *UNHCR Emergency Response*, www.unhcr.org/pages/503352e46.html.

UNEP

Given the widespread and long-lasting environmental damage that is likely to result from a nuclear detonation event, and its mandate to promote and facilitate sound environmental management for sustainable development, UNEP has a interest in the prevention of such a detonation. It is a member of IACRNE, the secretariat of UNSCEAR is functionally linked to UNEP, and the JEU helps member states to prepare for and respond to environmental emergencies. UNEP also has a sub-programme on disasters and conflicts.

Other United Nations agencies

There is not space here to identify all the agencies in the United Nations system and other international organizations that would be involved in responding to the challenges of humanitarian action in the event of nuclear weapon detonations. Nor does our very brief mention of organizations like UNICEF and the WFP adequately reflect the level of the engagement perhaps necessary from them in a nuclear weapon detonation event. Beyond the entities that are members of IACRNE, the JPLAN, IASC, and the cluster system, mention should also be made of organizations such as:

- The United Nations Office for Disaster Risk Reduction (UNISDR) with a remit not only to help in reducing the risk of disasters resulting from natural hazards and environmental emergencies but also from those of a technological kind.
- The Global Disaster Alert and Coordination System (GDACS), a cooperation framework comprising the United Nations, the European Union, and national-level disaster managers and disaster information systems worldwide. It aims to fill the information and coordination gap in the first phase after major disasters. GDACS provides real-time access to web-based disaster information systems and related coordination tools. In the United Nations system the United Nations Institute for Training and Research facilitates the service through the Operational Satellite Applications Programme. The Emergency Relief Coordination Centre in OCHA in Geneva acts as GDACS Secretariat.

Intergovernmental organizations

IOM

The International Organization for Migration (IOM) helps to ensure the orderly and humane management of migration and internally displaced people. People displaced by a nuclear detonation event would be the immediate responsibility of the affected state, but could overwhelm national authorities, which would necessitate the IOM's involvement.

Red Cross and Red Crescent Movement: planning for response

Outside the United Nations system, and yet a core part of the international humanitarian framework, the RCRC is the world's largest humanitarian relief and development network. The Movement is made up of nearly 100 million members, volunteers, and supporters in 189 National Societies worldwide. It has three main components, which are National Societies, the ICRC, and the IFRC, the umbrella body for national Red Cross and Red Crescent Societies. The RCRC has long experience in confronting nuclear or radiological emergencies. The Japanese Red Cross Society provided humanitarian aid to Hiroshima and Nagasaki in the wake of the 1945 nuclear bombings, later establishing survivors' hospitals in both cities to treat radiation sicknesses and other after-effects. A number of National Societies were involved during the time of the Cold War to strengthen the preparedness of the population on issues related to radiation protection following a nuclear attack. The knowledge base acquired has been used in assisting Chernobyl victims through the IFRC Chernobyl Humanitarian Assistance Programme and more recently in responding to the Fukushima Daiichi accident.

As mentioned in part one, National Societies, the ICRC, and the IFRC have been active in the past decade both in drawing attention to humanitarian issues relating to nuclear weapons and also in taking a greater role in preparedness and response to nuclear accidents. Indeed, the growth in the public consciousness of humanitarian perspectives on nuclear weapons was given a significant boost by the resolution of 26 November 2011 of the Council of Delegates, the body of the RCRC where all members meet to discuss matters that concern the Movement as a whole. The Council placed emphasis not only on the "incalculable human suffering that can be expected to result from any use of nuclear weapons" but also on "the lack of any adequate humanitarian response capacity" to respond to the casualties of such use. The Council found it "difficult to envisage how any use of nuclear weapons could be compatible with the rules of international humanitarian law, in particular the rules of distinction, precaution and proportionality".[239]

The OCHA "linking" study recognized the significant role national Red Cross and Red Crescent Societies play in response to nuclear emergencies and recommended that the IFRC should become a member of the JPLAN and IACRNE. The IFRC applied in April 2013 to become an observer to IACRNE and was granted the status of corresponding member (observer) in October 2013.

As already noted, ICRC delegates witnessed the aftermath of the detonation of the nuclear weapon in Japan in 1945,[240] and the ICRC has periodically voiced its concerns about nuclear weapons use ever since. From the middle of the last decade, the ICRC also began to look carefully at how it could be called upon to respond to assist victims of CBRN weapon events. At the time, such scenarios seemed remote, even to some within the organization. However, the use of chemical weapons in the Syrian conflict in recent years has underlined the relevance of prior doctrine formation and operational planning for CBRN-related events.

In view of their relevance to this study, some of the main findings of ICRC experts are set out here with respect to detonation of nuclear weapons:[241]

- Any action to assist victims would have to be coordinated at a global level. Factors complicating this coordination include the fact that realistic coordination mechanisms are in their infancy; lack of clarity as to who would be responsible for coordinating such a response; cancellation or prohibition of flights into or out of a contaminated area; as well as the question of whether the event was accidental (as alleged intentional detonation would carry heavy political, security, and media implications).
- State military expertise in assisting victims pertains to force protection and to continuing to function militarily in a contaminated environment or presence of a threat—not necessarily to assisting large numbers of civilians.
- Nearly all relevant international players have security policies that involve withdrawal of staff in the event of CBRN use, something that may not be consistent with their humanitarian mandates or the practicalities of the situation.
- To the ICRC's knowledge, no government, international organization, NGO, or collaborative body has either realistic plans or the capacity to mount an international response.
- For international players embarking on creating a capacity for an adequate assistance response to such low-probability/high-impact events, huge initial investments together with long-term commitments would be required. These investments are not only financial; they include massive investment in human resources and commitments to maintaining this capacity, especially in training. It thus would also require sustained political motivation and willingness to coordinate efforts.
- An unplanned, uncoordinated, and badly executed assistance response is likely to be ineffective. For persons providing that assistance, it may make such an event more dangerous than it need be.
- Dialogue among international players on this complex issue is in its earliest stages. Further work is required to understand better the roles, resources, capacities, and collaboration mechanisms of all international players who might be involved in assisting victims of a nuclear weapon detonation event.
- The evident lack of an international capacity to help victims underscores the inescapable fact that preventing the use of nuclear weapons is an absolute imperative.[242]

239 See Council of Delegates of the International Red Cross and Red Crescent Movement, *Resolution 1*, 26 November 2011, www.icrc.org/eng/resources/documents/resolution/council-delegates-resolution-1-2011.htm.

240 See F. Bugnion, "The ICRC and nuclear weapons: from Hiroshima to the dawn of the 21st century", *International Review of the Red Cross*, vol. 87, 2005, p. 511.

241 D. Loye and R. Coupland, "Who will assist the victims of use of nuclear, radiological, biological or chemical weapons—and how?", *International Review of the Red Cross*, vol. 89, no. 866, 2007, especially pp. 341–344.

242 Most of these findings also relate to other kinds of CBRN weapon use. However, here only their pertinence to nuclear weapon detonation is reflected.

In a further analysis, ICRC experts emphasized that some of the challenges to assisting the victims are "non-buyable" in the sense that these:

> go much further than deciding what materials and equipment should be purchased and which people are needed with what skills. … We propose that the challenges for which the solutions are "non-buyable" pertain to three domains: first, the many and complex practical aspects of developing, acquiring, training for and planning an appropriate response capacity to assist the victims of [a CBRN] event; second, the issues specific to deploying this capacity in an event; and third, the different mandates and policies of pertinent international organizations and how such organizations interact.[243]

In these respects, the authors of the analysis stated that they anticipated particular challenges for the United Nations system's ability to respond to or coordinate assistance. Since then, while continuing to stress the "near impossibility" of bringing effective humanitarian assistance to the victims of an event such as the detonation of a nuclear weapon in a populated area and the necessity of preventing the use of such weapons, the ICRC has sought to develop an in-house (and yet unpublished) CBRN response framework. Such a framework appears likely to include a "minimal capacity" to mount an appropriate operational response using a risk-based approach to management and systematic decision-making and standardized operational practices. This would involve:

- undertaking informed risk assessments of CBRN scenarios and events;
- devising ways in which to take timely and competent decisions downstream from this; and
- effectively mobilizing resources (in terms of information, human resources, and materials) to implement these decisions.

In a recent article published by ICRC experts, the ICRC's three key objectives were noted:

1. Minimize risk to health, safety and security of ICRC staff;
2. Ensure the integrity of the institution and continuation of its activities;
3. Provide assistance to affected people, as possible, whether directly affected or indirectly affected (e.g. displaced by the event).[244]

The ICRC's approach is a relevant guide currently to the kinds of challenge that the United Nations system would face in providing humanitarian coordination and assistance in the event of a nuclear weapon detonation event in a populated area.

Summary

This part has provided an outline of various ways in which components of the United Nations system and the Red Cross and Red Crescent Movement are organized to prepare for and respond to the humanitarian consequences of nuclear emergencies, namely those stemming from civilian nuclear sources. Those arrangements centre upon comprehensive—and well-tested—mechanisms for inter-agency coordination. However, with the exception of the ICRC, their plans do not explicitly extend to trying to respond to the specific assessment and decision-making challenges of a humanitarian emergency arising from a nuclear weapon detonation event. These challenges for the United Nations will be diverse and formidable, and are considered in the following part.

243 R.M Coupland and D. Loye, "International assistance for victims of use of nuclear, radiological, biological and chemical weapons: time for a reality check?", *International Review of the Red Cross*, vol. 91, 2009, pp. 329–340.

244 See G. Malich et al., "A proposal for field-level medical assistance in an international humanitarian response to chemical, biological, radiological or nuclear events", *Emergency Medicine*, vol. 30, 2013, pp. 804–808, p. 805.

PART 4: CHALLENGES FOR UNITED NATIONS HUMANITARIAN RESPONSE TO NUCLEAR WEAPON DETONATION EVENTS

In part two of the study we described the effects and humanitarian consequences of a nuclear weapon detonation event in differing contexts. Inevitably the precise nature of the consequences in a given situation remains educated guesswork. But it is clear that the explosion of even one low-yield nuclear weapon in an environment such as a city would cause death, injury, trauma, and suffering on a large scale, massive physical destruction (which would impede emergency response), the possibility of radioactive fallout that could drift a long distance and pose a threat outside the blast, heat, and prompt radiation-affected zone, and major disruption including displacement of many people. High-yield or multiple nuclear weapon detonations would compound the challenges of humanitarian coordination and response greatly.

Part three identified the most relevant parts of the United Nations system in terms of humanitarian coordination and assistance after a nuclear weapon detonation event. We observed that although the humanitarian system has experience in dealing with various kinds of sudden-onset major disasters, including certain civil radiological emergencies, there has been no recent systematic thinking or planning within the United Nations on the specific challenges of bringing assistance to the victims of nuclear weapon detonation events. In this part of the study, we consider the implications of this point in terms of the problems it could pose, and realistically what the United Nations system could begin to do about it.

