World Health Organization
REGIONAL OFFICE FOR Europe

FLOODS IN THE WHO EUROPEAN REGION:

HEALTH EFFECTS AND THEIR PREVENTION

Public Health England

World Health Organization

REGIONAL OFFICE FOR Europe

Floods in the WHO European Region:

health effects and their prevention

Edited by:
Bettina Menne and Virginia Murray

Public Health England

ABSTRACT

In 2009–2011, the WHO Regional Office for Europe and the United Kingdom Health Protection Agency undertook a project to investigate the adverse health effects of floods and to understand how best to protect the health of populations during floods in the European Region. The project had two main components. A questionnaire was sent to 50 of the 53 Member States of the WHO European Region to collect information on recent experience of floods, their health effects and current preparedness and response mechanisms. Furthermore, a systematic review was undertaken of the epidemiological literature on the global impact of flooding on health. Analysis of the returned questionnaires and the peer-reviewed literature brought to light many issues pertinent to Europe. These findings will help WHO to prepare evidence-based guidance for the European Region on health concerns before, during and after flooding incidents and the measures for prevention, response and recovery.

Keywords

Delivery of health care – organization and administration
Disaster planning
Emergencies
Environment and public health
Natural disasters
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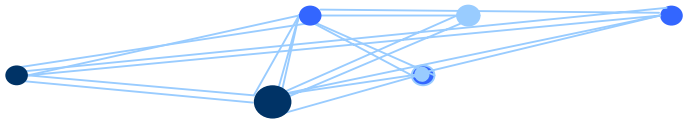

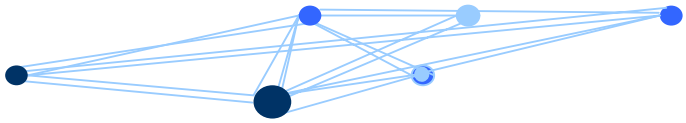

Foreword

Natural disasters commonly have deep, far-reaching consequences for the communities affected. In the European Region, floods are the most common disasters, causing extensive damage and disruption. The magnitude of the physical and human cost of such events can, however, be reduced if adequate emergency preparedness and planning are implemented, mitigation actions are undertaken and timely and coordinated responses are launched throughout and after the event.

In particular, much can be done to prevent or minimize the health impacts and human suffering. Globally and at the European level, WHO has been heavily involved in addressing the health dimensions of emergency management. The Hyogo Framework for Action (2005–2015) adopted by the World Conference on Disaster Reduction highlights the need to integrate planning for disaster risk reduction into the health sector. World Health Assembly resolutions 58.1 and 59.22 (2005 and 2006, respectively) urged Member States to formulate national emergency preparedness plans giving due attention to public health, including health infrastructure, and reiterated the importance of building national capacity in emergency preparedness. The WHO Eleventh General Programme of Work (2006–2015) identifies strengthening of global security as a priority, supporting an integrated approach and society-wide responses to emerging and new threats to health, including disasters and emergencies. At the European level, the Regional Framework for action on climate change sets as an objective improved provision of early warning systems, the preparation of action plans for extreme weather events, disaster preparedness and response and development of climate-resilient health care and other public service infrastructure.

The purpose of this review is to assist Member States in better understanding the health risks of flooding and developing their own public health responses for flood prevention in the context of wider emergency planning. Its findings are based on a comprehensive review of the scientific literature, web-based governmental and nongovernmental reports and a survey conducted by the WHO Regional Office for Europe with the United Kingdom Health Protection Agency (HPA)[1] between 2009 and 2011.

Resilient, proactive health systems that anticipate needs and challenges are more likely to respond effectively during emergencies, save lives and alleviate human suffering. The WHO Regional Office for Europe will continue to support Member States in their efforts to minimize the health impacts of floods. We hope this publication will provide background for that collaborative work and promote progress in this area.

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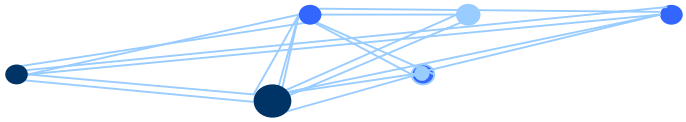
[1] Since 1 April 2013, the HPA has been part of Public Health England.



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Furthermore, we are grateful for financial and moral support received from the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety in the preparation of this document and for the expert review meeting on extreme weather event responses held in Bonn in November 2010.

Executive summary

Floods are the most common natural disaster in the European Region, which has experienced in recent years some of the largest flooding events in its history. The effects of flooding on health are extensive and significant, ranging from mortality and injuries resulting from trauma and drowning to infectious diseases and mental health problems (acute and long-term). While some of these outcomes are relatively easy to track, ascertainment of the human impact of floods in Europe is still weak. The WHO Regional Office for Europe and the United Kingdom HPA collaborated to assess the health effects of floods as well as to identify measures to prevent or minimize their health effects. The result is this document, which is intended to provide decision-makers with evidence for action before, during and after flooding events.

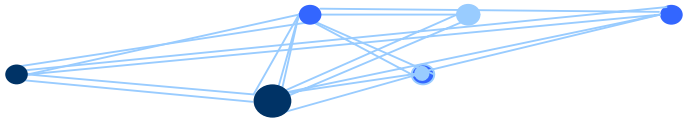
The information for this report was obtained through a comprehensive review of scientific evidence and "grey" literature, governmental and nongovernmental reports and data. Valuable information on practices and experiences of flooding and related public health measures was ascertained from the responses to a questionnaire sent to WHO Member States in the European Region. The key messages of this publication are as follows.

Extreme precipitation events and floods are frequent, and projected to increase, in the European Region.

- Flooding occurred in 50 of the 53 countries in the WHO European Region during the past decade, with the most severe floods in Romania, the Russian Federation, Turkey and the United Kingdom.
- It is projected that climate change will cause more rainfall. This may result in more frequent and more intense floods of various types such as local, sudden floods (flash floods); extensive, longer-lasting pluvial and fluvial floods; coastal floods and snowmelt floods.
- Heavy precipitation is likely to become more frequent throughout Europe. Even in summer, when the frequency of wet days is projected to decrease, the intensity of extreme rain showers may still increase. In addition, the frequency of precipitation for several days is projected to increase. In consequence, if no measures are taken, river flooding is projected to affect 250 000–400 000 additional people per year in Europe by the 2080s, more than doubling the numbers from those in 1961–1990. The populations most severely affected will be those of central Europe and the British Isles *(1)*. Rises in sea-level and storm surges, which cause coastal flooding, will affect several million more people, in particular in northern and western Europe, by 2080 *(2)*.

Floods have significant health impacts.

- During the past 30 years, flooding killed more than 200 000 people and affected more than 2.8 billion others worldwide. During the past 10 years, in the European Region, 1000 persons are reported to have been killed by floods and more than 3.4 million affected *(42)*. A review of European data for the years 2000–2011 shows that the number of deaths from flooding was highest in central Europe and the former Soviet Republics.
- Two thirds of deaths associated with flooding are from drowning, and the other third are from physical trauma, heart attacks, electrocution, carbon monoxide (CO) poisoning and fire. Often, only immediate traumatic deaths from flooding are recorded.



- Morbidity associated with floods is usually due to injuries, infections, chemical hazards and mental health effects (acute as well as delayed). The longer-term health effects associated with a flood are less easily identified. They include effects due to displacement, destruction of homes, delayed recovery and water shortages.
- The most common health-relevant occurrences during floods reported by European Member States are shortages of safe water, injuries and disruption of access to health services. Outbreaks of infectious diseases are rare.
- Known risk factors for flood-related mortality and morbidity are: fast-flowing water, hidden hazards, water of unknown depth, driving and walking through flood-water, flood-water contamination (by chemicals, sewage and residual mud), exposure to electrical hazards during recovery and cleaning, unsafe drinking-water and food shortages and contamination, incomplete routine hygiene, CO poisoning, and lack of access to health services.
- Flooding of health facilities results in interruption of business, loss of infrastructure, such as water supply and electrical power, increased patient admissions and increased difficulty in providing routine medical and nursing care for patients with chronic diseases, such as diabetes, renal failure, cystic fibrosis, cancer and mental illness.
- Population vulnerability to the health effects of flooding is due to a complex interaction of a variety of factors: severity and rapidity of the flooding, health status and necessity of regular treatment, access and availability of warning, rapidity of response measures and being located in high-risk areas and high-risk built environments.

Adequate planning is vital in order to effectively minimize health effects from floods.

- The most important measure to minimize health impacts from floods is implementation of a wide, multisectoral all-hazards approach to emergency preparedness, translated into a local plan that includes public health and primary care.
- Adequate land use is important in reducing health effects from floods. For instance, the building of health care facilities in a flood-plain should be avoided.
- Early warning systems are important components of flood emergency plans, allowing adequate time for preparation and response.
- Provisions should be made to ensure water quality, sanitation and hygiene and food safety after the flood; health precautions during clean-up activities; protective measures against communicable diseases and chemical hazards; and measures to track and ensure mental health and well-being.
- In addition to the core elements, emergency planning should be comprehensive, taking into account gender considerations, recommendations on evacuation and displacement and the health protection of vulnerable groups.
- Surveillance for mortality and morbidity during and after the event is important, in order to obtain timely information for any interventions required.
- Further work is needed to integrate health into emergency flood plans. Whereas health is often not considered explicitly in emergency plans, flood–health prevention requires an adequate coordination of health authorities with emergency response agencies.

- Very often, only short-term health effects of floods are considered in emergency plans. However, several outcomes (including long term mental health problems) have longer latency periods and need to be monitored and acted upon in the longer term.

A multisectoral approach is required to prevent flood health effects.

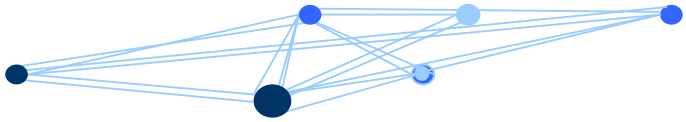
A range of primary, secondary and tertiary prevention measures can be adopted to minimize the health impact of flooding events.

- Primary prevention can be either structural (physically engineered interventions) or non structural (policy and organization). Examples of primary prevention include emergency plans and other methods to reduce the effects of floods, like land use management; tree planting; control of water sources and flow, including drainage systems; flood defences and barriers; design and architectural strategies; and flood insurance. These measures are normally planned far in advance.
- Secondary prevention includes identification of vulnerable or high-risk populations before floods occur, early warning systems, evacuation plans including communication and information strategies, and planned refuge areas. Secondary prevention measures for flood risk management can be taken either just before or during a flood to mitigate the health effects of the flood. Multisectoral collaboration is required between health services, early warning systems, water supply companies and emergency services for evacuation. Secondary prevention measures for vulnerable populations should account for difficulties in communication and mobility and the needs of people with chronic diseases.
- Tertiary measures include moving belongings to safe areas, ensuring the provision of clean drinking-water, surveillance and monitoring of health impacts, treating ill people to reduce the health impacts of flooding, and recovery and rehabilitation of flooded houses. Multisectoral collaboration among the military, fire department, police, water supply companies and health services is required. Robust surveillance is necessary during and after flood events to identify and control infectious disease outbreaks and non-infectious health hazards, tailor health service provision to the needs of the population, monitor vulnerable groups and provide information for research on possible associations between flooding and ill health.

There are still many gaps in knowledge regarding floods and health.

There are a number of gaps in knowledge about health impacts, response and recovery:

- a definition of “flood” for health purposes (The three approaches commonly used are water depth and spatial scale, population effects and temporal perspectives. Definitions would be particularly useful for assessing effects on health and on infrastructure and the financial toll and as a trigger for activation of emergency responses.);
- impacts of flooding on health facilities and health care provision, including economic impacts;
- delivery of health care and ensuring the continuity of care during a flood, especially for people with chronic diseases;
- structural protection and flood-proofing of health care facilities;
- risk mapping, including the identification and involvement of vulnerable groups and



targeted interventions;

- health information management during floods, including how to set up effective surveillance and monitoring systems;
- health effects of population displacement by evacuation and relocation;
- health protection for victims and vulnerable groups during the disaster recovery phase;
- appropriateness of triggering indicators for activation of emergency plans;
- locally relevant climate change adaptation planning to protect health from extreme weather events;
- validity of alternative sources of information for flood events (e.g. media, nongovernmental organizations, differences in reporting);
- culturally appropriate, age- and gender-sensitive mental health programmes for disaster victims;
- vulnerability to flooding, increased resilience, vulnerability boundaries;
- interactions between emergency response agencies and health care providers, response of hospitals to early warning systems;
- timely, effective communication during electricity cuts and population movement;
- better institutional and public responses to early warning systems; and
- emergency and longer-term mental health care in response and recovery.

1. Introduction and methods

This report, prepared by the HPA and the WHO Regional Office for Europe, is based on a review of the scientific evidence on the health effects of floods and preventive activities and on an analysis of the responses to a questionnaire sent to WHO European Member States in 2009–2010. The goal was to review data and information on flooding in order to understand its health effects and the measures used in Member States.

The main questions posed were:

- What are the frequencies, effects and probable future development of floods?
- What are the health effects of floods?
- Which prevention, preparedness and response measures are available?
- What are the knowledge gaps?

The three methods used to compile this report were a qualitative survey, an extensive review of the epidemiological literature and screening the web sites of relevant organizations.

1.1 Qualitative survey

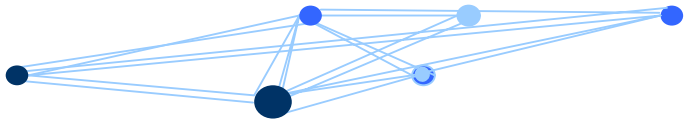
A questionnaire (see Annex 1) was sent to 50 of the 53 WHO Member States in the European Region and to Kosovo[2]. Andorra, Monaco and San Marino had not reported floods and were excluded from the survey. The questionnaires were distributed through four channels: focal points of the WHO Regional Office for Europe, the EuroHEAT[3] Network, the National Platform Network and local contacts. The questionnaire elicited information on recent flooding events, the health effects observed, emergency plans and any evaluation or monitoring systems in place. The questionnaire contained both closed and open questions and spaces for free text.

The topics covered by the questionnaire were:

- definition of a flood,
- descriptions of floods that activated emergency plans,
- health effects of floods during the past 5 years
- deaths from flooding,
- effects of floods on health care and health facilities,
- existence of emergency plans for floods,
- structure of emergency response systems,
- actions related to public health,
- surveillance of health impacts and
- monitoring and evaluation of the emergency plan.

[2] For the purpose of this publication all references, including in the bibliography, “Kosovo” should be understood/read as “Kosovo in accordance with Security Council resolution 1244 (1999)”.

[3] EuroHEAT was a research project coordinated by the WHO Regional Office for Europe and co-funded by the European Commission from 2005 to 2007. It quantified the health effects of heat in European cities and identified options for improving health systems’ preparedness and response. It also produced an active network of scientists and practitioners in the field of public health emergencies management.



The themes assessed from the answers to the questionnaire were health before, during and after a flood, with a focus on disaster planning and response, evidence-based best practice and guidance on health facility preparedness and post-flood recovery.

1.1.1 Response rates

Of the countries and areas targeted in the survey, 27 (54%) returned the questionnaire. More countries in eastern Europe and countries that had recently joined the European Union were represented than those in western Europe. The countries that replied were: Albania, Armenia, Austria, Azerbaijan, Bosnia and Herzegovina, Croatia, the Czech Republic, Georgia, Hungary, Iceland, Israel, Kyrgyzstan, Malta, the Netherlands, Poland, the Republic of Moldova, Serbia, Slovakia, Slovenia, Spain, Sweden, Tajikistan, the former Yugoslav Republic of Macedonia, Turkey, Ukraine and the United Kingdom. Kosovo[4] also returned the questionnaire.

The quality of the responses to the survey depended on the government sector that provided answers. Over half the questionnaires were completed in a governmental department within the health sector; just over a third were completed in emergency departments (the National Protection and Rescue Directorate in Croatia, the Crisis Management Centre in the former Yugoslav Republic of Macedonia and the Administration for Civil Protection and Disaster Relief in Slovenia), and some by collaboration among sectors.

The responses were analysed to derive answers to the main questions being addressed. The report includes case studies and examples provided by countries. An attempt was made to understand which flooding situations triggered an emergency plan, and the components and alert levels of the plans were identified.

1.1.2 Limitations

A number of limitations to the survey were identified. The response rate was low, and some of the questionnaires that were returned contained little detail. Moreover, several responders stated that some details and actual plans could not be released. In addition, not all the answers on emergency plans were specific to health; however, this was considered a finding in itself, as it illustrates disunity among sectors and the fact that health is not always part of an emergency plan. More information was derived from questionnaires that were completed in full, which may have led to a country bias. Selection bias occurred because of the greater effectiveness of one of the contact channels (WHO focal points); therefore, this report is not a true representation of flooding emergency plans and health effects in Europe.

The questionnaire itself had limitations. Most of the questions addressed what was done and did not focus enough on how it was done, therefore eliciting few details. For example, answers to the question about alert levels for emergency plans referred to “activities during floods”, with no further detail. Some of the questions could have been more explicit, such as how the health of people with chronic diseases was protected or how “flood death” was defined. For countries in which health was not part of the emergency plan, more questions could have been asked about how links to health were maintained in an emergency.

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[4] For the purpose of this publication all references, including in the bibliography, “Kosovo” should be understood/read as “Kosovo in accordance with Security Council resolution 1244 (1999)”.

1.2 Literature review

The objectives of the literature search were to review the epidemiological evidence on flood-related health impacts by critically appraising the evidence from published studies of flooding events worldwide. Epidemiology is the "The study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to control of health problems" (*3*). Epidemiological data are important for defining public health priorities, guiding intervention practice and evaluation, understanding the nature of the association between an event and its outcome and providing evidence for planning and response.

Another aim of the review was to identify gaps in knowledge about effects on public health and health services. The health outcomes of flooding are complex, and epidemiological data can help public health agencies and disaster planners to understand them and how best to prepare and respond. To represent the wide climate variation within the European Region, we reviewed global literature on the health impacts of flooding and not only those for Europe. The methods used in a review on the health impacts of flooding published in 2005 *(4)* were adapted. It was decided to update the literature review for the following reasons.

- Many disasters involving flooding have occurred since 2004, from which much has been learnt and published, including in New Orleans, Louisiana, United States, in 2004–2005, in the United Kingdom in 2007 and in France in 2010.
- Climate change and the associated threat of increased flooding have increased, and understanding of the phenomenon has advanced.
- The health effects of natural disasters require further research; they may be worse than was understood in 2004.
- The risk of flooding to health facilities has risen in importance on the agendas of the United Nations and WHO.
- The team that prepared the review *(4)* agreed that an update was necessary; furthermore, they considered that more factors should be covered, such as the effect of floods on health facilities and the identification of vulnerable groups.

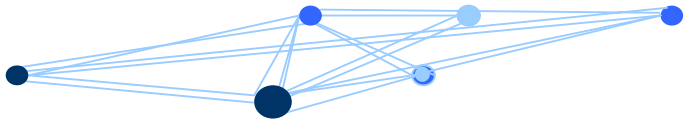
A search algorithm was prepared and entered into the Scopus search engine (see Box 1), which scans many large academic databases, including Medline, PubMed, EmBase and Psychinfo, and 15 000 peer-reviewed journals, as well as conference proceedings and book series.

Box 1. Search algorithm (in title, abstract and keywords) for the literature review

(TITLE-ABS-KEY(flood* OR dams OR embankment* OR hurricane* OR inundation OR overflow* OR "seawater intrusion" OR "storm surge*" OR "storm water*" OR "tropical storm*" OR typhoon* OR "water logging" OR waterlogging) AND TITLE-ABS-KEY(accident* OR alcoholi* OR allergy OR allergen OR allergies OR anxiet* OR burul* OR campylo* OR "cardiac arrest" OR cardiovascular OR (chemical AND pollut*) OR cholera OR conjunctivitis OR contamination OR death* OR dengue OR dermatitis OR diarrhoea* OR diarrhea* OR disease* OR "drug suppl*" OR drown* OR dysentery OR electrocution* OR epidemic* OR escherichia OR gastrointestinal OR giardia* OR health OR hepatitis OR hospital* OR hypothermia OR illness OR infectio* OR injur* OR leptospirosis OR malaria OR malnutrition OR "medical facility*" OR medicine* OR mental OR morbidity OR mortality OR mosquito* OR naegl* OR outbreak* OR pesticide* OR poison* OR pollut* OR psychological OR psychosocial OR respiratory OR "risk factor*" OR shigella OR shock OR "side effect*" OR "snake bite*" OR stress OR suicide* OR waterborne OR water-borne OR water-related OR wound* OR "yellow fever")) AND (LIMIT-TO(PUBYEAR, **2010**) OR LIMIT-TO(PUBYEAR, **2009**) OR LIMIT-TO(PUBYEAR, **2008**) OR LIMIT-TO(PUBYEAR, **2007**) OR LIMIT-TO(PUBYEAR, **2006**) OR LIMIT-TO(PUBYEAR, **2005**) OR LIMIT-TO(PUBYEAR, **2004**))

AND (LIMIT-TO(SUBJAREA, **"MEDI"**) OR LIMIT-TO(SUBJAREA, **"PHAR"**) OR LIMIT-TO(SUBJAREA, **"PSYC"**) OR LIMIT-TO(SUBJAREA, **"NURS"**) OR LIMIT-TO(SUBJAREA, **"MULT"**) OR LIMIT-TO(SUBJAREA, **"MULT"**))

Note: Some words were truncated with a *, as is common practice, so that all syntactic compounds are included.



Other databases searched for epidemiological reviews were: the Database of Abstracts of Reviews of Effects, the Cochrane Database of Systematic Reviews, the Evidence for Policy and Practice Information Centre and a database of health effectiveness reviews. No reviews were found.

1.2.1 Inclusion and exclusion criteria

Peer-reviewed journal articles reporting quantitative and qualitative studies, books, conference papers, unpublished manuscripts, dissertations and previous reviews available in 2004–2010 were included. The search was limited to the broad subject areas of medicine, nursing, psychology, pharmacology and toxicology in order to exclude papers on unconnected subjects, such as river health and mosquito colonies. Papers considered irrelevant to the search and which were excluded were those on "flood" and "flooding" used to mean inundation, biochemistry, genetics and molecular biology.

1.2.2 Search results

The search generated 3585 references, of which 827 were retained after exclusions. The 181 papers found to fit the epidemiological criteria were categorized as:

- suggestions for improvements during future flood events, which were often general statements, projections, recommendations, planning and "lessons learnt";
- interventions during and immediately after flooding events, including personal accounts, and the effectiveness of the interventions, which were usually at individual or unit level;
- epidemiological studies of particular exposed groups, according to the definition of epidemiology quoted above *(3)*; and
- discussions of particular hazards and effects, that might shed new light but were not considered to be epidemiological studies.

See Annex 2 for lists of studies on the health impacts of flooding.

1.2.3 Methodological difficulties of epidemiological studies on flooding

The health impacts of flooding cannot generally be assessed in controlled prospective epidemiological studies because of the time and costs involved; therefore, much of the literature on health effects and advice reflects opportunistic retrospective analyses and case studies *(5)*. Moreover, the effects of weather disasters such as floods on health are difficult to quantify because the secondary delayed consequences are poorly reported. The evidence base for assessing the health effects of flooding is weak, generally consisting only of mortality statistics, with relatively few rigorous epidemiological studies. It is difficult to assess the duration of symptoms and disease or their causes without longitudinal data. The epidemiological studies on the effects of flooding on health are frequently limited because they are based on small, non-representative samples *(6)*. Good baseline data are often difficult to obtain because they are not collected before a flood. In addition, the health outcomes attributable to flooding are not always recorded in medical notes, so that the association between the health complaint and its cause is not made.

Natural disasters such as flooding are unique circumstances and have been the object of much research in the past few years. This is particularly true of flooding caused by hurricanes in the United States, such as Floyd, Katrina and Ivan. The Pitt review *(7)*, following the floods in the United Kingdom in 2007, cites evidence from two surveys. Many of the effects reported in this report, however, are based on "anecdotal" and qualitative evidence, as is the case in much

of the published work. While there can be no doubt about the indirect health impacts, quantifying them with good, evidence-based epidemiology is difficult *(8)*.

Furthermore, the health impacts of floods are underreported. Some people do not consult a doctor after a flood, and those who do may not explain the circumstances to the clinician or make the association themselves because of the delayed psychological impact of flooding or injuries sustained during the recovery process weeks after the flood. In Europe, however, hospital admission and general practice consultation records are available, obviating the methodological difficulties when the association and health complaint are noted.

Thus, the epidemiological literature on the health impacts of flooding is incomplete. Records of events before, during and after a flood would significantly increase understanding as a basis for planning appropriate interventions.

1.3 Methods used to assess interventions

Evidence for chapter 4 on intervention measures was obtained by both a structured search and pragmatic techniques. A broad search algorithm was devised, and the Scopus search engine was used as shown in Box 2. The search covered publications in 2000–2010.

This search produced 663 results. Papers for which abstracts were available were then searched for the terms "structural", "nonstructural", "regional planning", "spatial planning", "storm water", "urban drainage", "building" and "technology". This resulted in 32 full papers for review. In addition, as it is known that the "grey literature" on these subjects is vast, references from the main English-language reports and organization documents were searched. A pragmatic approach was taken to searching for evidence of small-scale interventions, such as for individual households. An "eco-building" conference was attended to identify emerging techniques for flood protection, but this was sadly unproductive, as few research results and technical literature were presented.

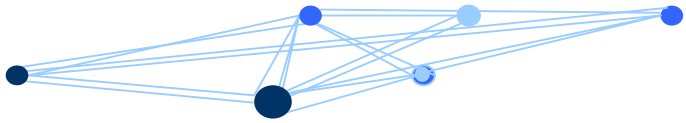
A pragmatic search was conducted of the web sites of major bodies that provide health advice and use English as the first language: the HPA, the Centers for Disease Control and Prevention (CDC) in the United States, WHO, the United Kingdom National Health Service, the European Environment Agency and the United Kingdom Environment Agency. Each web site was searched for pages or online factsheets, guidelines or documents about flooding and health effects. Information on health responses to a flood, both immediate and long-term, was extracted. The information published by the HPA was used as the baseline and was compared with information from the other sources, highlighting concurrences and discrepancies in both the content and scope of advice.

Box 2. Search algorithm (in title, abstract and keywords) for assessing intervention measures

TITLE-ABS-KEY(flood prevention) AND (LIMIT-TO(LANGUAGE, "English") AND (LIMIT-TO(SRCTYPE, "j"))AND((LIMIT-TO(PUBYEAR, 2010) OR LIMIT-TO(PUBYEAR, 2009) OR LIMIT-TO(PUBYEAR, 2008) OR LIMIT-TO(PUBYEAR, 2007) OR LIMIT-TO(PUBYEAR, 2006) OR LIMIT-TO(PUBYEAR, 2005) OR LIMIT-TO(PUBYEAR, 2004) OR LIMIT-TO(PUBYEAR, 2003) OR LIMIT-TO(PUBYEAR, 2002)OR LIMIT-TO(PUBYEAR, 2001) OR LIMIT-TO(PUBYEAR, 2000))

2. Current and projected trends in flooding in Europe

This chapter introduces key concepts and data on flooding. It has three main sections: definitions and types of floods, sources of data on flooding events and data on flooding in Europe, including projections of future events.



2.1 Definitions of flooding

Definitions of floods are useful for assessing the health effects, the damage to infrastructure and the financial toll they can cause and deciding on a trigger for activation of emergency response. There is, however, no universal definition of what constitutes a flood. Examples of currently used definitions include:

- the presence of water in areas that are usually dry; a "flood disaster" is a flood that significantly disrupts or interferes with human and social activity *(9)*;
- an increase of water that has a significant impact on human life and well-being *(10)*;
- a significant rise of water level in a stream, lake, reservoir or coastal region *(11)*; and
- any case where land not normally covered by water becomes covered by water *(12)*.

New definitions of flooding and coastal erosion include "flood risk" as the relation between the probability of occurrence and the associated consequences, which are then listed, with health as the first concern, followed by social and economic welfare (*12*). Three ways are suggested for defining a flood for health purposes: as scientific thresholds, as descriptions of population effects and as temporal perspectives. A *scientific threshold* could be a specified depth of water or a temporal or spatial boundary, i.e. the length of time and/or the area of land that is flooded (*4*). *Population effects* could be broad, such as medical, social and economic disruption to normal life, or specific, such as the number of deaths or people affected (*9*). A *temporal perspective* or latency approach would take into account immediate outcomes, during or immediately after flooding; short-term outcomes, in the days or early weeks after flooding; and long-term outcomes, occurring after flooding and/or lasting for months or years (*13*).

The variety of definitions reflects the difficulty of finding an adequate way to describe the overall effects of flooding from a health perspective. Temporal health perspectives are probably the most helpful. Table 1 lists the definitions for triggering emergency plans reported in the questionnaires returned by Member States. Descriptions that represent scientific thresholds and population effects predominate, while the temporal health perspective is underrepresented, and some descriptions are based on combinations of approaches. This is not unexpected, because floods cause so much damage to infrastructure and upheaval to people's everyday lives. In Europe, a threat to health may not be considered the defining factor for activating an emergency plan, especially as the number of deaths from floods is relatively low in most countries.

Table 1. Flood conditions that would trigger activation of an emergency plan

Country	Definition	Category of definition
Albania	Critical depth of groundwater	Scientific threshold
Armenia	No specific definition, case-by-case basis	
Azerbaijan	Massive flooding in several districts	Scientific threshold
Bosnia and Herzegovina	Shortage of safe water and/or houses flooded with water; extensive flooding endangering population settlements, infrastructure, roads, railways, etc.	Population effects
Croatia	Disastrous flood	Population effects
Czech Republic	Third level of emergency plan	Population effects

Table 1. contd

Country	Definition [a]	Category of definition
Georgia	Disruption to normal lifestyle and working conditions, threats to life and health or harm to the population and natural environment that demands immediate action	Population effects
Hungary	An emergency situation due to flooding is declared when the water level reaches the critical threshold value defined for the given part of the river, and further increases are forecast.	Scientific threshold
Israel	The protocols for mass casualty events are immediately activated in any emergency in which there is a discrepancy between needs and the ordinary resources that are available. When there is a forecast of a potential emergency, such as a flood, the resources are reinforced and alerted in advance.	Temporal perspective
Kyrgyzstan	None given	
Malta	None given	
Netherlands	If a flood or the threat of a flood occurs on a national level because of a storm surge or high river water levels in one of our two main rivers (Maas, Rijn)	Scientific threshold
Poland	Flood that affects a significant population on health-related issues and/or destroys property to a degree that exceeds the local ability to respond	Population effects and temporal perspective
Republic of Moldova	When a flood causes considerable material and mortal damage, covering relatively large plots of land in river valleys; flooding of approximately 10–15% of agricultural lands; significantly disturbing the household and economic activity of the population, leading to partial evacuation of people	Population effects and scientific threshold
Serbia	None given	Population effects
Slovenia	The National Protection and Rescue Plan in the event of floods shall be activated in the event of a catastrophically high water level.	Scientific threshold
Spain	None given	
Sweden	A flood with such consequences that it affects society's critical functions requires a disaster management plan. This can be an infrastructure or a service that is important for the functioning of society (such as reservoirs, roads, railways, electrical networks, water pipes, sewer systems).	Population effects
Tajikistan	Any flood that causes any damage to community assets or loss of life	Temporal perspective and population effects
The former Yugoslav Republic of Macedonia	Increase in water level of rivers and lakes so that they overflow for over 24 h	Scientific threshold
Turkey	If the flood has affected the life of the population in that area and caused loss of life and property	Temporal perspective and population effects
United Kingdom (England and Wales)	An event that threatens to cause serious damage to human welfare. The National Resilience Capability Framework, led by the Cabinet Office, is the Government framework for determining and assessing a range of threats and hazards.	Temporal perspective and scientific threshold

[a] In Kosovo, activation is triggered when the situation exceeds the local level capacity.

2.2 Types of flood

Several different types and causes of floods (Table 2) can have varying implications for human health. It can be helpful to differentiate between two general categories of flood according to the size of the affected area and the duration of precipitation (spatial and temporal scale of flood events) (*14*).

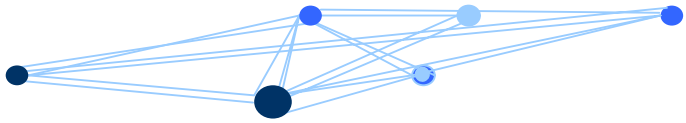


Table 2. Types of flood, by cause

Cause	Examples
Heavy or intense rainfall	Slow-onset riverine flood (fluvial) Flash flood (rapid onset) Pluvial or surface water flood affecting sewers and urban drainage Groundwater flood
Thawing of ice	Glacial meltwater Snowmelt
Dam failure	Dam break Dam overtopping
Tidal wave or wave extremes	Storm surge Tsunami

Local, sudden floods (flash floods) result in flooding in small catchments and are due mainly to short, intensive precipitation (e.g. thunderstorms). Flash floods occur primarily in hilly or mountainous areas and are due to convective rainfall mechanisms, thin soils and high runoff velocities. The warning time for these events is short. In general, the duration of a flood is also short, but this sort of flooding is frequently associated with severe damage. Intense precipitation can also lead to pluvial or surface water flooding of urban areas where sewers and drainage systems lack the capacity to cope with the volume of water.

Extensive, long-lasting floods (plain floods) often result in flooding of larger areas. They are almost invariably caused by rainfall lasting several days or weeks, associated with prior soil saturation. Flooding caused by extensive, long-lasting rainfall, which can also be due to melting snow and ice, occurs mainly in plains, when dikes or defences along wide rivers can no longer contain the flood discharge. This can lead to flooding of wide areas, as occurred, for example, during flooding of the Rhine and Maas rivers in December 1993 and in January–February 1995 and during flooding in central Europe in 2002. One advantage of this type of flooding is that it often has a slower onset, so that early warnings can be issued and preparations made. When these conditions create a flood "wave" in catchments, however, the onset of flooding can be fast and similar to that of flash floods.

Coastal flooding can be defined as inundation of coastal areas to a greater extent than that expected from normal tides. Coastal flooding is usually caused by extreme weather conditions, such as a combination of high tides and storms *(15)*. The three main mechanisms are high tides, usually caused by gravitational effects from the sun and the moon, which may be superimposed on a spring–neap tide cycle; a surge caused by heavy on-shore winds combined with low atmospheric pressure; and local sea wave action *(16)*.

In 1953, a storm tide flooded the low-lying coastal areas of countries around the North Sea. As the high waters reached a peak during the night, the storm surprised many people in their sleep and the resulting effects on mortality and infrastructure were enormous: 1836 people were killed in the Netherlands, 307 in the United Kingdom, and 22 in Belgium *(17)*.

Coastal floods may potentially affect significant numbers of people; it was estimated in 1990 that about 1.2 billion people lived in coastal areas *(18)*, and this number is expected to increase to at least 1.8 billion in the coming decades. It was estimated that 10 million people globally experienced coastal flooding in 1990 *(19)*. The risk of coastal flooding has already increased since 1990, and it is generally considered that it will increase even more during the next few decades due to the predicted sea-level rise, more extreme weather conditions and increasing coastal erosion due to increasing atmospheric carbon dioxide levels and a global increase of ambient temperatures *(18)*. In addition, the risk zone is expected to move upwards and landwards due to sea-level changes *(19)*.

At the global level, most exposed populations live in countries with limited adaptive capacity, where coastal floods will potentially affect a larger number of people more severely, as flood defences and emergency planning are less well developed *(20)*. Coastal population densities make it likely that the health effects of floods will affect large numbers of people. Additionally, the causal mechanisms of coastal flooding (e.g. cyclones, hurricanes and tsunamis) mean that the extent of coastal flooding and its effects exceed those of floods further inland and present a greater risk to life.

Many *direct* effects of coastal floods on human health, such as injury, drowning, infectious diseases and psychological effects (*4*) are generic and are discussed elsewhere in this report. The *indirect* effects of coastal flooding are also likely to be significant. Most importantly, coastal flooding affects fresh water and food supplies for surrounding areas as well as people's livelihoods. Coastal flooding can lead to destruction of crops due to seawater intrusion or flooding in general. The transport of food and fresh water may be impeded by flooding of roads or railway lines. Drinking-water supplies can be contaminated by intrusion of seawater or (as in other floods) sewage. Fresh water supplies are already scarce in many coastal areas of the world, and the expected population increase is likely to further aggravate this imbalance (*18*).

In the longer term, the destruction of coastal shorelines and maritime coastal areas may affect livelihoods by reducing fishing grounds or coral reefs, and destruction of the coastal shoreline and natural defences can also make an area more vulnerable to subsequent floods, as seen in Louisiana, United States, in the aftermath of Hurricane Katrina (*18*).

2.3 Data on flood events

Two databases that provide information on flooding in the WHO European Region were consulted to determine which countries had suffered floods and their impacts between 2000 and 2011.

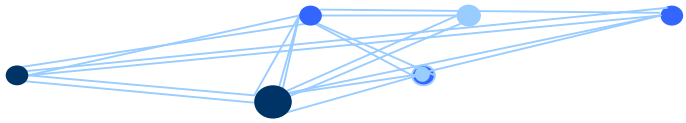
2.3.1 Emergency Events Database

The Centre for Research on the Epidemiology of Disasters at the School of Public Health of the Université Catholique de Louvain in Brussels, Belgium, maintains the Emergency Events Database (EM-DAT) (*21*). EM-DAT includes emergencies dating back to 1900 and has recorded over 17 000 disasters, both man-made and natural. The criterion that defines a flood is a significant rise in the water level in a stream, lake, reservoir or coastal region. The EM-DAT definition of flood includes general river floods, flash floods and storm surges or coastal flooding. The criteria that a flood (or any other type of disaster) must meet to be classified as a disaster or flood event by EM-DAT are: 10 or more people killed, 100 or more people affected, declaration of a state of emergency and/or a call for international assistance. Thus, only the largest disasters are captured. The database is compiled from various sources, including United Nations agencies, governments, nongovernmental organizations, insurance companies, research institutes and press agencies. Priority is given to data from United Nations agencies, governments and the International Federation of Red Cross and Red Crescent Societies, as these sources are generally considered to be of the highest quality and are most likely to be complete.