It is important to recognize that a nuclear weapon detonation event of any kind in a highly populated area would cause an immediate international crisis, of which humanitarian response concerns would only be a part. Such an event, if deliberately caused, would represent the breaking of a 70-year taboo against nuclear weapon use. Claims by the state or states responsible that a detonation was accidentally caused might not be believed, at least initially. Until such time as sufficient facts are established about the causes,[245] fears about the prospect of further nuclear weapon detonation events may be expected to preoccupy the attention of governments, media, and publics, and be the focus of international diplomacy, including in United Nations organs such as the Security Council.[246] Establishing these facts could take some time, for many reasons. During this period considerable international disruption from the crisis-driven responses of states can be envisaged—quite aside from the direct consequences of one or more nuclear detonations. These security-driven responses, such as the widespread suspension of flight networks, port operations, and routine government activities, could form significant hurdles to the undertaking of humanitarian operations to assist the victims.

The crisis context of a nuclear weapon detonation event is especially important to consider for at least two reasons. First, the General Assembly has called upon the United Nations to improve coordination in planning a response to a terrorist CBRN attack in order to assist states.[247] (This is discussed further below in the context of the Counter-Terrorism Implementation Task Force.) In contrast, on matters related to the United Nations responding to assist states due to state use of nuclear weapons there has been far less engagement—and perhaps even reluctance

245 At present there is no mechanism specific to investigating the cause of such an event. It is perhaps notable that the CTBTO could launch an on-site inspection in an area in which a suspicious nuclear explosion has occurred if the data from the International Monitoring System indicated that a nuclear test had taken place there, with a view to CTBTO inspectors collecting evidence on the ground at the suspected site. However, such an inspection can only be requested and approved by the CTBT's member states once the treaty has entered into force internationally. See IAEA, *Joint Radiation Emergency Management Plan of the International Organizations*, 2013, appendix B, p. 2.

246 See earlier footnote 183.

247 See General Assembly, The United Nations Global Counter-Terrorism Strategy, UN document A/RES/60/288, 20 September 2006. Paragraph 17 asks "the United Nations to improve coordination in planning a response to a terrorist attack using nuclear, chemical, biological or radiological weapons or materials, in particular by reviewing and improving the effectiveness of the existing inter-agency coordination mechanisms for assistance delivery, relief operations and victim support, so that all States can receive adequate assistance. In this regard, we invite the General Assembly and the Security Council to develop guidelines for the necessary cooperation and assistance in the event of a terrorist attack using weapons of mass destruction".

because of the controversy it might provoke—let alone direct assistance to the victims. Yet in the initial phases of response, the cause or identities of the perpetrators of a nuclear weapon detonation may not be known.

Second, in the majority of circumstances, it is not United Nations agencies themselves that provide the bulk of personnel and assets, but other actors such as states (including, in some cases, from national militaries), NGOs, and the private sector. These actors are not under the control of the ERC or the humanitarian system: they cooperate and accept United Nations coordination, for instance through IASC or clusters. Presumably this is because these actors consider there are benefits to cooperating within a United Nations-coordinated humanitarian system—both to themselves and in the broader effort to deliver assistance. With heterogeneous actors there are also heterogeneous orientations and capacities, and perhaps differing levels of risk acceptance. The United Nations' power to coordinate effectively will be reduced if it appears hesitant, unprepared, or lacking in competence. And as already noted, in terms of the range of potential scenarios involving use of nuclear, radiological, biological, or chemical weapons ICRC experts have concluded that an "unplanned, uncoordinated and badly executed assistance response is likely to be ineffective. For persons providing that assistance, it may make [a CBRN] event more dangerous than it need be".[248]

State obligations, decisions, and capacity

Assessing state preparedness and response to nuclear weapon detonation events lies outside the scope of this study, suffice to say that we consider it is unlikely that most states could handle the humanitarian challenges of assisting the victims of even a single nuclear weapon detonation event in a highly populated area without outside help in view of the consequences. Alongside this, it is important to recall that in respect to radiological issues the IAEA's 2011 Action Plan makes it clear that the "responsibility for ensuring the application of the highest standards of nuclear safety and for providing a timely, transparent and adequate response to nuclear emergencies, including addressing vulnerabilities revealed by accidents, lies with each Member State".[249] In other words, states and their civilian nuclear organizations, rather than the IAEA or international system, are primarily responsible for maintaining safety and responding to nuclear accidents. As for humanitarian emergency assistance in general, the United Nations General Assembly's guiding principles of emergency humanitarian assistance provide that "Each State has the responsibility first and foremost to take care of the victims of natural disasters and other emergencies occurring on its territory".[250]

Whether this would amount in practice to meaningful assistance to the survivors of the event is impossible to predict, especially in view of the many permutations possible in such scenarios. In addition to variables discussed in part two, such as the severity of the occurrence in terms of casualties, or radioactive fallout impacts (including for populations outside the blast and thermal radiation-affected zone—with no respect for national borders), there are other factors to be considered. These include the existence of an armed conflict and the possibility of further nuclear weapon detonations. Moreover, such is the destructive power of nuclear weapons that governmental "decapitation" could conceivably occur, for instance if a nuclear detonation event occurred in a capital city.

In the absence of a mandate to intervene, the IAEA and the broader United Nations system might also look to the state responsible for causing a nuclear detonation event (if it is a state) to offer assistance to the affected state(s). This assistance might or might not extend to directly assisting the victims, and would depend both on the willingness and capacity of the state(s) responsible. In principle, such assistance is conceivable if the detonation event was caused by an accidental nuclear weapon launch, although it seems unlikely to be provided in cases in which the use was deliberate. With regard to capacity, a number of states, for instance those

248 D. Loye and R. Coupland, "Who will assist the victims of use of nuclear, radiological, biological or chemical weapons—and how?", *International Review of the Red Cross*, vol. 89, no. 866, 2007, p. 343.

249 IAEA, *Action Plan on Nuclear Safety*, 13 September 2011, p. 1, www.iaea.org/newscenter/focus/actionplan/reports/actionplanns130911.pdf.

250 General Assembly, *Strengthening of the Coordination of Humanitarian Emergency Assistance of the United Nations*, UN document A/RES/46/182, 19 December 1991.

possessing nuclear weapons[251] as well as others with these arms stationed on their territory or nearby,[252] have national plans for how to respond to a variety of nuclear emergencies, which might extend to nuclear weapon detonation events occurring on their home soil. It is unclear how effective these plans would be in assisting the victims, and even less obvious to what extent any national assistance capacities specific to the consequences of nuclear detonations could be turned to assisting victims of such events beyond their borders. Moreover, of those states that possess niche military capacities in radiological detection, protection, and decontamination, these are mostly oriented towards force protection (that is, the ability to survive and fight in CBRN environments) and not humanitarian assistance delivery.[253]

An additional point to consider is the willingness of the state on whose territory a nuclear weapon detonation event has occurred to request and permit help from outside its borders for victims. It is not a straightforward question, either in the case of accepting help directly from other states on a bilateral basis, or from the United Nations system. Possible reasons for the refusal of a state to request or admit humanitarian assistance could include (but are not limited to):

- a state's sense of adequacy in believing (at least initially) that responding to the humanitarian consequences of the nuclear detonation event is within national means;
- concern that further nuclear weapon detonation events will occur on its territory due to uncertainty or threats of further use;
- concern that international humanitarian relief efforts could conflict with or undermine its own relief efforts (or military operations);
- the state or states affected are in a high state of security emergency (this is not limited to a situation of armed conflict, but could include a "lock down" situation like that following the 11 September 2001 attacks); and
- a state might be concerned that accepting humanitarian assistance would provide a pretext for military intervention or investigation of the detonations prejudicial toward it.

Obviously, it would be challenging (to say the least) for the United Nations system to coordinate and deliver humanitarian assistance to the victims without the consent of the state or states on whose territory the nuclear detonation event(s) occurred.

Activation of the humanitarian system

As explained earlier in the study, a nuclear weapon detonation event with mass casualties would warrant Level 3 activation—rapid, system-wide mobilization. The ERC is responsible for taking a decision based on an assessment in consultation with field staff and IASC Principals

251 For the United States see, for example, "Nuclear/Radiological Incident Annex", 2008, www.fema.gov/pdf/emergency/nrf/nrf_nuclearradiologicalincidentannex.pdf. The United States National Nuclear Security Administration assists Israel with training for a nuclear or radiological emergency; see "NNSA holds radiation emergency consequence management training in Israel", 10 January 2013, www.nnsa.energy.gov/mediaroom/pressreleases/israeltraining011013.
For the United Kingdom, one example is Cabinet Office, *National Risk Register of Civil Emergencies*, 2012, www.gov.uk/government/uploads/system/uploads/attachment_data/file/211858/CO_NationalRiskRegister_2012_acc.pdf.
For France, see for instance Government of France, "Circulaire interministérielle des exercices d'urgence nucléaire et radiologique", 13 December 2012, http://circulaires.legifrance.gouv.fr/pdf/2013/01/cir_36327.pdf.
India and Pakistan have an agreement on reducing the risk of accidents with their nuclear weapons; see "Indo-Pak agreement on reducing the risk from accidents relating to nuclear weapons—full text", *The Hindu*, 21 February 2007, www.hindu.com/nic/nuclear.htm. One source on Indian national planning is Indian National Disaster Management Authority, *National Disaster Management Guidelines—Management of Nuclear and Radiological Emergencies*, 2009, http://ndma.gov.in/ndma/guidelines/Management+of+Nuclear+&+Radiological+Emergencies.pdf. For Pakistan see Pakistan Nuclear Regulatory Authority, "Statutory notification", *The Gazette of Pakistan*, 1 September 2008, www.pnra.org/legal_basis/PAK-914.pdf.
One official document for the Russian Federation recognizing the possibility of accidents with nuclear weapons is Government of the Russian Federation, *Decree No. 794 of December 30, 2003 on the Unified State System of Prevention and Liquidation of Emergency Situations*, 30 December 2003, http://en.gosnadzor.ru/framework/nuclear/RF%20Government%20Decree%20No.794.doc.

252 See for example, German Federal Ministry of the Interior, *Protecting Critical Infrastructures—Risk and Crisis Management*, 2008, www.bbk.bund.de/SharedDocs/Downloads/BBK/DE/Publikationen/PublikationenKritis/Protecting-Critical-Infrastructures.pdf.