EM-DAT not only counts the number of floods but also the numbers of deaths, the numbers affected and the damage done.

2.3.2 Dartmouth Flood Observatory

The Dartmouth Flood Observatory (DFO), based at Dartmouth College in the United States, maintains the Dartmouth Global Active Archive of Large Flood Events (*22*), a global



database of flood disasters, with information derived from a wide variety of news and government sources. Online news reports, the web sites of governments and international relief agencies and other electronic data sources are scanned for reports of flooding. Satellite and aerial images of flooding are used to map areas where flooding has occurred.

Only "large" floods are included by DFO, defined as significant damage to structures or agriculture, long reported intervals (decades) since the last similar event and/or fatalities. DFO does not specifically define what constitutes a flood and appears to base its definition on reports of flooding combined with recording only large events. As the DFO does consider the main cause of the flood, it is likely to capture more flood events than EM-DAT: any large flood event is recorded as a flood by the DFO, whereas EM-DAT may classify it as another type of disaster. (Tropical) storms are included only when they also cause flooding. The DFO also records the number of fatalities and the damage caused.

2.3.3 Limitations of the databases

EM-DAT and DFO derive their information on events from reports by government organizations, insurers, nongovernmental organizations and the media, whereas many small-scale floods may not be reported or recorded by such organizations, particularly if government organizations are discouraged from reporting or if nongovernmental organizations or international media are not operating in countries. The DFO states that developed, industrialized countries tend to report more rapidly and in greater detail than less well developed countries. Also, the amount and type of media and other coverage is not necessarily proportional to the size of a flood event.

National data are the basis for both databases. Disasters that affect many countries simultaneously are entered multiple times into EM-DAT (but with the same identifier) and as a single entry by DFO. At country level, they are treated as separate events; but at European level, they are considered a single event. This can result in multiple counting of the same event. A further potential limitation of EM-DAT is the way in which it classifies disaster events. For example, windstorms can cause flooding, as can tsunamis, and floods may cause land-slides. For any given event, it is important to know what criteria were used to classify the event and whether there has been any random or systematic misclassification, which in turn could lead to over- or undercounting of events.

The consideration of flooding exclusively at country level can be misleading. A better measure would be of the risks for specific places and people, beyond border considerations. Individuals' risks are likely to depend on whether they live on a flood-plain or in a coastal area. Similarly, individuals' vulnerability to flooding may depend on their age or sex (see section 4.2.1 for more information on vulnerable groups). The type of flood may also shift risk profiles (*9*). Therefore, it is difficult on the basis of the current data to make inferences beyond the numbers of floods and the numbers of people killed.

Financial damage associated with flood events was not analysed, even though the data were available in both DFO and EM-DAT. Barredo (*23*) argued that flood losses are in effect a proxy for development and are more closely correlated with gross domestic product than with the severity of a flood, thus limiting their usefulness.

These limitations aside, the two databases are complete enough to map roughly the larger flood events and disasters that have affected the WHO European Region over the past 10 years.

2.3.4 Media reports

The main disaster databases—EM-DAT and DFO—are not complete, and often the media (albeit with flawed, incomplete methods) are a source of information about smaller, less

dramatic floods that have a smaller health impact. In England, for example, the Office of National Statistics did not officially record any deaths during the severe 2007 floods, for a variety of reasons, most related to the complexity of defining flood-related deaths, and the media were an important source for recording 13 flood-related deaths.

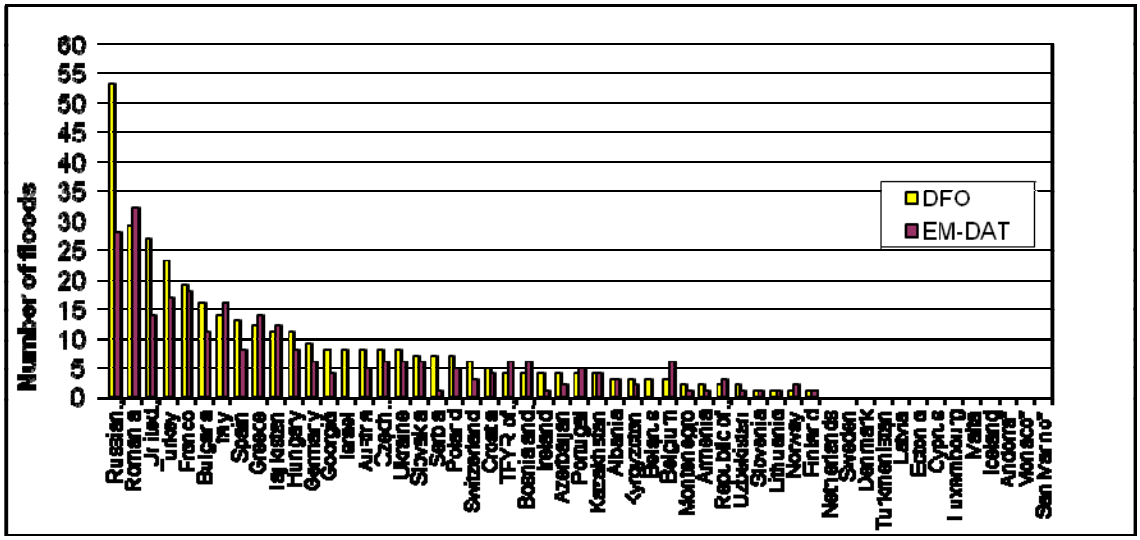
There are many media reports on flooding. BBC News, Google and other Internet sources have reported floods in most countries of the WHO European Region in the past 10 years. These reports do not, however, not take into account the extent of flooding: flood disasters and events are included with "other" floods. Further research is needed to compare media reporting of floods with the data held by EM-DAT and DFO in order assess the completeness of the two data sets.

2.4 Current flood risk and number of floods

The proportion of the population that lives in flood-prone areas varies widely in European countries. In 2001, for example, 3.5% of the population of France and 50% of that of the Netherlands lived in such areas (*24*). The proportion in the United Kingdom was 4.8%. In the United Kingdom, over 5 million people who live and work on 2.4 million properties are at risk from flooding in rivers, the sea, surface or groundwater. The average annual loss due to floods is estimated at more than £1 billion. London's flood-plain alone has 16 hospitals, about 200 schools and 500 000 properties on it. New housing developments on flood-plains continue to be proposed: in south-east England, one third of the proposed 200 000 houses are in flood-prone areas. The increasing pressure to develop on flood-plains and the forecasted effects of climate change may make the cost of flood defences and insurance prohibitive, and other, nonstructural measures should be explored (*24*, *25*).

The number of floods recorded in EM-DAT increased greatly between 1900—the first year for which data are available—and 2011. Most of this secular increase can probably be attributed to improvements in access to information and reporting of disasters itself. However, it can be safely assumed that reporting levels have not changed significantly for the European Region in the past decade. The numbers of flood events between 2000 and 2009 in the two datasets were compared (Fig. 1).

Fig. 1. Number of floods per country of the European Region* recorded in DFO and EM-DAT from 2000 to 2009

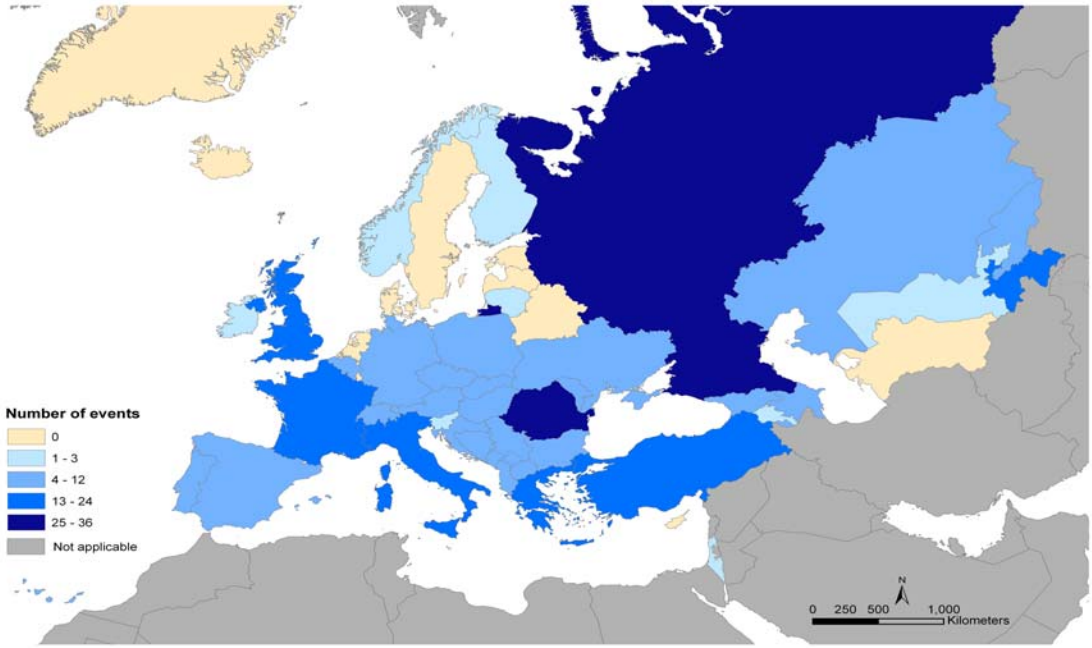


* As per regional distribution within WHO

The DFO recorded more flood events than EM-DAT, perhaps partly because the DFO uses a

looser definition of a flood event and does not classify disaster types. Country-specific data can also be represented in geographical form. Fig. 2 represents the number of floods and wet mass movement events in the European Region from 2000 to 2011, according to EM-DAT. Flooding occurred across most of the European Region during the period. Several floods were reported in Romania and the Russian Federation, as well as in Turkey, the United Kingdom, France and Italy; however, these countries also have some of the largest populations in the Region. In a more sensitive analysis, population numbers would be weighted for potential exposure to flooding, so that people living on flood-plains and in other flood-prone areas would count more than those living in areas considered to be at low risk for flooding. The effects of small numbers within the dataset should also be considered, in particular with regard to the number of flood events. For instance, Montenegro had a population of just over 600 000 in mid-2005, when two floods were recorded by the DFO. Increasing or decreasing the number of floods by one would have a significant effect on the rate of flooding in Montenegro, exacerbated by the small population relative to some other countries in Europe.

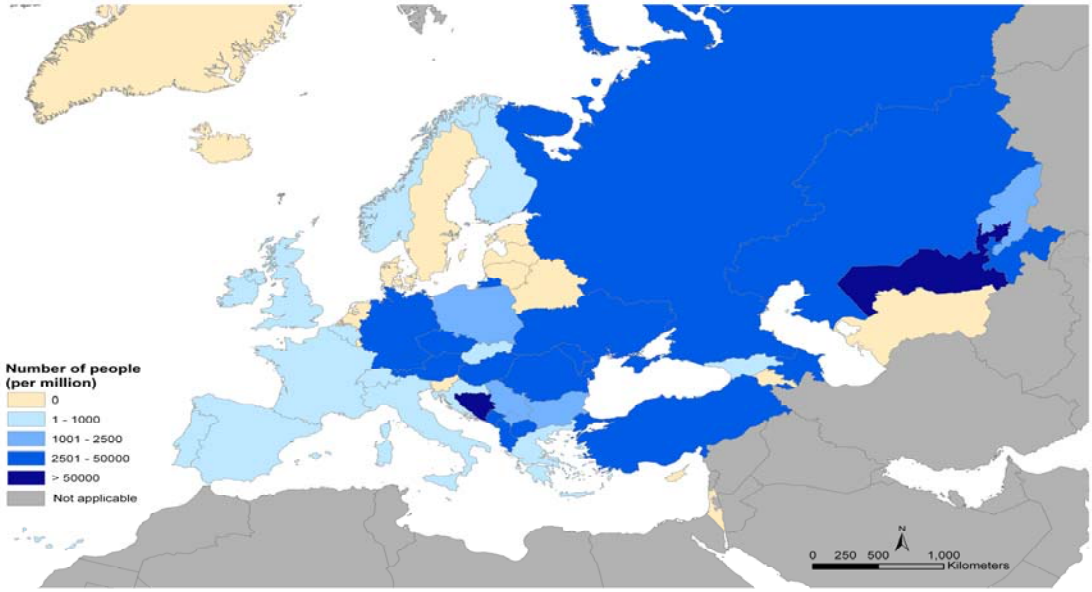
Fig. 2. Number of flooding and wet mass movement events in the WHO European Region, 2000–2011



Data source: EM-DAT *(21)*.

Fig. 3 shows the number of people per million by country in the WHO European Region affected by floods between 2000 and 2011. As flooding tends to occur systematically in certain areas and often affects the same populations, this is a slightly more accurate indicator of flood exposure. Cumulatively over the period, more than 50 000 people per million were affected by floods in Bosnia and Herzegovina and Uzbekistan. In the same period, 10 000–50 000 per million people were affected in Albania, the Czech Republic, Tajikistan and the former Yugoslav Republic of Macedonia, while 5000–10 000 per million were affected in Azerbaijan, Montenegro, Romania and Turkey. On the basis of the numbers of floods recorded in the DFO divided by the populations of European countries (HFA database, 2005), the rates of flood events appear to be highest in central Europe. Montenegro had the highest rate, with 0.32 flood events per million population per year. The River Danube flows through many of these countries and has a drainage area that affects many more, which may help explain the concentration of flood events. The rates also appeared to be higher in many of the southern states of the former Soviet Union than indicated by the simple counts in Fig. 2.

Fig. 3. Numbers of people per million affected by flooding in the WHO European Region, 2000–2011



Data source: EM-DAT *(21)*.

2.5 Temporal trends in the severity of flooding

Temperature and precipitation in Europe appear to be changing. During the past 50 years, the intensity of heavy rains has increased throughout Europe, even in areas where mean precipitation has decreased, such as central Europe and the Mediterranean. Total precipitation during autumn and winter increased in northern Europe and decreased in central Europe and the Mediterranean (*26*). The Intergovernmental Panel on Climate Change reported a 66–100% probability that the frequency of heavy precipitation will increase in the twenty-first century in many areas of the globe (*27*). Extreme precipitation results in flash floods, river floods, sewage system failure and land-slides and can initiate devastating floods that affect large areas over longer periods. Factors unrelated to climate, such as land use, also contribute to damage by floods. Barredo (*23*) described the difference between hydrological floods (which occur in unpopulated areas and may not cause damage) and disasters (floods that are the result of interactions between hydrological floods and social systems). Despite evidence of changes in temperature and precipitation, however, there is no conclusive evidence for a climate-related trend in hydrological floods in Europe, supporting the hypothesis that increased flood losses should be attributed to social shifts in exposed areas. Table 3 summarizes studies on changes in climate and flood indicators in Europe.

Table 3. Studies on changes in climate and flood indicators in Europe

Reference	Variable	Spatial and temporal domain
28–30	Winter precipitation	Increased flooding in most of the Atlantic and northern parts of Europe during the second half of the twentieth century, with a general decrease southwards to the Mediterranean
31, *32*	Winter precipitation	Total winter precipitation in central Europe has increased significantly by about 12% during the past 100 years. Increases in average precipitation during summer were about 1%.
33	Autumn and winter precipitation	A pronounced increase observed in autumn and winter precipitation in the latter part of the twentieth century in northern Europe and western Russian Federation

Table 3. contd

Reference	Variable	Spatial and temporal domain
28, *29*, *34–36*	Mean precipitation per wet day	Recent evidence of an increase in most parts of Europe, even in some areas that are becoming drier
32	Mean precipitation per wet day	The frequency of both precipitation and average precipitation per wet day have increased in central and western Europe.
35	Extreme precipitation events	In winter, wetter conditions and more extreme precipitation in northern and central Europe and drier conditions in the south, with a slight increase in the occurrence of extreme events
37–41	Extreme river flows	No conclusive evidence for a climate-related trend in floods in Europe; no homogeneous trend in extreme river flows, on either a continental or a regional scale (i.e. Dutch Rhine Delta, central Europe, Sweden and British uplands)

Source: Barredo *(23)*.

During the past 10 years, floods in Europe have killed more than 1000 people and affected 3.4 million others (*42*). Nevertheless, it is difficult to classify which deaths are actually associated with a flood. Immediate flood deaths are best recorded, but deaths during clean-up and longer-term mortality associated with flooding are often not recorded as such. Both EM-DAT and DFO record the listed number of fatalities associated with a given flood event. Fig. 4 shows the death rates associated with flooding in the EM-DAT dataset; the number of flood events that caused these deaths is likely to be higher. The number of deaths appears to be highest in central Europe and the former Soviet Republics.

Another marker of the severity of flooding is the total number of people affected. EM-DAT defines the people affected as all those injured, homeless, displaced and evacuated and requiring immediate assistance during the emergency, which does not include those affected in the longer term, which may be greater. This is therefore a less definitive end-point than fatalities, and drawing further inferences from these data is difficult. DFO does not record this information. The number of people affected by flooding is hard to categorize, and no subregional picture emerges. The marker may not be useful for comparing countries, as the inclusion criteria are wide and open to interpretation.

Fig. 4. Deaths per million related to flooding and wet mass movement in the WHO European Region, 2000–2011

Data source: EM-DAT *(21)*.

2.6 Costs of flooding

Few data are available on the economic and financial costs of flood events to public health and health services. Increased costs can result from disruption of normal health care provision and social programmes, as occurred in Dresden, Germany, in 2002 (*43*), and from costs to the economy of people being unable to work. The flood in the Gard, France, in 2002 resulted in a net increase in the consumption of psychotropic drugs, with a cost to health insurance in excess of €230 000 (*44*). In the United Kingdom after the floods in 2007, direct costs for relocating patients from a flooded hospital and for rebuilding and repairing the hospital were reported by one primary care trust and the National Health Service (*45*).

The United Kingdom Environment Agency estimated that the impacts on public health (including schooling) accounted for about 9% (£287 million) of the economic cost of the 2007 floods, of which £260 million was for the mental health effects associated with flooding. This figure was based on estimates of people's willingness to pay to avoid the distress caused by flooding and may not adequately evaluate the negative impact of the flood on psychiatric health. It was estimated that 400 000 pupil days were lost due to school closures. Valued at the cost of a pupil day with parent work days lost, this accounted for about £12 million, which is probably an underestimate of the disruptive effect on children's education (*45*).

2.7 Results of the survey of Member States

Only five countries that completed the questionnaire for this report, Armenia, Azerbaijan, Georgia, Israel and Turkey, stated that they had not had a flood for which an emergency response was needed between 2005 and 2010. This does not mean that those countries did not have floods; the events were either not large enough to cause significant damage, or the emergency plan triggers were set at a high hazard level and the floods were not severe enough to activate them. The causes of the floods that occurred in Member States during that period are given in Table 4: pluvial and fluvial origins were the causes of over half the floods.

Table 4. Causes of floods in Member States of the WHO European Region in 2005–2010

Cause	Number of countries	Countries
Pluvial	16	Bosnia and Herzegovina, Croatia, Czech Republic, Hungary, Malta, Poland, Republic of Moldova, Serbia, Slovenia, Spain, Sweden, Tajikistan, the former Yugoslav Republic of Macedonia, Turkey, Ukraine, United Kingdom (England and Wales)
Fluvial	11	Armenia, Croatia, Netherlands, Poland, Republic of Moldova, Serbia, Spain, Sweden, the former Yugoslav Republic of Macedonia, Ukraine, United Kingdom (England and Wales)
Tidal	2	Poland, United Kingdom (England and Wales)
Ice melt	3	Iceland, Kyrgyzstan, Slovenia
Structural	2	Armenia, Poland

Case studies of flooding events are listed in Table 5; some had dramatic effects. Two floods that occurred outside 2005–2010 are included to further illustrate the effects of flooding on European countries.

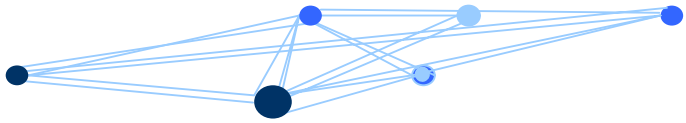


Table 5. Case studies of flooding reported in the WHO questionnaire survey

Country	Date of event	Details
Kyrgyzstan	May 1998	A mountain torrent in Suzak Dzhalal in the Abadskii Council Area overflowed on 19 May 1998, completely destroying 1017 houses. The value of the damage was 134 million Kyrgyzstan soms, equivalent to approximately €2.1 million at the time of writing.
Albania	October–December 2002	Flooding in the areas of Lezhe, Shkoder, Berat, Skrapar and Gjirokaster, affecting 30 000 ha of agricultural land and damaging 494 houses.
	October 2003	Flooding in the areas of Shkoder, Puke and Tropoje, affecting 200 ha of agricultural land, 120 km of roads and 400 families.
Slovenia	August 2005	Strong precipitation between 20 and 22 August 2005 caused severe torrential floods and land-slides in the Posavje region, around Sevnica. The measured rainfall at some stations in the Posavje region exceeded the 100-year record. The consequences were catastrophic. Small tributaries of the Sava and Savinja rivers flooded and caused severe damage in nearby villages. The enormous amount of water caused many land-slides that damaged the road infrastructure in the region.
	2007	Six people died in 2007 during floods, and the water changed the shape of some mountainous regions.
	2008	The sea flooded parts of coastal towns and salt pans in areas where floods are not usually frequent.
United Kingdom (England and Wales)	Summer 2007	The floods that struck much of the country during June and July 2007 affected hundreds of thousands of people. The event was the most serious inland pluvial and fluvial flood ever recorded, with 13 deaths; about 7000 people were rescued from floodwaters by the emergency services, and about 48 000 households and nearly 7300 businesses were flooded, with billions of euros of damage. The floods caused the loss of essential services, and almost half a million people were without mains water or electricity. Transport networks failed, a dam breach was narrowly averted, and emergency facilities and telecommunications were put out of action. Many of the areas most critically affected were in the west of England, where care homes and hospitals were among the first to be evacuated. Over 90 patients in long-term care were moved to temporary accommodation, two hospitals were flooded, and there were many significant health effects.
Republic of Moldova	July–August 2008	Flooding occurred in 14 regions in the vicinity of the Dniestr and Prut rivers as a result of heavy rains in northern Moldova, Romania and Ukraine. After a rapid increase in water levels in the rivers, more than 600 houses were partially or totally flooded; of these, 137 were destroyed. About 12 000 people were evacuated from flooded areas. The material damage was estimated at about 90 million Moldovan leu, equivalent to approximately €5.4 million at the time of writing.
Sweden	Summer 2009	The counties of Dalarna and Västmanland experienced many days of rain, and the soil was quickly saturated. The runoff caused flooding in several areas and affected municipalities to varying degrees.
Ukraine	Summer 2009	Flooding affected practically all of western Ukraine, with 38 people declared dead or missing, including 8 children, in the Ivano-Frankivsk area; 24, including 7 children, in the Tchernivtsi area; and 12, including 1 child in the Vinnytsya area. The total number of victims was 498, and 2088 people were hospitalized, including 172 children.

2.8 Future flood risk

Risk can be associated with population density, location and spatial distribution and can vary between rural and urban areas (*24*). As demographics continue to change and populations continue to grow, risk may also change quickly.

The European Environment Agency listed various reasons for a probable increase in flooding risks in Europe *(26)*.

- Although no significant increase in extreme river flows has yet been observed, twice as many river flow maxima occurred in Europe between 1981 and 2000 than between 1961 and 1980.
- Since 1990, 259 major river floods have been reported in Europe, of which 165 were reported after 2000. This may be due to better reporting and also to changing land use (more development on flood-plains). If the land use trends continue, increased rates of flooding are likely.
- Climate change is projected to increase the occurrence and frequency of flood events in large parts of Europe, although the estimates of changes in flood frequency and size are highly uncertain.

Thus, development on flood-prone land, population pressures and climate change will increase the number and severity of floods and flood events in the future. Addressing these risks will mitigate and reduce the potential effects of floods. Therefore, further work is needed on the epidemiology of flooding, with agreed definitions and procedures for the activation of flood plans and for the surveillance of flood events.

2.8.1 Projection techniques

Modelling precipitation change and river flow trends is complex. Several studies from a project to elicit "regional scenarios and uncertainties for defining European climate change risks and effects" (*46*) predicted extreme precipitation over Europe from regional and global climate change model simulations. Broadly, the results showed an increase in extreme precipitation of both long and short duration, predominantly in the winter and over northern Europe. The results varied more widely in predicting the scenarios for the summer; however, all the models showed a general pattern of extreme summer rainfall decreasing over southern Europe and increasing over northern and eastern parts of the continent (*47*).

Dankers and Feyen (*48*) used high-resolution simulations of the regional climate model HIRHAM with the hydrological model LISFLOOD to simulate river discharge by the end of the twenty-first century in a high emissions climate change scenario. They found a decrease in flood hazard in northern and north-eastern Europe associated with a shorter, less heavy snow season and an increase in flood frequency and magnitude in western and eastern Europe. In these projection techniques, regional climate models (simulations of temperature, precipitation, solar and thermal radiation, humidity and wind speed), general circulation models and greenhouse gas emissions scenarios are fed into hydrological models. Building on their earlier work, Dankers and Feyen (*49*) showed that the differences between the scenarios could be lessened by using an ensemble of model scenarios. They carried out eight experiments with simulations of two regional climate models, both run with boundary conditions from two global models, and for two scenarios of greenhouse gas emissions, to drive LISFLOOD.

The results of these studies showed that the annual changes in precipitation would be fairly small when averaged over the whole continent but that there would be large regional and seasonal differences. Generally, precipitation will increase the most in northern Europe in the winter and decrease in the south, especially in summer. With regard to the patterns of change in extreme river discharge, Dankers and Feyen (*48*, *49*) found that the simulated and observed mean annual maximum discharge at the end of the twenty-first century would decrease in north-eastern Europe, but that the extent and location were related to reduced snow accumulation. The predicted rise in temperatures will reduce the length of the snow season

considerably, but whether this will leads to less snow depends on changes in winter precipitation, which is predicted to be higher in northern Europe. Thus, the higher winter precipitation may compensate for the shorter snow season in some areas.

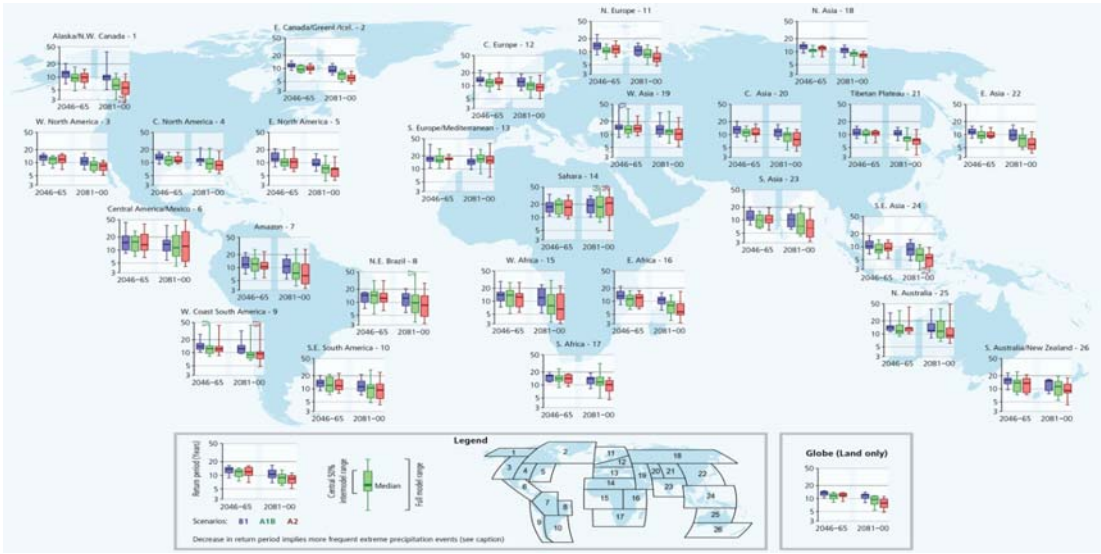
Although the models at continental level gave similar results, large differences in simulated scenarios were found at the level of local or river basins. Some rivers, such as the Neva, Thames and the Upper Danube at Bratislava, were predicted consistently to rise or fall, but the magnitude of change varied among scenarios. The Loire, Garonne and Rhone rivers in France, the Po River in Italy and the Danube River in central and eastern Europe nevertheless showed a consistent tendency for higher flood hazards in most model experiments.

2.8.2 Projected effects of future flooding

Several projections are available for Europe. Coastal flooding due to increasing storms and sea-level rises is likely to threaten up to 1.6 million additional people annually in the European Union alone (*50*). A study of the economic impacts of climate change in sectors of the European Union based on "bottom-up analysis" showed that the number of people affected by coastal flooding in 1995, the reference year, was 36 000. Without adaptation, such as the construction of dikes and beach nourishment to counter erosion, the number of people who would be affected by flooding annually by 2085 would increases significantly in all scenarios, to 775 000 to 5.5 million. The areas potentially most severely affected by coastal flooding are the British Isles, central Europe and northern and southern Europe. Adaptation would significantly reduce the numbers of people flooded relatively consistently in the sea-level scenarios, to 22 000–40 000 per year by 2085 (*51*).

It is likely (66% probability) that heavy precipitation will continue to become more frequent throughout Europe (*30*). The return period of a once-in-twenty-years precipitation event (i.e. exceedingly rare because of its intensity) will continue to decrease, which means that heavy precipitation events will be more frequent (Fig. 5). In northern temperate areas, this increased frequency will probably occur mainly in winter *(27)*. Even in summer, when the frequency of wet days is projected to decrease, the intensity of extreme rain showers may still increase. In addition, the overall frequency of precipitation lasting several days is projected to increase.

Fig. 5. Projected return periods for a daily precipitation event that was exceeded in the late twentieth century on average once during a 20-year period (1981–2000)



Source: Intergovernmental Panel on Climate Change (*27*).

Precipitation extremes can cause flash flooding or initiate large-scale river floods; sea-level rises and storm surges cause coastal flooding. Geographically, however, the projections show considerable regional differences in the occurrence of both floods and droughts (*52*). Table 6 lists future changes in the risks for coastal and river flooding associated with climate change in Europe. Regions at increased risk for coastal flooding include the Baltic and Arctic coasts (after 2050), and fewer but more extreme storm surges are projected in the Baltic Sea and southern North Sea in the 2070s.

Table 6. Projections of impacts of climate change on flooding in Europe

Period	River floods	Coastal floods
2020s	Increasing risks for winter flooding in northern Europe and for flash flooding throughout Europe; shift of risk for snowmelt flooding from spring to winter	
2050s		Increased risk for flooding on the Baltic and Arctic coasts after 2050
2070s	More frequent 100-year floods in northern and north-eastern Europe (Finland, northern Russian Federation, Sweden), in Ireland, in central and eastern Europe (Poland, Alpine rivers), in parts of southern Europe with Atlantic coasts (Portugal, Spain); less frequent in large parts of southern Europe	Decline in storminess and wind intensity in Mediterranean region; fewer but more extreme storm surges in the Baltic Sea and southern North Sea

Source: Adapted from Alcamo et al. (*30*).

3. Effects of flooding on health and health services

This chapter addresses the health effects associated with flooding and the effects of flooding on health services.

Some common patterns of major health effects are found after different types of disaster, although some are hazard-specific. Noji (*53*) at the Office of Emergency Preparedness and Disaster Relief Coordination in the United States reported that the short-term effects common to flooding are few deaths and injuries and little potential for an increased frequency of communicable diseases but frequent food scarcity and major population movements. Each natural disaster is unique and has unique effects, because countries have different economic, social, cultural and health contexts. Nevertheless, there are some similarities in health effects, so that good planning can enable effective management of health and emergency relief in any disaster.

The health effects of flooding can be divided into those associated with the immediate event and those arising afterwards (Table 7). Immediate, direct effects are caused by the flood-water and the debris in it and include drowning and injuries, but a flood continues to have health effects during the clean-up process and subsequently, which may persist for months or years (*13*). The longer-term, indirect health effects include those due to damage to infrastructure, food and water supplies, displacement, disruption to people's lives and on mental health (*9*, *13*).

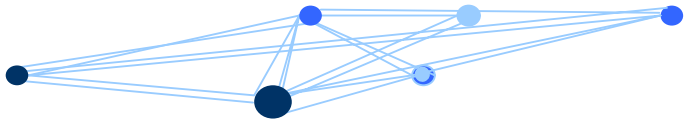


Table 7. Potential health effects of flooding

Type of effect	Health effect
Direct: effects on people exposed to flood-water	Drowning and injuries from walking or driving through flood-water, contact with debris in flood-water, falling into hidden manholes, injuries from submerged objects, injuries while trying to move possessions during floods
	Building collapse and damage (injuries)
	Electrocution
	Diarrhoeal, vector- and rodent-borne diseases
	Respiratory, skin and eye infections
	Chemical contamination, particularly carbon monoxide poisoning from generators used for pumping and dehumidifying
	Water shortages and contamination due to loss of water treatment works and sewage treatment plants
	Stress, short- and longer-term mental health issues, including the impacts of displacement
Indirect: effects of flood-water on other health determinants	Loss of access to and failure to obtain continuing health care
	Damage to health care infrastructure, and loss of access to essential care
	Damage to or destruction of property, including hospitals and other vital community facilities
	Damage to water and sanitation infrastructure
	Damage to crops, disruption of food supplies
	Disruption of livelihoods and income
	Population displacement
	Mental health problems due to length of flood recovery and fear of recurrence; indirect effects of stress in dealing with insurance claims and refurbishing properties

Source: Adapted from Ahern and Kovats (*1*).

3.1 Mortality

Over the past 30 years flooding killed more than 200 000 people and affected more than 2.8 billion others worldwide (*42*). It has been postulated that two thirds of flood-related deaths worldwide are from drowning and one third from physical trauma, heart attacks, electrocution, CO poisoning or fire. Moreover, 70% of flood-related deaths are among males (*9*). Flood-water creates an immediate risk of drowning (*54*), and it is dangerous to walk or drive through flood-water. The CDC stated that people in vehicles are at greatest risk for drowning (*55*, *56*), while the HPA reported that 6 inches (15.2 cm) of fast-flowing water can knock over an adult, and 2 feet (61 cm) will float a car (*57*).

Particular risks for death are due to: falling into fast-flowing water (*54*, *58*), driving through flood-water (*55*), hidden hazards under the flood-water (e.g. dislodged manhole covers) (*54*), water of unknown depth (*54*), exposure to insects, animals and reptiles in flood-water (*59*), standing on bridges that might be washed away (*60*), crossing flooded rivers or streams (*60*) and building collapse (*61*). Furthermore, small children can drown in standing shallow water (*58*). Other factors that affect the risk to life during floods include how many storeys buildings have, whether people were evacuated before the flood, the time of day or of the week in which flooding occurs and the early warning system.

As mentioned above, there is no clear definition of what actually constitutes a death from flooding. Some deaths are immediate (drowning) and others are delayed (cardio-respiratory disease). In many cases, only immediate, traumatic deaths are recorded, and longer-term health events associated with a flood go unreported (*62*). In the aftermath of a flood, deaths

can be caused not only by the physical dimensions of the flood but also by effects on the health and socioeconomic conditions of the population (*63*). The longer-term effects of floods on mortality were investigated in the United Kingdom after floods in Bristol in 1968. During the 12 months after the flood, there was a 50% increase in population mortality in flooded communities and no appreciable increase in unaffected communities. Further work is needed to understand immediate and longer-term mortality from flooding and to confirm these findings (*64*).

Milojevic et al. (*65*) undertook a systematic study of mortality patterns on the basis of postcodes of residence in relation to flooding in England and Wales. Data on mortality were linked to a national database of flood events in 1994–2005, in which 319 flood events were recorded. There were 771 deaths in the year before a flood with a known date of onset and 693 deaths for the same postcodes the year after flooding, reflecting a relative reduction in mortality of 10%. A decrease in mortality after flooding is counterintuitive and is difficult to interpret. The authors described a number of limitations to their study that may explain this finding, including lack of information on flood severity and the possible influence of evacuation on recorded addresses at the time of death.

Jonkman et al. (*66*) used mathematical modelling and spatial mapping techniques to analyse the relation between mortality and flood characteristics in New Orleans, United States, after Hurricane Katrina. They found that one third of 771 fatalities (of a total of 1118 found and analysed) occurred outside flooded areas or in hospitals or shelters in the flooded area and were due to the adverse public health situation after the flood; the remaining two thirds were associated with the direct physical effects of the flood and were mostly due to drowning. Most of the victims were elderly, nearly 60% being > 65 years old. The mortality rates were highest in areas near severe breaches and areas of deep water. No association was found between the rate of rise of the flood and mortality. The overall mortality rate in the exposed population was 1.2%, which is similar to that in previous flood events.

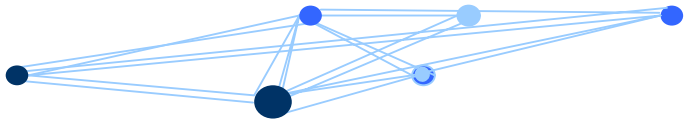
Li et al. (*67*) reported the results of a retrospective cohort study of "years of potential life lost" in Hunan, China, after flooding. Although the conditions in Hunan are different from those in much of Europe, the study showed that the standard rates of years of potential life lost per 1000 population exposed to river flooding and drainage problems were significantly higher than those for people who were not exposed. The rate was significantly higher for males than for females in both exposed groups, and the standardized mortality rates due to injury and poisoning were higher in exposed than unexposed groups. The authors concluded that prevention of injury, poisoning and chronic noninfectious diseases and ensuring psychological and social support and better access to health services could reduce long-term mortality as a result of flooding.

3.2 Injury and exposure to chemical hazards

3.2.1 Injury

Surprisingly little information is available on injuries due to floods. Most are not routinely reported, and, when they are reported, they are often not associated with a flood. Data on the causes and types of injury therefore remain incomplete, and further work is required to document the hazards more completely in order to prepare for and respond to these events.

Injuries can occur during all phases of flooding. Those incurred before and during a flood are often associated with people attempting to remove themselves, their families, pets or valued possessions from approaching flood-waters. Water can displace vehicles, trees and material such as chemical drums and can hide unseen hazards, such as debris, which can cause injury.