253 D. Loye and R. Coupland, "Who will assist the victims of use of nuclear, radiological, biological or chemical weapons—and how?", *International Review of the Red Cross*, vol. 89, no. 866, 2007, pp. 341–342.

once a determination has been reached that it is a Level 3 emergency. It is supposed to be a rapid process, with a final decision on activation taken by the ERC within 48 hours of the onset situation. However, finding out what is going on in the affected zone will be hampered in view of the damage and disruption to communications infrastructure including from blast, heat, and EMP effects, which would complicate Level 3 activation assessment. The sheer scale of destruction in some potential scenarios would make it difficult to develop a timely overview of what is needed where, or where areas of particular hazard to human health remain, for instance due to radioactive fallout. Without the benefit of well-coordinated data gathering, analysis, and information-sharing (for instance, from the CTBTO, IAEA, and WMO, which each collect relevant data or have pertinent expertise) it may not be clear to United Nations officials during the first 48 hours following a nuclear weapon detonation event whether it constitutes a Level 3 emergency, and thus is a matter for activation of the cluster system.

There is also the important matter of ensuring, to the greatest degree feasible, the safety of any humanitarian personnel entering or operating in the nuclear detonation-affected zone. Affecting the ERC's ability to make such a determination will include factors such as:

- whether there is communication with the affected area(s) so as to inform the inter-agency assessment procedure;
- to what extent actors within the United Nations system can provide or gain access to credible and context-specific information or advice, including on the effects of ionizing radiation and the spread of radioactive fallout;
- whether there is a credible threat of further nuclear weapon detonations; and
- what actions the affected state(s) or other states are undertaking that could impede the coordination and delivery of humanitarian assistance to the victims, including military actions or threats, or "no fly" conditions.

Delivery of humanitarian assistance can become a highly charged political issue, and the ERC will be at pains to avoid exceeding a humanitarian mandate. However, that may be difficult to do because of the broader context in which assessments and decisions have to be made in the United Nations following a nuclear weapon detonation event, as discussed in the next section. Even a decision to refrain from delivering assistance—or to decline to authorize certain forms of humanitarian activity, or confine them to certain places for reasons of staff safety—may nevertheless have political ramifications because of the way such decisions are perceived by states, media, and the public.

The broader United Nations system

It may be anticipated that any humanitarian cluster response would be expected to be consistent with broader United Nations crisis-response efforts. The Secretary-General is almost certain to convene a meeting of relevant United Nations agency principals to assess the situation immediately after becoming aware of a nuclear weapon detonation event. The ERC's assessment and role in activating the humanitarian cluster system would no doubt be taken note of. Nevertheless, because of the event's political consequences the Secretary-General's assessment will by necessity be a broader exercise. For example, even in the case of an accidental detonation in the sparsely populated hinterland of a large country (e.g. the United States or the Russian Federation) where that state assumed full responsibility for the accident and claimed to be self-sufficient in terms of assisting any victims, the Secretary-General would need advice from IAEA, CTBTO, UNEP, WMO, UNHCR, and others concerning down-stream, transboundary impacts such as longer-term human displacement and potential effects on the environment. There would also be significant implications for international diplomacy (Department of Political Affairs for the Security Council, Office of Disarmament Affairs for NPT ramifications) and various parts of the system concerning liability and safety issues for United Nations staff operating in or near the affected area at the time of the nuclear weapon detonation event. Decisions would have to be made for the protection or evacuation of United Nations staff in affected areas, people who may not be contactable immediately (and who may not know what to do, wherever they are).

The Secretary-General must also report to and advise states in the Security Council and the General Assembly. This is important not least because the Security Council can pass resolutions that are binding on the international community—this power extends to authorizing military action by states and the imposition of sanctions of various kinds. The actions of the Security Council therefore have the potential to impact on how and to what extent humanitarian assistance can be delivered by the international community.

And humanitarian access, in an armed conflict situation, could be contingent on the brokering of broader mediation efforts. Taken together, these points imply the Secretary-General might wish to give the "green light" before preparedness for cluster activation moves into its active phase. This would represent a departure from the normal cluster activation procedure initiated by the ERC, but it cannot be discounted since the nature of a nuclear weapon detonation event and the attendant political crisis would also be unprecedented.

The purpose of raising these issues is to illustrate that a nuclear weapon detonation event would have a range of implications that are as yet uncertain in their impact on a United Nations-coordinated humanitarian response. It should not be assumed that the response, including a Level 3 designation, would be "business as usual" without further consideration of the variety of factors influencing the international context or the establishment of a procedural mechanism for this eventuality. To reiterate—at present no coherent mechanism exists that is specific to dealing with the challenges that a nuclear weapon detonation event would create for communications (including chain of command) and coordination, as well as for assisting the victims.

Mandates, time, and a credible humanitarian response in the circumstances

As was discussed in part three, a range of actors in the United Nations system have mandates and responsibilities that would be relevant—and in some cases necessary—for a coordinated system-led humanitarian response. At present, however, our assessment is that it is not clear where lines of accountability would lie for responding to a nuclear weapon detonation event. There is no widespread awareness about the constraints of existing mandates such as that of the IAEA, an agency not oriented towards response to a nuclear weapon detonation event in the case of state use. Nor is there a general appreciation within the humanitarian system that many of the skills, capacities, and materiel to be called upon in a nuclear weapon detonation event in fact do not currently exist. While there have been international exercises in the recent past on scenarios such as radiological "dirty bombs" or chemical weapon use,[254] there have been no equivalent table-top exercises (to our knowledge) on coordinating a response to assisting the victims of nuclear weapon detonation events. This means that with the best intent to assist the victims following a nuclear weapon detonation event, the United Nations system would be impeded from doing so while it navigated its way through these issues, or found workarounds.

For example, as outlined in part three, the WHO and IAEA have central roles in radiation emergency preparedness in order to fulfil obligations under the two international conventions on early notification and assistance in the case of nuclear accidents and radiological emergencies. These conventions do not mention nuclear detonations, but even if they did the WHO's role would probably be limited to providing technical advice and assisting with risk assessment. This is because the WHO is not currently equipped to deploy its staff in the field in an actual nuclear or radiological emergency with essential related gear such as radiation protective garments or dosimeters, nor are its staff specifically trained in their use. The WHO has its Radiation Emergency Medical Preparedness and Assistance Network of national technical experts (see box 11), but each member is governed by their national occupational safety regulations, and broader national policies of various kinds, which will differ.[255]

The IAEA is better equipped than the WHO for such emergencies, but its radiation protection equipment is intended for use in controlled conditions such as civil nuclear facilities, and its personnel are not trained for the consequences of nuclear detonations or for humanitarian operations. It too has a Response and Assistance Network (RANET) of state experts for radiological emergencies. In principle, these personnel might assist in the field in assisting humanitarian operations by identifying the presence of radiation, mapping contamination, and assessing safe levels of exposure—key actions to be undertaken in order to protect humanitarian staff and assist in the aftermath of nuclear weapon detonation events. However, currently there are no obvious plans for deploying the IAEA or WHO

254 For example, on 20–21 November 2013, the ConvEx-3 exercise was convened by the IAEA and hosted by Morocco. Staff from emergency operation centres from 59 states and 10 international organizations took part, in order to test their responses to a simulated radiological weapon attack; see www-pub.iaea.org/MTCD/Publications/PDF/Newsletters/IEC-IB_46_Q4.pdf.

255 Written communication from WHO official, 16 April 2014.

in this way, or procedures to take advantage of their specializations in matters such as ionizing radiation levels in scenarios specific to nuclear weapon detonations.

Box 11: Radiation Emergency Medical Preparedness and Assistance Network

The WHO established the Radiation Emergency Medical Preparedness and Assistance Network (REMPAN) in 1987 in order to fulfil the organization's mandate under the Early Notification and Assistance Conventions. The key purpose of the network is to support WHO's work in assisting member states in building relevant national capacities for emergency medical and public health assistance to people over-exposed to radiation, as required by the IHR. In emergencies, WHO staff or REMPAN experts may join IAEA's missions deployed to the field. Expert guidance and technical tools can be obtained through the WHO Radiation Programme of the Interventions for Healthy Environment Unit. Meanwhile, key health-related actions to be undertaken in response to a radiation emergency, such as identifying the presence of radiation, mapping contamination, identifying isotopes, and assessing the levels of exposure, are within the IAEA's domain rather than the WHO's. The IAEA would be expected to supply and monitor personal dosimeters to response teams to ensure occupational safety limits are not exceeded.

Overcoming these kinds of problems is not impossible, especially in light of the galvanizing effect that concern about the effects of a nuclear weapon detonation event would probably have on the United Nations system. But, with the best will in the world, gaining a clear picture of the situation with respect to mandates and capacities of relevant actors (let alone more broadly, for instance in terms of a comprehensive picture of available national capacities and other humanitarian actors such as the Red Cross and Red Crescent Movement) would take time. And the clock will be ticking, for three reasons.

The first and most important reason is, as we have already explained, that even if a United Nations coordinated humanitarian response can do little for the victims in the immediate hours and first days after the event in terms of direct assistance, there will be extensive and perhaps burgeoning need for a range of cluster-related assistance as the full effects of the event, including the possibility of radioactive fallout, are encountered. This includes obvious elements such as provision of emergency shelter, food, clean water, and medical help and supplies. There will also be a wide range of other needs, for example, those of displaced people, longer-term medical care (for instance, in the context of those suffering from ARS, multiple trauma of various kinds, or chronic medical conditions requiring continuous treatment), and psychosocial assistance. In other words, as noted earlier, the profile of relief needed will evolve.

The second reason is that there are ways in which the United Nations system could be of immediate help, with some prior preparation and planning, in:

- enabling states to coordinate their capacities and resources for response to the victims;
- acting as a credible source of practical information and advice to the public on the situation and hazards following a nuclear weapon detonation event, delivered in an accurate manner consistent across different parts of the United Nations system. This could have an impact on the numbers of people exposing themselves to fallout, for instance, or conversely self-displacing for reasons of personal safety when there is no need to do so (the "worried well");[256] and
- performing specialized functions in data gathering and analysis (for instance of fallout spread) for the humanitarian system's use straight away for the purposes of assessment, planning, and coordination in operations, and protection of humanitarian personnel.

The importance of all of these roles was underlined by the experience of the Fukushima Daiichi reactor emergency following a severe earthquake and tsunami,[257] and are areas in which linking humanitarian coordination and response in the context of civil nuclear accidents is directly relevant to nuclear weapon detonation events.[258] Ideally, these capacities would already be in

256 See figure 8 in part two, p. 46.

257 See IAEA, *IAEA Report on Preparedness and Response for a Nuclear or Radiological Emergency in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant*, 2013, p. 33.

258 See Environmental Emergencies Section (Joint UNEP/OCHA) of the UN Office for the Coordination of Humanitarian Affairs, *Linking Humanitarian and Nuclear Response Systems: A Study by the Office for the Coordination of Humanitarian Affairs*, 2013, p. 8, https://ochanet.unocha.org/p/Documents/Linking%20Humanitarian%20and%20Nuclear%20Response%20Systems.pdf.

place before a nuclear weapon detonation event occurred rather than having to be established in the midst of an unfolding post-event humanitarian crisis when it may be much more difficult, or just not possible, to achieve. In some cases, these roles would build upon existing competencies of the United Nations system (for instance, CTBTO and WMO roles in analysing the interaction between radioactive fallout and weather, the websites of the IAEA, WHO, and OCHA offering information and expert advice for the public on ionizing radiation or other effects of sudden-onset major disasters). These roles would be planned in advance and formally coordinated rather than carried out or adapted in an ad hoc manner.

The third way in which the clock will be ticking relates to the importance of the humanitarian system being seen to be mounting a credible humanitarian response in the circumstances. As discussed earlier, the immediate preoccupation of states in the international community, the media, and most of the public, is likely to be on what happened and who caused the nuclear weapon detonation event. Quite reasonably, this will be linked to fears about the risk of further detonation events, and other immediate political or military consequences. Moreover, early reports from the zone or zones directly affected will initially be fragmentary and confused. The scale and precise nature of the humanitarian need will not yet be fully apparent. Over time, the situation can be expected to become clearer. Among the sources of information, there will be reports from traditional media and also the accounts of survivors and others via social media. As the scale of suffering and humanitarian need becomes more widely known, the experience of recent major disasters indicates that the speed and adequacy of the response at all levels will become a major focus of media and public attention—and possibly for their criticism.

This is something the ICRC is conscious of in the context of its role as a humanitarian organization with a mandate to assist the victims of armed conflict. Despite "having no specific plans to assist the victims of [a CBRN] event, the ICRC intervened several times during the twentieth century in armed conflicts in which nuclear, chemical and biological weapons were used or allegedly used"[259] as it recognized the duty to do so under the general terms of its mandate. Not to do so would perhaps be widely seen as a dereliction of duty. Because of the clear limitations to what is possible in terms of response and the risks to its personnel, the ICRC and the broader Red Cross and Red Crescent Movement have, in recent years, begun to formulate more systematic arrangements for risk assessment and response to CBRN events with a hierarchy of priorities (see parts one and three). It was recognized within the ICRC that such an approach is more likely to lead to outcomes in which overall human suffering may be reduced (including for humanitarian staff), and is more defensible than leaving matters to chance.

We suggest the principle of ensuring a credible response in the circumstances is of relevance to the United Nations system and its humanitarian responsiveness. Management of the expectations of states, the media, and the public about the inevitable constraints on the humanitarian system's ability to respond to a nuclear weapon detonation event, which will be a major issue, will be made easier if the United Nations can demonstrate that it undertook risk assessment and prepared a general approach prior to such an event occurring. A related point is that for almost 70 years the United Nations has played a significant role in promoting nuclear disarmament, arms control, and non-proliferation efforts because of the consequences of nuclear weapon use as shown by the bombings of Hiroshima and Nagasaki, and the effects of nuclear weapon testing—so it cannot claim ignorance of those consequences. Lending some studied thought within the humanitarian system to preparing for how it could respond—even if this is palliative, rather than curative—would seem rational, especially when other humanitarian actors like some in the Red Cross and Red Crescent Movement are doing so. A failure in this regard for the United Nations system to respond rapidly and competently goes deeper than reputational risk for the Organization. It would amount to a damaging "systemic failure" to meet its responsibilities to protect people at odds with the purposes of the United Nations.[260]

259 D. Loye and R. Coupland, "Who will assist the victims of use of nuclear, radiological, biological or chemical weapons—and how?", *International Review of the Red Cross*, vol. 89, no. 866, 2007, p. 329.

260 Ban Ki-Moon, "Renewing our commitment to the peoples and purposes of the United Nations", 22 November 2013, www.un.org/apps/news/infocus/sgspeeches/statments_full.asp?statID=2068.

The advantages of prior planning and coordination efforts

In view of the points made in preceding sections, the United Nations would be in a stronger position to coordinate humanitarian response following a nuclear weapon detonation event if attention were paid prior to its occurrence to the kinds of issues existing response mechanisms would confront. On the face of it, the probability of such an event occurring seems low to some people. However, because of the risk of accident or mishap involving nuclear weapons, the possibility cannot be discounted and, as noted in the introduction to this study, may be significantly higher than thought. In view of this, there is no time like the present for consideration to begin at policy and planning levels.

In this respect, it is noteworthy that analogous work has already been undertaken with respect to efforts by states and the United Nations system to respond to the challenges of terrorism. Following the call of the United Nations General Assembly in 2006[261] as part of the Global Counter-Terrorism Strategy for improved coordination in planning a response to a terrorist attack using CBRN weapons or materials, a Counter-Terrorism Implementation Task Force (CTITF) Working Group on preventing and responding to weapons of mass destruction (WMD) attacks was established (see box 12). It carried out a review of how the United Nations system would respond to such a terrorist attack. The group also considered the level of planned coordination that would be needed among the different entities for the rapid provision of assistance to the affected state or states—although, notably for the purposes of this study, not with a focus on humanitarian assistance delivered via the cluster system.

Box 12: The CTITF Working Group on preventing and responding to WMD attacks

This Working Group produced a report entitled Interagency Coordination in the Event of a Nuclear or Radiological Terrorist Attack: Current Status, Future Prospects.[262] The Working Group's study concluded that Member States should receive rapid and coordinated assistance from the relevant United Nations entities and international organizations in the event of a nuclear/radiological terrorist attack. Its main recommendation was for the coordination of information during a nuclear or radiological emergency between the IAEA and United Nations Headquarters via the Organization's Communication Group run by the Department of Public Information, building on the IAEA's broader role as the global focal point for the coordination of public information in such an emergency.

The CTITF Working Group's report is also of interest for some of its working assumptions, and for what it excludes from consideration. It asserts that the IAEA, WHO, and other relevant parts of the United Nations would, if requested, play roles in providing assistance to Member States in radiological emergencies "regardless of their origin"—that is, in the context of the report, a terrorist attack with a nuclear or radiological weapon. Yet, the report does not discuss state use of a nuclear weapon, whether accidental or deliberate, a scenario in which the IAEA has indicated elsewhere it does not see itself as having a role to play. This is a point that might usefully be clarified, since as already explained it has implications for the delivery of humanitarian assistance.

The Working Group argued that the:

> existence of IACRNE, and its related JPLAN, demonstrates that there is already an effective and comprehensive interagency mechanism in place, providing coordination and facilitating clarity with regard to the roles and capabilities of the participating international organizations in preventing, preparing for and responding to nuclear or radiological emergencies. … Each [participating organization] has some capacity to provide assistance to States on the prevention and/or response to a terrorist attack using nuclear/radiological materials.[263]

261 General Assembly, The United Nations Global Counter-Terrorism Strategy, UN document A/RES/60/288, 20 September 2006.

262 CTITF Working Group, *Interagency Coordination in the Event of a Nuclear or Radiological Terrorist Attack: Current Status, Future Prospects*, 2010, www.un.org/en/terrorism/pdfs/10-48863_ctitf_wmd_wg_report_interagency_coordination.pdf.

263 Ibid., para. 18.

This is reassuring, although the report does not define what response and assistance mean for its purposes. Given the CTITF's anti-terror orientation it may be meant in a different sense to that of humanitarian assistance, especially since OCHA's roles in response are only briefly mentioned.

It is notable, given the IAEA's civil-oriented mandate, that one of the workshops that it organized for the Working Group was titled—in similar vein to the report itself—International Response and Mitigation of a Terrorist Attack Using Nuclear and Radiological Weapons or Materials. It may be that the Agency differentiates in the application of its mandate between terrorist attacks using nuclear weapons and other types of nuclear weapon detonations, based perhaps on the disinclinations of some states to recognize the possibility of such nuclear weapon detonations occurring. Nonetheless, it raises questions as to whether the IAEA's role could extend to nuclear weapon detonations "regardless of their origin", for which there would be a strong case in practical terms in view of its expertise and willingness to assume roles in the context of use of a nuclear weapon by terrorists.

Among the issues that could productively be tackled in the context of prior planning and coordination efforts within the United Nations-coordinated humanitarian system, we identify the following.

Safety issues for humanitarian staff

Besides determining how to assist victims in the aftermath of a nuclear weapon detonation event, the United Nations has obligations to try to ensure the safety of its personnel. Duty station Security Risk Assessments are important here, and need to align with broader policies and procedures in order to act on the assessments in ways that protect staff. It is an area in which the DSS must play a leading role, although it has been noted that "DSS does not, however, possess the expertise for the technical aspects of emergency planning when dealing with nuclear or radiological events (or those involving other WMDs)".[264] This would imply a need for involvement of agencies including WHO, WMO, IAEA, UNEP, and the CTBTO, for example, alongside OCHA and other parts of the United Nations system likely to be affected by such policies.

There will be those United Nations personnel directly affected by the event—these staff and their dependents may be dead or injured, incommunicado with the United Nations, or in contact but unable to be evacuated from an affected area. So specific advance guidance would be advisable to help staff in the field that survived the nuclear detonation event's initial effects. For instance, as discussed in parts one and two, the question of whether to stay put or to move away from the detonation zone following a nuclear weapon detonation is dependent upon factors such as allowing time for prompt radiation to decrease and avoiding exposure to delayed fallout.[265] A second category of person will be United Nations staff and their dependents at risk of being exposed to fallout some distance from the hypocentre of the nuclear explosion. A third category are those personnel that activation of the humanitarian cluster system would see sent into areas made hazardous by the effects of a nuclear weapon detonation event, and radioactive fallout in particular. What level of training and equipment is necessary or appropriate? What is the protocol to be followed for making decisions about these questions? And what about appropriate levels of information about the risks, training, and equipment for staff of other humanitarian organizations coordinated within the cluster system?

Maintaining continuity in humanitarian assistance delivery in other contexts

There is also the need for the humanitarian system to maintain continuity in its other humanitarian operations. The United Nations has some "surge" capacity in emergency situations. Is its existing surge capacity structured in a way that it could supply personnel with the right training and experience in the aftermath of a nuclear weapon detonation event? And what about disruption to other United Nations-coordinated humanitarian operations around the globe that make the difference between life and death for many people, including in terms of continued donor funding for existing programmes? Could the unprecedented and perhaps extraordinary disruption caused by a nuclear weapon detonation event interrupt continuity in these operations in ways that would compound human suffering? And, should the

264 Ibid., paras. 18, 57.

265 See, for instance, I.E. Redlener et al., *Regional Health and Public Health Preparedness for Nuclear Terrorism: Optimizing Survival in a Low Probability/High Consequence Disaster*, National Center for Disaster Preparedness, Columbia University Mailman School of Public Health, 2010, p. 17.

United Nations system, for its part, plan in ways intended to ensure continuity?

More assessment of nuclear weapon detonation scenarios and how response capabilities fit together

There are different ways to frame nuclear weapon detonation events, and earlier we implied that simply framing such a possibility solely in terms of the cause (e.g. terrorists) may not necessarily make most sense when reflecting on challenges for humanitarian assistance. In contrast, in part two we discussed several nuclear weapon detonation scenarios that were considered to be plausible in order to compare them in terms of their humanitarian consequences and the challenges each would pose to the humanitarian system's capacity to respond. It is clear that in the scenarios involving detonation of a single nuclear weapon, while the consequences could be catastrophic in the level of human harm and destruction inflicted, these fall well short of a threshold at which the effects were so apocalyptic that a poor United Nations-coordinated humanitarian response could be excused.