More serious injuries include fractures and punctures, and there is also a risk for hypothermia from standing in water at less than 24 °C (*56*).

Injuries can also occur after a flood, when people return to their homes and businesses during recovery and clean-up (*13*). The types of injuries can include wounds caused by sharp objects or hazards concealed under flood-waters, such as raised nails in floorboards and sharp-edged tiles (*68*). Water conducts electricity, so power lines and electrical appliances pose a risk for electric shock or electrocution when they are wet or in contact with water.

During the clean-up phase, care must be taken to avoid unstable buildings, which have caused death or injury in many parts of Europe (*61*). Injuries may also be caused by, reptiles and animals, as flood-water displaces them, increasing potential contact with people. Standing water can force insects such as wasps out from their ground nests and increase the risk for hymenopterid stings (*59*).

In general, floods with a slow onset are less likely to result in injuries (*69*). In a community survey of 108 181 households after the floods in Nîmes, France, in 1988, 6% of households reported mild injuries (contusions, cuts and sprains) related to the flood (*70*). People's behaviour and decisions can influence the likelihood of injury and even fatalities, particularly when they do not comply with evacuation orders, as occurred in New Orleans during Hurricane Katrina (*71*). Walking and driving through flood-waters, rescuing people and pets, trying to protect or recover assets and even flood "tourism" have all been reported (*72*). In Germany after the floods in 2002, contact with flood-waters was identified as a risk factor for injuries and diarrhoea (*73*).

3.2.2 Exposure to chemical hazards

The disruption and damages cause by floods can release chemicals that pose a health hazard to responders, the general population and clean-up workers. Moreover, inadequate use of portable generators or other combustion engine-powered machinery because of power disruption can entail a significant risk for CO poisoning. In addition to industrial chemicals, even household items (e.g. car batteries, propane tanks) can pose a significant hazard after a flood.

Carbon monoxide poisoning

CO is produced in the exhaust emissions from diesel generators and other fuel-driven equipment or from faulty equipment used in the aftermath of a flood inside buildings and enclosed spaces to dry them or to pump out flood-water *(54, 74)*. Other sources are portable grills, pressure washers, camp stoves, paraffin-fuelled heaters and other devices powered by gasoline, propane or natural gas. Gases can build up if there is inadequate ventilation, and fumes can accumulate, e.g. in garages, and there may be a risk from generators located outside buildings but near open windows *(54)*.

No studies on CO poisoning in Europe were found in the literature review, although two deaths were reported after the 2007 floods in the United Kingdom *(7)*. In the United States, the CDC carried out an investigation based on medical notes *(75)* into six deaths and 167 patients with CO poisoning after four hurricanes in Florida in 2004. Presentation peaked 3 days after landfall of the hurricane, and most symptoms occurred during the night. Portable, gasoline-powered generators had been used in 96% of the incidents, five of the six deaths were among males, and most of the generators were inappropriately placed (in garages or outdoors but near windows).

Van Sickle et al. (*76*) also studied victims of the Florida hurricanes in 2004, by interviewing 35 of 51 people who were hospitalized after non-fatal incidents. All the households involved had lost their power supply during the hurricanes and were using gas-powered equipment.

Most participants (74%) reported that a generator had not been used in the household before. In almost half the cases (46%), it had been placed an average of 7 feet (21 m) from the house; in a third of cases it was in the garage, with the door was shut in 64% of cases; and 15% reported that the generator was placed inside the house. The authors also investigated awareness of CO in the household. None reported buying a CO detector, but 11% said that they had one at the time of the incident; however, the detector was reported to have sounded in only one case. Almost two thirds (63%) of participants reported having heard a CO awareness message before the incident, and these households were nearly twice as likely to place generators outside. The authors concluded that the participants were generally unaware of the danger of CO, even after the event, and noted that the awareness message lacked information about generator placement.

In a case series studied after Hurricane Rita in Beaumont, Texas, Cukor and Restuccia (*77*) identified 21 patients who had presented with exposure to CO from among all patients who had presented to the medical facility during the first 5 days after the hurricane, and five fatalities. The causes were similar to those described above.

The samples in these two studies were small and subject to case ascertainment bias, as only people who attended hospital were identified. Furthermore, the second study was conducted in a cultural context in which people readily turn to gas-powered generators if they lose household power. This may limit the generalizability of the results to other populations.

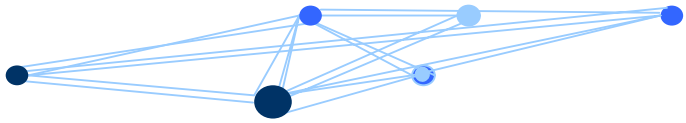
Chemical pollution of flood-water

Pollution and contamination of flood-water present health risks *(78)*. The CDC has stated that flood-water can move chemicals from their normal storage place *(58)*, although chemicals are likely to be diluted in water and probably pose little acute risk *(54)*. Generally, skin contact with flood-water has been reported not to be a serious health threat *(79)*. Eczema is the commonest form of dermatitis reported *(80)*.

Chemical releases can be a more serious threat to health if waste storage facilities or industrial plants are flooded. Depending on the severity and extent of flooding, uncontrolled release of various chemicals into the environment can occur, with a potential risk to public health. In a typical flooding scenario, released chemicals are diluted with flood-water, decreasing their toxicity. In unusual circumstances, however, such as high-intensity, short flooding, the public can be exposed to high levels of toxic chemicals. Moreover, in the event of continual release, such as from acid mine drainage (see below), people can be exposed chronically, by direct contact, or indirectly if there is contamination of the food chain. As the toxicity of many of these chemicals (lead, arsenic, polycyclic aromatic hydrocarbons, pesticides) has no threshold, they represent a health hazard at any level of exposure.

A concern with regard to the studies reviewed thus far is the use of proxy measures of exposure rather than direct measures. Generally, little environmental sampling has been undertaken after flooding events. Effective environmental data collection and monitoring would enhance future studies on health effects (*74*). Although the information on chemical contamination is incomplete, the source of contaminated flood-water may predict the type of chemical contamination (*74*), thus indicating the likely health impacts. Three sources of chemical contamination, storm-water floods, overloaded sewers and acid mine drainage, are described below.

The extent of chemical contamination due to *storm-water floods* depends on land use and associated infrastructure. In the case of run-off from roads, motorways and bridges, the type of chemical release would reflect pollution due to road traffic and include chemicals such as heavy metals, petroleum hydrocarbons and polycyclic aromatic hydrocarbons. In a rural catchment area, the run-off would be expected to consist of eroded soil containing fertilizers,



herbicides and pesticides. The extent of pollution depends on geological factors, land management practices and the volume of flood-water. The contamination from urban and semi-urban land would be diverse and can include pharmaceutical residues, domestic, industrial and commercial chemicals and road run-off.

Backflow in combined sewer systems can overflow, releasing a variety of residential, industrial and storm-water wastes, including chemicals, as residues of industrial discharges. Chemical contamination of residential sewers, canals and residential rivers collects as sludge as a result of run-off. National and local regulatory bodies, such as the Environment Agency and local authorities in the United Kingdom, regulate discharges and can provide information.

In the United Kingdom there is a risk for acid mine drainage from abandoned mines, especially coal mines. For example, in England, the counties of Devon and Cornwall alone have approximately 1700 abandoned mine works, which have seriously affected more than 200 km of rivers. The effects remain significant in some rivers many decades after the mines have closed (*81*). Under normal operating conditions, the mines were constantly drained with large pumps; however, after closure they can flood. When mine water is exposed to fresh air at the face, sulfides can oxidize, leading to the formation of sulfuric acid, commonly with a pH of 2–3. Heavy metals may dissolve in such acidic conditions and thus become more mobile and available. Typical minerals and metals found in mines include aluminium, arsenic, cadmium, cobalt, copper, iron, lead and manganese.

Hazardous landfill sites and wastewater lagoons can also contaminate flood-water. For example, in Japan, river water contaminated with cadmium from mining in 1910–1945 was used to flood rice fields and resulted in *itai-itai* disease in people who ate the contaminated rice (*82*). In another example, melting snow and ice in Bashkiria, Russian Federation, formed a toxic waste lagoon, the contents of which washed into the Ufa River just above the intake for the water supply of 600 000 people in 1990 (*83*).

Cox, Amundson and Brackin (*84*) compared the numbers of telephone calls to the Mississippi poisons centre 0–2, 3–4 and 5–12 weeks after Hurricane Katrina to the numbers received in the preceding 3 years. The call volume was 13% higher in the 12 weeks after the hurricane. Two thirds of the calls were about "exposures" (68.3%), and the remainder were for information. The number of calls for information increased by 25%, while those about exposure increased by only 8%. During the 0–2 weeks after hurricane, there was a significant increase in the number of calls about exposure to lamp oil, gasoline and CO than in 2002–2004, reflecting changes in energy supplies after loss of electricity and the shortages of gasoline. In the first 4 weeks after the hurricane, siphoning was mentioned in 70% of the calls about exposure to gasoline.

3.3 Infections and risk for epidemics

Flooding can affect health by altering the balance of the environment and ecosystems, allowing bacteria and vectors of disease to flourish. Outbreaks of cholera and an increased incidence of malaria have been reported in developing countries. In Europe and North America, however, natural disasters do not usually result in outbreaks of infectious disease, although they can increase disease transmission under certain circumstances. Food can be a source of infection and disease if it has been in contact with flood-water or prepared on dirty surfaces or with unclean hands (*57*). The risk to public health of communicable diseases is thus relatively infrequent in industrialized countries with good sanitation and water supplies and little overcrowding (*1*, *43*, *85–88*). Loss of normal conditions, for example for cooking and washing, can exacerbate risks to human health. A few, small outbreaks of disease have been reported so far, although the risk could increase with global warming.

The risk for epidemics is generally proportional to population size, density and other characteristics, such as proximity to safe water, sanitation, nutritional status and level of immunity (*53*, *89*), and the extent to which the natural environment has been altered or disrupted. The increases in communicable diseases most frequently observed are those due to faecal contamination of water and respiratory infections. In the longer-term, the incidence of vector-borne diseases can increase due to disruption of control activities (*53*). Jablecki et al. (*90*) listed the diseases that occurred among evacuees and rescue workers after Hurricane Katrina, which included dermatological diseases such as with methicillin-resistant *Staphylococcus aureus* and tinea corporis, diarrhoeal diseases due to noroviruses and non-typhoidal *Salmonella* and respiratory diseases including upper respiratory tract infections and pneumonia. An "editorial note" from the CDC (*91*) on the descriptive epidemiology reported by Jablecki et al. confirmed increased prevalences of diarrhoea, wound infections and amplification of infections in evacuation camps. There was only one outbreak of norovirus infection that required mobilization of public health action, perhaps indicating little need for a public health intervention in similar scenarios.

Lin, Hsu and Guo (*92*) compared the incidence of lower limb cellulitis seen at a major hospital in the Province of Taiwan, China, in the 2 weeks before (n=22) and after (n=43) Typhoon Haitang in 2005. Of the patients seen in the weeks after the typhoon, 28% reported having immersed their limb in flood-water, whereas none reported immersing their limb in anything other than tap water in the 2 weeks before the event. Although this study is small, it shows that cellulitis is a potential concern after flooding events.

The HPA reported that infection during floods in the United Kingdom was rare, as pathogens are diluted, thus diminishing the risk. "No evidence of increased outbreaks of illness" was found after the 2007 floods (*54*). Nevertheless, vector-borne and waterborne diseases require special attention. Table 8 lists global infectious diseases that could theoretically be associated with flooding.

Table 8. Infections that can occur during floods, globally

Category of infection	Infection
Faecal–oral (waterborne or water-washed)	Diarrhoea and dysentery
	Amoebic dysentery
	Balantidiasis
	Campylobacter enteritis
	Cholera
	Cryptosporidiosis
	Escherichia coli diarrhoea
	Giardiasis
	Rotavirus diarrhoea
	Salmonellosis
	Shigellosis (bacillary dysentery)
	Yersiniosis
	Enteric fever
	Typhoid
	Paratyphoid
	Hepatitis A
	Poliomyelitis
Water-washed	
Skin and eye infections	Infectious eye diseases
	Infectious skin diseases

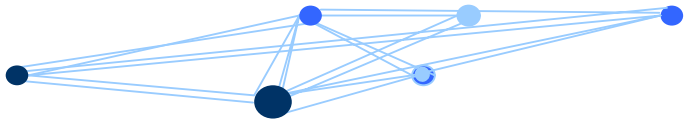


Table 8. contd

Category of infection	Infection
Other	Louse-borne relapsing fever
	Louse-borne typhus
Water-based	
Penetrating skin	Schistosomiasis
	Clonorchiasis
Ingested	Diphyllobothriasis
	Fasciolopsiasis
	Guinea worm
	Paragonimiasis
	Others
Soil-transmitted helminths	Ascariasis (roundworm)
	Hookworm
	Strongyloidasis
	Trichuriasis (whipworm)
Water-related insect vectors	Sleeping sickness
Biting near water	Filariasis
Breeding in water	Malaria
	Mosquito-borne viruses
	Dengue
	Yellow fever
	Others
	River blindness

Source: Adapted from Ahern and Kovats (*1*).

3.3.1 Faeco-oral transmission and waterborne disease

Waterborne diseases may be transmitted during flooding through contamination of drinking-water supplies, contact with contaminated flood-water and from sewage systems overloaded by flood-water. Drinking-water can be contaminated by sewage, agricultural waste, industrial waste or chemicals *(93)*. The HPA reported that water supplies and distribution networks are usually unaffected by floods, and that it is therefore assumed safe to drink water *(57)*. The CDC reported that no disease-causing strains of *E. coli* (O157:H7) were found in flood-water during Hurricane Katrina, although generic *E. coli* (the usual commensal strains from humans and animals) was found *(94)*. Toxic water contaminated many areas of New Orleans, however, and seven people were exposed to *Vibrio vulnificus*, of whom four died. The people at greatest risk were those with liver disease and with compromised immune systems. Most cases were due to skin infection *(95)*.

Flooding can also increase exposure to other environmental pathogens. In Germany, after flooding of the Elbe and Mulde rivers in 2002, high bacterial cell counts were observed in the cellars of flooded houses and in streets and playgrounds. Some bacteria thought to be derived from flooded sewerage plants or farms showed resistance to multiple antibiotics (*96*).

Griffith et al. (*97*) reviewed reports[5] of cholera outbreaks that occurred between 1995 and 2005 and found subregional variation in the reported risk factors for such outbreaks. Globally, the three commonest factors were contaminated water sources (29%), rainfall and flooding (25%) and refugee shelters (13%).

Setzer et al. (*98*) investigated outpatient visits for infections with six water-borne pathogens—

[5] From the Federation of American Scientists' programme for monitoring emerging diseases (*ProMED*)

Cryptosporidium, *Giardia lamblia*, *Toxoplasma gondii*, *Helicobacter pylori*, *Mycobacterium avium* and adenoviruses—before and after Hurricane Floyd in the United States in 1999. They included visits for ill-defined intestinal infections in their study, in order not to miss uncoded cases. They found a statistically significant increase in outpatient visits for *T. gondii* and adenoviruses after the hurricane in severely affected areas, although the numbers were small. A significant increase in outpatient visits for ill-defined intestinal infections was seen in both severely and moderately affected counties as compared with unaffected counties.

Hashizume et al. (*99*) studied the factors that determine vulnerability to diarrhoea during and after floods in Bangladesh in a case–control study by comparing the number of observed cases of cholera and non-cholera diarrhoea per week with the numbers expected. The numbers of cholera and non-cholera cases were almost six and two times higher, respectively, after flooding. The number of non-cholera cases was also two times higher than expected during the flood period. Significant risks for cholera after flooding were associated with drinking tube-well water and using unsanitary toilets. There was little difference in risk by age or sex either during or after flooding, although other studies (*100*, *101*) suggest that children and women are more vulnerable.

Some of these findings may be relevant for people returning to Europe after travelling to countries where cholera after flooding is an immediate threat to public health.

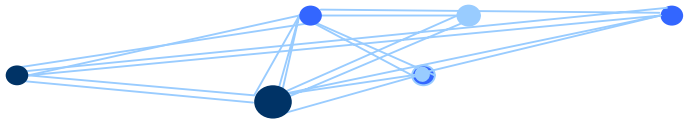
3.3.2 Vector-borne disease

There is some evidence that vector-borne diseases are associated with floods in Europe, and the risk could increase with a warmer climate. In temperate Europe, West Nile virus causes sporadic human cases, clusters or outbreaks of fever. The re-emergence of this mosquito-borne disease might be caused by environmental factors that enhance vector population densities, such as irrigation, heavy rains followed by floods and higher than usual temperatures. For instance, global warming scenarios predict warmer, more humid weather, which might increase the distribution and abundance of mosquito vectors *(102)*. Populations in affected areas should therefore be screened for West Nile fever *(103)*, such as by monitoring the population densities and infection rates of the principal vectors, conducting serosurveys of vertebrates and exposed human groups, and routine diagnosis of human infections. West Nile virus is not immediately associated with flooding, however, as the main vectors are *Culex* spp. mosquitoes, which do not usually respond to flooding *(104)*. In the United States, West Nile virus outbreaks are associated with droughts, as lack of water depletes predators, thus allowing mosquitoes to proliferate *(105)*. Tahyna virus outbreaks associated with flooding in the Danube River system have also been documented *(106)*.

Vector-borne diseases are reported more commonly in other parts of the world. Schistosomiasis is acquired by skin contact with water containing free-swimming larval forms. Wu et al. (*107*) assessed the effect of floods on transmission of schistosomiasis in the Yangtze River valley over a 22-year period. They found that the average number of acute cases was 2.8 times higher in flood years than in years with no or little flooding. Collapse of embankments and the flooding of marshlands were identified as the main drivers of dispersal of the snail host.

Su et al. (*108*) described an outbreak of melioidosis in the Province of Taiwan, China, in 2005, in which the incidence rates were statistically significantly higher before and after Typhoon Haitang. They concluded that the outbreak was associated with the typhoon, as clonal diversity characteristic of extreme weather was observed. As the incubation period of meliodoisis can be up to 62 years, the organism may have been present before the typhoon.

These findings may be relevant for people returning to Europe after travelling to countries where schistosomiasis or melioidosis is an immediate threat to public health.



3.3.3 Rodent-borne disease

Ahern et al. (*4*) showed that the incidence of diseases transmitted by rodents could increase during or after heavy rainfall and flooding as a result of altered patterns of contact. An example of such diseases is leptospirosis. The European Centre for Disease Prevention and Control reported 841 confirmed cases in 26 European Union countries in 2007, mostly between July and September *(109)*. An outbreak of leptospirosis was reported in Mumbai, India, after heavy rainfall in July 2005, with an eightfold increase in prevalence from the previous year *(110)*.

An observational study by Pappachan, Sheela and Aravindan *(111)* to assess the relation between patterns of daily rainfall and flooding in Kerala, India, in 2002 showed that peak prevalences of leptospirosis were associated with heavy rainfall 7–10 days previously. The risk factors for the disease were found not to be direct exposure to animals but cutaneous exposure of the legs in stagnant water or moist soil, fissures or wounds on the feet and footwear that did not protect against possible infection. Most of the cases were due to *Leptospira* that multiplied on paths that remained wet for 2–3 days.

Typhoon-related floods may increase the risk, as described by Chiu et al. *(112)*, who reported six hospitalized cases of leptospirosis in the Province of Taiwan, China, five of which developed the disease after typhoons accompanied by heavy rainfall. A history of contact with contaminated water or soil was a risk factor in all six cases. Three of the patients were soldiers who were exposed during routine outdoor exercise. A high incidence of leptospirosis has been reported previously in soldiers (*113*).

A cross-sectional seroprevalence study of urban slums in Brazil by Reis et al. *(114)* showed that people who lived less than 20 m from an open sewer and at the lowest point in the valley (i.e. flood risk areas) had a 1.42 times higher risk for leptospirosis, and people who lived less than 20 m from accumulated refuse had a 1.43 times higher risk. After control for confounders, the significant risk factors were those associated with households, showing that slum households are sites for transmission of leptospirosis, especially those built on land susceptible to flooding.

As above, these findings may be relevant for people returning to Europe after travelling to countries where leptospirosis is an immediate threat to public health.

3.4 Health effects associated with buildings that have been flooded

This section outlines the health problems that may arise during the recovery of homes and buildings and people's return to them.

Properties built of brick, load-bearing masonry walls may be in significant danger of collapse if there is a difference in the depth of the water inside and outside the house of more than 1 m. Walls are expected to fail under such loading conditions.

In England, the Housing Health and Safety Rating System is used by local authority housing and health departments to assess houses that are either reported by the occupant or by other agencies as posing potential hazards to health (*115*). While the system of inspection and grading of hazards under this system is comprehensive and allows inspectors to make recommendations to the owners of the property on the repair or remediation required to reduce health risks, the current guidance makes no specific mention of flooding. It does, however, offer a means for occupants, particularly in the private rented sector, to have their houses assessed for health hazards when they have been flooded or are affected by damage resulting from flooding.

3.4.1 Health effects of damp buildings

People living in damp buildings after floods, often for long periods, have been reported to have health problems. Cummings et al. (*116*) reported respiratory symptoms in people living in water-damaged homes in New Orleans 6 months after hurricanes Katrina and Rita. The respiratory symptom scores increased linearly with exposure. Use of disposable respirators was associated with decreased odds for exacerbation of moderate or severe symptoms of lower respiratory tract disease. Their findings show that any exposure to water-damaged homes result in a greater risk for upper and lower respiratory tract symptoms, whether or not the exposure included cleaning up homes, and that the risk for respiratory symptoms due e.g. to fungal spores persists for 6 months after a flood.

Moisture damage of buildings is associated with microbial or mould growth indoors. The main elements in controlling indoor microbial growth are the availability of water and the characteristics of the material surfaces (*117*). Several fungal genera have been found to grow commonly in moist building materials, the most frequently reported being *Penicillium* spp., *Aspergillus* spp., *Acremonium* spp., *Phoma* spp., *Cladosporium* spp., *Chaetomium* spp. and *Stachybotrys* spp. (*118–121*). The bacteria that grow on moisture-damaged building materials have been less extensively studied, although actinomycetes, mycobacteria and Gram-negative bacteria have been described (*118*, *121*, *122*).

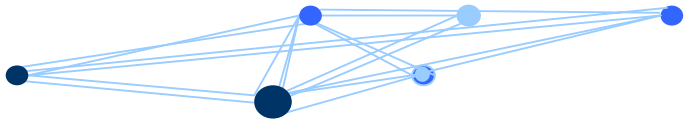
Fungal species found in higher concentrations in mouldy buildings than in reference buildings include *Aspergillus versicolor*, *Cladosporium* spp., *Fusarium* spp., *Ulocladium* spp., *Bacillus mycoides*, *Mucor* spp., *Exophiala* spp., *Stachybotrys* spp. and *Tritirachium* spp. (*121*, *123–126*). Air sampling of mould-affected buildings showed that the fungal composition differed from that in buildings without moisture damage, including both homes and schools (*127–131*). *Aspergillus versicolor* and *Stachybotrys* spp. are strongly associated with moisture damage and dampness and are considered indicator fungi for such damage (*121*, *124*, *131*, *132*).

For most people, undisturbed mould is not a substantial health hazard, but excessive exposure to contaminated materials can harm the health of susceptible people, and protective equipment should be used when cleaning properties (*133*). The adverse health effects most often associated with dampness and mould in buildings are mainly respiratory (cough, wheeze, rhinitis) and irritation of the eyes and skin. Non-specific symptoms such as tiredness and headache are also commonly described in a variety of climatic settings. Similar symptoms have been reported in children and in adults (*123*, *134–136*).

Other associations found include a higher prevalence of respiratory infections in occupants of mouldy buildings (*137–139*) and a higher risk for asthma associated with damp housing (*126*, *134*, *140*). It has been suggested that exposure to microbes in moisture-damaged buildings is the cause of asthma symptoms or atopy in adults (*141*, *142*) and young children (*143*). While many studies and reviews have reported associations between moisture damage in buildings and health problems such as allergy, asthma, chronic respiratory infections and skin and respiratory tract irritation, no causal relations have been demonstrated (*134*, *136*, *144, 145*).

3.5 Psychological distress

Psychological distress is common immediately after a flood. It may present as emotional symptoms, like tearfulness, numbness or difficulty in sleeping, or as cognitive or physical symptoms (*104*). People may experience symptoms such as anger, hyperactivity, low mood and lethargy, all of which are common (although not inevitable) after a flood. Such symptoms can be considered a “normal response to an abnormal event”; however, when they persist for more than about a month and begin to affect a person’s functioning, he or she has probably



developed a common mental disorder such as anxiety, depression or post-traumatic stress disorder, which are amenable to treatment.

3.5.1 Long-term effects on mental health

The epidemiological studies on mental health after flooding are difficult to assess (*146*), and a number of methodological limitations should be taken into account. The scale of the event being investigated must be clearly understood, and the effect of a disaster must be distinguished from that of the subsequent flooding, as was seen with Hurricane Katrina. Many tools are used to assess mental illness, especially post-traumatic stress disorder, and they are not always comparable or adequately validated. Furthermore, the timing of assessment after an event is often unclear. Another methodological limitation in interpreting the prevalence and incidence of mental ill health after a disaster is that the previous levels are usually not known. Many correlates and statistical models are used to document associations, and it is difficult to find a general application to public health.

Despite these methodological issues, it is well established that mental health and well-being are adversely affected by floods. The size of the effect varies across studies, and the nature of the effects is subject to differing cultural interpretations and definitions. A number of studies provide excellent examples of some of the issues identified.

- In a case–control study of households directly and indirectly affected by floods and unaffected controls, up to 75% of affected people experienced mental health effects, and older age correlated with more severe effects (*147*).
- In a cohort study in south-east England after severe river flooding in 2000, adults had a four times higher risk for psychological distress, which explained some of the excess physical illness reported 9 months after the flood (*148*).
- Tunstall et al. (*149*) found that two thirds of flood victims in 30 locations in England and Wales had scores on a general 12-scale health questionnaire indicating mental health problems. Evacuation and the disruption associated with it were reported to be the most significant stressors of flooding. The quality and speed of response by insurers and contractors involved in reconstruction can also affect mental distress.
- Paranjothy et al. (*150*) reported the results of a survey of psychosocial outcomes after flooding in two areas of England that were badly affected by the floods in 2007. The prevalence of all mental health symptoms (psychological distress, probable anxiety, probable depression and probable post-traumatic stress disorder) was two to five times higher among people who reported flood-water in their home than in people who did not.
- A study on a randomly generated sample of 1510 people within those who survived the Hurricane Katrina floods in New Orleans showed significant racial and gender differences in psychological impacts, including sleeplessness, anxiety, depression and worries for the future (*151*).

There are many established risk factors for mental health disorders, but their predictive value varies according to population and cultural context. While the established risk factors in Europe are mainly the same (gender, age, exposure), the social context in which flooding occurs and its aftermath can affect the severity and longevity of mental distress. Recovery after flooding depends on factors including the extent of damage and loss and the individual and community resources for dealing with it. The extent of damage usually determines the length of displacement and disruption to life. When damage is extensive, many people have to live in temporary housing, such as hotels, mobile homes and rented accommodation, for many

months and even up to a year. Such displacement and disruption can have a significant socio-psychological impact. In the United Kingdom in 2000, mental disorder was still common 10 months after the floods, displacement being an important factor, in addition to loss and damage to property and possessions and financial concerns (*13*).

Substantial evidence from the United Kingdom (*149*, *152–154*) indicates that a major factor is how people are treated by the organizations with which they come into contact after a flood (e.g. builders, loss adjusters, insurance and utility companies). Consequently, immediate, practical problems should be solved before attempting to solve mental health issues. According to Whittle et al. (*154*), labelling people as "mentally ill" or "traumatized" will lead them to take tranquillizers, anti-depressants and counselling and to neglect their practical problems, such as difficulties with insurance claims or problems with builders.

The lack of studies of the impacts of flooding on children's mental health is a concern, especially as those that have been conducted show a high prevalence (*155–158*). They also show that children with good home support fare better, suggesting that not all children are vulnerable; therefore, public health activities should focus on those who are more vulnerable. In a questionnaire survey of general practitioners conducted by the HPA in Doncaster, United Kingdom, it was reported that mental health teams had to be sent to schools after the floods, as the teachers considered that they did not have the necessary skills to cope with the children, who were reporting terrible stories related to the floods. More than 18 months after the flood, some children still became upset during rainfall (personal communication from Doncaster National Health Service).

3.5.2 Post-traumatic stress disorder

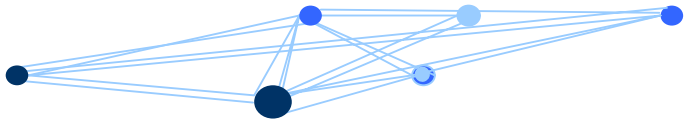
Post-traumatic stress disorder is a delayed or protracted response to a stressful event or situation of either brief or long duration that is exceptionally threatening or catastrophic (*159*). It is sometimes considered to be the dominant post-disaster mental health condition; however, this review showed that other mental health disorders are also important and should be included in public health analyses.

The prevalence of post-traumatic stress disorder depends on the characteristics of the population, the time and place of the event and the life situation before the event. Such estimates also depend on the tool used and the method of research. Tools such as the post-traumatic stress scale (*160*) have been designed and tested to link post-traumatic stress with specific events. Nevertheless, a wide range of estimates is found, and it is difficult to compare studies and the effects of events of different severities on mental health.

In a study of the prevalence and predictors of symptoms of post-traumatic stress disorder among 533 students (aged 11–21) 28 months after the 1997 flood in south-western Poland, 18% of the participants met all the diagnostic criteria, which were positively correlated with the degree of exposure to trauma during the disaster. A three-way interaction of trauma, age and gender was observed, with more symptoms among younger participants and among girls than among older boys. Research is therefore needed to devise culturally sensitive mental health programmes for young victims of disasters, taking into account age and gender (*161*).

Table 9 summarizes 24 studies on the prevalence of symptoms of post-traumatic stress disorder after flooding or disasters that involved flooding. The most frequently studied event was Hurricane Katrina (although two authors used the same data set). Most of the populations consisted of adults, four were of children, and two included both. A wide range of estimates was found, the highest being 50.5% for groups exposed during Hurricane Katrina (*180*).

In the study by Heo et al. (*169*), 31% of the population met the threshold for clinical post-traumatic stress disorder on the "impact of event scale-revised", 10% on the "Minnesota



multiphasic personality inventory-post-traumatic stress disorder" scale and 22% on both scales. Thus, different tools can give different prevalence estimates, explaining some of the variation seen in Table 9, with the other methodological difficulties outlined above.

Table 9. Studies of the prevalence of post-traumatic stress disorder after flooding events

Reference	Country, type and year of disaster	Time(s) after event (months)	Population	No.	Study type	Prevalence (%)
Europe						
162	Poland, floods, 1997	60–63	Flood-affected population	97	Cross-sectional	30.9
163	Italy, floods, 1996	94	Adults	61	Cross-sectional	45.9
164	Germany, flood, 2002	1 and 7	Heart centre patients	164	Cohort	18 (n=99) and 23.6 (n=67)
149	England & Wales, floods, 1998–2002	58–60	983 flooded adults, 527 at risk	1510	Case–control	15 (flooded group)
	Czech Republic, flood, 2002	8	71 flooded adults, 67 not flooded	138	Case–control	11.2 (cases)
Asia						
	Sri Lanka, tsunami, 2004	Not specified	90 affected adults, 18 not affected	108	Case–control	42 (cases)
	Hunan, China, floods, 1998 and 1999	18–24	≥ 7 years	33340	Cross-sectional	8.6
	Hunan, China, floods, 1998	18–24	Flood-affected population	25478	Cross-sectional	9.7
	Republic of Korea, floods, 2006	18	Adults	58	Cohort (pre- and post-disaster)	22 (post-disaster)
170	Viet Nam, typhoon, 2006	3	Adults	797	Cohort (pre- and post-disaster)	2.6 (post-disaster)
171	Hunan, China, floods, 1998	18–24	≥ 16 years	25478	Cross-sectional	9.2
Americas						
	Mexico, floods, 1999	6 and 24	Adults affected by floods in two villages	561	Cohort	Village A, 14 and 8; village B, 46 and 19
173	St Louis, United States, 1993	4 and 16	Adults	162	Cohort	22 and 16
	Hurricane Katrina, 2005	0–2 weeks	Evacuees	124	Cross-sectional	38.6 moderate; 23.9 severe
	Florida, United States, hurricane, 2004, and Hurricane Katrina, 2005	6–9	Adults	1452	Cross-sectional	3.6
155	Hurricane Katrina, 2005	5–8	10–15 years	302	Cross-sectional	37 moderate–severe

Table 9. contd

Reference	Country, type and year of disaster	Time(s) after event (months)	Population	No.	Study type	Prevalence (%)
	Hurricane Katrina, 2005	5–8 and 18	Adults	815	Cohort	14.9 and 20.9
177	Hurricane Katrina, 2005	12	Adults (university)	364	Cross-sectional	22
	Hurricane Katrina, 2005	6–7	Average, 11 years	46	Cross-sectional	23.9
	Hurricane Katrina, 2005	6	3–6 years	70	Cross-sectional	15.7
	Hurricane Katrina, 2005	6–20	Pregnant women	292	Cohort	13
179	Hurricane Katrina, 2005	12	Adult Vietnamese Americans	82	Cross-sectional	5
6	Hurricane Katrina, 2005	7–11	Adults	1452	Cross-sectional	3.6
158	Hurricane Katrina, 2005	24 and 30	Ethnic minority, 8–15 years	191	Cohort	41 and 39 moderate–severe
	Hurricane Katrina, 2005	12	Evacuated adults	101	Cross-sectional	50.5

3.6 Vulnerable populations

All populations affected by a flood are at direct or indirect risk of health impacts during and after the event, due to displacement, property damage or psychological reactions. However, certain groups are at higher risk than others for morbidity and mortality associated with flooding, and known factors and determinants increase the risk. For example, people with limited physical capacity or limited mobility, who rely on medication, who require home care or regular visits to health care facilities, and who have weak social networks, poor flood awareness, few resources and little access to flood warnings are at particularly high risk (*149*). Table 10 lists factors that can increase the vulnerability of certain population groups.

Table 10. Indicators of vulnerable groups

Factor that increases vulnerability	Population group at risk
Limited physical capacity	The elderly, children, people with chronic conditions or disabilities or who rely on home care
Limited mobility	The elderly, children, people with chronic conditions or disabilities or who rely on home care
Reliance on medication	The elderly, people with chronic conditions or disabilities, those who rely on home care, substance misusers
Reliance on regular home care	The elderly, people with chronic conditions or disabilities
Reliance on regular care at health facility	The elderly, people with chronic conditions or disabilities, substance misusers

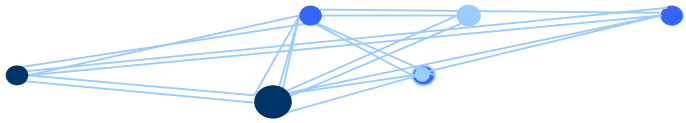


Table 10. contd

Factor that increases vulnerability	Population group at risk
Weak social networks	The elderly, people with chronic conditions or disabilities, those who rely on home care, are homeless or live alone, substance misusers, ethnic minorities, rural inhabitants
Poor flood awareness	All vulnerable health groups, those living in high-risk flood areas, those with a low income, ethnic minorities
Lack of resources for resilience and response	All vulnerable health groups, those living in high-risk flood areas, those with a low income, ethnic minorities
Little access to public warnings and guidance	The elderly, migrants and ethnic minorities, homeless people, tourists and visitors
High-risk built environment	People living in high-risk flood and deprived areas

The results of a longitudinal study in which victims of a major flooding episode were followed for 18 months (*154*) showed that there is no direct causal pathway between a flood event and health effects among people at greatest risk. The findings suggest a complex interaction between the circumstances of the flood and the person's life that determine how, when and whether they become vulnerable. When a number of vulnerable groups intersect, in a deprived community for example, the problems raised by flooding can intensify because of links with poor flood awareness, lack of resources to protect, repair and insure property, weak social networks, poor health at baseline and lack of mobility or physical capacity. The situation can be exacerbated if the area is poorly maintained, leading to a built environment that is at high risk for flood damage. Whittle et al. (*154*) stated that "these factors do not necessarily determine vulnerability to experiencing a flood hazard itself. Rather, they are factors that may influence vulnerability to the impacts of flood hazards."

The Marmot review (*181*) found that people living in the least favourable environmental conditions, including flood risk, in the United Kingdom were also those with the greatest deprivation, who will have the greatest health effects. People who are already disadvantaged in society are likely to experience more severe consequences of a flood (*13*). Migrants, ethnic minorities and visitors may be at risk during a flood because of communication barriers, which could result in delayed response or misinformation. Disaster preparedness plans should fully integrate factors related to race, culture and language into risk communication, public health actions and policy at every level (*182*). The British Standards Institution (BSI) (*183*) identified a number of vulnerable groups, including children, pregnant women, people with physical or sensory impairment and people with culture or language vulnerability (Table 11).