A valid question to ask, in view of limited time and resources, competing priorities, and the destructive power of nuclear weapons, is what kind of scenarios can feasibly be planned for, and which clearly cannot (and why not). Planning for how to respond to a single nuclear detonation in an urban area as the result of an accident or a non-state armed group attack might be prudent in view of the large quantities of nuclear weapons and fissile material in the world. If it is not feasible to plan for the consequences of a conflict involving use of 100 "Fat Man"-sized bombs on cities, then that should be reflected upon by policymakers in the humanitarian system and communicated to states and the public as part of the system's responsibility to identify humanitarian risk and contribute to trying to reduce it. This also relates directly to other obligations of the United Nations, including efforts to reduce dependence on, and eliminate, nuclear weapon arsenals, including through disarmament, because of their consequences for humanity.

Consideration should extend to the areas in which United Nations agencies could contribute most in assisting the victims following a nuclear weapon detonation event. As is clear from parts two and three of the study, taken as a whole, United Nations agencies are more competent and experienced in some areas than in others. Conversely, some of the capabilities developed in a specific context could be more broadly applicable. The expertise of relevant United Nations agencies in handling issues of displacement and migration, for instance, will be more effective if mated to other relevant capabilities such as the measurement of ionizing radiation, decontamination, and dealing with the health effects of radiation.

"Buyable" and "non-buyable" capabilities

In its own study of the problems of the challenges of preparing to respond to CBRN events, the ICRC distinguished between "buyable" and "non-buyable" capabilities, consideration of which it believes will force a "reality check" on relevant policymakers:

> This confrontation will take the form of very difficult questions and dilemmas, many of which are foreseeable, but not necessarily resolvable in anticipation. These and other challenges will have to be faced at the time of deciding whether to acquire a response capacity; yet more will have to be faced at the time of deployment of that capacity in a given context.[266]

By "buyable" it is meant solutions to which a financial price tag can be attached. This ranges from detection, protection, and decontamination equipment to training, medical infrastructure, and so forth. Here the cost is potentially unlimited, yet it is likely that such capabilities will have limited shelf-lives, and there can be enormous difficulties in retaining such capabilities after the initial investment, especially in view of more pressing priorities.

Challenges for which solutions are "non-buyable" in the ICRC's view pertain to three domains:

1. the different mandates and policies of pertinent international organizations and how such organizations interact;
2. the many and complex practical aspects of developing, acquiring, training for, and planning an appropriate response capacity to assist the victims of an CBRN event; and
3. the issues specific to deploying this capacity in an event.[267]

266 R.M Coupland and D. Loye, "International assistance for victims of use of nuclear, radiological, biological and chemical weapons: time for a reality check?", *International Review of the Red Cross*, vol. 91, 2009, pp. 329–340.
267 Ibid., pp. 332–333.

This study indicates that (parallel exercises notwithstanding such as United Nations system's internal response to chemical weapons use in the Syrian Arab Republic or the CTITF Working Group's exercise on nuclear and radiological terrorism) there is a considerable gap where the first of the challenges listed above is concerned in the context of nuclear weapon detonation events. Before a discussion about the development of capabilities can take place, there is a need for the components of the United Nations system itself, including the agencies with prominent roles in the humanitarian system, to clarify their relationship to one another and assistance in this specific context rather than the current state of ambiguity and lack of engagement. Lessons might usefully be learned from the relevant experiences of United Nations actors sometimes considered peripheral to humanitarian assistance such as the CTBTO and the OPCW.

There is also an opportunity for the United Nations to learn from, and improve, coordination with other humanitarian actors such as states that are likely to put assets at the disposal of the humanitarian system in the event of a nuclear weapon detonation event. Engagement with the Red Cross and Red Crescent Movement, which has already some reflection in this regard, is also important. This could lead to a better understanding of how their priorities and policies on responding to nuclear weapon detonation events (to the extent they have them) differ from those of the postures of United Nations agencies, and where harmonization, which would take time, would be preferable.

PART 5: CONCLUSIONS

This study's purpose has been to explore the validity of a finding from the Oslo conference that:

> it is unlikely that any state or international body could address the immediate humanitarian emergency caused by a nuclear weapon detonation in an adequate manner and provide sufficient assistance to those affected. Moreover, it might not be possible to establish such capacities, even if it were attempted.[268]

We conclude that the Oslo conference's finding is largely a valid one, although with some need for further distinction with refer ence to the given scenario. The first obvious caveat is that it we think it holds for population centres, but may not be true of nuclear weapon detonations in sparsely populated regions or areas in which no people are present. Additionally, in the case of a low-yield explosion in a sparsely populated area the impact of the United Nations and other aid efforts is likely to have minimal effects on the outcome. However, this said, the radioactive fallout effects of groundburst or large-yield airburst nuclear detonations could conceivably cause a humanitarian emergency far from "ground zero" in the days and weeks following such an event, not to mention impacts on agricultural production and longer-term environmental effects. This implies that an early decision would need to be made about the likely magnitude of the event and its potential impact on large populations.

There is a very wide range of potential scenarios in which nuclear detonations could occur, and these would have varying effects both in their effects and the level of response required or possible. One cannot be categorical in stating that a government could not deal within its national resources with the humanitarian consequences of a single nuclear weapon detonation in certain scenarios. However, even in those cases the level of harm and destruction caused in a highly populated area would defy any reasonable state of local preparedness—help would have to come from outside; the question is, from how far away. The scale of that need for assistance would in our view probably be too great for the majority of states to cope within their own response capacities, let alone in cases of multiple nuclear weapon detonations. Moreover, consequences such as radioactive fallout, displacement, and the sheer demand for potable water, food, and medical assistance are likely to have transboundary implications in themselves, which will require a degree of international coordination.

In certain senses, the kinds of response needed in the aftermath of a nuclear weapon detonation event can be thought of as analogous to those in the wake of major natural disasters. This means that some of the existing systems and capacities within the humanitarian system will be of some relevance such as those within the cluster system. However, in other important senses they are not analogous. Radiation effects of nuclear detonations—especially radioactive fallout—create particular complications including risks for responders, the need for decontamination of victims, and, indeed, for protection of populations dwelling downwind of such events, including the displaced. The difficulties of determining exposure for individuals would exacerbate the problems of delivering care. Medical response would also be made more difficult because of the delayed effects of ARS and other radiation-related conditions, including immune suppression, which could exacerbate mortality from other injuries or illnesses.[269] There would also be very large numbers of burn victims—people in great pain, who without particularly intensive medical help face death or who need palliative care to relieve suffering before their inevitable death.

For many reasons, especially because of the scale and nature of nuclear weapon detonation events, adequate humanitarian response solutions are not "buyable". However, that does not mean that a meaningful humanitarian response is not possible in some scenarios. In this regard, we turn now to some specific findings.

268 E. Barth Eide, "Chair's summary: Humanitarian Impact of Nuclear Weapons", 5 March 2013, www.regjeringen.no/en/archive/Stoltenbergs-2nd-Government/Ministry-of-Foreign-Affairs/taler-og-artikler-2013/nuclear_summary.html?id=716343.

269 A.B. Wolbarst et al., "Medical response to a major radiologic emergency: a primer for medical and public health practitioners", *Radiology*, vol. 254, no. 3, 2010, p. 671.

Findings

1. The current level of awareness within the humanitarian system is generally low about the specificities of nuclear weapon detonation events or its ability to respond to them.

Our study has pointed to the absence of a coherent framework within the United Nations system for coordinating a humanitarian response to the range of nuclear weapon detonation scenarios we have discussed, even at basic levels of preparedness, let alone a large-scale nuclear war. Anecdotal evidence, based on our interviews with United Nations humanitarian personnel in various agencies, indicates that this fact would come as a surprise to many of them—some assume plans exist for "lower end" nuclear weapon detonation events, with the IAEA assumed to play a leadership role in providing expertise, equipment, and operational capacity. Even when the CTITF's report, and the recent formation of bodies such as the Operational Preparedness Group on CBRN are taken into account, this does not appear to be the case yet.

2. For the United Nations to offer or be called on to coordinate humanitarian assistance suggests an event is already beyond the capacity of the state or states affected to respond effectively to assist the victims. Moreover, as a rule it would depend upon an affected state requesting it, or appropriate international decision-making to be enacted if its government was incapacitated.

This may seem like an obvious point, but in order for a United Nations-coordinated humanitarian response to be necessary, the situation is already a humanitarian disaster. It implies that the nuclear weapon detonation event has occurred in a populated area, or will soon affect it via delayed effects such as fallout. The instantaneous effects of such a detonation event—the blast, thermal radiation, and prompt radiation from the explosion of one or more nuclear weapons—will have created many casualties and destroyed a great deal of critical infrastructure. It will have generated fear and disruption, which may lead many people to alter their normal patterns of behaviour and make disruption worse (for instance, fleeing their homes to go to already overwhelmed hospitals because they fear radiation contamination). In an important sense, any response is by definition inadequate because the immediate harm has already been done. Anything that the United Nations system can do at this point is in responding to an already serious level of harm. See part four for discussion of the issue of affected states needing to request assistance.

3. The United Nations is unlikely to be able to offer much humanitarian assistance in the immediate aftermath of a nuclear weapon detonation event, and it would take time for the humanitarian system to deploy.

Most experts seem to agree that the immediate needs of the victims in a nuclear weapon detonation event will fall on local and national authorities to the extent they still function. In a highly populated area the humanitarian need will be vast, including from large numbers of seriously burned and injured people (many of them dying). Much of the expert literature in this area assumes that help will take days or longer to arrive—let alone international assistance. This has implications for the kinds of role the United Nations could meaningfully play, in particular:

- helping to coordinate the responses of states in the international community offering to assist the affected state(s);
- acting as a reputable and consistent source of expert advice to the public;
- assisting the international community with scientific data and analysis to inform state decisions about provision of resources for humanitarian assistance; and
- stepping up to handle "second wave" crisis issues such as assisting and protecting the displaced, and helping establish medical infrastructure—some of it unavoidably palliative in nature. The needs of affected people and communities will evolve in the weeks, months, and years following the detonation event, but may be necessary for years or even decades.

4. At present there are a number of foreseeable challenges to prompt and effective use of the humanitarian cluster system in the context of a nuclear weapon detonation event.

These challenges include the following.

- Until now, no studied attention has been paid to what the particular characteristics of nuclear detonation events would be in a plausible range of contexts, and the extent of the humanitarian consequences. Moreover, there appears to have been little specifically actionable planning yet for humanitarian response to nuclear weapon detonation events, either within the components of the United Nations system, or at an inter-agency level. Although there have been international exercises in the recent past based on scenarios such as radiological “dirty bombs” or chemical weapons use, there have been no equivalent exercises in order to understand the challenges to the humanitarian system of assisting the victims of nuclear weapon detonations events in highly populated areas.

- There is no focal point within the humanitarian system for systematic planning for response to nuclear weapon detonation-specific phenomena.
- Specialized standing responsibilities such as radiation monitoring and radiation decontamination at the field level in support of humanitarian operations in the event of nuclear weapon detonations do not appear to have explicitly been allocated, either to international agencies or humanitarian partners.
- It is currently not clear, either to those within the humanitarian system or outside it, as to whether and how present agency mandates would apply in the context of nuclear weapon detonation events. A key finding in this respect is that while some in the United Nations system appear to assume that existing response mechanisms for civil radiological incidents would simply carry over, after intensive study this does not appear to us to be the case. For instance, some specialized agencies view their mandated responsibilities as applying in civil radiological emergencies but not in cases of nuclear weapon use, or to certain kinds of nuclear weapon detonation scenarios (e.g. terrorism) but not others (e.g. state use, nuclear weapon accidents).
- Standing arrangements for coordination between the United Nations humanitarian system and relevant national authorities in the specific case of a nuclear weapon detonation event do not appear to exist, although the formation of bodies such as the Operational Preparedness Group on CBRN are encouraging developments.

While we have no doubt the humanitarian system would swing into action as swiftly as it could, developing these arrangements in the heat of the crisis is not ideal, and would take time—with ample chance of confusion or misinterpretation that would be likely to impede the most timely and effective response.

5. Threat or fear of further nuclear weapon detonation events could vastly complicate decision-making about the nature and scale of humanitarian coordination and response, let alone its delivery.

In the hours, days, or even weeks following a nuclear weapon detonation event, its origin, or the identity of those responsible for it, may not be known. Such uncertainty could create further nuclear crises of its own. Moreover, in terms of risk assessment, humanitarian actors (including relevant United Nations agencies) may feel it is too hazardous to deliver humanitarian relief to the affected. For their part, the state (or states) affected might be unwilling to accept relief until the environment is sufficiently “secure”. States in a position to offer assistance coordinated by the humanitarian system might be unwilling to do so if they fear further nuclear weapon detonation events are plausible. This could exacerbate suffering for those directly affected or displaced.

6. Prevention is the best response to nuclear weapon detonation events.

However, it also incumbent upon those humanitarian actors in a position to do so, such as the United Nations, to plan for the likely challenges of “lower end” nuclear weapon detonation events. Such planning would, in reality, also reinforce the need for action to reduce the risk of nuclear detonations taking place.

Some advance thought and planning within the United Nations system could plausibly reduce the overall level of human suffering arising from some nuclear weapon detonation events significantly, even if there is not much it could do in the immediate aftermath. Organizing a capacity for a response, however inadequate it may prove to be, is not simply a matter of responsible anticipation, organizational cohesion, and readiness to meet public expectations. It may also help save lives in reducing the time necessary for devising decision-making channels, coordinating the mobilization of resources, and resolving health issues relating to positioning personnel to conduct relief activities. In essence, what is needed are systematic decision-making processes determined in advance and setting out clearly the premises on which mobilization will be “triggered” based on assessments of the hazards arising, levels of contamination, and other risks to be weighed in deploying relief personnel.

The humanitarian system

It is not our intention to anticipate the conduct or outcome of any future assessment within the United Nations system of the need or shape of a strategy for preparing and responding to a nuclear detonation event. However, below are some ideas to help frame such an exercise.

1. Focused attention to the issue in the IASC

The IASC should ensure focused attention to this issue by facilitating coordinated efforts by its membership, over time, to identify and devise means to respond less inadequately to nuclear weapon detonation events.

2. Assign responsibility to a new or existing IASC task team

In particular, the IASC could establish a new "task team" dedicated to implementing this work stream, or else assign responsibility to the existing Task Team on Preparedness and Resilience. Whichever option it chooses, the task team would assess the degree of preparedness required for a credible United Nations-coordinated humanitarian response, and for which nuclear weapon detonation events this would be plausible (or not). Since coordination has been well honed within the United Nations system both in the humanitarian sphere and in dealing with civil radiological issues (IACRNE), consideration should be given to inviting IACRNE to participate in the task team's work. This would also serve to strengthen the system as a whole.

In addition, assigning a mandate of the kind just suggested would rectify any misapprehension that existing response mechanisms for civil radiological incidents would simply carry over and be applied in responding to a nuclear weapon detonation event. At the same time, existing disaster response capacity in the United Nations system would provide some foundation for implementing that mandate. As identified in this study, valuable analogies can be drawn from experience derived from preparing for or responding to civil nuclear emergencies and other humanitarian disasters. Tasks or issues this working group could look at include (but are not limited to):

- Clarifying how current agency mandates would have to be adapted or developed in order to apply to respond to nuclear weapon detonation events.
- Establishing standing arrangements for coordination between the humanitarian system and relevant national authorities in the event of a nuclear weapon detonation event.
- Responding to the urgency and importance of educating and communicating with the public about radiation hazards in order to mitigate panic in the event of a nuclear weapon detonation event, and best advise people how best to try to protect themselves.
- Also, in this regard, facilitating the availability of prompt, accurate data for informing effective coordination of relief activities, and for reducing health risks and anxiety levels among affected populations. The experience of agencies involved in events such as the Fukushima Daiichi and Chernobyl nuclear accidents has demonstrated the need also for preparedness in this respect.
- Designating responsibilities such as radiation monitoring and decontamination at the field level in support of humanitarian operations in the event of nuclear weapon detonation events. The ability to measure radioactive fallout levels and predict its spread on a local basis as precisely as possible, from as soon after the moment of detonation as possible, will help to ensure the safety both of humanitarian personnel and affected populations.
- To this end, investigating the prospect of a standing arrangement between the CTBTO and the IASC for the former to share analysed data in a timely way and in plain language to assist humanitarian operations in the event of a nuclear weapon detonation event. WMO and other relevant agencies might also play roles in such an arrangement, as could regional data collection networks (for instance, the European Community Urgent Radiological Information Exchange (ECURIE), which already liaises with the IAEA).
- Anticipating the implications of large-scale human displacement from a nuclear weapon detonation event including the ways in which a mass exodus could disrupt or even cripple rescue and response efforts.
- With a view to maximizing responsiveness, considering whether a nuclear weapon detonation event in a populated area should automatically be assessed as a Level 3 emergency and that the state(s) affected will require humanitarian assistance unless the ERC is informed by the state(s) concerned that it does not.

3. Study and simulate varied nuclear weapon detonation scenarios with a view to humanitarian response

As noted in the study, a number of international agencies carry out exercises or simulations both individually (e.g. WHO) and in terms of inter-agency planning (for instance in the context of anti-terrorism) for a range of crisis scenarios. These could be extended, or exercises undertaken by the IASC separately, to consider varied nuclear weapon detonation scenarios in order to identify the kinds of challenges to be considered before they occur. Prior familiarization among emergency response staff and key decision-makers in the inter-agency process can save time in terms of getting up to speed in response and coordination. As one WHO official told us, "It's always messy in the beginning. It's how quickly you get it together that counts. That's why preparation is important".[270]

4. The IASC should consider including representative nuclear detonation event scenarios in future revisions of humanitarian procedures for large, complex, sudden-onset disasters

Such scenario planning could have benefits both at the level of the IASC, and operationally and in terms of awareness-raising at the field-office level for United Nations agencies and their humanitarian partners. It is worth recalling here that certain governments, such as the United States, have already done such inter-agency planning domestically with respect to crisis response to an IND detonated in an American city. However, as noted, this is not the only or necessarily even most plausible way in which a nuclear weapon detonation event could occur. For this reason, it would be worth considering a range of plausible scenarios in diverse parts of the world in the context of the humanitarian system.

5. Review current capacities and plans

Given both the enormous destruction of nuclear detonation events and the low historical frequency of their occurrence, it would be unrealistic for the United Nations system as a whole to invest in stockpiling specialized relief materials or technical equipment. Nevertheless, individual specialized agencies already capable of providing protective access for certain of their staff in radiation hazardous zones should review their emergency response plans to incorporate whatever they could do to assist the humanitarian system in addressing the consequences of a nuclear weapon detonation event. Contingency planning and training for responding to a nuclear detonation event should identify readily available sources of relevant skills, training, material, and suppliers for purposes of facilitating quick access. Equally, there may be value in establishing an inventory of specialists with skills relevant to the treatment of victims of nuclear weapon detonation events beyond the REMPAN and RANET networks.

States and the Secretary-General

As distinct from the operations of the humanitarian system, states and the Secretary-General could also play roles in prompting relevant humanitarian agencies and specialized agencies such as the IAEA, WHO, and CTBTO to clarify their mandates, policies, roles, and capabilities with a view to responding to nuclear weapon detonation events. These agencies all face budgetary constraints and many pressing priorities but could reasonably be asked to provide information as to how current capabilities and systems are adaptable, or where major gaps lie. For instance, there is the CTBTO Preparatory Commission's global detection network for nuclear testing, and WMO weather data capabilities for providing forecasting of fallout. Existing inter-agency plans and bodies are also relevant to this exercise (e.g. the JPLAN, IACRNE, UNSCEAR, RANET).

States might also lend thought to how inter-state decision-making processes could impinge on timely activation of humanitarian coordination and response efforts in the event of a nuclear detonation event, as discussed in part four. For example, some states appear sensitive to the roles and mandates accorded to relevant specialized agencies—sensitivities that might be obstacles to humanitarian action, even in a crisis situation. Ways should be found to assuage these concerns with a view to improving humanitarian preparedness and response.

Concluding comment

Humanitarianism marks the broader mission of the United Nations, and since its inception it has taken a strong stand in favour of nuclear disarmament. The initiation of specific planning for how to respond to a nuclear weapon detonation event would appear to be logical

270 Meeting with WHO officials, 10 October 2013.

and consistent with both these aims. And, in view of existing coordination practices in the context of the humanitarian system as well as more broadly (for instance, CTITF work in the terrorism context), the development of necessary understandings about decision-making and a protocol for planning need not entail a lot of resources.

Establishing appropriate inter-agency arrangements and understandings is one thing. Nevertheless, we should not delude ourselves that a humanitarian emergency caused by many nuclear weapon detonation events could be addressed in "an adequate manner and provide sufficient assistance to those affected" (in the words of the Oslo conference Chair's summary). Defining its general approach and enhancing planning for "lower end" nuclear weapon detonation events such as single detonations may be all that is feasible for a response that is—even in those cases—palliative in nature. It is inescapable, that in the face of the immensity of the challenges of responding to a nuclear weapon detonation event in a populated area, primary prevention is the only fully effective humanitarian or public health approach. This was also the conclusion of the chairs of Oslo and Nayarit in their summaries of the discussions of the conferences on the humanitarian impact of nuclear weapons. While nuclear weapons exist the risk of their detonation does too, whether deliberately or inadvertently. It is clear that the humanitarian system cannot be expected to put matters right in view of the magnitude of the harm and suffering nuclear weapon use would inflict, even if it is a prospect for which it should prepare.