Table 11. Vulnerable groups identified by "optimization through research on chemical incident decontamination systems", adapted to flooding

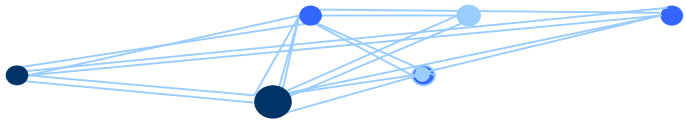
Vulnerable group	Reasons for vulnerability
Children	May become separated from their parents or caregivers May witness the death of a close family member May not have adequate cognitive or motor skills to move from danger or seek help if faced with a stressful event May be unable to vocalize their symptoms May have immature immune systems, which can make them vulnerable to infectious agents Greater risk for anxiety reactions

Table 11. contd

Vulnerable group	Reasons for vulnerability
Pregnant women	May be reluctant to accept treatment because of possible adverse health effects on their fetus May consider that the best treatment option for themselves is not the best treatment option for their fetus Poorer immune response than non-pregnant women
People with physical impairments	May rely on mobility aids, such as wheelchairs, walking canes and walkers, loss of which during a flood may result in a loss of independence May be unable to move, and emergency personnel may not have the required skills to move them
People with sensory impairment	May be unable to communicate aurally or visually by modes of communication commonly used in emergency responses
People with cognitive impairment	May believe that authority figures are trying to harm them May not have the same perception of risk as people without impairments May be unable to express their symptoms when receiving triage health care
Elderly people	May have reduced mobility, impaired balance or reduced strength May have decreased physical strength and weakened physiological responses due to health conditions such as hypertension, heart disease, cancer, stroke or dementia May have a decreased immune response May be more susceptible to temperature extremes May have sensory impairment May have delayed verbal and physical responses May have reduced ability to retain information, understand what is happening and follow rescue instructions; may become disoriented or confused in unfamiliar surroundings May lose hearing aids, eyeglasses or dentures, which may impede recovery
People with chronic illnesses	Likely to rely on medications; if these are unavailable, may suffer adverse health consequences (e.g. diabetes, asthma and epilepsy)
Tourists	May be unable to speak the language, perhaps resulting in difficulty in obtaining help or understanding instructions May be unfamiliar with the local resources that can be relied on in emergency situations
Homeless	May have a substantial rate of mental illness, which can be exacerbated by the acute stress of flooding May have difficulty in reading or interpreting written instructions May be at disproportionately greater risk of being disabled or persistently ill
People with cultural and language vulnerability	May be unable to speak the language, perhaps resulting in difficulty in understanding instructions May be unable to express their needs to health care providers, resulting in incorrect treatment or diagnosis May be assumed to be uncooperative if they are unable to read written instructions May lose vital components of messages May lack trust in authority figures or members of the medical community May express differences in gender roles or gender-appropriate behaviour May have different beliefs regarding health and treatment of illness

Source: Edkins et al. (*184*).

Patients with chronic diseases such as sickle-cell anaemia, diabetes, renal failure, cystic fibrosis, tuberculosis, HIV/AIDS, cancer and mental illness require specific assistance from health sector workers, and they should be taught how to prepare for disasters such as flooding. In Grenada after Hurricane Katrina, the incidence of diabetic foot was increased (*185*). Patients with diabetes must be given advice on the proper footwear to wear near flood-water and preventing cuts from debris. Lack of electricity makes it difficult to store insulin properly, and health care facilities must ensure sufficient stocks of properly stored insulin and its



distribution to different centres. Kutner et al. (*186*) reported that Hurricane Katrina did not result in a statistically significant increase in deaths among dialysis patients; however, the event may have lead to more incidents of hospitalization. A flood can disrupt the normal routine of patients with cystic fibrosis, displacing them from home, interrupting the electricity needed to run equipment such as nebulizers, oxygen tanks and refrigerators, and disrupting the supply of clean water required to disinfect equipment. These patients may need more than the recommended supply of approximately 1 gallon (4.5 l) of water per person, and 3 gallons (14 l) has been proposed (*187*).

Disabled people may suffer if they have to be displaced or evacuated, as they need wheeled mobility, special transfer techniques and specific medical supplies, especially those with spinal-cord injuries (*188*). The treatment of pain and the handling of controlled substances may be difficult to address. The mental health of the chronically ill can be affected by evacuation and displacement.

A number of studies after Hurricane Katrina illustrate the types of disruption experienced after flooding, particularly after mass evacuations. Fonseca et al. (*189*) investigated the impact of a disaster on the health outcomes and health-related expenses of patients with diabetes. They looked at changes from 6 months before Hurricane Katrina to the time when clinical care was resumed 6–16 months later. Overall, there were significant increases in mean glycosylated haemoglobin, mean systolic blood pressure, mean diastolic blood pressure and mean low-density lipoprotein; there was also a significant decrease in mean high-density lipoprotein but no change in mean triglycerides. Detailed analysis showed that blood pressure increased in the early period and then returned to normal, whereas glycosylated haemoglobin was raised throughout the observation period. The authors estimated that the economic cost over a lifetime would be US$ 2270–5423 (€1873–4475) per person, depending on the health care facility, equivalent to a lifetime cost of US$ 454–555 million (€375–458 million) for the approximately 1 million people affected by the hurricane.

Anderson et al. (*190*) studied missed dialysis sessions to identify groups and factors related to evacuation that could be targets for interventions. Interviews with 457 patients showed that half had missed one session and 16.8% had missed three or more. Events related to evacuation were found to contribute to missed sessions: people evacuated on the day of or after landfall of the hurricane were more likely to miss sessions, as were those who were evacuated to a shelter and people who were unaware of the clinic's evacuation plan.

Hyre et al. (*191*) studied the psychosocial impact of the hurricane 7–14 months later by analysing data on the patients described by Anderson et al. (*190*). Although they had no information about the respondents' psychosocial health before the disaster, 45.5% reported symptoms of depression. The significance of the differences was not analysed, but women and people who lived alone before the hurricane had lower self-efficacy scores, people living with a roommate or who had started dialysis fewer than 5 years earlier had more depressive symptoms and poorer perceived mental health, and people over 50 years had poorer perceived physical health. Later evacuation was associated with more depressive symptoms, less self-efficacy and poorer perceived mental health. Evacuation to a hotel was associated with poorer perceived physical health, while evacuation to a shelter was associated with poorer perceived mental health and more depressive symptoms. Patients who had been aware of their dialysis unit's evacuation plan had higher self-efficacy scores and fewer depressive symptoms.

Sharma et al. (*192*) used data from the CDC active surveillance system collected at visits to eight hospitals and 21 other health care facilities about 1 week after Hurricane Katrina made landfall to determine the reasons for presentations for health care. Of the 21 673 visits to emergency treatment facilities, 7.2% were to refill prescriptions, 5.7% for follow-up visits, 29.1% for injuries and the remaining 58% for illness. Of all presentations, 14.1% were for a

chronic disease or related condition, and the proportion of presentations for chronic disease increased with age.

Kessler et al. (*193*) conducted a telephone survey of 1043 people to determine the effect of the disaster on their health care. Reduced access to physicians was reported by 41%, reduced access to medications by 32.5%, financial or insurance problems by 29.3%, transport problems by 23.2% and competing demands on time by 10.9%. Nearly three fourths (73.9%) of the respondents reported having had at least one chronic health condition in the year before the hurricane, and over one fifth (20.6%) reported that treatment of at least one condition was disrupted after the hurricane. Disruption was reported to be greatest for mental disorders other than depression, drug and alcohol disorders and psychiatric problems. Treatment disruption was more likely in people under 65 years, those with a limited social network and those with residential instability after the hurricane.

Jhung et al. (*194*) examined the demands for care and resources after Hurricane Katrina by analysing the medications dispensed to people in an evacuee centre in San Antonio, Texas, in the first month after the hurricane's landfall. Of the daily median of 3707 people in the evacuation centre daily, a median of 218 (5% of the evacuee population) sought health care encounters. Of these, 84% were categorized: 15% were for chronic conditions and 18% for reasons such as routine vaccination and refilling prescriptions. During the study period, 22 005 prescriptions were dispensed. Data from one pharmacy showed that 38% were for chronic care, the most commonly prescribed medications being amoxicillin, albuterol (salbutamol) and ibuprofen.

The safety and welfare of both frontline and secondary emergency responders should also be considered.

3.7 Results of the survey of Member States

The survey conducted for this study included discrete closed questions on health effects observed during and after floods (Table 12). The effects reported most frequently during floods were shortages of safe water and injuries. In all cases, the reported shortages of safe water persisted after the flood. As expected, only four countries reported increased incidences of infectious disease. In Croatia, an increase in the number of mosquitoes was described, which was reduced by use of insecticides.

Table 12. Health effects reported during and after floods in the questionnaire survey

Health effect	No. of countries	Countries
During floods		
Disruption of routine hospital care	3	Republic of Moldova, Ukraine, United Kingdom (England and Wales)
Rise in infectious disease incidence	4	Bosnia and Herzegovina, Hungary, Tajikistan, Ukraine
Food shortages	2	Poland, Turkey
Safe water shortages	11	Armenia, Bosnia and Herzegovina, Croatia, Georgia, Hungary, Republic of Moldova, Slovenia, Tajikistan, the former Yugoslav Republic of Macedonia, Ukraine, United Kingdom (England and Wales)

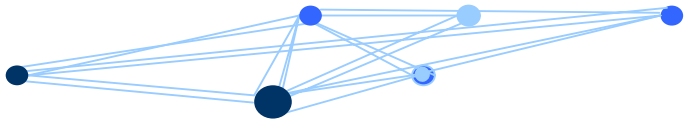


Table 12. contd

Health effect	No. of countries	Countries
Mental health problems	3	Poland, Slovenia, United Kingdom (England and Wales)
Injuries	10	Czech Republic, Georgia, Hungary, Malta, Republic of Moldova, Slovenia, Tajikistan, Turkey, Ukraine, United Kingdom (England and Wales)
After floods		
Injuries	9	Georgia, Hungary, Malta, Republic of Moldova, Slovenia, Tajikistan, Turkey, Ukraine, United Kingdom (England and Wales)
Safe water shortages	12	Armenia, Bosnia and Herzegovina, Georgia, Hungary, Poland, Republic of Moldova, Slovenia, Tajikistan, the former Yugoslav Republic Macedonia, Turkey, Ukraine, United Kingdom (England and Wales)
Mental health problems	4	Poland, Slovenia, Spain, United Kingdom (England and Wales)
Carbon monoxide poisoning	1	United Kingdom (England and Wales)

Of the 27 countries that returned the questionnaire, nine reported deaths due to flooding (Table 13); the largest number of deaths was reported from Ukraine (38), and four countries reported an average of 14 deaths. The Czech Republic and Ukraine both reported having experienced floods in 2 years that had caused many deaths, all reportedly due to drowning. Albania and the Czech Republic added that the deaths were related to water depth, debris and rapid currents.

Table 13. Numbers of deaths reported by country and year

Country	Year	No. of deaths
Czech Republic	2009	15
Georgia	2009	2
Hungary	2009	2
Poland	2005–2010	10–15
Republic of Moldova	2008	3
Slovenia	2007	6
The former Yugoslav Republic of Macedonia	2008	1
Ukraine	2008	13
	2009	38
United Kingdom (England and Wales)	2007	13
	2009	2

Two pathways were used for reporting deaths. The first started in a medical facility and was passed up through a public health or emergency response hierarchy. The second was through the department of emergencies or the police.

Examples of the first pathway are:

- from hospital to regional director of public health, which reports to the ministry of

health and the national institute of statistics (Albania);

- from hospitals to the ministry of health, which passes the information to the ministry of emergency situations and then the cabinet of ministers (Azerbaijan);
- deaths reported to medical authorities (Republic of Moldova);
- from the coroner, then statistical data are collected by the institute for public health (Slovenia);
- local committees for emergency situations and hospitals that treat victims in villages and cities report to regional and national committees and the ministry of health (Tajikistan, Ukraine).

Examples of the second pathway:

- post-flooding reports completed by a flood incident management unit within the environment agency after local teams respond to a flood; police and other emergency responders file separate reports (United Kingdom);
- a crisis management centre reports to the ministry of the interior (the former Yugoslav Republic of Macedonia);
- all deaths reported to the police (Malta);
- flood deaths reported to the presidency of disaster and emergency management by provincial directorates (Turkey).

Some countries, such as Sweden, have no specific surveillance system for mortality during emergencies. There is no formal requirement for local authorities to report deaths due to flooding to the Swedish National Board of Health and Welfare. Statistics Sweden collects data on accidents and emergencies, including loss of life, for all of Sweden. There is no special procedure for reporting deaths related solely to flooding.

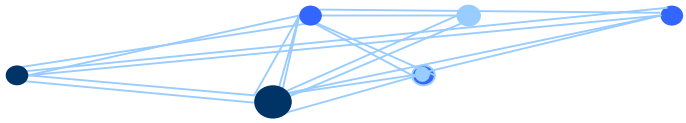
3.7.1 Results concerning vulnerable groups from the questionnaire survey

The questionnaire included a section on how vulnerable groups are identified in European Member States and the steps taken to protect them. The responses regarding specific population groups recognized in emergency plans were poor, probably due to lack of expertise in the area by the people who completed the questionnaire. Four countries (Poland, Spain, Sweden and Turkey answered "Yes" with no detail; five countries (Armenia, the Czech Republic, Georgia, the Republic of Moldova and Slovenia) answered "No"; two countries (Malta and the Netherlands) answered "Not applicable"; and five countries (Albania, Croatia, Kyrgyzstan, Serbia, and Ukraine) and Kosovo[6] did not answer the question.

The groups defined were:

- the elderly, in Azerbaijan, Bosnia and Herzegovina, Israel and Tajikistan;
- children, in Azerbaijan and the former Yugoslav Republic of Macedonia;
- people with chronic diseases, in Azerbaijan and Hungary;

[6] For the purpose of this publication all references, including in the bibliography, "Kosovo" should be understood/read as "Kosovo in accordance with Security Council resolution 1244 (1999)".



- women with children, in Bosnia and Herzegovina;
- patients in medical care homes, in Israel;
- mentally ill patients, in Israel;
- pregnant women, in the former Yugoslav Republic of Macedonia; and
- socially isolated people, in the former Yugoslav Republic of Macedonia.

Two systems were used to identify who was at risk. The first was that applied during the emergency by organizations involved in the response: on the basis of data from the Ministry for Emergency Situations and the Ministry of Health (Azerbaijan), by nongovernmental organizations and the Red Cross (the former Yugoslav Republic of Macedonia) and by local medical officers (Israel). The second was based on lists generated either during or before the event: by psychological services (Israel), by general practitioners before the flood (Hungary) and from the local database of social authorities (Israel).

Few specific responses to vulnerable groups were reported, except by Hungary, which described the care provided. The responses were described as rescue during the emergency by Azerbaijan, transport during the emergency by Azerbaijan and Hungary, health interventions by Azerbaijan, and treatment and evacuation of patients requiring special health care (dialysis patients) in Hungary.

As expected, the services responsible for responding were the emergency and health services. In Azerbaijan, the Ministry of Emergency Situations assures logistics and the Ministry of Health provides health care. In Hungary, general practitioners and public health nurses attend to vulnerable groups. In Israel, the Ministry of Health is responsible.

3.8 Impact of floods on health services

There has been little research on the impact of flooding on health facilities, partly because epidemiological studies would be difficult to conduct. Most studies have focused on specific population groups (such as people with diabetes), how continuity of care is achieved or the effect on capacity and demand for specific clinics or services. Case studies and reports on "lesson learnt" have been published, but mostly for the United States. The United Nations International Strategy for Disaster Reduction initiative "Safer Hospitals" (*195*) and the WHO "Hospitals Safe in Emergencies" (*196*) have issued tools for assessing the structural and functional safety of hospitals in emergencies (*197*). Areas of concern for health services (including capacity) and infrastructure are identified below.

3.8.1 Health facilities in Europe

Flooding can either damage health care facilities directly or disrupt access to them, as reported in Germany by Meusel and Kirch (*43*). The responses to the questionnaire showed that health facilities had been directly affected in eight countries. Kyrgyzstan reported minor damage that was quickly repaired. The Republic of Moldova reported that buildings in two hospitals and one general practitioner surgery had been damaged. Poland reported damage to hospitals, emergency stations and ambulances; and Ukraine reported damage to 122 hospitals and four secondary health facilities in 2009. Serbia, Slovenia and the United Kingdom (England and Wales) all reported flooding of health centres and hospitals. Malta reported that the roads around health facilities had disrupted emergency vehicle operation, which can have significant consequences for both response and for people who need routine hospital care, such as patients on dialysis.

3.8.2 Capacity during and after flooding

Health facilities in Europe have not experienced extreme increases in patient loads as a direct consequence of flooding, perhaps because of small numbers of patients with serious injuries or near-drowning. If flooding is widespread and has disrupted infrastructure, patients who are usually cared for in the community may be admitted to hospital, either because the usual care structures have been disrupted or because the patient's condition has deteriorated due to the absence of vital routine care, such as for dialysis patients and people with cystic fibrosis. This could create pressure on capacity but would be unlikely to trigger emergency plans. Situations that would trigger emergency plans include the following.

- After population displacement, health facilities may have an increased patient load as they admit emergency cases or take on the routine care of displaced people. The frequencies of both "major" and "minor" injuries may increase, disrupting the standard triage system. People with injuries may continue to present during clean-up.
- Emergency patients may be transferred to neighbouring facilities if the nearest one is incapacitated by flooding; however, patient transfer and emergency services can be affected if the transport infrastructure is disrupted.
- The case load may increase after an event if outpatient clinics have been disrupted.

To meet increasing population numbers, more health infrastructure is being built in at-risk areas. Thus, local community clinics may be sited in areas that are vulnerable both in terms of risk for flooding and the population they serve.

Therefore, all health facilities should have plans to create "surge capacity" (*198*), which is defined as "The ability to manage a sudden, unexpected increase in patient volume that would otherwise severely challenge or exceed the current capacity of the health care system" (*199*). It is important to understand the role of health facilities in the wider public health response to flooding and to ensure surge capacity in less obvious places, such as laboratories (*198*).

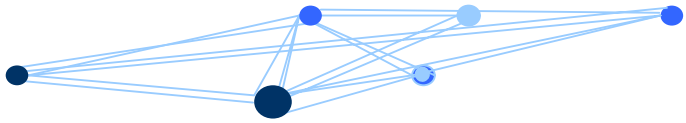
3.8.3 Facilities and infrastructure

Power supply

Electrical power is vulnerable to failure during a flood event. Both internal and external communication systems in a health facility may be affected, jeopardizing the internal functioning of the hospital and the transfer of patients within it or communication between facilities, especially with emergency services. In most facilities, emergency generators are located in the basement, and many medical physics departments are located below ground level. Therefore, expensive, vital pieces of equipment can be put out of action in a flood, disrupting diagnostic care and the electricity supply of the entire hospital. Emergency power can often be connected to selected areas, such as intensive care and laboratories, and in some hospitals emergency generators are surrounded by flood walls and kept dry (*200*). It is recommended that the location of strategic facilities and services be reviewed and if necessary relocated. When Tewkesbury hospital in England was under threat of flooding in 2007, an early decision was taken to evacuate it and transfer about 20 patients to other facilities (*201*). Collaborative plans with other hospitals are important, so that patient care can be assured if one becomes incapacitated (*202*).

Availability of water

A clean water supply and sanitation systems are a priority, as the excess of water in flooding can lead to a shortage of clean, drinkable water. This affects not only health systems but entire communities and can cause outbreaks of e.g. *Legionella* (*201*. Bringing in bottled water can be difficult when transport systems have flooded. During the floods in Gloucestershire,



United Kingdom, in 2007, a local mains water pumping station was affected, cutting off mains water, thus also affecting populations outside the flooded area. All hospital sites were affected, as the flood-water contaminated pipes throughout the county. If the fresh water supply is affected, patients may have to be transferred elsewhere.

Patient records

Patient records may also be at risk from damage, by flood-water if kept on paper and from loss of power if kept as electronic files (*200*, *203*). A robust electronic patient record system is needed that can be accessed outside the principal facility, so that records are not lost if computers are destroyed or electricity is down. This will also allow remote back-up of files. People may not be able to access their medical records during an emergency. The CDC has instituted a personal medical information form to serve as a temporary record, which contains basic personal information, active diagnoses, allergies, a list of current medications and encounters with the health system (*204*).

Ambulance services

Ambulance stations may be flooded, as occurred in Poland and the Republic of Moldova, stranding vehicles and disrupting power and the emergency call system. Ambulance fleets usually consist of a variety of vehicles, all of which cannot operate on flooded roads; some of the fleet may therefore be temporarily disabled. Ambulance services are in great demand during flooding, initially to answer calls to people who are drowning or seriously injured and to assist fire brigades in rescue missions. After a flood, they must answer calls to transport stranded patients in need of routine care, to move or evacuate patients in health facilities, to assist people injured in clean-up operations and to provide access to primary health and outreach services.

Outreach and continuity of care

Flooding can disrupt outpatient services by restricting the movement of either staff or patients. People who require outreach care, such as the homeless and substance misusers, are often vulnerable, and loss of this service can affect their stability. Loss of transport and communication can also disrupt continuity of care, such as that between facilities (referral from primary to secondary and tertiary), routine care for people with chronic diseases and routine public health care, such as vaccination, sexual health, child development markers and pregnancy.

In the questionnaire survey, health care delivery was reported to have been affected by four countries. Poland reported disruption of the ambulance response at some stations and evacuation of three hospitals. The Republic of Moldova reported that health care was affected by flooding of some buildings at two hospitals. In Slovenia in 2007, no great effects on health care were reported, even though some houses and villages were unreachable for a few days. After destruction of one health centre, first aid was given in an elementary school, and primary health care was offered at the nearest health centre. After the flood, health care was offered in a rectory until restoration of the health centre was completed in March 2009. Ukraine reported no interruption of health care, and mobile units reached people who were stranded.

3.8.4 Evacuation of hospitals and nursing homes

The main reasons for evacuation are the presence of water in buildings and loss of power. The flooding of the River Elbe in 2002 affected four of six hospitals in Dresden; total electricity and communication failure cut off one hospital complex from the city, resulting in the evacuation of 950 patients, despite loss of communication by computer and telephone (*43*).

Nursing homes represent a particular problem in a disaster, and many deaths occur in such establishments in the United States during the hurricane season. A qualitative study of nursing homes in Louisiana after hurricanes Rita and Katrina in 2006 (*205*) was conducted to compare evacuation with sheltering on site. Of 20 nursing homes, nine evacuated patients before the hurricanes and 11 sheltered them on site; six additional nursing homes evacuated people after the hurricanes. The most common perceived consequences of evacuation were morbidity or mortality, transport problems and staff deficiencies. Nursing homes that sheltered patients on site experienced shortages of power, water and essential medical supplies, facility damage and difficulty in retaining staff and dealing with staff child care.

This document does not describe evacuation plans, as each country has its own criteria and procedures. For example, the United Kingdom Department of Health has issued guidance on the evacuation of people from health care facilities in the event of emergencies, including natural hazards (*206*).

4. Effective interventions and recommended approaches

This chapter addresses primary, secondary and tertiary prevention for managing flood risk with a range of interventions and measures to reduce the impact on human health. Structural and nonstructural and resistance and resilience measures are described. Flood management can also be conceptualized as resistance (flood defence) or resilience (coping) strategies.

Secondary prevention mitigates or reduces the impact of floods and involves the identification of vulnerable and high-risk populations and high-risk geographical areas. The role of the health sector is to set up health-related early warning systems, prepare evacuation and flood plans, plan refuge areas and ensure that the population is vaccinated; other sectors are responsible for general early warning systems and evacuation.

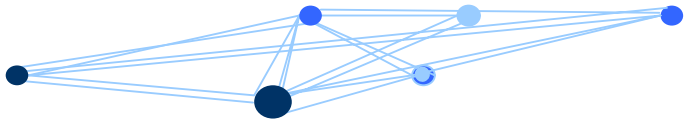
Tertiary prevention involves moving people's belongings, ensuring the availability of clean drinking-water, rehabilitating infrastructure and providing appropriate medical care. The health sector provides health care and treatment during and after a flood, while other sectors undertake clean-up and reduce disruption of housing and social networks to aid rehabilitation.

4.1 Primary prevention

Primary prevention involves approaches to prevent effects of flooding on human populations and includes either structural (physically engineered interventions) or nonstructural (policy and organization) approaches.

Key messages – primary prevention

- Examples of primary prevention include emergency plans and other methods to reduce the effects of floods, including land use management; tree planting; control of water sources and flow, including drainage systems; flood defences and barriers; design and architectural strategies; and flood insurance.
- A wide, multi-sectoral all-hazards approach to emergency preparedness is needed to minimize health impacts from floods. This approach should be implemented through a plan that includes public health and health care sections.
- Emergency planning for flooding of health facilities and services is insufficient and is not always incorporated into national emergency plans. Further work is required to improve the resilience of health services and to effectively integrate health into broader emergency management structures.
- Physical resilience of the built environment is important in the prevention of health impacts of floods. For settings with high flood risk, resiliency and resistance measures are highly economically worthwhile.
- Policies and legal statutes must provide the operational basis for the necessary interventions.
- Insurance can help reduce the mental stress that people experience after flooding, particularly with regard to the financial impact.



4.1.1 Approaches to flood management

The literature on flood risk prevention and management is extensive and covers engineering, geology, hydrology, land management, ecology, spatial planning, architectural design and a rich seam of historical and sociological evidence. The health literature in this area is not, however, comprehensive. In 2009, the Kings Fund found that "there are no known peer reviewed interventions to reduce the health effects of flooding in the United Kingdom" (*207*). Although there are few peer-reviewed publications on the risk of flooding, there is much grey literature in the form of policy guidance, mainly from government departments, on flood risk reduction.

The term "risk" in the context of flooding is usually defined as probability × consequences (*208*). The various methods and approaches for mitigating and controlling flooding to reduce the impact on human health are described in several sources, each of which has different classifications. Nevertheless, a clear distinction is made between structural and nonstructural measures (*209*, *210*): structural measures are physically engineered interventions, and nonstructural measures include policy and institutional or organizational approaches to alleviate impacts. In reviewing the literature on these issues, the need to conceptualize the different approaches became apparent. One simple classification is the "source, pathway, receptor" model (Table 14), which was designed to classify environmental and pollution threats but which can be applied to situations in which the "receptor" is the human or built environment or a wider ecological domain. The model was the basis for the "Foresight Future Flooding Report" (*208*, *211*) and its subsequent update, as part of the Pitt review (*7*). The United Kingdom Planning Policy Statement on flood risk suggested that the model be used for assessing proposed development in areas at risk of flooding (*212*).

Table 14. Descriptive model of flood management based on the "source, pathway, receptor" approach

Intervention	Control of water leading to flooding (e.g. fluvial, pluvial, storm-water, coastal, glacial melt waters) at **source**	Containment of flow through **pathway** (e.g. watercourses, polder, flood-plain, other land, sewerage and drainage systems)	Prevention of impact on **receptor** (e.g. people, property, infrastructure including health care and utilities, and ecosystems)
Structural	Dikes, levees Temporary barriers Permanent barriers Hydraulic barrier systems Storm-water storage	Hydroelectric schemes Dredging of watercourses Redirecting flood-water or watercourses Making room for water Modifying watercourses e.g. planting trees on riverbanks	Abandonment (removal of receptor) Refuge areas for safe egress from flood Product design Utility redesign
Nonstructural	Storm-water planning Cross-border collaboration	Land use policy Urban and spatial planning	Spatial planning Architectural design Building regulations Citizen involvement Organizational change

Use of an ecological systems approach to flooding in the context of climate change has potential benefits for health. In the United Kingdom for instance, the Building Research Establishment (*213*) offers architectural and master-planning guidance and has suggested that the potential effects of climate change should be taken into consideration in planning buildings. Some of the interventions proposed, such as "green roofs", sustainable drainage systems and tree planting, will not only mitigate flooding but also benefit health, by reducing the effects of floods and improving well-being and mental health.

Another approach to defining structural and nonstructural interventions is conceptualizing resistance and resilience strategies (*214*). Resistance strategies are those usually used for flood protection, which are defensive structures; a resilience approach is improving the ability to cope with uncertainties, as in the Netherlands. Resilience is a concept derived from a systems approach in ecology: a resilient system maintains its characteristics after being disturbed (e.g. by flooding). These systems can include human and organizational responses. Resilience to climate change and natural hazards is receiving much attention in both the natural and the social sciences. The aim of many of the approaches outlined below is to increase resilience to flood risk.

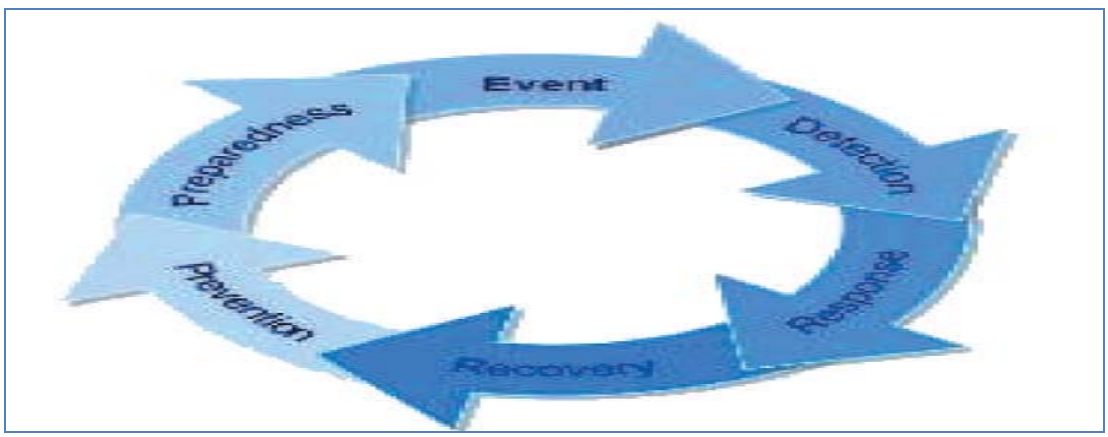
4.1.2 Emergency health plans and command structures

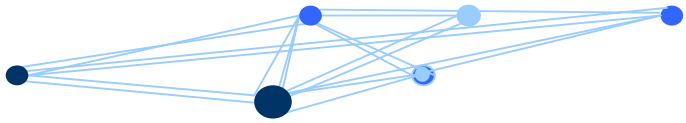
Whatever the disaster, some responses will always be necessary. The most effective disaster resilience planning is part of one generic plan with specific elements for different types of disaster. Emergency plans for health care should have a clear command structure and communication strategy with all sectors of the health system if normal routes are disrupted. There should also be channels for working with other sectors. Each country will have its own command structure for the emergency plan. What is vital is a clear chain of command, clear leadership and clear roles for each sector and layer within the plan.

A communication task force should be established to establish communication strategies if standard telephone and Internet communications go down (*215*). The strategies can include the media, landlocked telephone lines, mobile and "smart" phones, text messaging, two-way radios, battery-powered radios, e-mail, web sites and satellite phones. If communication within a hospital is lost, the movement of doctors into and out of hospital should be monitored; thus, the number of entrances and exits should be limited, and clerical staff should monitor them and keep a log. Communication with other health facilities and agents like the fire brigade and police is also essential (*216*).

WHO and the United Nations advocate a holistic "all-hazards" approach to emergency response, which was launched in January 2008 (*217*). Fig. 6 illustrates the different phases of a disaster. The characteristics of each type of disaster (causes) and of the potential casualties must first be understood, as well as their relation to the available resources; then, an all-hazards approach is recommended, with specific plans based on a hypothetical list of high-risk events (*198*). It would be impossible to plan for all types of natural disasters, as the problems would far outweigh the time and resources necessary. Therefore, a well-considered, general approach to planning for natural disasters is proposed, with a well-communicated and -coordinated response. State and local officials must coordinate local plans to generate a response, including the necessary infrastructure (*218*).

Fig. 6. Phases of the emergency management cycle





"All-hazards" reflects the idea that, while the source of hazards varies (natural, technological, social), they often challenge health systems in similar ways. Thus, risk reduction, emergency preparedness, response and community recovery are usually implemented according to the same model. A substantial proportion of essential responses are generic (e.g. management of health information, emergency operations centres, coordination, logistics, public communication), irrespective of the hazard, and setting priorities for these generic responses helps to address the hazard-specific aspects (*219*).

Ideally, emergency preparedness planning, overall coordination and surge and operational activities should be led and coordinated by an emergency coordination body at central and local levels, inclusive of all relevant disciplines of the health sector to address all potential health risks (*220*).

4.1.3 Results of the survey of Member States

As mentioned in the methodological section, a questionnaire was sent to Member States in order to elicit information on recent flooding events, the health effects observed, emergency plans and any evaluation or monitoring systems in place. The questionnaire contained both closed and open questions and spaces for free text. Box 3 features some of the most relevant results derived from the responses to the survey.

Box 3. Key primary prevention results derived from questionnaire responses

- Most countries have general emergency management plans in place, at the national and/or sub-national levels and with a clear regulatory and hierarchical basis.
- Many have specific plans for floods, often triggered exclusively by water levels.
- Health preparedness and response to floods is generally segregated from the main civil emergency response mechanisms.
- The health sector is directly involved in over half of the emergency plans.
- In the plans in which health is considered explicitly, usually only short term effects are considered.
- Only a third of the plans involved provisions for coordination with neighbouring countries.
- The plans did not generally addressed the needs of vulnerable groups and/or gender considerations.

The results from the survey (described in detail in this section) can be interpreted according to the dimensions proposed by WHO *(221)* as part of a framework to be used by ministries of health for crisis preparedness planning to ensure the inclusion of components considered to be essential (Table 15). The four core functions of the framework are:

- stewardship and governance to ensure that national policy includes health system crisis preparedness, comprising policy and legislation and an institutional framework for risk reduction and crisis management;
- resource generation to ensure sufficient means to respond to crises, covering all health workers, data handling, needs assessments, early warning systems, information management, pharmaceutical and medical supplies and equipment, infrastructure and provision of health information;
- a health financing system to ensure adequate funds for crisis preparedness planning, access to essential services during crises and insurance for health facilities; and
- service delivery for effective, safe, high-quality, equitable health interventions for mass casualties and health facilities and continuity of medical supplies.

The health emergency plans for flooding reported by countries included these four core functions generally, but not enough detail was given for a thorough analysis. Furthermore, these conclusions are not applicable to the entire WHO European Region because of missing data. Nevertheless, the analysis indicates the main gaps and weaknesses and where more work is needed.

Table 15. Core components of the WHO Health Systems Performance Framework

Stewardship and legislation	Resource generation	Health financing	Service delivery
Policy and legislation	Human resources strategy	Preparedness	Management of mass casualties and health facilities
Institutional framework	Pharmaceutical, medical, equipment supplies and infrastructure	Financing	Medical supply continuity
Health sector risk reduction and crisis management	Health information	Contingency	
		Funding	

Source: World Health Organization (*221*).

Stewardship and governance: Countries were asked whether flood plans were part of their generic plan in order to determine how many were applying the concepts of all-hazards and all-health. The framework requires consideration of all phases of crisis management: anticipation, prevention, reduction, mitigation, preparedness, response and recovery. Those reported most frequently were preparedness and response. Anticipation systems are, however, more developed than suggested, as highly sophisticated early warning systems are now available; these should be made more widely available, with better communication pathways. Research and the questionnaire both suggest that recovery is a neglected part of emergency planning.

All the countries had some sort of crisis management structure, with a hierarchy including either local or regional level up to a national body, and most had a legal basis for the plan. The plans included a broad range of sectors, although the extent to which they included private and international sectors, as stipulated in the framework, is unclear.

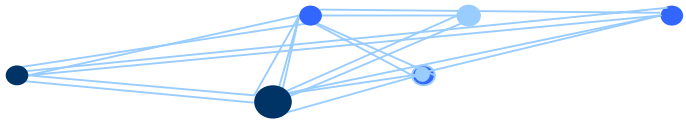
Definition of how a state of emergency is declared, by whom and on the basis of which criteria has already been shown to vary widely in terms of triggers, alerts and activation. More detailed research is needed for each country on how well this is achieved.

The responses suggested that more effort is needed in some countries for specific consideration of gender and vulnerable groups. Identifying vulnerable groups is difficult and depends on the situation, event, resources and culture.

Resource generation: A few countries mentioned checking stocks and supplies of medical equipment and sending them to the site of an event, although the questionnaire did not specify this aspect. Regular checks of the quality and quantity of supplies, transport, water, emergency communications and standard operating procedures for activating temporary health services such as surge capacity are specified in the framework.

More research is needed on the building and structural protection of health facilities. Some countries mentioned having taken measures, and the Pan American Health Organization and the United Nations International Strategy for Disaster Reduction have initiatives to make hospitals safer (*195–197*).

The levels of health information management, which includes data collection and analysis,



early warning systems and laboratory services, are diverse in the Region. This area is known to be under-researched, with few available practical systems.

Rapid assessments of health needs are required in the framework, but few countries mentioned such assessments.

Health financing: Although questions on funding were not included, some respondents noted that one barrier to emergency response was that resources were not forthcoming from their governments.

Service delivery: Mass casualty triage systems and organization of on-the-scene medical care were part of some health plans. Communicable disease management was mentioned frequently, with sophisticated systems in some countries. Their availability relies, however, on baseline systems, which are not standard in the Region. Health in evacuation shelters was part of some plans, but few countries had experienced floods that were severe enough to trigger this. Activation of individual hospital plans was often included in responses to questions on public health measures. Although continuity of care is part of the framework, this was not mentioned, even by countries that recognize specific patient groups. Cross-border and international collaboration were not part of emergency plans, and further investigation is needed.

The responses to the questionnaire show that health and civil emergency planning for flooding are segregated. Many countries found it difficult to collect the necessary information because so many different departments and ministries were involved. Furthermore, health was not considered in most plans, whereas effective mitigation of the health effects of flooding requires that health be integrated into civil plans, with good coordination and communication among all response sectors. In the countries in which health was part of emergency plans, usually only immediate effects were addressed, such as mortality, injury and infectious disease outbreaks, with little acknowledgement of the long-term health effects or of the continuity of routine care. This evidence, in combination with studies reported in the literature, highlights the need to improve flood preparedness and response.

Most of the countries (26) that replied to the questionnaire reported having an emergency plan of some kind that was administered at either national, regional or municipal level. Natural hazards were included in 21 plans. Ten countries and Kosovo[7] reported specific plans for flooding: Bosnia and Herzegovina (for selected regions), Croatia, the Czech Republic, Malta, the Netherlands, Poland, Serbia, Slovenia, Spain, the United Kingdom (England and Wales); 17 countries reported generic plans with specific mention of flooding or generic plans that could be adapted for use in flooding: Albania, Armenia, Azerbaijan, Bosnia and Herzegovina (for selected regions), Georgia, Hungary, Iceland, Israel, Kyrgyzstan, Poland, the Republic of Moldova, Slovakia, Sweden, Tajikistan, the former Yugoslav Republic of Macedonia, Turkey and Ukraine). Little detail was available on Austria's emergency plans, and Serbia was the only country that reported no emergency plan of any kind but described a "law on emergency situations", which covered disaster management.