APPENDIX 1: THE UNITED NATIONS HUMANITARIAN CLUSTER SYSTEM IN MORE DETAIL

The Humanitarian Cluster Approach is a system designed to ensure effective, predictable, and accountable coordination in humanitarian emergencies. By ensuring clear leadership and accountability at all levels of the system, the aim is to maximize the overall preparedness and response capacity.[271]

The cluster approach is a system of 11 thematic clusters with differing lead agencies, both United Nations agencies and international NGOs, depending on the cluster. The clusters exist at the global and national level; often with the same lead agencies at both levels.[272] When a cluster is established at country level, it means that a coordinated response is initiated for that thematic area in that country, involving some or all of the international and national member agencies of the cluster. As emphasized by the IASC, "there is no 'one-size fits all' approach to cluster management. Due to the varying size, scope and complexity of disasters and cluster response, the choice of a management approach must be adapted to need and may change as the response evolves".[273] Clusters can, for instance, be combined if that is the most effective approach in a given emergency, and clusters different from the 11 global clusters can also be established.[274] This is seen for instance in the ongoing response to the crisis in the Syrian Arab Republic, where a separate cluster for *Staff Safety Services* was added to facilitate the protection of coordination staff and implementing partners.[275]

The global cluster lead agencies are responsible for developing and disseminating policies and standards, building response capacity and ensuring long-term operational needs can be met.[276] At the national level, the Humanitarian Coordinator is responsible for leadership and coordination of the overall response and is supported by the cluster lead agencies that coordinate the relevant sectoral activities of humanitarian actors in that country. The lead agencies also carry the responsibility of provider of last resort.[277] This means that they must be vigilant to possible gaps in the response, and point them out to the relevant responders. If those actors are not able to deliver the adequate assistance, the lead agency itself must provide this to the extent possible.[278]

If there are not enough funds, the cluster leads work with the Humanitarian Coordinator and donors to acquire the resources needed. Where the security situation or lack of access to a particular location prevents the cluster lead, the national humanitarian responders, and the Humanitarian Coordinator from delivering aid, "the provider of last resort will still be expected to continue advocacy efforts and to explain the constraints to stakeholders".[279]

Cross-cutting issues in the Humanitarian Cluster Approach

Apart from the thematic clusters, there are six focus areas to be incorporated into any humanitarian response involving one or more clusters. These are "age; environment; gender; HIV/AIDS; mental health and social well-being; and persons with disabilities".[280]

Early recovery and disaster risk reduction are also meant be an integrated part of the cluster response. Although an Early Recovery Cluster

271 IASC, *Guidance Note on Cluster Approach to Strengthen Humanitarian Response*, 24 November 2006, p. 2, www.refworld.org/pdfid/460a8ccc2.pdf.
272 Ibid., p. 5.
273 IASC, "Cluster Coordination Reference Module", in *Transformative Agenda Reference Document*, 13 April 2012, p. 5, www.humanitarianinfo.org/iasc/downloaddoc.aspx?docID=6143&type=pdf.
274 IASC, *Guidance Note on Cluster Approach to Strengthen Humanitarian Response*, 24 November 2006, p. 5, www.refworld.org/pdfid/460a8ccc2.pdf.
275 OCHA, "2014 Syrian Arab Republic Humanitarian Assistance Response Plan (SHARP)", December 2013, pp. 130–131, https://docs.unocha.org/sites/dms/CAP/2014_Syria_SHARP.pdf.
276 IASC, *Guidance Note on Cluster Approach to Strengthen Humanitarian Response*, 2006, p. 4.
277 Ibid., pp. 1, 7. There is one exception to this responsibility, as the IFRC is not accountable to the United Nations system, but has committed to providing the best possible response considering its available resources, and given that the security situation allows it.
278 Ibid., p. 1.
279 Ibid.
280 IASC, *Reference Module for Cluster Coordination at the Country Level*, 2013, p. 10, https://clusters.humanitarianresponse.info/system/files/documents/files/iasc-coordination-reference%20module-en_0.pdf.

may be established if the need is critical, Early Recovery Networks are often established first to address "the multi-dimensional nature of early recovery by bringing together early recovery focal points from each of the clusters/sectors to work together on the integration, mainstreaming and coordination of early recovery issues and activities across all clusters/sectors".[281]

Activities of each cluster

Logistics

WFP is the Global Cluster Logistics Lead, but its global activities are driven by a focal point called the Global Logistics Cluster Support Cell (GLCSC), which in cooperation with the humanitarian community has "operationalized" the mandate given by IASC into certain focus areas, and it also runs the official logistics cluster website.[282]

Humanitarian logistics are "the process of planning, implementing and controlling the efficient, cost-effective flow and storage of goods and materials, as well as related information, from the point of origin to the point of consumption for the purpose of alleviating the suffering of vulnerable people. The function encompasses a range of activities, including preparedness, planning, procurement, transport, warehousing, tracking and tracing and customs clearance".[283] However, the work of the logistics cluster does not include procurement.

Camp coordination and camp management

IOM and UNHCR are the Global Cluster Leads for camp coordination and camp management in situations involving internally displaced persons. IOM is the lead if the situation is a result of natural disasters, and UNHCR is the lead if it stems from a conflict situation. This cluster is responsible for "coordinating protection and services, establishing governance and community participation, ensuring maintenance of camp infrastructure, collecting and sharing data and monitoring the standard of services and identifying gaps".[284] The overall goal for the cluster is for the affected people to be able to end camp-life and return to their homes.

Early recovery

UNDP is the Global Cluster Lead for early recovery, which is "a multidimensional process of recovery that begins in a humanitarian setting. It is an integrated, inclusive and coordinated approach implemented by humanitarian clusters to gradually turn the dividends of humanitarian action into sustainable crisis recovery, resilience building, and development opportunities".[285] This cluster's activities seek to:

- "augment on-going humanitarian assistance operations";
- "support spontaneous recovery initiatives by affected communities"; and
- "establish the foundations of longer-term recovery".[286]

Education

"Education in emergencies can be defined as: A set of linked project activities that enable structured learning to continue in times of acute crisis or long-term instability".[287] UNICEF and Save the Children lead the education cluster globally, which includes technical support and development of capacity in coordination with education authorities and national clusters.[288]

Shelter

The IFRC and UNHCR are the Global Cluster Leads. The IFRC convenes in natural disaster situations, while UNHCR leads the cluster in responding to the shelter needs of internally displaced persons resulting from conflict situations:

> Appropriate emergency shelter solutions based on immediate needs should assure:
>
> - protection from climate
> - security and personal safety

281 Ibid. (including footnote).
282 WFP, "About the logistics cluster", http://logcluster.org/logistics-cluster.
283 The Global Logistics Cluster Support Cell, *Logistics Cluster and Humanitarian Reform*, 2010, p. 26, http://logcluster.org/sites/default/files/documents/general_overview.
284 Global Camp Coordination and Camp Management Cluster, "What we do", www.globalcccmcluster.org/about/what-we-do.
285 Cluster Working Group on Early Recovery, "Early recovery", www.earlyrecovery.info.
286 OCHA, "About early recovery", www.humanitarianresponse.info/clusters/early-recovery.
287 S. Nicolai, *Education in Emergencies: A Tool Kit for Starting and Managing Education in Emergencies*, Save the Children, 2003, p. 11.
288 Global Education Cluster, "Education cluster: what we do", http://education.humanitarianresponse.info/what-we-do.

- enhanced resistance to ill health and disease
- support for family and community life
- communal coping strategies
- that self-sufficiency is encouraged and dependency is discouraged
- that adverse impacts on local environment and economy are minimized
- that household livelihood support and local economic activities are maximized.[289]

Specifically, this includes "household-related Non Food Items (NFIs), emergency and longer term shelter support, housing construction and reconstruction, and settlement support such as site planning and urban planning".[290]

Emergency telecommunications

WFP leads this cluster globally, which is intended to "provide timely, predictable and effective Information Communications Technology services to support [the] humanitarian community in carrying out their work efficiently, effectively and safely".[291] The activities of the cluster are field-driven, and at the onset of a disaster it delivers basic channels for security communications as well as internet and voice connections for humanitarian responders within 48 hours.

Food security

FAO and WFP are the Global Cluster Leads for this cluster intended to enhance "food availability, access and utilization", terms defined in the following manner:

- Food availability is the food [of appropriate quality] that is physically present in the area of concern—and expected to become available for use in that area within the period of concern—from domestic production and imports (including food aid).
- Food access (of households in specific population groups) is the ability of households to regularly acquire adequate amounts of appropriate food for a nutritious diet.
- Food utilization (by households in specific population groups) refers to the use that households make of the food to which they have access and individuals' ability to absorb and metabolize the nutrients—the conversion efficiency of the body.[292]

Health

The cluster, led globally by the WHO, envisages "Optimized health outcomes through timely, effective, complementary and coordinated action before, during and after crises". The mission is to "Build consensus on humanitarian health priorities and related best practices, and strengthen system-wide capacities to ensure an effective and predictable response".[293]

Nutrition

Led globally by UNICEF, the nutrition cluster seeks to "safeguard and improve the nutritional status of emergency affected populations by ensuring an appropriate response that is predictable, timely, effective and at scale".[294]

Protection

> Protection encompasses "all activities aimed at ensuring full respect for the rights of the individual in accordance with the letter and spirit of the relevant bodies of law (i.e. human rights law, international humanitarian law and refugee law)." Based on this internationally endorsed definition, the vision of the [Global Protection Cluster] is a world in which boys, girls, women and men affected or threatened by humanitarian crises are fully protected in accordance with their rights.[295]

UNHCR is the Global Cluster Lead for Protection, and other agencies function as leads of specific areas of responsibility—UNICEF for child protection, United Nations Population Fund (UNFPA) and UNICEF for sexual violence, the United Nations Human Settlements Programme

289 IFRC, *The IFRC Shelter Kit*, 2009, p. x, www.ifrc.org/PageFiles/95526/publications/D.03.a.07.%20IFRC%20shelter-kit-guidelines-EN-LR.pdf.
290 Global Shelter Cluster, "Scope of the Global Shelter Cluster", www.sheltercluster.org/Global/Working%20Groups%202012%20Documents/GSC%20Scope%20121017_final.doc.
291 Emergency Telecommunications Cluster, "Emergency Telecommunications Cluster", http://ictemergency.wfp.org/web/ictepr/emergency-telecommunications-cluster;jsessionid=806673F3B4AECD8BB1CFDC66F6727D0B.
292 Global Food Security Cluster, *Food Security Cluster Coordination Handbook*, draft 3, June 2012, pp. 52–53, http://foodsecuritycluster.net/sites/default/files/FSC%20Handbook%20draft%203%20final%20for%20web.pdf.
293 WHO, "The strategic framework of the Global Health Cluster", www.who.int/hac/global_health_cluster/about/mission_commitments/en/.
294 UNICEF, "Global Nutrition Cluster: about the GNC", 29 October 2013, www.unicef.org/nutritioncluster/index_aboutgnc.html.
295 Global Protection Cluster, "Who we are", www.globalprotectioncluster.org/en/about-us/who-we-are.html.