In all countries, the organization that prepared the plan was still responsible for planning and activating it. The sectors included in the emergency plans were transport (18 countries), health (17), communication (16), water (15), the military (15), infrastructure (14), engineering (14) and sewage (14). The plans were linked to emergency services (24 countries), the police

[7] For the purpose of this publication all references, including in the bibliography, "Kosovo" should be understood/read as "Kosovo in accordance with Security Council resolution 1244 (1999)".

department (22), the fire department (22), a government agency (21) and the water administration (17). All the countries (except Azerbaijan, Georgia, Serbia) reported that their plans were linked to meteorological systems. Several countries reported collaboration with agricultural or irrigation organizations. Only 10 plans were linked to those of neighbouring countries, although flooding can affect several countries simultaneously or sequentially. Public health was mentioned in the plans of 16 countries: Albania, Azerbaijan, Bosnia and Herzegovina, Georgia, Hungary, Iceland, Israel, Poland, the Republic of Moldova, Slovakia, Slovenia, Sweden, Tajikistan, the former Yugoslav Republic of Macedonia, Ukraine and the United Kingdom (England and Wales). Examples include links to health operations and regional emergency medical plans, hospital emergency plans, provision of public health advice and methods for communicating with the public. Other countries and Kosovo [8] indicated that public health in emergencies was addressed elsewhere, such as in hospitals, as it was outside the scope of emergency coordination planning (Netherlands, Serbia, and Spain). In Sweden, an interagency group discusses preparedness and coordination before and during catastrophes that could adversely affect drinking-water supplies, such as flooding. The group is led by the National Food Administration and also a "water catastrophe group", which is on call 24 hours a day, 7 days a week, to handle emergencies that could affect drinking-water supplies.

The questionnaire asked who or what activates the emergency plan and what the alert levels are. This section was answered with a range of detail (Table 16).

Table 16. Emergency flood plan triggers and alert levels, by country or territory

Country	Who or what triggers plan	Alert levels
Albania	Disaster management involves monitoring and announcing; operative and active; operative and supportive. Monitoring data sent to General Directorate of Civil Emergencies	Alert: inform local, regional and national bodies, check emergency responders and prepare communications Stand-by: convene emergency commissions, give early warning through media Activate: joint assessment teams go to area, engage communication systems, engage international community if necessary
Armenia	Depends on event	From bottom to top in response sector, followed by a top-to-bottom system for national response. No horizontal system
Azerbaijan	Ministry of Emergency Situations gives activation order	Constant readiness is normal situation Heightened readiness before an emergency
Bosnia and Herzegovina	Water agencies or regional government organizations	Not known
Croatia	Rising water levels	Regional: water authorities
Czech Republic	Alert warning from meteorological office, water levels in gauges	Alert: more attention to watercourses and structures Danger: activate system, technical preparation Emergency: protective and safety measures, rescue and evacuation
Georgia	Department of Emergency Situations Coordination and Regime, Ministry of Labour, Health and Social Affairs	Six alert levels, depending on type of emergency

[8] For the purpose of this publication all references, including in the bibliography, "Kosovo" should be understood/read as "Kosovo in accordance with Security Council resolution 1244 (1999)".

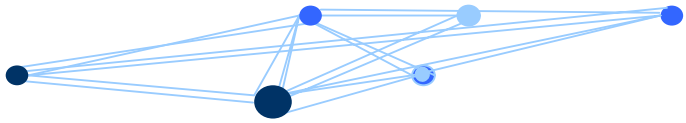


Table 16. contd

Country	Who or what triggers plan[a]	Alert levels
Hungary	Critical local water level and weather forecast	Three levels of flood defined; actions before, during and after, not according to level
Iceland	Depends on situation: meteorological office, people on site, police	Alert: information, data collection and monitoring Hazard: increased monitoring, preparation of emergency coordination centre, preventive actions, e.g. traffic control (road blocks), evacuation Emergency: immediate activation of plan, rescue and relief operations
Israel	First responders	Four levels, each with specific people involved, timing for deployment, equipment and infrastructure for mobilization and control and command mechanism
Kyrgyzstan	Not answered	Local, regional and national
Malta	Civil Protection Department	Not answered
Netherlands	Not answered	Not answered
Poland	Depends on situation: local or regional authorities or government department; based on assessment by State Meteorological Service	Not answered
Republic of Moldova	Emergency Operation Centre of the Civil Protection and Emergency Situations Service	Threat of emergency: increased level of preparedness for response and mitigation Emergency: response to consequences
Serbia	Minister of the Interior	Local or regional, depending of flooded areas
Slovenia	Civil Protection Command	1 Rivers and tributaries near flood level on water scale 2 Rivers and tributaries at flood level, localized flooding of agricultural land and roads 3 As above but with more local material damage 4 Considerable consequences, larger areas affected, traffic routes, infrastructure and buildings damaged. Recovery takes days. 5 As above, with drinking-water shortages, floods lasting more than 2 days, threat of land-slides, chemical spills, evacuation. Recovery takes weeks.
Spain	Regional water administration	Pre-emergency Emergency at regional level Emergency at national level
Sweden	Meteorological organization provides information and early weather warnings. Local municipalities activate plans when necessary.	Different levels for different kinds of weather-related events
Tajikistan	Committee of Emergency Situations offices at district level	Not answered

[a]In Kosovo the plan was triggered by uninterrupted rains for a few days, alert level not specified.

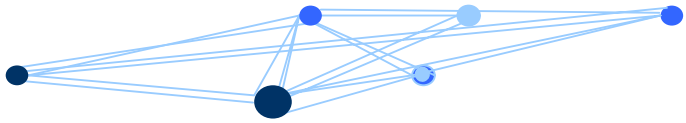
Table 16. contd

Country	Who or what triggers plan	Alert levels
The former Yugoslav Republic Macedonia	Crisis management centre gives recommendation to activate. Crisis committee within protection and rescue department activates it.	Preparation before floods Activities for critical water levels Activities during floods Activities to minimize damage from dumps
Turkey	When an event exceeds the response capacity of the region	No specific alarm level
Ukraine	Hierarchical structure of Ministry of Emergencies	Alert rescue section of military and specialized teams from Ministry of Emergencies
United Kingdom (England and Wales)	Local authorities, for local resilience and activating local emergency plans	Most alerts sent by environmental health officer as part of flood warning, extreme rainfall alerts for surface or groundwater flooding, flood alerts for infrastructure operators or probabilistic long-term forecasting from Flood Forecasting Centre

The plans were inevitably triggered by water levels, but more variation was seen in who activated the plan, between meteorological and emergency departments for example, and between local and regional levels. The alert levels also varied: some were described in terms of a vertical hierarchy from local to national response, and others by the actions that accompanied each alert level or water level. The emergency plans of several WHO European Region Member States in relation to preparation, protection and recovery from flooding are described below.

The national civil emergency plan of Albania includes the following.

- Coordinated information, an established early warning system and a public information plan are essential for saving lives and property in areas at risk for flooding.
- The public and institutions must be made aware of the evacuation plan and of identified places for safe shelter and refuge.
- Specific plans for rapid evacuation of populations living downstream from major dams are important for situations in which a dam is placed under stress and water may have to be released rapidly.
- Planning must include, as a priority, the provision of essential public health services, including water and primary health care. Advice to the public should include boiling water for 10 min and discouraging children from playing in flood-water.
- Secondary and tertiary health care services must have contingency plans for maintaining electricity and a potable water supply for a designated period and for an increased number of patients after a flood event.
- Depending on the foreseeable conditions, an inventory should be made of high-clearance vehicles, any suitable small boats and equipment such as water bowsers, water pumps and tanks and should be maintained locally to provide support during flooding.
- Contacts with the nearest or most appropriate search-and-rescue service must be kept up to date, and the contacts must be aware of each other and locations at risk, including shared maps and other information.



The national plan for disaster response in Kyrgyzstan lists the following rescue work:

- delivery of medical help and evacuation of victims to health institutions;
- searching for people under avalanches and blockages, retrieving them and evacuating them to safe areas;
- provision of medical and other types of assistance;
- repair of access roads and construction of paths into disaster areas;
- engineering rescue work;
- supplying victims with water, food and clothes;
- repair of roads and bridges; and
- averting accidents in communal power networks and communication lines.

In Hungary, the public health service is responsible for:

- isolating patients with infectious diseases and transporting those with renal disease;
- ensuring the health of inhabitants and rescue staff, assuring the epidemiological situation and taking the necessary preventive measures;
- maintaining contact with general practitioners, pharmacies and ambulance services;
- ensuring the health care of settlements isolated by the flood and of evacuated populations at temporary camps;
- ensuring medical staff at temporary camps;
- ensuring continuous reporting of the situation;
- informing the public about changes in consultation hours for health care;
- ensuring stricter reporting of infectious diseases;
- providing antiseptics for rescue brigades;
- ordering and monitoring use of protective clothing; and
- providing vaccination.

The public health service, with officials of municipalities, are responsible for informing inhabitants about preventive health measures, limiting or banning use of well-water, piped drinking-water and contaminated food, and the health consequences of moving back to their homes.

4.1.4 Land management

Flood-plain and land use management and spatial planning

Spatial planning has a major role in managing flood risk. In England, the Government's Planning Policy Statement 25 requires that the risks for flooding be taken into consideration at all the stages of a planning application and that a formal "flood risk assessment" be made (*212*). All land proposed for development is to be assessed for the likelihood of flooding on the basis of Environment Agency flood zones, and appropriate use of the land should be determined. If building or development is proposed on a site prone to flooding, the area of potential flooding should be carefully delineated with reference to the river catchment (*213*). The Environment Agency can object to a planning application if it questions any aspect of the

flood risk assessment. Of 6232 applications to which the Environment Agency submitted an objection in 2007–2008, only 123, which included 15 major developments, were approved against this advice (*25*).

A study of two flood events in Switzerland suggested that they affected knowledge about the human and physical geography of the affected areas, and that modified planning dynamics and readjustments often resulted (*222*). New housing areas that later flooded were built under spatial plans, which mentioned flood risk but did not specify its nature or options for prevention or mitigation. Some houses were built with habitable basement areas, which were specifically prohibited by local building and planning regulations.

In addition to major spatial planning strategies, small-scale recommendations can be made. The Pitt report (*7*), for example, recommends that paving and hard-landscaping of gardens be included in planning in order to reduce "urban creep" and the loss of soakaway areas.

Tree planting

A canopy of trees can slow precipitation, intercept rainfall and slow its flow into natural and engineered drainage systems (*223*). In an experiment in Manchester, England, to quantify the environmental benefits of trees in urban areas, cooling and flood prevention effects were measured. Although previous hydrological studies showed that woodland can reduce runoff by as much as 40% more than buildings and roads, an increase in urban tree cover by 10% would reduce runoff from a once-a-year storm by around 5% because of the higher rates of evaporation from trees and greater infiltration into ground planted with trees (conference presentation at Ecobuild 2010: Quantifying the environmental benefits of trees in urban areas).

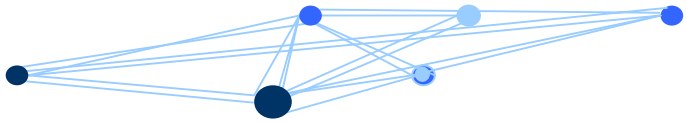
Abandonment, realignment and managed retreat

Managed realignment (also known as "managed retreat" or "setback") is a coastal defence system for sustainable flood defence consisting of re-creating eroded saltmarsh and mudflat habitats. New defences are created further inland, and the existing defence line is allowed to breach, so that the land can be tidally inundated (*224*). Hunt (*225*) found that variations in a country's human and physical geography are reflected in technical and administrative measures to manage floods. A law in the Netherlands ensures that no land will be lost as a result of sea-level rise, reflecting the traditionally defensive approach. In the United Kingdom, managed retreat intentionally leaves some areas undefended, essentially abandoning some coastal and estuarine areas to the sea.

The rural catchment areas of rivers that pose a flood risk to urban centres could be considered part of urban systems (*226*) and might be adapted, such as by upstream catchment storage. These systems include rural areas the functions of which are associated with urban needs, such as for agricultural production. Kenyon, Hill and Shannon (*227*) used Delphi[9] methods to identify the role of agriculture in sustainable flood management. They found that farmers needed advice and guidance on flood management and policies for both catchment areas and individual farms to address flooding. Both government and European agricultural policies should ensure the avoidance of any perverse incentives that could increase flood risk directly or indirectly.

Green belts or green wedges, consisting of land immediately surrounding or adjacent to large

[9] Delphi methods generally consist of several rounds of surveys in which the participants have access to the results of the previous round and are able to modify their own assessment. The underlying rationale is that the method optimizes the use of group interaction (368)



towns and cities that is protected from development, are common in many European cities. They are seen as having a potential role in reducing flood risk in adjacent urban areas (*229*), although the mechanisms have not been investigated.

Cities occupy less than 3% of the Earth's land surface but house over 50% of the population, and the rate of urbanization is increasing (*226*, *230*). Addressing the risk for flooding in urban areas is therefore important but can be difficult, because of the complexity of drainage systems, including culverts, storm and foul sewers and the nature and surfacing of river channels (*231*). The United Kingdom Government published a strategy for flood and coastal erosion risk management (*232*) comprising integrated urban drainage management, taking into account the inherent complexity of the systems. The approach addresses pluvial flooding, fluvial flooding, sewer flooding, groundwater flooding, groundwater rebound, impacts on and from the transport network and sustainable drainage systems. It proposes integration of drainage management, and pilot models are being tested, including integration with upstream catchment management.

Green spaces within urban areas can mitigate against the effects of climate change, by a cooling effect, improving air quality and reducing urban flood risk by soaking up storm-water run-off and providing flood-water storage (*231*). Green spaces also offer benefits for mental health and well-being and space for physical activity (*233*). Dawson (*226*) suggested that, as urban systems are dynamic, the approach of designing for specific activities should be replaced by consideration of the urban system as a whole for a range of behaviours and outcomes associated with climate change.

4.1.5 Controlling water sources and water flow

In these interventions, water is physically prevented from becoming a hazard, by keeping it where it should be or, in the case of populated flood-plains, where it was designed to be, in manageable volumes and flows. The interventions include physical or engineering works to keep water flowing in the appropriate channels at rates that will not become problematic. Depending on the river basin, this could include measures taken to speed or slow the rate of drainage and thus regulate the level and peaking of flood-waters to reduce the intensity of flooding. Water level control structures include gates, sluices, lock gates, weirs and pumping stations. The interventions also include areas that are allowed to hold or accommodate water in certain situations. Such flood storage areas or reservoirs attenuate flow by storing water behind an embankment or dam, so that the peak of the flood is reduced and water can be released gradually.

The construction of hydroelectric power plants has affected the hydrology of some river systems, which in turn has affected the long-term evaluation of attempts to control flooding. For instance, the building of hydroelectric plants on the Rhine River in the 1930s affected flow, so that the effects of straightening the River in the early nineteenth century will not fully be known (*234*).

Sustainable drainage systems

These are systems of physical interventions that together prevent flooding and manage surface water and run-off so that it can be used in times of water shortages. They are being used increasingly throughout Europe and are designed to mimic the natural movement of water, slowing its escape into the watercourse and reducing the burden on urban sewer systems (*7*). The objectives of sustainable drainage systems are to:

- control water as soon as possible after precipitation,
- slow the speed of discharge,

- filter and settle suspended matter with passive techniques and
- add value to the urban environment by integrating the systems into a built form.

Such systems often include features such as swales, grassed shallow channels to drain water evenly from areas of hard landscape, dry basins that are allowed to flood in times of heavy rain, and ponds, which can become landscape features (*235*, *236*).

The concept of urban drainage has usually consisted of storm-water disposal, transferring any amount of storm-water away from urban areas as quickly as possible, with foul water systems for human waste operating separately or in parallel. This approach might have eliminated localized flooding but may well have contributed to problems such as pollution of watercourses from sewerage in combined systems or overflow of one system into the other at times of inundation. A newer concept is *storm-water management*, whereby storm-water is treated as a source of water by use of infiltration capacity (*237*). This method recharges ground- and soil water, reduces peak run-off and total run-off volume and reduces volumes in potentially polluting combined systems. More work is needed on transforming existing urban drainage systems, rather than designing and building new ones.

Storm-water can be polluted by contact with contaminants that would not usually enter watercourses, and the control of such pollution is considered as important as flood control. Structural methods for managing storm-water include filter drains, porous surfacing, swales and retention or balancing ponds, as well as constructed wetlands (*238*). Regeneration of the Ekostaden area of Malmö, Sweden, was based on retrofitting open water channels along pavements and installing reed beds fed by downpipes in housing areas. The aim was to reduce the flood risk by relieving pressure on the combined sewer system (*236*).

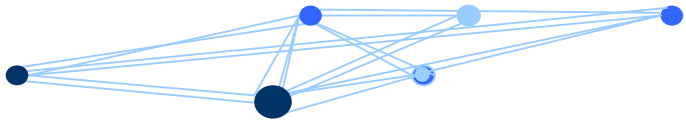
One aspect of storm-water management is storing it for release after the flood risk or peak flow has passed or for other uses such as irrigation or toilet flushing. In one example of this approach, a temporary balancing pond was created in Sutcliffe Park in south-east London, and the minor watercourse, the River Quaggy, was de-canalized from its concrete culverts so that storm-water could be stored temporarily on the parkland, to avoid flooding of the town centre a few kilometres downstream (*239*). Smaller initiatives, such as encouraging households to store run-off for use in gardens and toilet flushing, have been suggested for reducing use of potable water in drought-prone areas and also contributing to control of the sources of flooding (*7*).

Dredging watercourses

Dredging for gravel and sediments increases the space available for water flow. Less dredging is usually required for flood prevention than for commercial extraction, and the results are limited, with a return to the pre-dredged riverbed after only 10 years (*240*). Dredging should take account of the type of river (*7*) and can be done as part of active, medium-term river management. Dredging of coastal and fluvial gravels can, however, be essential to replenish and strengthen beaches and sea dikes, as seen commonly in the Netherlands (*225*).

Dikes, levees and barriers

The Dutch have relied on river and sea dikes for flood protection for almost a millennium, to protect land that is below sea level from the water in the estuaries and rivers that define the nation's delta geography. The traditional approach has been to raise the level of the dikes continually by a safety margin above the height of the last highest recorded tide or level. This has been called "the self-learning" dike (*241*). The risk of this approach is that increasingly higher dikes pose greater risks to the population if they fail (*242*). The Dutch are moving to a more risk-oriented approach to dike design and maintenance, taking into account the consequences and probability of flooding (*241*). The traditional approach to dike management



has been described as socially constructed, even though it is highly technological (*243*), because the protection is perceived as absolute. Closure-dikes are a more recent development, closing off North Sea inlets to form lakes (*244*).

Integrating spillways into existing dikes is an efficient, effective way of reducing exposure to extreme floods. Spillways make dikes more reliable, because failure and overtopping are unlikely, and they allow more time for emergency measures, such as evacuation. The potential for damage to infrastructure is also decreased. A combination of flood mitigation measures, spillways and a ban on building in flood-plains is the most effective flood risk management strategy (*245*).

In England, the Environment Agency is responsible for 25 400 miles (40 200 km) of flood defences to reduce the risk for flooding from rivers and the sea. The Agency has estimated that the flood defence schemes represent good value for money, reducing the expected damage by £8 (€10) for every £1 (€1.25) spent (*25*). Flood defences can, however, have unintended consequences, which could increase the flood risk and pose further potential risks to health. For instance, rebuilding and strengthening the major flood defences along the east coast of England after flooding in 1953 was followed by more building and population growth in the settlements that had been most affected by the floods, such as at Canvey Island. Baxter (*246*) noted that such population increases exacerbate the potential for further human disaster should the defences be breached in the future. Hydraulic barriers, such as the Thames Barrier in London, are one means of controlling storm and tidal surges. They allow navigation of the River but can be raised at short notice.

Demountable or temporary flood defences are portable, free-standing barriers located usually along river banks at a distance from the structures to be protected. Their function is to hold back or deflect flood-water from reaching groups of properties or roads. They can be effective in reducing flood risk and effects on the lower reaches of large river catchments, when there is sufficient warning. They can be erected rapidly by only a few people, and no permanent planning permission is required. Although the initial cost of demountable defences is lower than that of permanent barriers, they cost more to operate. They cannot prevent seepage of groundwater through the subsoil below properties, nor can they prevent flooding as a result of backflow from an overloaded drainage or sewer system (*208*, *211*). Small, demountable, temporary barriers have been a feature of the routine response of England's Environment Agency to flooding, although the Agency does not hold a strategic stockpile. Even traditional barriers against flooding applied at the individual scale, such as sandbags, have played their part, although they appear to be relatively ineffective in protecting households from flooding *(7)*.

All flood protection infrastructure, such as dikes, levees, embankments, flood walls, sluices and pumping stations, requires proper maintenance (*24*), as supplies of clean, potable water, sewage and wastewater treatment and the production and supply of energy all support human health.

Controlling water sources and flow by policy and law

Policies and legal statutes can provide the operational basis to define the pathways through which water is allowed to flow and those through which it should be prevented from flowing. They also designate infrastructure that must be maintained free of water, such as transport routes. For example, storm-water, which is likely to be polluted, is controlled by nonstructural approaches (*238*) such as cleaning streets and reducing the use of pollutants so that it becomes easier to manage.

A "room for the river" policy approach was instituted after major floods in the Rhine basin in the 1990s showed that raising dikes was not enough. This led to a project for sustainable

development of the flood-plain between Germany and the Netherlands (*247*). The structural aspects of this project include: dike relocation; creation of retention polders; construction of inlet works; creation of side-channels; removal of hydraulic obstructions, such as a ferry causeway; lowering the flood-plain; and creating ecological flooding.

A report by the United Kingdom Department for Environment, Food and Rural Affairs (*232*) provides a similar policy context: the Communities and Local Government Planning Policy Statement (*212*) advocates setting development back from riverbanks, incorporating stepped planting and soft landscaping instead of traditional riverside walls with hard edges. This allows the river to spread sideways to the natural flood-plain and increase its volume. The main principles are to (*213*):

- give space to the river, while protecting the natural flood-plain, by creating areas that flood and direct water away from residences;
- give space to rain, by reducing surface run-off in developing areas that can slow rainwater run out;
- create space for amenities with a permeable surface;
- design for larger volumes and more frequent floods in the future; and
- provide back-ups, such as more resilient buildings that can be used for refuge.

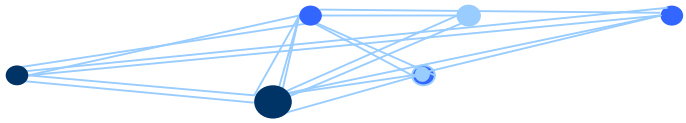
In the Netherlands, a different approach to new development has been taken. Rather than restricting new building in areas prone to flooding, other areas have been developed, including floating houses on controlled inland waters, such as at Nesselande in Rotterdam (*236*).

"Green roofs" are an architectural feature that has benefits for flood prevention, health and the environment. The manufacturers have estimated that run-off of as much as 95% of a day's rainfall can be prevented (*248*), while engineering researchers give estimates of 65–85% of annual precipitation (*249*). A review of the performance of green roofs in managing run-off noted, however, that the roofs can have a cooling effect in urban heat islands and help to mitigate the health risks associated with heat waves; they cannot resolve engineering problems in a cost-effective way (*250*).

Organizational approaches

Source water and river systems are just one source of flooding. Multidisciplinary approaches, including spatial and regional planning, agriculture, forestry and water management are now necessary in the era of climate change, as exemplified by the Dutch–German project for the Rhine River system (*234*).

The organization of the Dutch flood defence strategy has, since the twelfth century, been based on the creation of "water boards", a form of local government. Recent awareness in the Netherlands that flooding cannot be fully prevented has raised questions about what individuals can do, in addition to the traditional Government responses. Sharing responsibility for managing flood risk with the communities at risk is also being promoted in other European countries, such as Germany and the United Kingdom. Individual and community action is as important as government organizational activity in flood protection. A qualitative study in the Netherlands showed that individuals' perceptions of their responsibility for flood protection reflected their response to risk management (*244*). Individual perceptions are socially constructed and depend on factors that may include previous experience, socioeconomic factors and level of trust in authorities. The Dutch Government had no real choice other than to continue with the status quo of technological flood defences (*243*), although nonstructural measures are also being pursued, with community involvement.



The transnational approach of the Dutch–German project (*234*) is also seen in other European projects, such as for the sustainable development of flood-plains, funded by the European Union INTERREG IIIb programme (*247*). This is another Dutch–German project for preventing flooding of the Rhine River and nature development, based on the "room for the river" concept. As river catchments cross boundaries, structural approaches to flood management are best done by transnational cooperation. Cooperation in nonstructural measures may, however, be difficult because of different legislation and organizational systems (*210*).

4.1.6 Flood insurance

Residents and businesses in flood-risk areas in some European countries can prepare for flooding by taking out private insurance to cover potential damage to structures and their contents in the event of flooding. Insurance can help reduce the mental stress that people experience after flooding, particularly with regard to the financial impact. In England and Wales, insurance has been the main mechanism by which flood victims are compensated for damage to their property since the early 1960s. Flood insurance has been made available routinely by the competitive insurance market as part of ordinary household insurance. In the Netherlands, such insurance is not available, and the Government provides damage relief from flooding. It has been questioned whether this is economically efficient, however, and it has been suggested that social welfare improves when insurance companies take responsibility for some of the risk (*251*).

4.1.7 Methods for protecting buildings

The type of construction of properties was an important factor in the "great flood" of 1953 along the coasts of Britain and the Netherlands. Many of the people who were killed in England lived in flimsy, prefabricated, single-storey dwellings in the coastal areas. These were simply smashed apart by the sea or floated away on the flood-waters, as at Jaywick Sands and Canvey Island, where most fatalities occurred. People living in two-storey brick houses often fared better (*246*). Therefore, measures can be taken to make buildings more flood resistant and resilient. In 2007, the United Kingdom Government published guidelines for developers and designers on improving the resilience and resistance of new properties in flood-risk areas by the use of suitable materials and construction details (*252*). The concepts are defined in Table 17.

Table 17. Definitions and concepts of flooding in relation to structure

Concept	Definition
Flood avoidance	Constructing a building and its surroundings in such a way to prevent it from being flooded, e.g. by raising it above the flood level or siting it outside flood-risk area
Flood resistance	Constructing a building in such a way to prevent flood-water from entering it and damaging its fabric
Flood resilience	Constructing a building in such a way that the effect of any flood-water that enters it is minimized and no permanent damage is caused, structural integrity is maintained and drying and cleaning are facilitated
Flood repair	Constructing a building in such a way that any elements damaged by flood-water can be easily repaired or replaced; a form of flood resilience
Damp-proof course	Layer or coating of material placed in a wall to resist the passage of moisture from the ground

Table 17. contd

Concept	Definition
Damp-proof layer	Sheet of material placed beneath or within a floor to prevent passage of moisture. To be fully effective it should be lapped to the damp-proof course in the surrounding walls.
Sustainable drainage system	Sequence of management practices and control structures used to attenuate run-off from development sites and to treat run-off to remove pollutants, thus reducing the effect on receiving water bodies
Flood-plain	Area of land that borders a watercourse, an estuary or the sea, over which water flows in times of flood or would flow if flood defences were not erected

Sources: Department of Communities and Local Government (*252*), Flood Sense Ltd (*253*) and Chesterfield Borough Council, Bolsover District Council and North-East Derbyshire District Council (*254*).

It is very difficult to prevent water from entering a building. The two strategies usually used to achieve resilience depend on the depth of water to which a property is subjected.

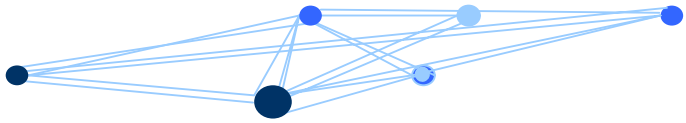
- In a *water exclusion strategy*, water entry is minimized while maintaining structural integrity by the use of materials and construction techniques that facilitate drying and cleaning. This strategy is favoured when flood-water is no more than 0.3 m deep. It is technically a resistance measure but is part of a strategy to achieve building resilience.
- In a *water entry strategy*, water is allowed into the building, facilitating draining and subsequent drying. Standard masonry buildings are at risk of structural damage if the difference in water level between the outside and the inside is 0.6 m or more. This strategy is therefore favoured for flood-water deeper than 0.6 m.

Flood-proofing (*24*) is a means of making new buildings more resistant to flood or retrofitting buildings at risk. The methods include:

- elevation: raising inhabited parts of a building that are at flood level on stilts or using land-fill to make basements watertight;
- wet flood-proofing: making parts of a building uninhabitable, so that it is resistant to flood damage and water is allowed to run through it during a flood;
- dry flood-proofing: sealing a property to prevent water from entering, e.g. by portable floodgates or flood boards and non-return valves;
- flood walls: constructing a wall around a building to prevent flood-water from coming near;
- relocation: moving a timber house to higher ground; and
- demolition: rebuilding a structure that is damaged beyond repair, either on the same site or on one at less risk.

There is a growing demand for the design and installation of products intended to protect properties from flood events, such as air-brick covers, water and sewer anti-return valves and dams and barriers around whole buildings (*255*).

The aim of *temporary flood-proofing* is to reduce the ingress of flood-water into properties or at least to hold back the water long enough to enable homeowners to move their belongings and pets to a safe place, thereby reducing the amount of damage. The measures include fitting plastic, wooden or metal products to the building temporarily, such as floodgates to external



doors and windows, covers on air-bricks and flexible plastic skirting systems, using sandbags or fitting non-return valves into drains or sewer pipes. These measures can be effective for shallow floods of short duration and may make the difference between minimal flood damage and large-scale clean-up and restoration (*211*).

While flooding may be inevitable in some circumstances, extensive damage and loss of property are not. People can take a number of steps to protect their property. A few may make adaptations proactively even if they have not experienced flooding, if their property is at risk. The Pitt review on the floods in the United Kingdom in 2007 (*7*) showed, however, that even in areas badly affected by flooding tenants found it difficult to accept that they might experience flood again, and they were therefore reluctant to make changes to their homes to render them more resilient to floods. People often want their homes to be exactly as they were before the flood, and this emotional response outweighs the evidence for adaptation.

Resilience measures for interiors are exemplified by changes made in one flooded household in the United Kingdom (*7*): installing lightweight doors that could be moved upstairs easily, moving electrical sockets higher up on walls, laying concrete floors, finishing walls with waterproof cement-type plastering and applying waterproof finishes such as yacht varnish to skirting boards and internal woodwork. Another example is the Kings Arms public house in York, United Kingdom. Situated on the quayside, this ancient building floods almost every winter. Its interior has been adapted so that it can reopen within 24 h of flood-waters subsiding: it has hard, wipe-clean, tiled floors, and sumps have been fitted to the doorways so that any remaining water can be pumped away (*256*).

Many modern building materials, such as medium-density fibreboard, are more water-absorbent than traditional solid wood. When these materials are used for fittings such as stairs, skirting boards and kitchen units, even very shallow flooding can damage them beyond repair. It is recommended that any damaged fittings be replaced by solid timber products and that fittings that are generally painted, such as skirting boards, be painted on both sides to improve the seal against moisture. Unplasticized polyvinyl chloride (PVC) building products, including kitchen units, can be easily cleaned and reused after flooding, and existing units and appliances can be raised from the floor on plastic legs to prevent damage from future floods (*257*).

Householders can reduce the likelihood of damp reaching utilities (mains gas, electricity, water) by knowing where these services enter and are connected in their house and how to switch them off (*258*).

In some properties, flooding is caused by a back-up of foul sewers and not by fluvial or pluvial flood-water. Beyond its unpleasantness, this backup entails obvious health risks. The United Kingdom's National Flood Forum provides an independent online directory of companies that provide flood protection, mitigation equipment and services, ranging from toilet bungs to prevent sewerage back-flow to door gates to provide a sturdier barrier than sandbags. Sewerage protection devices such as non-return valves can be fitted individually or on the main sewer into a property (*255*). Environmental health authorities should issue advice not to pour fats, oils and food down sinks, as this impedes the flow of water and makes sewage water more likely to re-surface up drains when flooding occurs.

In the United Kingdom, detailed guidance is available on standards for the repair and restoration of buildings damaged by flooding from organizations such as the Construction Industry Research and Information Association (*183, 259*, *260*). Laboratory testing by such organizations has resulted in quantitative information on the behaviour of building materials and composites (floors and walls) subjected to flood conditions (*252*, *261*). Much of the guidance is based on expert opinion and experience in the repair of buildings that have been

flooded. The guidance includes advice on safe access to buildings, decontamination and drying after flooding. Templates and guidelines for flood risk assessment are also available for deciding which of the detailed standards of repair to use in improving the resistance and resilience of damaged buildings (*259*).

4.1.8 Economic benefits of resistance and resilience measures

Studies of the economic benefits of using resistance and resilience measures have been published by the United Kingdom Department for Environment and Rural Affairs in collaboration with the Environment Agency (*262*). The report provides insight into factors that influence people's decision to invest in resistance and resilience measures. The measures recommended for residential properties are listed in Table 18. In a telephone survey of 1131 households and businesses in areas at risk for flooding, it was found that many recognized the benefits of the measures, including potential long-term financial savings, a greater feeling of safety and less disruption due to floods, all of which affect people's health. The survey also showed that many people do not take action because they consider that the measures are expensive or not their responsibility. Other factors that deterred people from protecting their properties included not knowing which measures to use, concern about effects on the appearance of the property, not wishing to be reminded of the risk (denial) and concern that the measures might adversely affect the property's value or make it hard to sell.

Table 18. Flood resistance and resilience measures for residential properties

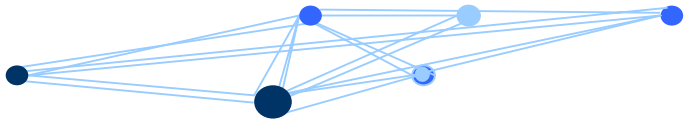
Aim	Measure
Temporary resistance	Manually installed door guards and air-brick covers, sump, pump and remedial works to seal water entry points
Permanent resistance	Permanent flood-proof external doors, automatic air-bricks and external wall rendering or facing, sump, pump and remedial works to seal water entry points
Resilience without resilient flooring	Resilient plaster (up to 1 m), lightweight internal doors, resilient windows and frames, resilient kitchen, raised electrics and appliances
Resilience with resilient flooring	Concrete or sealed floors, resilient plaster (up to 1 m), lightweight internal doors, resilient windows and frames, resilient kitchen, raised electrics and appliances

Source: Department for Environment, Food and Rural Affairs/Environment Agency (*262*).

Resistance measures are economically worthwhile for individual properties with an annual chance of flooding of 2% or greater, with a 50-year return. The greatest savings are for residential properties with an annual risk of flooding of 4% or more, with a 25-year return. Temporary resistance measures (i.e. temporary flood guards and air-brick covers) reduce the cost of damage by about 50% if they are properly installed before a flood. Investment in permanent resistance (i.e. permanent flood-proof doors, windows and air-brick covers) increases the prevented damage to 65–84% but is less cost-beneficial than temporary resistance. A full package of resilience measures (i.e. flood-resilient plaster, resilient kitchens and resilient flooring) is economically worthwhile only for buildings with a greater than 4% annual risk for flooding or for buildings with a greater than 2% annual risk that need repair or refurbishment (*262*).

4.2 Secondary prevention

This section describes measures that can be taken either immediately before or during a flood to mitigate or reduce the health effects, which include flood forecasting and warning systems and other practical emergency planning measures, planning for vulnerable groups, evacuation plans and planned refuge areas. Measures must be taken by many sectors in collaboration with health services, and specific measures must be taken directly by the health sector, such as protecting the health of the affected population. Vulnerable or high-risk populations must be



identified to ensure targeting of measures to reduce the impact of flooding on these groups and in high-risk geographical areas.

Key messages: secondary prevention

- Examples of secondary prevention measures include identification of vulnerable populations, early warning systems, evacuation plans with communication and information, planned refuge areas and maintaining health services.
- Secondary prevention should be multisectoral, with collaboration between health services, early warning systems, water supply companies and emergency services for evacuation.
- Secondary prevention measures for health facilities should also include planning for unexpected increases in patient volume and for disruption to the infrastructure, including loss of electricity and water supplies.
- Further research is required on vulnerability to flooding and on identifying vulnerable populations and their health needs.
- Secondary prevention measures for vulnerable populations should account for difficulties in communication and mobility and the needs of people with chronic diseases.

Measures to protect vulnerable groups from flooding

Groups usually identified as particularly vulnerable before, during or after flooding may not necessarily be vulnerable in all phases (*263*). A number of measures can be planned in advance of a flood (*264*).

To prepare for shelter use, those responsible should ensure that the shelter accepts people with medical needs. In all cases, an updated list of medications should be kept, including doses, a list of allergies and the names and telephone numbers of physicians. Care should be taken to ensure that there is an adequate supply of medications, whether they require refrigeration, whether pharmacies will be affected by the emergency and whether there is a pharmacy near the shelter. An adequate supply of oxygen must be assured, and the source of oxygen must be told where the shelter is. Clean water will be needed for cleaning equipment, and the necessary supplies for sterilizing water must be available. It should be ascertained whether there is a back-up source of electricity or generator and whether the shelter is on the list of priorities of the utility company (*187*).

A project for "optimization through research of chemical incident decontamination systems" has identified ways of looking after vulnerable groups during a disaster (*265*). In community engagement, the skills and knowledge of the groups are used in planning. Vulnerability maps can be drawn, with lists of vulnerable people and where they are in the community. In "buddy systems", people remain with their families or with people with whom they are familiar during relocation and evacuation,. This makes the care of vulnerable people more efficient and provides psychological support. Instructions and information should be provided in as many formats as possible, including pictures, Braille and audiovisual media. A short video or cartoon may help children to understand instructions. First responders can be trained to work with vulnerable groups, and vulnerable groups can be included in training.

The primary or local health service is the first health point, particularly for vulnerable groups, and its continuity ensures their management and care. Business continuity plans should be well established and reviewed and updated regularly.