(UN-Habitat) for land, housing, and property, and United Nations Mine Action Service (UNMAS) for mine action.[296]

As a general rule, in situations of armed conflict, UNHCR will assume the role of protection cluster lead. In situations of natural disaster, the arrangements are less predictable: the three core protection mandated agencies (UNHCR, UNICEF, and OHCHR) will consult closely and, under the overall leadership of the Humanitarian Coordinator, agree which agency, among the three, will assume the role of Cluster Lead Agency.[297]

Water, sanitation and hygiene (WASH)

UNICEF leads this cluster globally, with the purpose of delivering safe water, drainage, waste management, and sanitation solutions, as well as promoting hygiene.[298]

296 Ibid.

297 IASC, *Reference Module for Cluster Coordination at the Country Level*, 2013, p. 5 (footnote), https://clusters.humanitarianresponse.info/system/files/documents/files/iasc-coordination-reference%20module-en_0.pdf.

298 For definitions of these terms see UNICEF, *WASH Cluster Nepal Earthquake Contingency Plan*, ver. 2 (draft), 2009, pp. 2–3. www.unicef.org/nepal/WASH_Cluster_Contingency_Earthquake_3Apr09.pdf.

APPENDIX 2: RADIATION TERMINOLOGY[299]

Radioactivity and radiation are often used interchangeably but they describe different (yet related) processes.

Radiation is a general term for a travelling particle or wave. Light, heat, microwaves, and radio waves are forms of radiation. Radiation can be "ionizing" or "non-ionizing".

Non-ionizing radiation has enough energy to move atoms around or cause them to vibrate, but not enough energy to remove electrons from atoms. Light, heat, and microwaves are forms of non-ionizing radiation.

Ionizing radiation, on the other hand, has enough energy to cause atoms or molecules to gain or lose electrons. Adding or removing an electron from an atom creates a charged particle called an ion. The process by which an atom or a molecule acquires a positive or negative charge by gaining or losing an electron is called ionization.

Radioactivity is the term that describes the breaking-up (decay) or rearrangement of an unstable atom's nucleus to create a different nuclide and therefore different element. The energy that is released during radioactive decay (as alpha and beta particles and gamma/X-rays) is called nuclear radiation and is an ionizing radiation. (Note that many other processes can also produce ionizing radiation.)

Among their effects, nuclear weapon detonations produce ionizing radiation.

There are four forms of ionizing radiation that are pertinent here:

1. Alpha particles—these are helium nuclei. They have a very short range, and cannot penetrate beyond the outer layer of human skin (which they can burn badly), although if an alpha-emitting isotope is deposited in the human body, it can be harmful to tissue.
2. Beta particles—these are electrons or positrons emitted from the nucleus of a radioactive atom. A medium-energy beta particle travels about one metre in air and a millimetre in body tissue. Energetic beta particles travel up to several metres in air and tens of millimetres into the skin. Beta-emitting substances are also harmful to human tissue if deposited in the body.
3. Gamma rays are a form of electromagnetic radiation, and are the same as high energy X-rays but are produced in a different way to X-rays. Gamma rays can penetrate much more deeply than alpha or beta particles. High-energy gamma rays can pass right through a person without interacting with any tissue at all, but some will interact causing damage, particularly in high-density tissue.
4. Neutrons are nuclear particles with no electric charge. Neutrons can ionize indirectly in a variety of ways that result in the emission of protons, gamma rays, beta radiation, and more neutrons. Water is particularly susceptible to neutron damage and so the human body with its large amount of fluids is highly vulnerable to neutron flux exposure.

Why is ionizing radiation harmful?

Ionizing radiation can harm the body in two ways—it can directly kill cells, or it can cause mutations to DNA. If the mutations are not repaired, the cell may turn cancerous. Radiation effects on the human body are divided into "deterministic effects" and "stochastic effects". Deterministic effects are injuries caused when cells are killed by radiation, e.g. radiation burns, radiation sickness. This type of effect is observed immediately or soon after the exposure to radiation. Stochastic effects are caused by DNA mutations (e.g. cancer, genetic effects). These effects are observed a long time (possibly many years) after the radiation exposure.

299 This appendix is based partly on the section on radiation terms of the American Health Physics Society, available at http://hps.org/hpspublications/articles/RadiationTerms.html; D. Close and L. Ledwidge, "Measuring radiation: terminology and units", *Science for Democratic Action*, vol. 8, no. 4, 2000, pp. 8–10; and IAEA, *IAEA Safety Glossary: Terminology Used in Nuclear Safety and Radiation Protection, 2007 Edition*, 2007. See also A.B. Wolbarst et al., "Medical response to a major radiologic emergency: a primer for medical and public health practitioners", *Radiology*, vol. 254, no. 3, 2010. Thanks also to Shelley Bulling, Patricia Lewis, and Pavel Podvig, for help with this section.

Glossary

What follows is a brief description of additional radiation-related terms relevant to this study. The International System of Units (SI) has since replaced some traditional terms. Since the traditional terms are still in widespread use, both the traditional and the SI units are described here.

Radioactivity

The radioactivity (or "activity") of a substance is quantified by the number of nuclei that decay in a given time. The SI unit of radioactivity is the becquerel (Bq), which is the activity of a quantity of radioactive material in which one nuclear disintegration occurs per second. Historically, radioactivity has been measured in the curie (Ci). The curie (named after Marie Curie) is roughly the activity of one gram of the radium isotope ^{226}Ra, a substance studied by the Curies.

$$1 \text{ Ci} = 3.7 \times 10^{10} \text{ Bq} = 37 \text{ GBq}$$

The specific activity of a radionuclide is the radioactivity per amount of the substance, e.g. becquerels per kilogram or curies per gram. In general, the higher a radionuclide's specific activity, the shorter its half-life (decay rate) and the more "radioactive" it is compared to one with a lower specific activity.

Radiation exposure

Radiation exposure is a measure of the strength of a radiation field at some point in air. It is the amount of charge liberated by photons ("X-rays" or gamma radiation) in a unit mass of air. The SI unit is coulomb per kilogram (C kg^{-1}) but it is sometimes expressed in the legacy unit roentgen (R).

$$1 \text{ R} = 2.58 \text{ x } 10\text{-}4 \text{ C kg}^{-1}$$

Absorbed dose

As mentioned above, the quantity exposure only applies to X or gamma radiation, and is a measure of ionization in air only. The quantity "absorbed dose" is used to describe the quantity of radiation for all types of ionizing radiation. Absorbed dose (or simply "dose") is the meaningful quantity for estimating the biological effects of radiation. Dose is the amount of radiation energy that has been deposited in a medium such as a human organ or tissue. The SI unit for absorbed dose is the gray (Gy) and is defined as one joule per kilogram. The old unit of dose is the rad (an acronym for radiation absorbed dose).

$$100 \text{ rad} = 1 \text{ Gy}$$

Equivalent dose

Equivalent dose is used in radiation protection. Although the biological effects of radiation depend on the absorbed dose, some types of radiation produce greater effects than others for the same amount of energy deposited. For example, for the same absorbed dose, alpha particles may be 20 times more damaging than beta particles. Equivalent dose takes into account the relative biological damage potential of a particular type of radiation. The SI unit for equivalent dose is the sievert (Sv). The old unit is the rem (an acronym for roentgen equivalent in man).

$$100 \text{ rem} = 1 \text{ Sv}$$

Effective dose

Although it is not mentioned in this study, the standard metric for estimating stochastic risk (late effects such as cancers etc.) is the concept of "effective dose" (also measured in sieverts). Radiation exposures to the human body can involve all or a portion of the body. The health effects of one unit of dose to the entire body are more harmful than the same dose to only a portion of the body. To enable radiation protection specialists to express partial-body exposures (and the accompanying doses) to portions of the body in terms of an equal dose to the whole body, the comparison concept is effective dose. Effective dose is the uniform dose to the whole body that would carry with it the same risk as the non-uniform dose to only the portion of the body in question.

ABBREVIATIONS

ARS	Acute Radiation Syndrome
CBRN	chemical, biological, radiological, nuclear
CTBTO	Comprehensive Nuclear-Test-Ban Treaty Organization
CTITF	Counter-Terrorism Implementation Task Force
DSS	United Nations Department of Safety and Security
EMP	electromagnetic pulse
ERC	Emergency Relief Coordinator
EURATOM	European Atomic Energy Community
FAO	Food and Agriculture Organization of the United Nations
GDACS	Global Disaster Alert and Coordination System
HEU	highly enriched uranium
HAEMP	High-Altitude EMP
IACRNE	Inter-Agency Committee on Radiological and Nuclear Emergencies
IAEA	International Atomic Energy Agency
IASC	Inter-Agency Standing Committee
ICRC	International Committee of the Red Cross
IFRC	International Federation of the Red Cross and Red Crescent Societies
IHR	International Health Regulations
IND	improvised nuclear device
INES	International Nuclear Events Scale
INFOSAN	International Food Safety Authorities Network
IOM	International Organization for Migration
IPPNW	International Physicians for the Prevention of Nuclear War
JEU	Joint UNEP/OCHA Environment Unit
JPLAN	Joint Radiation Emergency Management Plan of the International Organizations
LEU	low-enriched uranium
MIRA	Multi-Cluster Initial Rapid Assessment
NGO	non-governmental organization
NPT	Nuclear Non-Proliferation Treaty
NRDC	National Resources Defense Council (US)
OCHA	United Nations Office for Coordination of Humanitarian Affairs
OPCW	Organisation for Prohibition of Chemical Weapons
RANET	Response and Assistance Network (IAEA)
RCRC	Red Cross and Red Crescent Movement
REMPAN	Radiation Emergency Medical Preparedness and Assistance Network
SIOP	Single Integrated Operational Plan (US)
SREMP	Source Region EMP
UNDAC	United Nations Disaster Assessment and Coordination
UNDP	United Nations Development Programme
UNDP BCPR	UNDP Bureau for Crisis Prevention and Recovery
UNEP	United Nations Environment Programme
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children's Fund
UNISDR	United Nations Office for Disaster Risk Reduction
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
WFP	World Food Programme
WHA	World Health Assembly
WHO	World Health Organization
WMD	weapons of mass destruction
WMO	World Meteorological Organization