Disaster preparedness should fully integrate factors related to race, culture and language into risk communication, public health and policy at every level. Translated information and resources can be useful for tourists, migrant workers and ethnic minority groups, although the

resources must be culturally and ethnically specific. Faith-based organizations and community partners can help to make the resources as sensitive and accessible as possible. Organizations that provide resources for minorities primarily on the Internet should remember that many racial and ethnic groups have limited access to this medium, especially at the time of a disaster (*182*).

Programmes for health sector surge capacity, emergency shelter and quarantine must also consider the specific needs of ethnic and racial groups. Audiovisual media, pictures, interpreters and other channels of communication must be used to disseminate culturally, racially, ethnically sensitive public health messages. The most appropriate person to deliver the message and where must also be considered, as trust can influence whether people act on the advice they receive (*182*). Further information on assisting patients with noncommunicable diseases during disasters is available from WHO and HPA (*266*).

Individual and household preparedness

There is plenty of advice available in several formats by international, national, regional and local organizations on how to prepare for floods individually and at the household level. Typically, an emergency kit should be available, with basic items necessary in the event of an emergency, like a torch, a battery-operated radio and batteries, a first-aid kit and manual, emergency food and water, a manual tin opener, cash, changes of clothing and sturdy shoes. Another common element is a family emergency plan that includes information on how and when to turn off the gas, electricity and water; how and when to call the police and fire departments; and how to find emergency information on the radio. Family communications provisions should be part of such a plan.

4.2.1 Flood forecasting, warning systems and other emergency plans

Early warning of flood risk coupled with an appropriate response by the population can reduce the risks to health (*13*). Flood forecasting and warning systems are designed to predict events and warn against them, so that professional agencies can put emergency plans into place, and households and businesses can take action to protect themselves and their families, employees, pets, livestock and belongings and assets. The systems become more accurate closer to a predicted event. The WHO Regional Office for Europe recommends warning systems that provide adequate notice to allow for an effective behavioural response to an event (*267*).

Flood warning systems should result in an appropriate response (*268*). The information required to draw “integrated risk maps” for an effective flood warning system (*269*) includes:

- the geographical distribution of the population, including vulnerable groups;
- detailed land use and the economic value of different areas;
- hydrometerological and topographical data; and
- a planned broadcast pathway for early warning messages, accompanied by clear alert levels and instructions.

Examples of warning systems in Europe are given in Table 19.

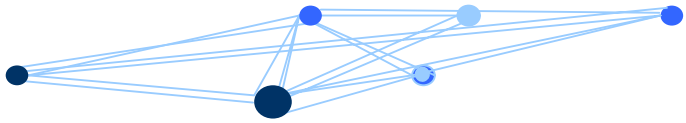


Table 19. Examples of European flood warning systems

Region or country	System
Europe	The European Flood Alert System was set up by the European Union in response to the flooding of the Elbe and Danube rivers in August 2002 (*270*). The system allows national water companies to prepare for flooding by giving medium-range (3–10 days) predictions of floods, and the European Union manages aid during flooding. The system provides information only to registered partners, through a password-protected Internet service. A research team at Kings College London is exploring the forecasting techniques used by the system to determine how the authorities receiving the flood warnings respond to them (*271*). This research is at the interface between flood warnings and decisions to take action by triggering a flood response.
Finland	The Finnish Environmental Institute has a hydrological forecasting system, the "watershed simulation and forecasting simulation", which covers the country (*272*). The system is based on "ensemble" forecasting techniques (*273*) and is linked to an automatic flood warning system, which covers 9 days into the future and is updated regularly.
France	France has a flood warning system developed by Cemagref and Météo France. It covers the French river network with the aim of improving the response to flash floods with the French hydrometeorological and flood forecasting service (*273*, *274*).
Hungary	The water resources research centre has a flood warning system for use in emergencies (*273*).
Netherlands	A national water plan was implemented in 2009 (*275*).
Slovakia	A Government-funded flood warning and forecasting system was approved in 2002 (*276*).
Sweden	The Swedish Meteorological and Hydrological Institute operates a flood warning system based on ensemble forecasting techniques (*273*).

The Environment Agency has been responsible for issuing flood warnings in England and Wales since 1996; they were previously issued mainly by the police. Warnings are based on forecasts provided by the Flood Forecasting Centre, which is a partnership between the Environment Agency and the Meteorological Office. The Centre has expertise in both meteorology and hydrology in order to forecast river, tidal and coastal flooding. Where technically feasible, warnings can be extended to groundwater flooding. The Environment Agency also raises awareness about surface water flooding by relating it to forecasts of extreme rainfall events. The Centre was set up as a direct response to a recommendation of the review into the floods in summer 2007 and began operation on 1 April 2009. It is fully operational 24 h a day, 7 days a week. The warning system consists of sending information to the public, professional partners and the media via a flood warning web site, a phone line and radio broadcasts. Information is also sent directly via e-mail, telephone, fax and SMS.

In 2010, the Environment Agency (*277*) changed their flood symbols and codes and updated their warning messages to make them easier to understand, provide more local information and give clearer guidance about what people should do. People who are registered for the free flood warning service, Floodline Warnings Direct, receive warnings of floods and severe floods and messages informing them when the warnings are no longer in force. The current flood warning codes and their meanings are shown in Fig. 7. These flood warnings then trigger a response by the United Kingdom Environment Agency, emergency services, local authorities and industry.

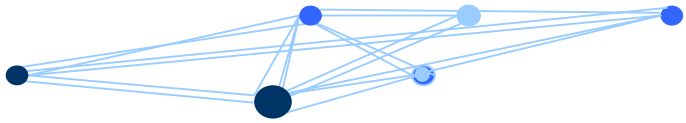
Fig. 7. Flood warning codes issued by the United Kingdom Environment Agency

Warning symbol	Warning code	What it means	When it is used	What to do
	Flood alert	Flooding is possible. Be prepared.	2 h to 2 days in advance of flooding	Be prepared to act on your flood plan. Prepare a flood kit of essential items. Monitor local water levels and the flood forecast on our web site.
	Flood warning	Flooding is expected. Immediate action is required.	30 min to 1 day in advance of flooding	Move family, pets and valuables to a safe place. Turn off gas, electricity and water supplies if safe to do so. Put flood protection equipment in place.
	Severe flood warning	Severe flood warning. Danger to life.	When flooding poses a significant threat to life	Stay in a safe place with a means of escape. Be ready should you need to evacuate from your home. Cooperate with the emergency services. Call 999 if you are in immediate danger.
	Warnings no longer in force	No further flooding is currently expected in your area	When river or sea conditions begin to return to normal	Be careful. Flood water may still be around for several days. If you have been flooded, ring your insurance company as soon as possible.

Source: Environment Agency (*277*).

4.2.2 Moving belongings and assets

Belongings and assets should be moved either to an upper floor or to another location. For homeowners, these could include personal belongings, items of sentimental value, personal papers and cars; farmers might have to move machinery and livestock; businesses might move stock, equipment, raw materials, papers, vehicles and other material. This measure can significantly reduce flood losses and the distress due to lost or damaged possessions. People often wait, however, until they perceive flooding to be "certain" before taking any action, particularly those with no previous flood experience and commercial companies or public institutions that are concerned that they will lose customer confidence and profits. Therefore, when actions are taken, they are less effective because they are done hastily. Better awareness of the issues associated with flooding and more confidence in forecasts and warnings might result in earlier, more effective responses (*208*, *211*).



4.2.3 Evacuation shelters and temporary and mobile structures

Evacuation

The function of evacuation is to save lives and reduce the danger to people and animals during a flood event. Evacuation measures are usually taken only during serious flood events, when it would not be safe or practicable for people to remain on their properties or for people living in ground-floor or single-storey dwellings or mobile homes. Evacuation plans should be in place before flooding so that emergency services and local authorities can provide support for the evacuation of vulnerable groups, e.g. residential homes. Moreover, evacuation is a process and not a short-term response, and it is not complete until the people who had to leave their homes have returned. Evacuation can, however, increase the overall disruption resulting from flooding. Although many people evacuate spontaneously to relatives or friends before being asked to do so officially, evacuation is still distressing and worrying, particularly when family or social structures are disrupted.

A decision to evacuate is influenced by public awareness and perceptions of flood risk, the accuracy of and public trust in flood forecasting, effective flood warnings, the information received about the flood (likely depth and duration) and education and official and unofficial preparedness plans. A lead time before a warning allows an effective, orderly evacuation. The effectiveness of the response also depends on understanding of the flood risk by evacuees and emergency responders, what evacuation implies, what actions are required, how the response will be organized and trust among the various parties (*208*, *211*). (See also section 3.6.4 on evacuation of hospitals and nursing homes.)

Refuges are both a physical and organizational response to flooding, in that they are protected or protectable from a flood but also designated as safe places. They are signposted, and people are informed about the designation. Safe areas obviously have to be planned and organized before a flood event. For example, after Canvey Island in the Thames Estuary in England was devastated by floods in 1953, major flood defence walls were built, and providing a safe escape refuge from flooding during evacuation was part of the regeneration plans for the Island. The local authority maintains the refuge, and it is well known to residents (*225*). Designation and signposting of refuge areas can be complemented by flood maps for use by agencies and the public (*278*).

A published point of reference on the minimum amount of floor space per person in an emergency shelter is 3.5 m^2 (*279*); however, the needs of disabled people must to be taken into account in planning shelters (*187*). For example, wheeled mobility should be available and volunteers trained in proper transfer techniques, and the medical supplies needed by people with spinal-cord injuries (such as catheters) should be on hand.

Floods, and particularly catastrophic floods, can result in significant displacement of populations, which can lead to a range of physical and psychological health outcomes. Access to essential medicines and health care may be affected, and large-scale population movements place an additional burden on local and national health care infrastructure. Evacuation before floods can reduce the risk to life from severe flooding and is often necessary after flooding, as properties are often uninhabitable for many months. Poorly organized and managed evacuation can, however, add to the distress of flood victims, as occurred during Hurricane Katrina (*280*). The floods in the United Kingdom in 2007 led to a re-evaluation of the location of evacuation shelters, as many were flooded (*7*).

Health effects

Most people who lose their homes in a flood will be able to find places to stay, with friends or family. Only when housing losses reach more than about 25% is it suggested that there will be a need to find other sources of shelter (*53*). Some displaced people will have major health

problems. They require an initial assessment of health care needs by a physician, determination of their prescription needs, identification and coordination of health care requirements and arrangements for post-disaster follow-up care. If possible, these should be logged on a database (*239*).

Management of health in shelters and evacuee centres requires links to established health networks, e.g. community health systems, medical clinics, pharmacies and medical support services (*215*). A case study of a rapid health assessment tool used during Hurricane Katrina is set out in Box 4. Additional advice is to use established health networks and identify leadership teams at the shelter, leaving one member at a clinic. A plan should be prepared for the use of volunteers, e.g. a database of people and skills, communication systems and nongovernmental organizations. Communication with community health care providers is key to successful arrival at a shelter, care throughout the stay and the return home. To reduce the risk of a bottleneck at the entrance to a shelter, paperwork should be kept to a minimum. Screening forms could be used to assess the needs of evacuees as soon as they arrive (*281*). Anyone with a medical problem or needing long-term prescriptions should be seen by nurses at a triage station to check their vital signs, oxygen saturation and capillary blood glucose level. These patients should then be seen by a physician and referred on if necessary.

Box 4. Rapid health assessment tool used in shelters

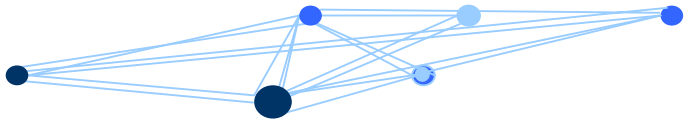
- Used in the Astrodome "megashelter" in Houston, Texas, after Hurricane Katrina. The rapid health survey confirmed an outbreak of acute gastroenteritis and became critical in monitoring its progress.
- Each person was approached to fill in the form. Volunteers were trained before conducting the survey each evening, so that they could appropriately refer patients to public health, medical and dental services.
- Data quality was stringently managed by use of double-entry booking and was validated by a second person. A daily report was compiled and sent to the health authority, and information was reported each morning during the team briefing. Initially, data were collected by hand, but subsequently personal digital assistants were used.
- Areas of the centre with higher incidences and prevalences of diarrhoea and vomiting were sanitized and monitored more closely, and an isolation area was created.

Source: Dutch Central Government *(275)*

A "medical hotline" was set up after Hurricane Katrina, and conference call times were established to coordinate hospital transfers, arranging for health needs and communication with pharmacies, community care structures and health partners (*282*). An electronic tracking system was devised to facilitate tracking of evacuees returning home, with detailed information about their health care needs.

No examples of demands on health services in large evacuation centres in Europe were found, but lessons can be learnt from other areas. Jenkins et al. (*283*) conducted a large cross-sectional study in American Red Cross shelters in several states to determine the health needs after Hurricane Katrina: 36.2% of patients received acute care, 33.3% received preventive or chronic care, and 30.6% received both types of care; 10.7% received some form of durable medical equipment. Glasses were given to 6.8% of people and were the most commonly dispensed item, followed by dental devices (1.6%) and glucose meters (1.1%).

Chiou-Tan et al. (*284*) conducted a cross-sectional study of physical medicine and rehabilitation at the Astrodome medical clinic after Hurricane Katrina. Most (75%) conditions were seen in the first week and comprised swollen feet and legs (22%), leg pain and cramps



(17%), headache (12%) and neck and back pain (10%). The study highlights the importance of including stocks of controlled pain relief medication, such as opioids, in emergency plans.

The health risks associated with displacement to temporary accommodation are not fully understood. Some evidence shows that long-term residents of coastal caravan sites have poorer health than national or regional rates (*285*). The population studied is different from those displaced after their homes were flooded, but living in such accommodation is associated with specific risks, which include falls and respiratory hazards from the building fabric, lack of good insulation and condensation and mould growth. The study did not address mental health. Such accommodation offers less structural stability during floods than permanent structures, and the effects on health of displacement to caravans and mobile homes after a flood should be further investigated.

4.2.4 Maintaining health services

All hospitals have the common goal of delivering an "acceptable" quality of care to preserve as many lives as possible in disasters with mass casualties and to prevent complications in the victims (*203*). Maintaining the capability of critical care areas in hospitals is an essential part of all disaster management planning, and expansion services must be planned effectively (*198*). The "hospital emergency incident command system" provides guidelines for establishing a command chain, accountability, communication, prioritization of actions and standard nomenclature (*203*). Interventions are required at multiple levels of a system to mitigate the impact of flooding and ensure service continuity. These include: ensuring access to health care, disease prevention and control activities, risk communication and education, coordination of response and long-term capital recovery (*286*). A health network of integrated primary, secondary and tertiary care, pharmacies and social care is best equipped to cope with a disaster (*199*. The skills and understanding of family physicians should also be fully used. A plan should be drawn up with other health care providers in the region to transfer or exchange drugs, evacuate patients and ensure communication (*216*).

Secondary prevention measures for health facilities should also include planning for unexpected increases in patient volume and for disruption to the infrastructure, including loss of electricity and water supplies. See section 3.7 for a discussion of the effects of flooding on the provision of health services.

The triage system might have to be adapted to create a "fast track" for patients with minor injuries or nonacute medical complaints, in order to relieve emergency departments (*216*). If possible, initial triage and treatment facilities could be set up away from emergency departments and hospital facilities, to avoid overwhelming them (*199*). Colour-coded tags could be used to sort injured people coming into emergency departments, so that staff can immediately identify who to treat first (*198*). Nurses might have to be reassigned from nonessential positions (e.g. routine outpatient care) (*216*). A decontamination area might have to be set up quickly or checked to ensure that it is operational (*287*).

Community and social services might be affected if routes are cut off, or they might represent the only available health care if secondary and tertiary facilities are unreachable. Community services are often the first source of care for vulnerable groups such as the homeless; therefore, if they cannot continue to run properly, some of the most vulnerable within the population may suffer. Social services should be included in the plan for health, psychological and emergency care, as displaced people and those whose routine care has been disrupted need extra support. The social services network might have to help health service networks to cope with the victims of inundation (*288*).

Tuberculosis control programmes should plan for possible displacement of patients on directly observed treatment (*289*), by:

- preparing lists of patients in different health districts who might be affected,
- giving patients a 2–4-week supply of medication in case treatment is interrupted,
- giving patients the telephone numbers of health facilities,
- obtaining complete contact details for patients and relatives,
- ensuring that patient records can be shared with other health facilities and
- stocking supplies in several places or in a place out of the risk area.

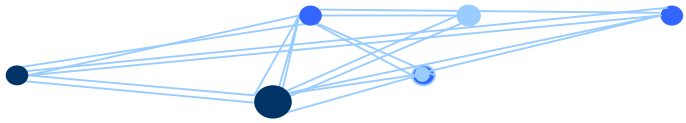
Clinics should prepare for changes in the populations who attend outpatient clinics, as flooding might cause population displacement. After Hurricane Katrina, the people attending the HIV outpatient clinic were more likely to be older, white and male. Living in severely damaged areas was associated with a poorer return rate for females and for black males, and higher CD4 counts[10] were associated with a higher return rate (*290*). A good database of contacts, with a back-up, is needed, so that patients can be traced.

Contingency plans for health facilities

The following planning activities for health services and facilities have been recommended on the basis of experience of flood events. Their relevance will depend on the severity and nature of the event (*291*), and hospitals will have time to put more contingency plans into action if there are good early warning systems in place. They should be prepared to:

- rapidly establish headquarters and space for administration (*292*);
- have baseline knowledge of the local population's health, which will affect the services and level of care that might be required (*293*);
- ensure access to primary care to prevent exacerbation of chronic conditions, reducing the likelihood of premature death and unnecessary hospitalization (*293*);
- coordinate mobile medical relief teams by the ministry of health and nongovernmental organizations to maintain communication (*294*);
- ensure that staff members are at work by making provisions for child care (*295*);
- ensure that staff bring their own supplies of food (*291*);
- for hurricanes, establish a disaster team of physicians and nurses that is on stand-by or in the hospital, with action triggered by warnings (*216*);
- reassign nurses from nonessential positions (e.g. routine outpatient care) (*216*);
- use point-of-care tests and analysers when generators fail (*216*);
- use alcohol-based hand sanitizers when the water supply or electricity is disrupted (*296*);
- prepare medical algorithms for discharging patients who can go home (*295*);
- create "fast-track" triage for patients with minor injuries or non-acute medical complaints (*216*);
- write succinct patient notes by hand and tape them to patients' chests if communication systems are disrupted (*291*);

[10] CD4 cells are part of the human immune system. CD4 count is used as an indicator to decide about treatment for HIV patients. Roughly, lower CD4 counts imply a weaker immune system and a likelier need for treatment.



- prepare for changes in outpatient populations if the flooding has caused population displacement (*290*);
- plan possible displacement of patients (*289*);
- prepare lists of patients in different health districts who might be affected (*289*);
- place large orders for hospital pharmacies, if there is time (*295*);
- ensure adequate supplies in several places or in areas at lower risk (*289*);
- bring forward or postpone elective surgical procedures (*295*);
- give patients supplies of medication (*289*);
- give patients the telephone numbers of other health facilities (*289*);
- obtain complete contact details of patients and close relatives (*289*);
- make sure that patient records can be shared among health facilities (*289*);
- anticipate temporary morgues, as hospital morgues may fill up sooner than expected (*216*); and
- set up a decontamination area or ensure that an existing one is operational (*287*).

Mobile field hospitals can provide back-up during incidents with mass casualties. These were used in 2002 during floods in the Czech Republic. They should be kept under civilian command and tested in emergency drills (*203*). Emergency equipment should be placed at a relatively high level in hospitals and other infrastructure (*203*); for instance, portable generators should be moved to upper floors. Sanitation, water and fuel supply systems should be part of any disaster plan (*216*); the fuel storage capacity and battery supply of hospitals should be checked and plans made for waste disposal (*203*). Enough liquid nitrogen should be stored to maintain critical cell lines and cultures (*200*). "Ham" (citizens' bands) radios and walkie-talkies should be available. The plan should include extensive cleaning after the flood (*297*).

As climate change is expected to increase the frequency and intensity of extreme weather events, adaptation in the health sector should address the resilience of health systems. Box 5 gives an example from a WHO European Region project to increase adaptation planning to protect health from extreme weather events in relation to climate change in seven Member States.

Box 5. Case study: Protecting health from climate change: a seven-country initiative

Climate change can increase the frequency and severity of extreme weather events, exacerbate health inequalities and place additional stress on the poor. In recognition of such threats to public health security, the WHO Regional Office for Europe started a 2-year project in 2008, funded by the International Climate Initiative of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. The aim of the project is to take action against the health effects of climate change, including floods, in Albania, Kazakhstan, Kyrgyzstan, the Russian Federation, Tajikistan, the former Yugoslav Republic of Macedonia and Uzbekistan.

The project supports activities and pilot interventions in countries that are already experiencing climate-related problems that could have severe health effects. Some of the activities are carried out in all the countries (e.g. health adaptation plans, capacity-building and increasing public awareness of health effects and adaptation), and some are country-specific. The two examples below are in the high-mountain areas of Kyrgyzstan and Tajikistan, where glacier lake outburst floods affect population health and health services.

<table>
<tr><th colspan="2">Box 5. contd</th></tr>
<tr><th>Kyrgyzstan</th><th>Tajikistan</th></tr>
<tr><td>The problem: about 5000 land-slides, mud flows and floods threaten almost 95% of settlements close to water sources. More than 90% of lakes are in the highlands, and most are in danger of outburst each year.</td><td>The problem: Tajikistan is a landlocked country in which mountains occupy 93% and glaciers 6% of the territory. The frequency of glacier lake outburst floods and related damage has increased, and every year 600 families are forced to migrate.</td></tr>
<tr><td colspan="2">In both countries, health effects are expected from the increased frequency and intensity of extreme weather events. The projected health effects include deaths and injuries, changes in infectious and vector-borne disease patterns, changes in the ranges of water- and foodborne diseases and potential nutritional deficiencies from decreasing food yields and loss of livelihoods.</td></tr>
<tr><td>Health adaptation has been identified as a priority in Kyrgyzstan. Therefore, scientific research must be done on the health effects of climate change, and a national action plan to prevent the health effects of climate change must be prepared. A national workshop showed the research gaps in adaptation planning and identified the need for training of health professionals and raising awareness throughout the health system.

Knowledge and information on climate change and health will be provided by partners, and a national information campaign will be disseminated by Internet to promote discussion on strengthening health systems to protect people's health from climate change, especially in vulnerable groups. The outputs will include:

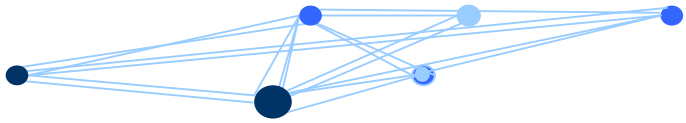
• a special edition of the national news agency magazine dedicated to climate change and health;
• on line news, articles and experts' comments on health and climate change;
• a youth web forum and online polls to debate the effects of climate change on health; and
• a public event for media and national partners.</td><td>The health care infrastructure in Tajikistan is precarious, and the heating, water supply, sewage, sanitation, electricity and communication systems in most health facilities are unsatisfactory. Any extreme event will therefore seriously affect the health system.

To address and prevent health threats, the health impact of and vulnerability and adaptation to climate change are being assessed, with a focus on the health system, as a basis for a national health adaptation strategy. Capacity is being built at national and subnational levels to improve early identification of infectious disease risk and outbreaks and contribute to improved disease surveillance.

A first workshop on preparing a health protection strategy in response to climate change defined the policy and the responsibilities of decision-makers and technical experts. Awareness-raising films, television documentaries and other activities are aimed at children and young people. Plans are being prepared for ensuring safe water in health care facilities. As small-scale supply systems are the predominant source of water, 55% of which are untreated surface water, a demonstration project on chlorination systems is being set up.</td></tr>
<tr><td colspan="2">Source: Sanders (292).</td></tr>
</table>

4.3 Tertiary measures

Protecting the health of the population during and after flooding requires cooperation and communication with all emergency response sectors. This will ensure that everyone affected is accounted for and their needs met in the most appropriate, efficient way. Implementation of disaster plans and home care after flooding in Germany in 2002 showed that emergency preparedness plans should be extended, to comprise a more comprehensive approach to emergency management involving communities, health care providers, individuals and families and also home health agencies, hospices and medical equipment companies (*73*). While the overall goal is the prevention and treatment of flood-related health outcomes, important specific aspects to address are water and food supplies, public health surveillance and monitoring in the short and medium term, gender and vulnerable groups, communications, clean-up and recovery management, as well as long-term monitoring of delayed health effects.



Key messages: tertiary prevention

- Tertiary measures include ensuring water quality, sanitation and hygiene, and food safety after the flood; health precautions during clean-up activities; protective measures against communicable diseases and chemical hazards; and measures to track and ensure mental health and well-being.
- Safe water is a key consideration during flooding events, and work is needed to ensure that adequate water supplies are available in the event of a flood.
- The specific needs of vulnerable groups should be taken into account in all phases of flood-health planning: preparedness, response and recovery.
- Field surveys and rapid needs assessments can be useful tools in tertiary prevention.

Surveillance of the health effects associated with flooding is necessary for local health service delivery during floods and for improving the epidemiological evidence base. Surveillance strategies should incorporate delayed outcomes like long-term mental health problems.

The objectives of public health before, during and after a disaster are (*53*) to:

- assess the needs of the affected population,
- match available resources to those needs,
- prevent exacerbation of adverse effects,
- protect the population from further health effects by implementing disease control strategies where appropriate and well defined,
- monitor and evaluate the effectiveness of emergency health plans and activities and
- improve contingency planning from the experience gained.

For these purposes, good disaster management must be based on accurate information about the population before, during and, when possible, after the disaster, and the data must be analysed to allow accurate, rapid decisions. Table 20 lists the role of different actors during flooding response. The causes of death, injury and illnesses must be known in order to determine the quantities of relief supplies, equipment and personnel needed.

Table 20. Roles of emergency sectors during flooding

Sector	Role
Military	A civil–military partnership (*287*) is usually the only force capable of functioning when all infrastructure is down. The military can ensure power, communication, food, water, medical assistance, transport, shelter and protective gear. A lead organization is needed to coordinate health, military and local authorities to avoid paralysis of action (*200*).
Fire brigade	Search and rescue and during recovery
Occupational health	The knowledge and skills of occupational health nurses should be used in preparing and testing a disaster plan for coping with unanticipated attrition rates and recovery after the disaster (*298*).
Water organizations	Water suppliers should work closely with health authorities after a flood to ensure rapid restoration of the drinking-water supply (*269*).
Police	Search and rescue and population control

4.3.1 Ensuring clean water and food supplies

Two main areas of importance in this stage of prevention are the maintenance of food supplies and of drinking-water supplies. Flooding and sea surges can damage household food stocks and crops, disrupt distribution and cause short-term shortages, although this has not proved to be a major issue in the European Region. Short-term food distribution is often required; long-term food donations are not usually necessary *(53)*. Specific advice has been prepared for

preparing, storing and discarding food (*54, 57, 79, 93*). The maintenance of the water supply during and after floods, however, requires extensive planning because of the potential rapid spread of severe health impacts.

Clean water is crucial for minimizing health impacts during and after a flood. In much of Europe, the systems are adequate to protect water from contamination, although the supplies may be interrupted if pumping stations or other infrastructure is affected. In general, each person needs a minimum of 15–20 l of clean water for domestic needs (*53*). Adequate quantities of relatively clean water are preferable to limited amounts of high-quality water. Experience shows that it is difficult to communicate the risks associated with unclean water and the actions to mitigate them. Leaflets and home visits have been found to be the most effective (*299*), although they should be done before people have put themselves at risk.

In the United Kingdom, the HPA advises people to follow the advice of their water supply company, which has a duty to protect public health (*54*, *300*). Depending on the extent to which the water supply is affected, three possible notices can be issued (*57*): boil tap-water before drinking and food preparation; do not drink tap-water; do not use tap-water. The CDC recommends that specific advice about safe water be given by the local health department or local authorities in public announcements (*93*).

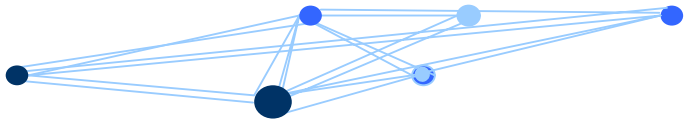
People with a private water supply should be advised to look for a change in colour, odour or smell and check whether their water source has been covered by flood-water. If they are concerned, they should assume that the water is unsafe to drink and boil it or use an alternative source (bottled or bowser), pending advice from the local authority (*57*). Bottled water should be checked to make sure it comes from a safe source; if this cannot be assured, the water should be boiled or treated before consumption (*93*). The CDC advises people to contact their local or state health department, as private water sources that have been contaminated with flood-water will have to be tested and disinfected after the flood-waters have receded (*93*).

The HPA advises flood victims not to drink water from the hot-water tap at any time (*301*) but to use boiled tap-water (*54*, *57*, *301*), bottled water, water from a bowser or treated water (*93*) until the supply is declared safe. These sources should be used for all water for drinking, food preparation (washing food, cooking, making ice), brushing teeth (*93*, *246*), washing hands and bathing (*82*), while unboiled water can be used to prepare food that will be cooked or boiled (*301*). If chemical contamination is suspected, tap-water should not be used (*93*). The HPA advises that boiling water kills pathogenic bacteria, viruses and parasites but not harmful chemicals (*54*). The CDC states that boiling is the preferred way to kill harmful bacteria and parasites, as treating water does not kill many parasitic organisms (*93*). If water cannot be boiled, disinfection is the alternative.

Water should be boiled and left to cool before use, or it can be disinfected with chlorine or iodine tablets or with unscented household bleach. A flocculent disinfectant product for household water treatment was distributed after tropical storm Jeanne in Haiti in 2004. In three intervention trials, it resulted in a significant reduction in diarrhoeal illness when the product and information were distributed quickly and effectively (*301*).

If there is no mains water, toilets should be flushed only for disposal of solid waste, with water saved from other sources, e.g. from washing and cleaning. If toilets are blocked, people should use an alternative; portable or chemical toilets may be set up, or disposable toilets may be distributed (*54*, *301*).

The United Kingdom Food Standards Agency recommends that when mains water is not suitable for consumption, infants who are not breastfed should be given ready-made formula or formula prepared with boiled or bowser water. If only bottled water is available, it should



be safe for infants if it is provided by a water company, which should comply with all drinking-water standards. If privately sourced water is used, the brand chosen should have a sodium content of < 200 mg/l. If only bottled water with a sodium content > 200 mg/l is available, it should be used for as short a time as possible. Formula prepared with bottled water should be used immediately (*57*, *301*). The CDC recommends use of ready-to-feed formula. If this is not available, formula should be made, in order of preference, with bottled > boiled > treated water (*93*).

After a flood, when the mains supply has returned, water should be run for a few minutes to clear the water pipes before the taps are used, and taps should be cleaned with hot water and detergent (*54*, *57*). Authorities and private water companies must protect and maintain the water supply and sanitation networks during and after flooding, providing an alternative supply as needed (*302*).

The roles and responsibilities regarding the maintenance of a safe water supply during and after a flood should be reflected in the relevant emergency plans. Table 21 lists the actions taken for provision of water in Hungary's emergency plan, as reported in the response to the questionnaire sent to Member States.

Table 21. Actions for provision of water in Hungary's emergency plan

Action	Time	Responsible body
Control of drinking-water supply and sewage water system Control of drinking-water quality, increased chlorination in case of risk for pollution When necessary, temporary supplies of drinking-water ordered from other sources (e.g. water tankers)	During flood	Public health service, water works
When necessary, temporary supplies of drinking-water ordered from other sources (e.g. water tankers)	During flood	Public health service, municipality
Control and order sterilization of water works and water pipes, individual wells, public places	After flood	Public health service

Overall, a number of actions can be taken to increase resilience and response to water shortages related to flooding.

Emergency planning

- Establish the roles of each organization, agency, individual, voluntary group or team that will respond in a crisis.
- Provide training and practical exercises in water delivery, to identify potential problems before an event.
- Involve water companies in emergency plans.
- Allow communities to advise on plans, to strengthen relations and build trust.
- Consider the indirect public health effects of having many tankers on roads.

Response

- In the absence of a mains supply, water should initially be provided by a combination of bottled water and tankers.
- The minimum quantity of water provided should be 15–20 l per person per day for drinking and essential hygiene. After 5 days, a volume of 20 l is recommended.

- In the absence of national standards for the quality of alternative water supplies, the Sphere Project guidelines (*279*) should be followed.
- Water from tanks must be boiled to avoid secondary contamination.
- Tankers should be supervised where possible to avoid vandalism, ensure filling and allow for dissemination of health advice and information in person.
- Mutual aid schemes should be prepared for regional sharing of equipment.
- Military involvement might be considered to assist mobilization and ensure secure distribution of supplies where necessary, although due consideration to the criteria for their deployment must be given as per national protocols.
- Involvement of the voluntary sector is important. This should be addressed in planning and be well coordinated during the event to avoid confusion and gaps in provision.
- It should be possible to activate responses remotely, and they should not depend on access of the emergency team to buildings or roads that may be cut off by flooding.

Communication of advice

- Communication should be diverse in delivery but consistent in content.
- Advice must be easy to access and understand and be given in various languages. It should be prepared early and be ready for immediate dissemination.
- One designated agency should lead the delivery of advice when possible.
- The advice should include the health reasons why consumers are being asked to perform actions such as boiling water and information on avoiding burns and CO poisoning.
- The volume of advice being delivered should be controlled to avoid overloading the public with too many messages at once.

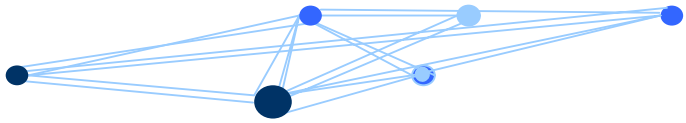
4.3.2 Surveillance and monitoring

Surveillance is the systematic collection, analysis, interpretation and dissemination of information for public health. As floods significantly affect public health, robust surveillance is important during and after flooding to identify and control infectious disease outbreaks and other health issues rapidly (*89*), to guide local and regional health service delivery and to add information about possible associations between floods and ill health (*303*). Surveillance during floods therefore acts as an early warning system for infectious disease outbreaks. It also provides information for identifying known and previously unknown noninfectious health hazards, and ensures that health services address the needs of the population and of vulnerable groups.

Morbidity and mortality

An attempt should be made to collect accurate numbers of cases of specific illnesses and to calculate rates (*304*). Timeliness is fundamental to surveillance. The level of data accuracy depends on local, regional or national circumstances; however, the system must be stable enough to allow the observation of trends, to prompt public health action (*303*).

Routine surveillance systems could be used or enhanced if available and of sufficient quality (see Box 6). An example is the routine primary care surveillance systems in England, which have been recommended for flood surveillance in the country (*303*, *305*). Various routine



surveillance systems could be combined and augmented by ad-hoc surveys to provide a more detailed overview (*306*). Routine data sources are, however, prone to underascertainment of minor illnesses and injuries (*303*). Conversely, after a disaster, these systems may result in higher numbers because of enhanced surveillance (ascertainment bias) (*5*).

In many situations, new data will have to be collected, often in the form of a health survey. A natural starting point would be the rapid health assessment recommended in the WHO guidelines for emergencies (*307*). Definitions of cases of infectious disease are available from WHO (*308*) and the CDC (*309*). Generic assessment tools and tally sheets have been devised for other disaster circumstances, which could be adapted for floods (*310*, *311*). It may be difficult but worthwhile to attempt establishing causality, e.g. between illness and floods, and questions have been suggested (*312*).

Timely collection, collation and analysis of surveillance data are essential for public health action. Free data collection and analysis tools are available online for this purpose (*313*, *314*). The difficulties of accurate surveillance in floods and other natural disasters have been well described (*89*). The data collected should be as accurate as possible, but in practice this depends on local capacity and infrastructure and the availability of routine data. In many situations, it is difficult to obtain accurate denominators (as people may be displaced) and numerators (which depend on health-seeking behaviour and the availability of health services). Timeliness and trends over time are probably more important, as excess rates are the most likely to trigger a public health response (*303*).

The data obtained by surveillance may represent only a small proportion of the actual health impact, as not everyone seeks medical advice, not all incidents are reported, and in many cases a health effect is not be linked to a flood event, especially after a lapse of time (*5*). There are therefore few data on the indirect effects of flooding on mortality and health. There are few obvious or easy methods for monitoring the incidence of common mental health disorders after a flood. Public health workers might have to work with primary care personnel or set up a special monitoring programme. Pre-existing severe mental illness (such as schizophrenia or dementia) may become symptomatically worse after a flood, and such patients may require more support.

Accurate information about health service capacity is necessary at the beginning of a disaster response. The available health care facilities may have been flooded or destroyed or lack staff, who might themselves have been affected by the disaster (*312*). Baseline values should be established for all health indicators, from routine data if they are available and of sufficient quality or from previous health surveys.

The size and scope of the public health emergency should be established, with at least daily reporting in the initial stages (*303*). The frequency could be reduced during the recovery phase to weekly, depending on the circumstances. The length of enhanced flood surveillance will also depend on circumstances. A representative, multiagency group should be set up as soon as practicable to agree on the scope of the surveillance system, data collection and the use of baseline or routine data. The group could also agree on the frequency and length of surveillance.

After a flood, a risk assessment should be conducted to determine the priorities for surveillance (*78*), although it may be difficult to obtain the necessary information, and surveillance systems may be destroyed or weakened by the disaster. Furthermore, population displacement will distort census information, as tracking people through evacuation and relocation is very difficult, and pre-disaster baseline data may no longer be available. The difficulty of coordinating health services provided by various national and international organizations in a disaster should be considered.

Box 6. Practical examples of surveillance systems: case study from the United Kingdom

In the United Kingdom, a combination of syndromic surveillance systems is used to monitor the emergence and spread of common infectious diseases in the community in real time. These systems are also used for surveillance in national incidents that could affect community health, including extreme events such as flooding and chemical and radiological emergencies. An HPA "real-time syndromic surveillance team" issues routine surveillance bulletins throughout the year. The systems are based on data already collected for other purposes and monitor symptoms rather than laboratory-confirmed diagnoses of disease, thus providing information at an earlier stage of illness (before diagnosis) so that timely action can be taken. Syndromic surveillance systems were found to be invaluable in providing advice on the health impacts of the extensive floods in England in 2007.

The three main systems are the HPA/National Health Service Direct Syndromic Surveillance System, the HPA/QSurveillance® national surveillance system and the Royal College of General Practitioners Weekly Returns Service. The Direct Syndromic Surveillance System is based on telephone calls about symptoms received daily from members of the public at National Health Service Direct, where the presenting symptoms are assessed and advice is given to the patient about further medical attention. The call outcomes are also recorded, with a breakdown of the advice provided to each patient. Any increase in the number of calls for a symptom or region is investigated.

The HPA/QSurveillance® system is based on data from general practices, coordinated by the HPA in collaboration with the University of Nottingham and EMIS (a supplier of general practitioner software in the United Kingdom). The system collects anonymous data on a range of clinical indicators, and the database is one of the largest of its kind, with data from over 3400 practices covering a population of over 23 million (representing almost 38% of the United Kingdom population). Data are collected weekly as cases (consultations), denominator populations and incident rates per 100 000 patients. In the event of a major national incident, data can be collected daily to improve the timeliness of surveillance.

The Royal College of General Practitioners weekly returns service has reported general practitioner-based morbidity data continually for over 40 years. This surveillance system is based on a network of 100 practices in England and Wales (approximately 500 general practitioners) covering a total patient population in excess of 900 000. Data are reported and analysed twice a week.

Source: HPA *(303)*.

The health effects for which surveillance is required are listed in Table 22.

Table 22. Health conditions to be covered by surveillance

Health effect	Description	Examples
Mortality	Deaths due directly to the flood	Drowning, hypothermia
	Deaths due to unsafe or unhealthy conditions, such as loss or disruption of usual services, personal loss and disruption (*64*, *312*, *315*)	Death from myocardial infarction because the person could not be attended to soon enough, although causality can be difficult to establish
Infectious disease	Local and regional disease patterns determine the types of illnesses to be monitored.	Gastrointestinal disease and food poisoning, including cholera (*148*, *316–319*) Rodent-borne diseases, such as leptospirosis (*320–322*) Vector-borne diseases, such as malaria (*323*) Respiratory illnesses (*303*, *304*)
Injuries and accidents (*148*, *303*)	Depend on type of flooding and local hazards. Often, accidents can be prevented, e.g. by messages to warn people about driving through floods or correct use of generators.	Drowning, electrocution, sprains or strains, lacerations, CO poisoning from use of generators, exposure to chemicals, animal bites or stings

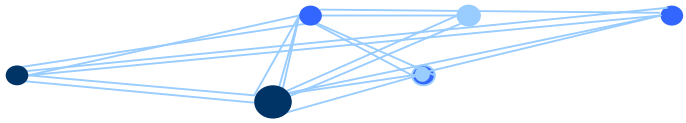


Table 22. contd

Health effect	Description	Examples
Mental health (*148*)	Often due to shock or loss of loved ones, pets or belongings; disruption, recovery and concern about future flooding	Depression, anxiety, stress, adjustment disorders, post-traumatic stress disorder
Other diseases and conditions	WHO recommends monitoring for other diseases, conditions and situations (*304*).	Measles and acute neurological diseases, nutritional stress, tuberculosis, HIV/AIDS, sexually transmitted infections, sexual and non-sexual assault, neonatal tetanus, infant and maternal mortality (*304*), health effects due to lack of water or electricity

Population at risk and vulnerable groups

The size of the affected population and their health needs should be defined as precisely as possible, and care should be taken to count the numbers of persons who migrate in and out of the area and those who are displaced (*304*). This information is necessary in order to coordinate an effective emergency plan fully and to determine any extra health needs imposed by the flood (*324*). Census information may be available but is often out of date or difficult to interpret. A rapid field survey may be necessary to obtain an indication of the population, vulnerable groups and health problems.

The recovery phase has not yet been fully addressed in research on flooding and health, although its management can significantly affect the latter, specifically mental health issues. Whittle et al. (*154*) concluded that vulnerability is "a dynamic process that is related to the ways in which the recovery process is managed." More research is needed on the effects of flood recovery on vulnerability and how they may change its dynamics and boundaries. Although insurance payments can reduce some of the vulnerability and financial stress after flooding, making insurance claims during recovery has been cited as a key stressor. One study in the United Kingdom showed that this was the most significant impact of floods, followed by dealing with building repairs and refurbishment contractors (*149*).

Classically, four populations are classified as vulnerable (*325*): infants, pregnant women, children and the elderly. Other groups that may also be considered vulnerable include people with existing morbid conditions, minority and migrant populations, displaced populations, people of low socioeconomic status and those with particular types of exposure, such to chemical contamination. (See also section 4.2.1.)

Surveillance in other settings

Floods can lead to migration and displacement, sometimes to temporary accommodation, such as emergency shelters. Therefore, settings such as emergency departments and shelters should be included in surveillance during floods (*326*), with more traditional settings such as primary care centres. Surveillance in shelters may require different methods from those used in established hospitals, clinics and emergency departments, as the staff of shelters may be less experienced in collecting and handling data. Guidance may be useful, and a telephone-based system such as a disease notification "hotline" might be suitable for these settings (*327*).

Collaboration and communication

Successful management and surveillance of the effects of floods depend on the collaboration of multiple agencies. It is recommended that the main stakeholders agree beforehand on the

scope, frequency and length of surveillance as part of their flood response plan.

It is an essential role of any surveillance system to communicate findings to all stakeholders and staff. Depending on the situation, this can be challenging.

Responses to the questionnaire

The responses to the questionnaire to Member States are shown in Table 23. The anticipated health problems were covered by coordinated surveillance among countries, and no one country collected data on infectious diseases, injuries and hospitalizations. Not all countries described the system used. Of particular interest is the information on the numbers of people evacuated in Ukraine, as it is notoriously difficult to follow people through evacuation and relocation. Data on infectious diseases were collected in only two countries, which might reflect the baseline level of surveillance in non-emergency situations.

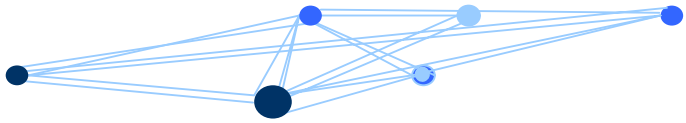
Table 23. Type of data on health effects and method of collection in the questionnaire survey of Member States

Health effect	Method of data collection	Lag time	Country
Infectious disease	General practitioners and emergency departments, weekly	1 week	Albania
	Epidemiological surveillance		United Kingdom
		2–3 days	Tajikistan
		1 day	Ukraine
Injury in flooded area	Ministry of Emergency Situations	< 1 day	Azerbaijan Republic of Moldova Ukraine
Hospital admissions	Hospital database	< 1 day	Azerbaijan Republic of Moldova Slovenia the former Yugoslav Republic of Macedonia Ukraine
Surge capacity at medical facilities		2–3 h	Republic of Moldova
Help-line calls		1 day	Slovenia
Number evacuated		1 day	Ukraine
Resources and medical personnel		1 day	Ukraine

Field surveys and needs assessments

For good disaster management, local capacity for rapid data collection must be established, with a reliable, local reporting mechanism (*324*). Rapid field surveys have been carried out in floods (*324*, *328*, *329*), and tools are available online (*310*). A rapid assessment of community needs, including a field survey, was conducted during Hurricane Katrina and was used by policy-makers to determine priorities in the severely affected area of Mississippi (*330*). The survey identified vulnerable populations, such as people with medical and mental health conditions and those with no health insurance. The estimates were used to calculate how many staff were required for health care facilities and even the police force.

The "seniors without families team" (SWiFT) tool (Table 24) is a 13-item questionnaire for rapid needs assessment, designed to facilitate the triage of vulnerable adults with medical and



mental health, financial and/or social needs. It was pilot-tested on 228 evacuees aged ≥ 65 years during Hurricane Katrina but requires further testing and validation before more widespread adoption (*328*).

Table 24. "Seniors without families team" (SWiFT) tool for rapid assessment of needs before a disaster

Level	Indicators	Recommended action
1 Health or mental health priority	Exhibits cognitive impairment; impairment in at least one activity of daily living (eating, bathing, toileting, walking, continence) and/or has one or more serious, untreated medical condition	Evacuate early, depending on circumstances. If possible, keep with a family member, companion or care-giver. Give assistance in collecting all devices, such as glasses, walkers, hearing aids, list of medicines, names of doctor(s), family telephone numbers and important papers.
2 Case management needs	Difficulty in managing finances and social benefits and assessing resources	Give assistance, if necessary, in collecting all devices, such as glasses, walkers, hearing aids, list of medicines, names of doctor(s), family telephone numbers and important papers.
3 Needs only to be linked with family or friends	Needs to maintain contact with family or care providers	Make sure that all devices, such as glasses, walkers, hearing aids, list of medicines, names of doctor(s), family telephone numbers and important papers are together and accessible.

Source: Dyer et al. (*328*).

Other data collection and tally sheets are available, depending on the type of data required. Annexes 3 and 4 give examples from WHO and the CDC.

Communication tools

Local capacity-building for rapid data collection and establishing reliable local reporting mechanisms were fundamental to surveillance during Hurricane Katrina. An Internet-based information forum, "Daily Dashboard", was set up by the CDC for communication between local field teams and decision-makers at the CDC offices in Atlanta, Georgia, and Washington DC, allowing rapid exchange of data and other practical information. This tool could also be used for exchanging public health and recovery information and to communicate with users to determine which data are the most useful (*324*).

A syndromic disease reporting telephone hotline for temporary shelters was set up during Hurricane Katrina, which was free. It resulted in timely surveillance data to prevent outbreaks, provided education and guidance to non-medically trained shelter staff about infectious disease risks and a rapid feedback service. Hotline staff can investigate disease outbreak patterns, give advice on optimal patient care and help local medical staff in evaluating ill evacuees. This allows immediate reporting, analysis and response to the threat of disease outbreak. It is a much more rapid system than paper-based data collection and allows immediate feedback for shelter staff (*327*).

Cookson et al. (*331*) demonstrated the effectiveness of Internet-based surveillance systems for morbidity and mortality among evacuees in shelters after Hurricane Katrina. Their study showed that use of such a system simplified rapid, systematic collection, analysis and interpretation of surveillance data from shelters, hospitals and medical examiners and coroners.

The American Red Cross established a system in which each shelter was visited by a team of physicians and public health professionals to make an initial assessment, to put tools in place and train staff. Posters in different styles were put up to list the symptoms that should be reported to the hotline, so that both staff and patients would understand them (*327*).

Fig. 8 shows examples of posters listing symptoms reportable to the surveillance hotline and notifiable to shelter staff.

Fig. 8. Examples of health notices

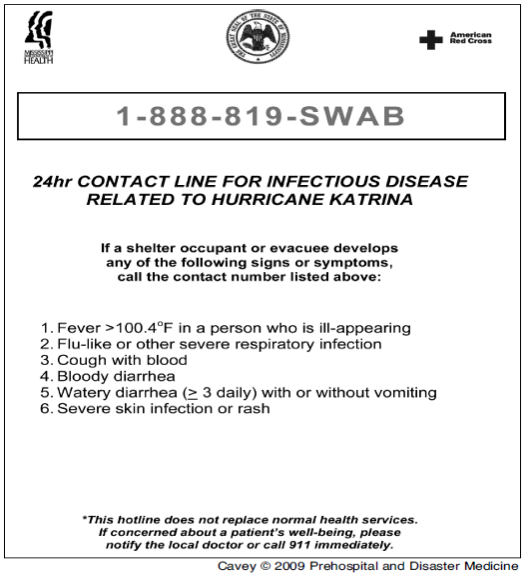


Figure 1—Poster listing symptoms reportable to the surveillance hotline

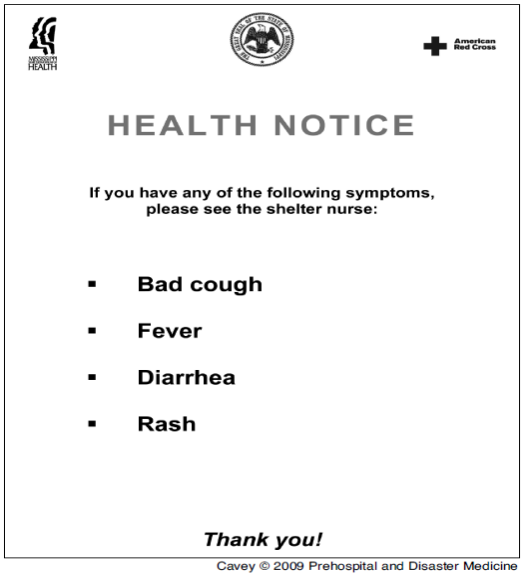


Figure 2—Public poster of symptoms notifiable to shelter staff

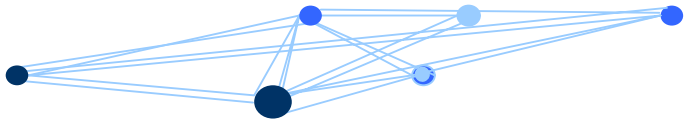
Post-disaster surveillance system to assess impact

Understanding the state of preparedness of the population for a disaster, their concerns and how they respond can make emergency plans more effective before the next event. Bailey, Glover and Huang (*332*) reported the findings of a survey of behavioural risk factor surveillance in Florida, United States, to assess the impact of four hurricanes on State residents. The results showed that nearly half (48.7%) the residents had had no evacuation plan before a hurricane. The main concerns associated with hurricanes were cited as drinking-water quality (50.9%), sewage disposal (13.2%) and food protection (11.8%). In 17.5% of homes, generators had been used after power outages, and 4.6% had been used inside a home or garage. Unexpectedly, residents of counties that had not been in the direct path of any of the hurricanes had health effects similar to those of people who lived in the direct paths. People living in counties in the hurricane paths were more likely (12.7%) to report difficulty in accessing essential medical equipment than people in other counties (1.9%). In terms of emotional and mental health, 10.7% reported nervousness, worry or anxiety because of the hurricanes, 6% said they felt sad, had lost their appetite or had difficulty in sleeping, and 3.9% reported poorer mental ability to work or study. The authors recommended that preparedness planning include both residents in the direct paths of hurricanes as well as others.

An ”editorial note” by the CDC (*91*) after publication of the survey suggested that the behavioural survey tool used for rapid assessment of the effects of hurricanes on the lives of residents and on public health was useful if implemented in a timely manner. Hurricane preparedness plans now include educating residents about the danger of CO poisoning, planning for mosquito control and a family preparedness guide.

4.3.3 Prevention and treatment of health effects

Health effects of floods can occur during the event, as well as in the clean-up phase and in the long term, so public health prevention must consistently address all stages and consider all relevant latency periods. Since the treatment of specific health effects is largely beyond the scope of this report, only occasional opportune references are made to the topic. Table 25



summarizes the main general public health advice regarding prevention of health outcomes related to flooding. Infections and mental health are addressed in separate subsections.

Table 25. General prevention of health effects of flooding

Health effect	Advice
Risk to life, or death	Information and warnings should be disseminated about the risks for drowning and deaths due to other causes, such as injuries and carbon monoxide poisoning (*9*). People should avoid walking or driving through flood-water (*60*), as those in vehicles are at greatest risk for drowning (*55*, *56*). People who have to drive should heed warnings and avoid driving into water of unknown depth (*56*). They should wear life jackets or flotation devices if near water (*55*, *56*) and keep children away from flood-water (*60*). They should not enter unstable buildings (*55*).
Injury	Injury and accidents can be prevented by avoiding contact with flood-water that is flowing fast, of unknown depth or contains concealed hazards and sharp objects. Personal protective equipment should be worn during contact with flood-water. The CDC recommends that people working in flood areas wear hard hats, goggles or safety glasses, heavy work gloves, watertight boots with steel toe and insole (not just steel shank) and hearing protection (depending on the equipment being used) (*333*). During clean-up, people should wear rubber boots, rubber gloves and goggles (*57*, *77*, *334*). If they are cleaning or if splashing is likely, they should also wear an apron and goggles or a face mask. After contact with contaminated water, they should take a bath or shower and clean wounds and clothes and possessions (*94*).
Wounds	People with wounds should avoid contact with flood-water and keep the wounds clean and covered with waterproof plasters (*68*, *335*). They should seek medical advice if there are signs of infection (*79*). *Vibrio vulnificus* should be considered in the differential diagnosis, and samples of wounds of people exposed to contaminated seawater should be cultured. If *V. vulnificus* is present, the wounds should be treated promptly with antibiotics, before the onset of septic shock (*95*).
Infection	Contact with flood-water should be generally avoided; specific measures are as follows (*94*). • Leave the affected area. • Avoid swallowing water. • Drink bottled > boiled > treated water. • Wash hands appropriately after clean-up. • Wear personal protective equipment for clean-up. • Disinfect or discard contaminated household items, including toys. • Keep cuts clean, wash after contact, and use antibiotic ointment. • Wash all contaminated clothes separately in hot water with detergent. • Avoid putting contact lenses into water, boiled or otherwise treated. People should call their local health advice line or their general practitioner if they have swallowed or been in contact with contaminated water, mud or objects within the previous 10 days and develop diarrhoea, vomiting, cramps, fever or abdominal pain (*54*, *68*, *94*).
Electrocution	Electrical appliances that have been in contact with flood-water should not be used until they have been checked by an appropriately qualified electrician (*54*, *68*). The mains electricity supply should be checked by the local electricity board (*68*). People should not touch fallen power lines (*55*).
Hypothermia	General population and particularly emergency response personnel and clean-up workers should be aware of hypothermia symptoms and risks and wear adequate gear (*54*, *68*). People working in water should wear waterproof outerwear, rubber boots and insulation and take regular breaks to avoid hypothermia (*56*).
Animals and reptiles	Avoid approaching rats and other wild animals. If bitten, seek medical attention. Dead rats should be disposed of with gloves, placed in a sealed plastic bag and thrown away with household rubbish (*57*).

Table 25. contd

Health effect	Advice
Hymenoptera stings	Emergency departments should prepare for more stings and allergic reactions after flooding (*297*).
Skin irritation	Topical medication with a combination of anti-inflammatory, antibacterial and antifungal properties is the most suitable treatment for chronic irritant dermatitis with secondary bacterial colonization (*336*).

One of the most important ways to reduce the health risk from flood-water is to use good hand-washing and general hygiene procedures (*68*). Guidance for hand-washing has been published (*54*, *60*, *68*, *93*, *337*). Children and pets should be kept away from flood-contaminated grassy areas until sunlight and soil have got rid of harmful bacteria (*54*) and should be kept away from contaminated areas until clean-up is completed (*68*, *334*). All toys should be disinfected (*68*, *301*).

Businesses and people working with food should seek advice from an environmental health officer at their local authority (*54*) and consult *The industry guide to good hygiene practice* (*338*). All surfaces that come into direct contact with food should be cleaned, and all areas of flooded premises should be cleaned thoroughly, including disinfection (*54*).

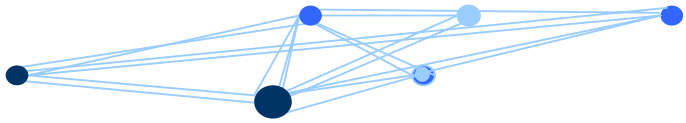
Vaccination and antibiotics

In the WHO European Region, flooding does not usually result in significant outbreaks of infectious disease; however, floods can increase transmission of diseases through contaminated drinking-water, spoilt food, greater exposure to vectors of some diseases (such as mosquitoes) or crowded living conditions (e.g. in emergency shelters). The most frequently observed routes of transmission are faecal–oral and respiratory, particularly in crowded temporary settings (*339*).

Floods can increase the transmission of various communicable diseases, including waterborne diseases such as cholera, hepatitis A, leptospirosis and typhoid fever, and vector-borne diseases (*4*, *340*). The HPA reported that flood-water, sewage and mud pose a small risk to health, and people do not need booster vaccination or antibiotics (*341*). Vaccination can give a false sense of prevention and deflect attention from more basic, effective protective measures, such as sanitation and hygiene.

In general, vaccination campaigns are not recommended during a flood or during the recovery phase; however, vaccination against vaccine-preventable diseases should be considered in the aftermath of a crisis to prevent epidemics, sporadic disease and death. Specific recommendations for vaccination should be considered on the basis of disease epidemiology and vaccination coverage in the affected population (*339*). Mass vaccination is necessary only if it is known that sanitation measures are proving ineffective and there is evidence of an increased incidence of disease. The optimum strategy is epidemiological surveillance, especially of infection rates in affected populations (*342*).

The vaccinations routinely offered by national programmes should be made available to all infants and other people as part of basic emergency health care services. Annex 5 gives WHO recommendations for routine vaccination. Exposure to flood-water itself does not increase the risk for tetanus (*343*), except for people whose vaccinations are not up to date, as there is an increased risk for injury and wounds during clean-up, which might lead to tetanus infection (*344*). Rabies vaccination is recommended only for post-exposure prophylaxis; cholera and typhoid vaccination are not recommended, as these diseases are rare in developed countries; immunocompromised people, such as people with HIV infection, pregnant women and people



receiving systemic steroids, should not receive the live virus vaccines for measles, mumps and rubella and for varicella (*343*).

When vaccination records are available, people should be vaccinated in line with the current immunization schedules. If medical records are not available, the CDC recommends the following (*343*, *345*, *346*).

- Children ≤ 10 years should be treated as if they were up to date for their age (unless there is information to the contrary, e.g. parental report) and given any doses recommended for their current age not received in the interim.
- Children and adolescents aged 11–18 years should receive the recommended vaccines (diphtheria, tetanus and pertussis; meningococcal conjugate vaccine; and influenza if indicated) if not already received.
- Adults should receive tetanus and diphtheria toxoids, pneumococcal polysaccharide vaccine and influenza vaccines if indicated.

Exceptions may be made for displaced people living in crowded shelters and those who generally live in a crowded group setting. In this case, specific vaccinations may be indicated; recommendations are available from WHO (*347*) and the CDC (*343*). The CDC advises that these populations should receive vaccines against influenza (*348*); varicella; measles, mumps and rubella; and, in some instances, hepatitis A (*338*, *343*). People who evacuated their homes under orderly conditions on the advice of local officials to a setting where sanitary conditions prevail should not require hepatitis A vaccine. Vaccination is required only if evacuees are congregated and have been evacuated from an area where exposure to hepatitis A virus was likely or they were exposed to people with suspected or proven hepatitis A (*343*). Vaccination is recommended for all children in the United States aged 12–23 months (*345*), but evacuation is not a specific indication for vaccination of previously unvaccinated children (*343*). Hepatitis A vaccine may also be considered for high-risk individuals such as public utility workers exposed to standing flood-water (*339*).

Table 26 lists recent examples of vaccination use, with advice from other sources. Emergency technicians and paramedics were trained to give vaccinations immediately after Hurricane Katrina. At a temporary health site in Louisiana, the local population was vaccinated against tetanus and certain high-risk people against hepatitis A, such as public utility workers exposed to standing water (*350*). Disaster relief volunteers were also vaccinated against tetanus and hepatitis B before going to help in Louisiana (*281*). The CDC advised that people from affected areas who were living in evacuation centres should be vaccinated, as the crowded conditions could facilitate person-to-person transmission. The vaccine was not recommended for relief or response workers, as they have previously been shown to be at low risk for hepatitis A infection. Moreover, people evacuated out of the affected areas were reported not to pose an increased risk to others of vaccine-preventable disease (*343*).

Table 26. Vaccination after flooding

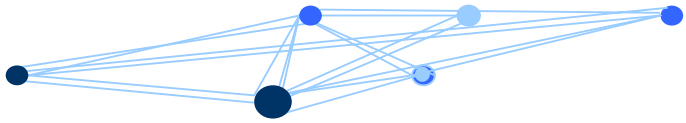
Vaccine	Reference	Action		Event	Reason
Hepatitis A	*349*	Recommendations for hepatitis A vaccination in outbreak situations depend on the epidemiology of hepatitis A in the community and the feasibility of rapidly implementing a widespread vaccination programme.	Vaccination should be supplemented by health education and improved sanitation.		Use of hepatitis A vaccine to control community-wide outbreaks has been most successful in small, self-contained communities, when vaccination is started early in the course of the outbreak and when high coverage of multiple-age cohorts is achieved.

Table 26. contd

Vaccine	Reference	Action	Event	Reason
	343	Recommended for all children in the United States aged 12–23 months		
		Evacuation is not a specific indication for vaccination of unvaccinated children.		
		Vaccination is not required when evacuation is coordinated and shelters are hygienic.	Hurricane Katrina	Hepatitis A was not usually circulating in the population before the event (0–2 cases per month).
		Vaccination is required if evacuees are congregated and come from an area where exposure is hepatitis A virus is likely.		
		Vaccination is required if shelters are crowded, to reduce the probability of an outbreak and associated health care costs.		
		Vaccination is not recommended for relief response workers.		No cases reported in the past 20 years in this population
	350	Vaccinated selected high-risk individuals, such as public utility workers exposed to standing water	Hurricane	
	89	Vaccination is generally not recommended to prevent outbreaks in the disaster area.		
Hepatitis B	*281*	Disaster relief volunteers were vaccinated.	Hurricane	
Tetanus	*343*	Recommended after any injury if vaccinations not up to date		Exposure to flood-water does not increase risk; however, the recovery process may increase the risk for injury.
	350	Local population near temporary health site vaccinated	Hurricane	
	280	Disaster relief volunteers were vaccinated.	Hurricane	
Cholera	*343*	Not recommended		Extremely rare in the United States
Typhoid	*343*	Not recommended		Extremely rare in the United States
Rabies	*343*	Recommended only for post-exposure prophylaxis		
Leptospirosis	*351*	Treated with doxycycline	Floods, Mumbai, India, 2005	
	78, 352	More research needed to determine the most effective antibiotic		

Watson, Gayer and Connolly (*89*) reported that measles and acute respiratory infections, which are =associated with crowding, were seen after tsunamis. A few cases of infection with *Neisseria meningitides*, which has been well documented after conflicts, were seen after the 2004 tsunami. Tetanus was also reported.

Leptospirosis is rare in Europe but occurred during floods in Mumbai, India, in 2005, where it was treated with doxycycline (*351*). Timely provision of antibiotics reduces pulmonary



complications, but more research is needed to determine which is the most effective antibiotic (*352*, *353*). Walking barefoot in flood-water, contact of an injury with flood-water, rats in the house and spending more than 4 days in cleaning-up are all risk factors for leptospirosis after flooding. Behavioural modification is necessary, as well as vigilant surveillance for fever before and during a flood, intensive public health messages, rodent control programmes and environmental sanitation (*354*).

4.3.4 Chemical hazards

People concerned about a major chemical or oil spill should contact emergency services, such as fire and rescue (*54*, *68*). Guidance should be given to the general public on possible chemical risks, including avoiding handling displaced gas canisters and using gloves when handling water-damaged car batteries. In general, floodwater should be assumed to be contaminated unless proven otherwise. Exposure to flood-water, residues and other hazards should be avoided when possible, for example by preventing children from playing in flood-waters. As clean-up workers and volunteers are at particular risk for exposure to chemical hazards, they should receive proper health and safety training and wear protective gear (preferably chemical-resistant), including goggles, gloves and boots. Only trained personnel with proper protective gear should be allow to handle toxic chemicals or hazardous waste.

CO poisoning after floods frequently results from inappropriate placement or use of power generators and/or gas-powered machinery. Inappropriate placement of gas-powered generators could be prevented by simple awareness-raising and advice. Legislation could be introduced to ensure that CO detectors are purchased with gas-powered generators. Clinical services should be alerted to the risk of CO poisoning, and environmental experts should agree on sampling protocols. Radio broadcasts and paper flyers warning of the dangers of generators for CO poisoning were used after Hurricane Rita (*282*) with instructions not to operate them indoors, in garages or near open doors or windows, even if residents feared that they would be stolen. Indicative safe CO levels are available (*355*); detectors should sound a warning at lower levels for people with medical conditions. The oxygen levels used to treat patients are also given, with advice that pregnant women need hyperbaric oxygen. Health facilities must know the location of their nearest hyperbaric oxygen chamber.

Buildings that have been flooded

In the event of catastrophic flooding, some buildings may be in a state of structural collapse. It is therefore important, before householders return or clean-up begins, that buildings be assessed properly for structural stability. Box 7 gives a case study of structural safety assessment after floods.

Box 7. Case study of Boscastle flood, United Kingdom

During a catastrophic flash flood in the Cornish village of Boscastle in August 2004, many buildings and structures were damaged. A key role in the emergency service response was taken by the Building Control service, a service provided by local authorities in England to ensure that buildings meet the required regulations. Local authorities have a statutory duty to ensure that all potentially dangerous structures within its area are made safe, and this function is most often provided by the Building Control service. This was one of the first services permitted access to the village immediately after the search-and-rescue operation. They identified five buildings that had to be demolished and seven that required structural propping up. The surveyors then identified potentially dangerous items, such as loose down pipes, slates and wall coverings, before the cordon was lifted to allow residents to return to their homes.

While most of the buildings were assessed as safe, they still contained safety hazards such as debris and silt, necessitating accompanying visits with the residents. As the clean-up process proceeded, the need to protect buildings from the weather and for security became apparent, as did the need to advise residents on electrical safety and to ensure that the electrical installations of flooded homes were tested and certified by a competent electrician.

Source: North Cornwall District Council Building Control Service (*373*).

In intervention studies, symptoms have been shown to be reduced after remediation of moisture damage. The symptoms and asthma-related visits for acute care of children were reported to decrease after repair of their water-damaged schools or houses (*127*, *356–359*). Both remediation and thorough cleaning of moisture-damaged buildings are necessary to normalize microbial conditions (*360*, *361*).

Opening buildings and otherwise disturbing them will release any fungal spores that are present as a result of moisture. Therefore, more fungal types and slow-growing mycobacteria have been detected during the remediation of moisture-damaged buildings than before (*362*, *363*). Use of air-filter masks might be useful during remediation to minimize the adverse health effects on building occupants and renovation workers. Decreased airborne fungal concentrations have been found after completion of remediation in homes, offices and schools (*120*, *364–366*).

When flood-waters inside buildings contained sewage or chemicals, all surfaces should be washed with hot water and detergent, bleach or disinfectant. New areas of mould can be removed with warm water and detergent, but professional attention should be sought for persistent mould (*54*). Gloves, masks and protective gear must be mandatory for recovery operations (*344*), as is hand-washing. It is essential to plan for the collection of rubbish (*367*), which may also include substantial amounts of contaminated home furnishings and belongings.

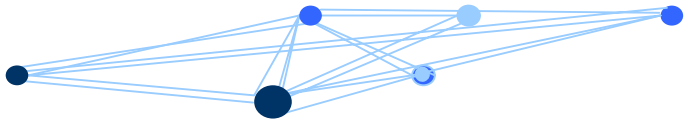
Table 27 lists various activities that can prevent adverse health effects and the authority responsible for each, from experience in Hungary reported in the survey of WHO European Region Member States.

Table 27. Activities undertaken in Hungary after flooding

Action taken	Responsible body
Control of and guidance on further use of materials (sand, building materials) used during the flood	Public health service, environment agency
Information for the public on health prevention	Public health service
Control and regulation of the collection and destruction of animal cadavers and related sterilization	Public health service, veterinary service
Identification of infectious diseases, isolation of causative agents, surveillance	Public health service
Eradication of insect and rodent vectors	Public health service, municipalities
Information on the need for and availability of chemicals for sterilization	Public health service

Detailed guidance exists in the United Kingdom on standards for the repair and restoration of buildings damaged by flooding (*183, 259, 260*). Laboratory testing by organizations such as the Construction Industry Research and Information Association produced quantitative baseline information on the behaviour of building materials and composites (floors and walls) subjected to flood conditions (*252*, *261*). The guidance provides advice on making a building safe for access, decontamination and drying after flooding. Templates and guidelines for flood risk assessment are provided, to explain which of the detailed standards for repair to use when improving the resistance and resilience of damaged buildings (*259*).

Long-lasting flooding and particular ground or geological conditions might result in flood-waters forcing up from the ground under suspended floors or through the floor. Many houses in Hull, United Kingdom, which had escaped the pluvial flooding of June 2007, became uninhabitable after groundwater flooding, which had contained itself in unseen voids beneath suspended floors or in basements (*154*). Events of the scale of the 2007 floods might cause



semi-permanent changes to the geology and hydrology of the affected areas. Changes in groundwater levels and distribution may mean that buildings designed and sited in those places will not have optimum structural stability or protection from rising groundwater.

Immediate response and recovery after a flood is usually followed by a process of "normalization" (i.e. putting things back as they were before the flood). After the major flood events of the first decade of the 2000s in the United Kingdom, however, the opportunities for improvement were investigated. Regeneration of the physical, social and economic infrastructure of flooded areas was proposed in order to transform and revitalize them. The city of Carlisle, which was flooded in 2005 to unprecedented depths, used the banner "Carlisle Renaissance" to symbolize the regeneration of the city, which includes built, social and economic interventions (*7*).

Mental health

The immediate response with regard to mental health should focus on practicalities, such as assisting with immediate personal needs or reuniting families (*199*). This is sometimes known as "psychological first aid", which concentrates on meeting each individual's crisis-related psycho-bio-social needs by listening and formulating a recovery plan. Single-session debriefing or emergency psychological counselling of people affected by flooding is not recommended. Suggestions to improve the detection of and provision of care for people with mental health problems include (*368*):

- monitoring the numbers of people treated for mental health problems in existing services (e.g. primary care);
- improving access to services;
- ensuring that services are aware of a possible increase in presentations for mental health problems and can assess them; and
- using a stepped approach to intervention, such that, if symptoms persist beyond about 4 weeks after the event, particularly if associated with functional impairment, referral to more specialized care is available.

Emergency service and hospital personnel can also be significantly psychologically affected, and they should be reminded to address their own basic needs (e.g. for rest and food) and to use colleagues for mutual support.

In the medium to longer term, disaster recovery should be extended to include long-term social re-engagement. As prior mental illness predicts mental health effects after flooding, the primary care system should concentrate on such patients after the event. The United Kingdom National Health Service advises the public that sleeplessness, anxiety, anger, hyperactivity, mild depression or lethargy are normal and may disappear with time. If people experience any of these symptoms on a long-term basis, they are advised to see their general practitioner *(68)*.

The advice to local services in previously or currently affected areas is to *(36, 369)*:

- monitor closely the number of people seeking psychosocial health care and facilitate access to the available mental health services;
- anticipate an upsurge in anxiety, particularly among children, during heavy rains, and plan for the capacity necessary to meet the demand;
- use a stepped approach to mental health; in particular, people with problems that are still present 4 weeks after the event should be assessed to identify the need for more specialized mental health care; in most cases, therapeutic interventions are likely to be concluded within 4–6 months of the event;

- include practical support for flood victims and provide appropriate psychological support in policies to promote population resilience to flooding when flood prevention has failed (*148*); and
- expand disaster recovery to include long-term social re-engagement to reduce mental health effects (*370*).

The psychological toll of a disaster on hospital and other emergency response personnel can be significant, and psychological help should be provided during the post-disaster period (*216*). Debriefing volunteers can reduce psychological harm by allowing them to share their experiences (*294*).

The Pitt review *(7)* recommended monthly summaries of progress during the recovery phase after a flood event to educate and inform decision-makers. The Government produced such briefings after the floods in Cumbria in 2009 (*371*), although they lack quantitative data and specific health information. A descriptive study of the response of the Thai Government to the 2004 tsunami showed that coordinating the response (in this case, setting up a mental health centre within the health department) and collaboration with the media were important in the mental health response to the disaster (*372)*.

4.3.5 Measures adopted by Member States

Measures related to population health

Some countries answered this question thoroughly, as reflected in the analysis below, in which many of the examples are from the same countries. Others gave less detailed responses, perhaps because the person completing the questionnaire was not fully aware of the measures. The countries that did not answer or did not know how to answer the question about population health measures were Croatia, the Czech Republic, Kyrgyzstan, Malta, Serbia and Ukraine. Examples of public health and epidemiological measures reported in the survey are shown in Table 28.

Table 28. Public health and epidemiological measures reported in the survey of Member States

Public health measures	Rapid health assessment and vulnerability assessment (Albania, Kyrgyzstan) • Danger (current and potential) • Nature of the danger • Number of people affected • Details of access to the flooded area and people in need Raise public awareness of health threats (Albania, Azerbaijan) Activate hospital plans (Azerbaijan, Georgia, Iceland, Israel, Slovenia, Tajikistan, Turkey, United Kingdom) Medical evacuation preparedness (Albania, Republic of Moldova) Survey and inventory of chemical and toxic hazards that might pollute the environment (Hungary) Survey potential exposure of people producing, storing, selling or using hazardous materials (Hungary) Check hazardous waste disposal sites (Hungary) Identify risks of stock farms, deposit of manure, canals in the area of flood inundation area (Hungary) Assess cemetery situation (Hungary) Monitor drinking-water supply and sewage water system (Albania, Hungary, Sweden, United Kingdom) Monitor drinking-water quality, increase chlorination in case of risk of pollution (Hungary, United Kingdom) When necessary, order and temporarily supply drinking-water from other sources (e.g. water tankers) (Albania, Hungary, United Kingdom) Activate surge capacity (Israel)

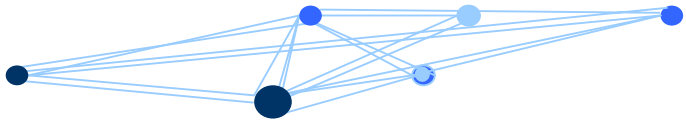


Table 28. contd

Epidemiological measures	Set up medical surveillance (Republic of Moldova) Monitor the hygienic and epidemiological situation (Hungary) Provide medical care and surveillance of settlements isolated by the flood (Hungary) Provide medical care and surveillance of evacuated populations at temporary camps (Hungary) Ensure the presence of medical staff at temporary camps (Hungary) Ensure continuous reporting of the health situation (Hungary) Increase surveillance of infectious diseases (Hungary) Evacuate and isolate people with infectious diseases (Hungary)

Control and command mechanisms

Setting up emergency groups is a common response for protecting population health during a flooding event. This is done either through a national body, such as the Civil Emergency Planning and Response Commission in the Ministry of Health in Albania, or through hospitals, which have their own guidelines although not on a population scale, as in Georgia and Turkey. Israel uses joint communication systems between first responders and health systems.

Setting up emergency centres

The Icelandic Government sets up temporary mortuaries and centres for casualties, survivors, evacuees, relatives and friends, and for the provision of food. Israel establishes information centres in charge of communicating with the public. Other countries set up evacuation and temporary health centres when necessary, as indicated when describing a recent flood; however, they are not mentioned as being part of the plan.

Delivery of public health advice

Public health advice is issued on web pages and through the media (e.g. in Iceland, Poland, Ukraine, United Kingdom). Continuous communication with general practitioners, pharmacies and ambulance services was reported by Hungary and the United Kingdom. Hungary also reported that public health officers are regularly present in flooded areas and advise the population by loudspeaker, advertisements and posters.

Guidance is given on:

- epidemics and hygiene (Republic of Moldova);
- drinking-water safety: announcements about pollution, recommendations on rebuilding the supply, limits or bans on use of well-water or piped drinking-water (Hungary, Slovenia, Sweden, United Kingdom);
- eating contaminated food (Hungary, Slovenia, United Kingdom);
- changes in consultation hours of general practitioners and health care facilities (Hungary); and
- health conditions of moving back (Hungary, United Kingdom).

Clinical guidance for protecting responders was given predominantly by Hungary, such as provision of antiseptics for rescue brigades and monitoring the use of protective clothing. Israel reinforced life-saving equipment in the flooded area from national stockpiles. The only population measure stated was provision of vaccination, again by Hungary.

The Icelandic Red Cross reinforces their telephone service for psychological support, which is active all year round. A psychosocial coordination committee is activated at national level at the beginning of a crisis, which supports activation of regional psychosocial coordination

committees if possible. In Israel, centres for the treatment of acute stress reaction were set up, while health counselling and psychological support were listed by Poland and the Republic of Moldova.

Measures to protect health infrastructure

Measures can be taken to minimize the extent and effects of flooding on health infrastructure in the first place. For example, in the former Yugoslav Republic of Macedonia, flood-prone zones are given early warnings, and in Malta the roads are controlled to keep access as clear as possible. The Republic of Moldova and Slovenia reported construction measures, such as building barriers, while Turkey and the United Kingdom do not allow hospitals to be built on flood plains.

When these preventive measures were inadequate or not present, practical, nonstructural measures were reported, such as: provision of pumps for pumping water (Republic of Moldova), equipping hospitals with back-up electricity power supply (generators) (Poland and the United Kingdom), providing an independent source of water for hospitals (Poland), placing medicine stockpiles in areas that could not be flooded (Poland) and placing radiological equipment above flood level (United Kingdom).

Public health actions after floods

Only four countries answered this question. Most of the activities were associated with the control of infectious disease. Albania reported that waterborne diseases continued to be monitored, even though post-flood health effects were not part of their plan. Hungary and the United Kingdom also maintain surveillance of infectious diseases, and the plan of the Republic of Moldova includes a series of anti-epidemic and hygiene measures (cleaning and disinfecting land and water sources and vaccination of the population if necessary).

Only one country addressed the mental health effects of flooding in this section: the national plan in Slovenia includes psychological support during and after an emergency for survivors and others affected by floods. In the United Kingdom, once the initial response is completed, the emergency services formally hand over to local authorities, which direct the return to normality, rehabilitation of the community and restoration of the environment. The main elements are rebuilding the community, managing resources, responding to community needs and identifying strategic issues.

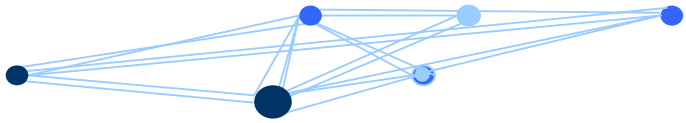
Precautions taken after a flood

In the Republic of Moldova, flood barriers were reinforced and new ones were built. Risk assessments of the current positions of health care facilities were carried out in Slovenia and Sweden, but by Government institutions other than health. In Poland, hospitals built in high-risk areas are subjected to precautionary measures and evacuation plans. Poland also stockpiles disinfectants for use in cleaning buildings, land and infrastructure.

5. Discussion and conclusions from the questionnaire survey

5.1 Discussion of results

The most practical, effective definition of a flood is one that includes an emergency response. One element of the definition must be water levels, as they are the only element for which there are definitive scales, and many countries use them. For health purposes, however, a more relevant element is the risk to the population, which is harder to define and is often subjective. The responses to the questionnaires on the human elements that activate the emergency plan were general and nonspecific.



The number of deaths reported was lower than in other natural disasters, but this does not reflect the severity of flooding. France in 2010 experienced flooding that caused 25 deaths and extensive damage. With the threat of an increased frequency of severe flooding, the death toll might remain low for individual events but will add up to larger numbers. Moreover, severe coastal floods can result in many fatalities. Various methods were used to measure mortality; immediate, direct deaths were counted, but deaths caused indirectly are difficult to attribute to a flood.

Water shortages during and after flooding were highlighted in the responses to the questionnaire. They are clearly a significant consequence of flooding that can result in serious secondary health effects. Only Hungary, Sweden and the United Kingdom gave details about mitigating or solving water shortage problems.

Mental health effects were given little attention. This is not surprising, as such effects may become evident only months after a flood, unless the onset and height of the flood were very severe. As mental health effects can be long term, they should be addressed in emergency plans, in the recovery phase and in longer-term plans.

The disruption to health facilities by flooding varied, although some suffered badly. Nevertheless, routine hospital care was maintained in many countries. The public health measures used to protect health facilities and health care were related to construction, permanent modifications and practical emergency interventions, while the section on vulnerable groups received little attention. The measures reported were risk assessment, hospital emergency plans, evacuation, increased capacity, chemical hazards and water provision, however with little or no detail. The countries that answered the question reported a comprehensive set of epidemiological surveillance measures, except for tracing people who had been displaced, which was not mentioned. The public health guidance offered was broad but not detailed enough understand how the activities were performed and how effective the measures were.

A broad list of vulnerable groups was drawn from the responses of six countries. The methods for identifying where vulnerable populations were located were based on systems already involved in the emergency. Only Hungary mentioned people with chronic diseases, although these groups can suffer greatly during a flood, especially if there are water shortages. The measures described were for their immediate care; none mentioned long-term care during the recovery period.

Generally, public health activities were poorly described, and few countries answered the questions about specific groups. This may have been because they had no measures or because the people filling in the questionnaire did not know the answers. As only four countries answered the question about public health activities after a flood, the only conclusion that can be drawn is that health is not considered in recovery from floods. Infectious disease surveillance was mentioned in three responses, and this may be the case in more countries. Given the time and amount of work that it can take to recover from flooding and the risks to health from injury, CO poisoning, disrupted water supplies and the considerable mental health problems that have been reported in the literature, this represents a large gap in the health and emergency planning response to flooding.

The degree of integration between health and emergency planning varied widely: public health fell outside the remit of the emergency plan in seven countries. The example of water shortages highlights this well, as in most countries the water sector is linked to the plan and many countries reported water shortages during and after a flood; nevertheless, public health measures and emergency planning did not appear to be coordinated.

The questionnaire did not ask about early warning systems directly; however, the existence of

such systems in Member States and the involvement of meteorological systems in the response to flooding were indicated by answers to the questions on who or what triggers an emergency plan and the alert systems. Albania, the Czech Republic, Hungary, Iceland, Sweden and the United Kingdom reported early warnings from meteorological systems, which are sent to a government civil body to act on. Literature searches and analysis showed that this important part of the emergency response to flooding is poorly linked to health and poorly applied to preparedness and response for health facilities.

Plans were commonly reported for three levels: local (city or individual health facility), regional and national; however, too few details were provided to draw any conclusions.

The lack of communication with neighbouring countries is a concern and is an important finding for the international coordination of disaster preparedness and response activities and in general for emergency planning in the WHO European Region.

5.2 Conclusions

Despite the limitations of this questionnaire survey, some tentative conclusions can be drawn.

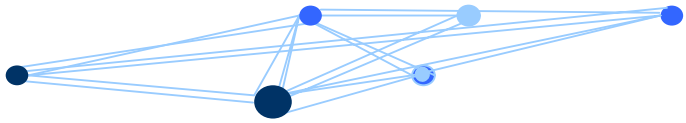
- Not all the emergency plans included health, and few of those that did had comprehensive preparedness and response systems.
- Establishing trigger points, alerts and definitions to activate an emergency plan is complex, and there is little consensus at present.
- The existence and extent of public health measures varied among countries, and few covered all the issues.
- Guidelines are needed on defining vulnerable groups, how they are affected by floods and the actions that could mitigate the effects.
- Water shortages are a significant problem during and after flooding.
- Mental health is neglected in emergency plans for flooding.
- Few monitoring and surveillance systems were reported, and tracing people through relocation and evacuation was found to be difficult.
- The recovery process and its impact on health were considered by a few countries but needs more research, as the delayed onset of some health effects and the long duration of others should be recognized in emergency plans.
- Plans were not updated after a flood event.
- The establishment of focal points in all countries would facilitate communication of heath issues nationally and internationally.

Those countries that responded to the questionnaire expressed strong support for this WHO project to obtain information on Member States' responses to natural hazards.

6. Further developments

The effects of flooding and other disasters on health can be significant and long lasting. The WHO Regional Office for Europe and the HPA collaborated to determine the health impacts of flooding, to collect "best practices" for their mitigation and prepare an evidence-based document for responding to events before, during and after flooding. Flooding has immediate health effects and also longer-term, complex, multiple effects on physical and mental health.

The questionnaire and the literature search revealed many important results, which extend



information and understanding of the effects on health of flooding and the gaps in knowledge and practice. The corroboration through the literature and member countries of the significant health impacts of floods is an important finding for the WHO Regional Office for Europe. This recognition will help to raise the priority of flooding in public health policy, especially in view of the increasing threat of flooding in the context of climate change. It is reassuring that the numbers of deaths and of cases of infectious disease and chemical poisoning have been relatively low during flood events in Europe, and few reports were made of damage to health facilities and disruption of health services. Nevertheless, there may be unreported damage and effects, as many countries in the western part of the European Region and some in the eastern part did not complete the questionnaire. This may be explained partly by the fact that this is the first survey of 50 countries and Kosovo[11] to determine the health impacts of flooding.

Among the serious, long-lasting effects of flooding on health, mental illness is of particular concern. Better preparedness and response are vital to maintain health security in times of flooding. It is important that health be embedded in the entire flooding response structure: ultimately, the actions of all the sectors considered may affect health, and the population's health will certainly affect other sectors.

Natural disasters have different effects in different countries because of economic, social and health differences. Responses must therefore be based on locally relevant evidence as well as on observed similarities in the health effects of flooding. This will result in well-informed practice in prevention and preparation, good cross-sectional planning and preparedness at all levels. Another important element for good planning and response is routine training for effective management of health and emergency relief in any disaster.

The literature review and the questionnaire survey revealed several research and intervention gaps with regard to health effects, health services and facilities, emergency plans and surveillance, monitoring and evaluation. Below are some recommendations based on the different aspects of flooding and health explored in this report.

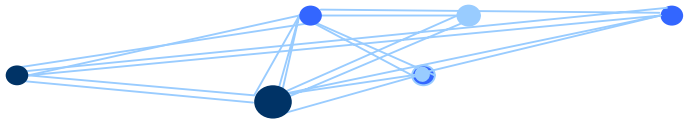
6.1 Research on the health effects of floods and on health services and facilities

- Prospective epidemiological studies and opportunistic retrospective studies should be conducted on the health effects of flooding.
- The epidemiological data on the health effects of flooding are incomplete. For future events, information should be obtained on health before, during and after floods.
- A standard reporting system of health effects should be used in each flood event, in order to build the evidence base on acute and chronic effects, from the immediate response to completion of recovery.
- Further work is needed to understand the immediate and longer-term mortality from flooding (e.g. to confirm the finding in the United Kingdom of a 50% increase in population mortality in flooded communities during the 12 subsequent months) (*64*).
- Definitions should be established of direct and indirect, immediate and delayed

[11] For the purpose of this publication all references, including in the bibliography, "Kosovo" should be understood/read as "Kosovo in accordance with Security Council resolution 1244 (1999)".

deaths due to flooding.

- Information on the causes and types of injury incurred during flooding is incomplete. Work is required to prepare for, respond to and document these injuries more completely.
- Relatively few epidemiological studies have been undertaken on populations exposed to infectious diseases after flooding. The results reported so far are reassuring, but the methods to be used for confirming the findings should be agreed upon.
- Data on chemical contamination are incomplete, and further work is required; in particular, health care providers should be alerted to the risk for CO poisoning, and environmental experts should agree on sampling protocols.
- Further research is required to determine the most effective tools and measures for investigating the mental health consequences of flood events and to plan an effective response. Few studies have addressed the long-term effects on mental health. Many different tools are used to measure mental health effects, making data interpretation complex; standardization of tools would be beneficial.
- Further research is required to understand vulnerability to flooding and to identify who is vulnerable and their health needs. While certain vulnerable groups have been recognized (e.g. dialysis patients after Hurricane Katrina), there is a paucity of data about others.
- More research is needed to understand the effects of flood resilience and recovery on vulnerability and whether they change the dynamics and boundaries of vulnerability.
- The management of chronically ill patients during a flood has received little consideration. The immediate and direct health consequences of floods for such patients should be studied further in order to identify effective strategies for their care during and after floods.
- More information is needed on the health consequences of living in damp buildings for long periods after flooding.
- More research is needed on:
    - disruption of health services and facilities during and after flooding, including the economic impact (The literature contains few accounts of disruption to health facilities and health services; most reports address disease and the health needs of affected groups, and many episodes may be unreported.);
    - how early warning alerts are communicated to hospitals and health care facilities before a flood and how they should prepare to respond; and
    - how health services and facilities actually respond to flooding (Successful strategies could be replicated elsewhere and/or serve as a basis for authoritative guidance on the matter.).
- Health facilities (including diagnostic laboratories) should have plans to manage sudden increases in patient volume.
- Health facilities should review the vulnerability of their electrical supply and equipment to flooding. Emergency generators and medical equipment should be placed above the reach of flood-waters.
- Back-up systems for the retrieval of patient records and other relevant information systems should be devised. A robust electronic patient record system could ideally be



accessed outside the principal facility, so that records are not lost if computers are destroyed or electricity is down.

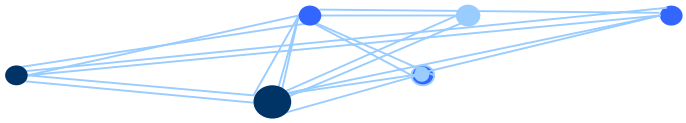
- Health authorities and providers should consider alternatives in the eventuality that ambulance fleets are temporarily disabled.
- Health care providers should design their strategies for the continuity of care in the event of flooding. Disruptions to outpatient and ambulance services can affect especially vulnerable groups (e.g. the homeless and drug addicts) and the chronically ill.
- Health care providers and nursing homes should evaluate their capacity to undertake a general evacuation before floods occur. Factors to plan for include timing, decision-making, patient and staff safety and sequence of events.

6.2 Development of flood health action plans

- The most important measure for minimizing the health impacts of floods is a wide, multisectoral all-hazards approach to emergency preparedness, translated into a plan that includes public health and health care sections.
- Emergency planning for flooding of health facilities and services is insufficient and is not always incorporated into national emergency plans. Further work is required to improve the resilience of health services and to effectively integrate health into the broader emergency management structures.
- Plans should cover ensuring water quality, sanitation and hygiene, and food safety after a flood; health precautions during clean-up activities; protective measures against communicable diseases and chemical hazards; and measures to track and ensure mental health and well-being.
- Beyond the core elements, health prevention planning for floods should be comprehensive, taking into account gender considerations, recommendations on evacuation and displacement and the protection of vulnerable groups.
- Cross-sectoral work should be promoted in flood preparedness and response. Flood–health prevention requires adequate coordination of health authorities with emergency response agencies.
- Definitions of floods and triggers for activation of plans should be agreed upon and made universal. Health planning for floods should take full advantage of existing early warning systems.
- Ensuring timely, effective communication with the population affected by floods is important for health prevention. For instance, advice on prevention of injuries, CO poisoning and other risks should be widely disseminated as soon as possible.
- The difficulties that arise from water shortages during flooding should be investigated further, and consensus should be found on the quantity, quality and delivery of water, including for vulnerable groups.

6.3 Surveillance, monitoring and evaluation

- Surveillance should be facilitated by setting up comprehensive pre-flood surveillance, monitoring and evaluation systems.
- Systems should be found for collecting accurate surveillance, monitoring and

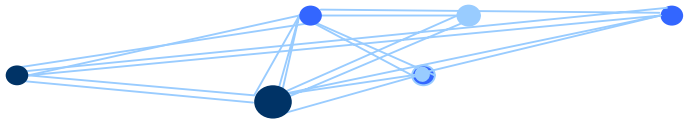


evaluation data during an emergency.

- A standard matrix is required to measure and evaluate programmes for vulnerable group in the context of disasters.
- The recording, monitoring and reporting of floods that do not initiate a national emergency plan but demand a local or regional response should be improved, as the health effects and long-term consequences can be significant.
- Systems are required to monitor and conduct surveillance of population displacement after a flood in order to understand the health hazards and risks.
- Long-term surveillance of the health effects of floods should be improved. Often, only short-term health effects of floods are considered in emergency plans; however, several outcomes (including long-term mental health problems) have a longer latency and should be monitored and acted upon in the longer term.
- An assessment tool is needed to associate health effects after a flood with the event.
- The costs to countries of the health effects of flooding (e.g. time lost from work) should be better understood in order to make decisions about the benefits of flood risk management.

6.4 Structural resilience and individual preparedness

- Adequate land use and physical infrastructure play major roles in reducing the health effects of floods. For instance, building health care facilities in a flood plain should be avoided. Physical interventions like tree planting, managed retreat, green belts, drainage, barriers and levees can help reduce exposure to and, ultimately, the outcomes of floods. Policies and legal statutes must provide the operational basis for the necessary interventions.
- Insurance can help reduce the mental stress that people experience after flooding, particularly with regard to the financial impact.
- Physical resilience of the built environment is important in the prevention of health impacts of floods in the short and long term. Various strategies can be adopted for making new buildings more resistant to flood or retrofitting buildings at risk. For settings with high flood risk, resiliency and resistance measures are highly economically worthwhile.
- The promotion of individual and household preparedness should be part of emergency planning and preparedness in flood-prone areas, within an all-hazards approach.
- Capacity-building, training, community engagement and effective communication strategies are all useful for increasing community resilience and contributing to the prevention and minimization of the health impacts of floods.



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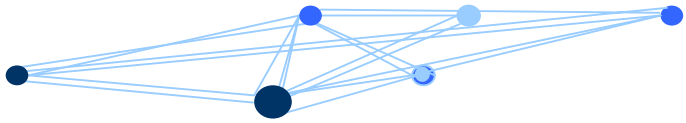

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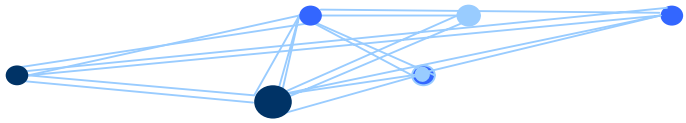

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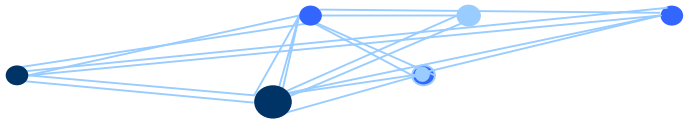

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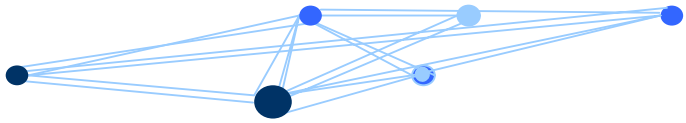

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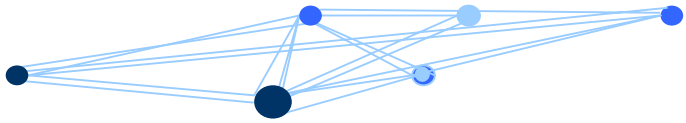

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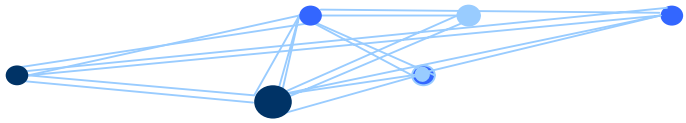

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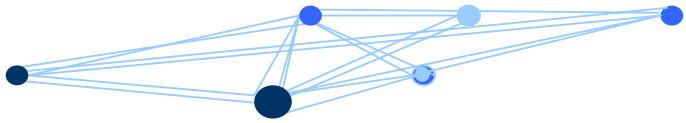

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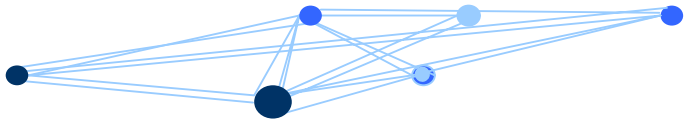

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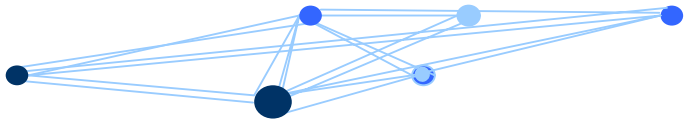

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Annex 1. Questionnaire for survey of WHO Member States in the European Region

Evidence for post-flood guidance information sheet

Improving Public Health Responses to Extreme Weather/Flood

Protecting Health from Floods

Questionnaire to assess your National Level Flooding Plans

Through this questionnaire, the WHO Regional Office for Europe is hoping to collect information from European countries and States about emergency plans and more particularly within those, plans related to flood incidents; supported by the United Kingdom Health Protection Agency in an advisory and research capacity. The WHO promotes an all-hazards approach to emergency preparedness, recognizing that there are common elements in the response to virtually all natural or human made disasters, be it a heat wave, drought, flood or any other crisis. We would like to hear about your generic disaster emergency plan but will also ask more specific questions related to a flood response and the experiences you have had in responding to floods. Further, the WHO Regional Office for Europe report is concentrating on the impact of flooding on health, which is little documented, so the questionnaire is designed to gather information not only about the emergency plans but the health effects of flooding as well.

Please tick and fill in the text fields electronically. If more space is needed, please add extra pages. Thank you very much!

PART I: Background information

1. Which country are you filling this questionnaire in for?

2. Does your country have a disaster or emergency preparedness plan?

Yes ☐ No ☐ Don't know ☐

3. Does it include preparedness and response to natural hazards such as heat waves, drought, extreme cold, floods and so on?

Yes ☐ No ☐ Don't know ☐

4. How would you define a flood that would be severe enough to activate your disaster emergency preparedness plan?

5. Has your country had floods that necessitated the use of an emergency plan?

Yes ☐ No ☐ Don't know ☐

If yes, when was the most recent flood emergency that involved the use of an emergency plan? (Month and year)

6. What was the (primary) cause of the flood?

Pluvial (rain) ☐ Fluvial (river) ☐ Structural failure ☐

Tidal (sea) ☐ Ice melt ☐ (Dam burst, fractured pipes) ☐

Other ☐

7. Please provide a description of the flood and send/attach if possible (news article, internal briefing…)

8. Please list the health impacts observed that were caused by flood experiences over the last five years in your country.

Disruption to routine hospital care ☐

Rise in infectious disease incidence ☐

Food shortages ☐

Safe water shortages ☐

Mental health problems ☐

Injuries ☐

Other – please explain

9. What health effects have you observed after flooding events in the last 5 years?

Injuries ☐

Safe water shortages ☐

Mental health problems ☐

Carbon monoxide poisoning ☐

Other – please explain

10. What are the recorded flood deaths in the last 5 years? If possible please include age and cause of death, and flood event.

11. Have any health facilities been affected, please specify the type (hospital, primary, secondary etc)?

12. a) Is there an emergency plan specifically for floods? ☐

b) or does the generic plan have parts designed particularly in response to floods? ☐

c) or is the generic plan adapted for use during flooding? ☐

d) Other ☐

Please describe/explain:

Please either fax or e-mail us the relevant parts to flooding or send us the weblink (+44 207 759 2889, harriet.caldin@hpa.org.uk or virginia.murray@hpa.org.uk) if it is in one of the WHO official working languages if it is available.

13. How many times in the last five years has the plan been activated in response to a flood?

PART II: Information on the plan you use in a flooding emergency

Please answer the following questions by using your plan:

a) specific flood plan ☐

b) generic plan that refers to flooding ☐

c) generic emergency plan and adapting it to a time of flooding ☐

1. When was the plan developed?

2. Who developed the plan (organization, agency…)?

3. Who is in charge of the plan now? Please give contact details if you are able to.

4. Please indicate the administrative level(s) of the plan

National ☐ Regional ☐ City ☐ Not applicable ☐

(in case of multiple answers please indicate all of them)

Please give brief details below:

For the national level:

For the regional level:

For the city level:

5. Does the plan have a legal basis?

Yes ☐ No ☐ Don't know ☐

If yes, please give details below:

6. Does an official link to the meteorological office of the country exist?

Yes ☐ No ☐ Not applicable ☐

If yes, please describe further:

7. Which sectors are linked to the plan and how?

Emergency services ☐

Water organizations ☐

Neighbouring countries ☐

Police ☐

Fire services ☐

Government organizations ☐

Other – please explain

8. Which service leads when implementing the plan (fire, police, government department, military, civil defence, ambulance)?

9. Who/what triggers the alarm that activates the plan?

10. What alert levels exist within the plan and what are the actions at each level?

11. What sectors are included in the plan? (Infrastructure: health, transport, communication; engineering solutions, chemical sites, water facilities, military, sewage systems…)

12. Does the plan address population welfare? If so, please explain how?

13. Did you use any guidelines or sources of advice during the crisis, if so which and where did you source them?

PART III: Public health actions of the plan

1. Are there any specific actions related to population health, such as giving public health advice, establishing emergency measures in hospitals? Please list them and describe:

2. Does the plan recognize specific populations (e.g. evacuees, the elderly, children, people with pre-existing health problems...)?

Yes ☐ No ☐ Don't know ☐ Not applicable ☐

If not please go to question 6

If so, how were the specific target groups defined? On the basis of what scientific or country specific evidence, for example specific water level/epidemiological evidence/specific health groups?

(Please enter brief details into the table below)

Target population	Definition	Scientific evidence

Comments:

What are the actions for the specific groups outlined in the plan? (If not applicable, please leave the table empty)

Actions	Behavioural	Medical	Health systems	Evidence

Comments:

3. How are these specific groups reached so that these activities can occur?

4. Who is responsible for implementing these actions and when?

Examples for responsible actors may be the lead agency, health care facilities, general practitioners, emergency services, care home managers, communities, media or the public. (If not applicable, please leave empty)

Action	When	Responsible actor

Comments:

5. Can you describe the flow of information between the lead agency and other groups? (Possibly add an information flow chart. If not applicable, please leave the text field empty)
6. How do you inform your target populations and what communication channels do you use? (e.g. general practitioners, pharmacies …)

   (If not applicable, please leave the table empty)

Target population	Information channel

Comments:

7. How are the media involved?

PART IV: Monitoring and evaluation of the plan

1. Which parts of the plan have been most successful from a general point of view?
2. Why and how do you think this has been the case?
3. Please describe any barriers to implementation and how you managed to overcome them. (If not applicable, please leave the table empty)

Action	Barrier	Solution

Comments:

What did you find most difficult?

4. Did you formally evaluate the effectiveness of the plan?

   Yes ☐ No ☐ Not applicable ☐

   If yes, please fill in the details in the table below:

Action or component of plan evaluated	Method of evaluation	Who evaluated	When?	What were the results?

Comments:

5. What has been shown to be most effective of the formally evaluated parts?

(If not applicable, please leave the text field empty or explain)

6. Has there been any evaluation of the short, medium and long-term activities of the plan?

(If not applicable, please leave the text field empty or explain)

7. What are the costs and what are the benefits of implementing the plan (e.g. per nation or person/year, per season, per flood in Europe) in Euro?

Has not been assessed ☐

Would it be possible to have copies of any evaluation reports that you have done?

PART V: Monitoring and evaluation of the health impacts of flooding

14. Do you use real time health data to modify your actions?

Yes ☐ No ☐ Don't know ☐ Not applicable ☐

If yes, which kind of data do you use and what is the lag time between data collection and analysis?

Type of data (e.g. mortality data, hospital admission, help line calls …)	Lag time (in days)

15. How are flood deaths reported?

16. If you have a database would we be able to access it?

17. Have any reports been done on health effects or any epidemiological investigations? Where are these reported and please could you share them with us?

Yes ☐ No ☐ Don't know ☐ Not applicable ☐

If yes, please explain further

18. Are post-flood health effects considered in the emergency plan? If so please give details

PART VI: Monitoring and evaluation of the impacts of flooding on health infrastructure in the last 5 years

1. What has been the impact on health infrastructure of flooding?

2. If health facilities were damaged how were they and when?

3. Was health care affected due to obstructed access to health facilities?

4. What were the financial costs of health facility damage?

5. What measures are foreseen in your plan to protect health infrastructure from flooding?

PART VII: Adaptations after flood event

1. Have any health facilities been built on high risk ground, such as flood-plains? If so please describe any precautionary measures

that have been taken to reduce the risk from flood damage.

2. Have you taken any flood precaution actions for either infrastructure of health as a consequence of your last big flood? What are they?

3. Has your plan changed (both during the emergency and in the aftermath)?

4. What information would you like to have from the WHO Regional Office for Europe (for example clear evidence of good practice) to help you prepare and recover from Natural Hazards?

Please add any comments that you may have.

Questionnaire filled in by:	Contact details:
	E-mail Address Telephone Organization Type of organization Health ☐ Emergency planning ☐ Government department ☐ Nongovernmental organization ☐ Other ☐

Date://

Please add other possible contacts or national agencies that are involved in flood responses

Please return the filled questionnaire to our office as an e-mail attachment to Harriet Caldin (harriet.caldin@hpa.org.uk) or by fax: +44 207 759 2889.

Thank you very much for your kind collaboration and valuable input!

Please contact the below for any query:

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Annex 2. Results of literature searches on associations between flooding, mortality, disease, exposure to chemicals and acute health effects, 2004–2010

Annex 2a. Results of literature search for studies of the association between flooding and mortality, 2004–2010

Reference no.	Location and year of flood	Study description	Main results
1	Hurricane Katrina, 2005[a]	771–1118 flood fatalities analysed by mathematical modelling and spatial mapping	One of three fatalities occurred outside flooded areas or in hospitals or shelters in flooded area. Two thirds of fatalities associated with direct physical effects of flood, mostly drowning. Mortality rates highest in areas near severe breaches (R^2 = 0.72) and areas of deep water (R^2 = 0.42)
2	Hurricane Katrina, deaths, Louisiana, 2005[a,b]	Assessment of mortality data, calculated mortality rates. Stratified analyses to compare observed with expected deaths for victim characteristics	Main causes of death: drowning (40%), injury and trauma (25%), heart conditions (11%); 49% of victims ≥ 75 years and significantly more likely to be storm victims ($P < 0.0001$). In Orleans Parish, mortality rate among blacks ≥ 18 years was 1.7–4 times higher than that among whites ≥ 18 years
3	Dong-Ting Lake area, Hunan Province, China, June–July 1998[c]	Analysis of years of potential life lost among residents affected by floods. Interviews with random households in 35 villages flooded by rivers, 68 with drainage problems and 174 with no flooding	Standard rates of years of potential life lost per 1000 in group with river flooding (89.6/1000) and with drainage problems (71.3/1000) significantly higher than in those with no flooding (65.7/1000, $P < 0.05$). Rate significantly higher for males than females in both flood and drainage problem groups. Rates of death from injury and poisoning and malignant neoplasm higher in the flood (151.4×10^{-5}, 127.3×10^{-5}) and drainage problems (143.7×10^{-5}, 105.9×10^{-5}) groups than in the no-flood group (113.4×10^{-5}, 74.8×10^{-5})

R^2, correlation coefficient

[a] Routine data (e.g. disease surveillance, hospital admissions, clinic attendance)

[b] Cross-sectional study design

[c] Cohort study design

References

1. Jonkman SN et al. Loss of life caused by the flooding of New Orleans after hurricane Katrina: analysis of the relationship between flood characteristics and mortality. *Risk Analysis*, 2009, 29:676–698.
2. Brunkard J, Namulanda G, Ratard R. Hurricane Katrina deaths, Louisiana, 2005. *Disaster Medicine and Public Health Preparedness*, 2008, 2:215–223.
3. Li X et al. Years of potential life lost in residents affected by floods in Hunan, China. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 2007, 101:299–304.

Annex 2b. Results of literature search for studies of the association between flooding and faecal-oral disease, 2004–2010

Reference no.	Location and year of flood	Study description	Main results
1	Bangladesh, 1998[a]	Number of observed cases of cholera and non-cholera diarrhoea per week compared with expected numbers during and after the flood	During flooding, the number of cholera cases was 5.9 times (CI, 5–7) higher and that of non-cholera 1.8 times higher (CI, 1.6–1.9) than expected. After flooding, cholera cases 2.1 (19–2.4) and non-cholera 1.2 (1.1–1.3) times higher. Ratio before flood also higher for cholera (1.8; 1.6–2.0), while that for non-cholera was 1.0 (1.0–1.1.).
2	Matlab, Bangladesh, 1983–2003[a]	Longitudinal analytical study of 21-year data; cluster analysis of health surveillance and geographical information system to study temporal and spatial distribution of cholera after flood protection interventions	8500 confirmed cholera cases. Two small clusters, three large clusters found. Incidence decreased both temporally and spatially after flood protection intervention
3	North Carolina, United States, after hurricane Floyd in 1999 [a]	Investigated six pathogens: *Cryptosporidium*, *Giardia lamblia*, *Toxoplasma gondii*, *Helicobacter pylori*, *Mycobacterium avium* and adenoviruses). "Difference-in-difference" estimation technique to examine change in outpatient visits by North Carolina Medicaid patients	Small, statistically significant increase in outpatient visits for *T. gondii* and adenoviruses after hurricane in severely affected areas. No relative increase for other pathogens or in moderately affected areas than in unaffected counties. Significant increase in outpatient visits for poorly identified intestinal infections in both severely and moderately affected counties as compared with unaffected counties

CI, confidence interval

[a] Routine data (e.g. disease surveillance, hospital admissions, clinic attendance)

References

1. Hashizume M et al. Factors determining vulnerability to diarrhoea during and after severe floods in Bangladesh. *Journal of Water and Health*, 2008, 6:323–332.
2. Carrel M et al. Spatio-temporal clustering of cholera: the impact of flood control in Matlab, Bangladesh, 1983–2003. *Health and Place*, 2009, 15:741–752.
3. Setzer C, Domino ME. Medicaid outpatient utilization for waterborne pathogenic illness following Hurricane Floyd. *Public Health Reports*, 2004, 119:472–478.

Annex 2c. Results of literature search for studies of the association between flooding and vector-borne disease, 2004–2010

Reference no.	Location and year of flood	Study description	Main results
1	Floods over 22 years in Yangtze River valley, China[a]	Review of retrospective clinical, epidemiological and malacological data for 1979–2000 to determine intermediate host snail dispersal patterns and acute and chronic schistosomiasis after floods	The reemerging and new snail-infested areas in flood years were on average 2.6 and 2.7 times larger than in years with normal water levels. The average number of cases of acute schistosomiaisis in flood years was 2.8 times higher than in years with no or little flooding. The density of and infection rate with *Oncomelania hupensis* decreased in the first 2 years after a flood and increased significantly in the third year. Collapse of embankments and flooding of marshlands were main drivers for dispersal of *O. hupensis*.
2	Brisbane, Australia, 1998–2001[a]	Effect of variation in environmental and vector factors on transmission of Ross River virus. Poisson time series regression analysis with monthly data on cases, climate variables, high tides and mosquito density	Increases in high tide (RR, 1.65; CI, 1.2–2.26), rainfall (RR, 1.45; 1.21–1.73), mosquito density (1.17; 1.09–1.27), density of *Culex annulirostris* (1.25; 1.13–1.37) and *Ochlerotatus vigilax* (2.39; 2.30–2.48) at a lag of 1 month statistically significantly associated with monthly increase in Ross River virus
3	Czech Republic, 2002[a]	Specimens from residents in flooded area examined serologically for mosquito-borne viruses	Antibodies detected after the 2002 flood for *Tahyna*, *Sindbis* and *Batai* viruses; activity found only for *Tahyna* virus, with one seroconversion among 150 residents

RR, relative risk; CI, confidence interval

[a] Routine data (e.g. disease surveillance, hospital admissions, clinic attendance)

References

1. Wu XH et al. Effect of floods on the transmission of schistosomiasis in the Yangtze River valley, People's Republic of China. *Parasitology International*, 2008, 57:271–276.
2. Tong S et al. Climatic, high tide and vector variables and the transmission of Ross River virus. *Internal Medicine Journal*, 2005, 35:677–680.
3. Hubalek Z et al. Mosquito-borne viruses, Czech Republic, 2002. *Emerging Infectious Diseases*, 2005, 11:116–118.

Annex 2d. Results of literature search for studies on the association between flooding and rodent-borne disease, 2004–2010

Reference no.	Location and year of flood	Study description	Main results
1	Surat City, India, 2006[a]	Population study to identify probable risk factors for leptospirosis during flooding. 62 confirmed cases, 253 age- and sex-matched people with fever and healthy controls; questionnaire interview	Factors associated with a case in multivariate model: contact of injured part with flood-water (OR, 6.69; CI, 3.05–14.64), walking barefoot (4.95; 2.22–11.06), constant presence of rats (4.95; 1.53–16.05) and spending > 4 days cleaning (2.64; 1.18–5.89)
2	Mumbai, India[b]	Longitudinal study of prevalence of leptospirosis (July, August, September of each year, 2001–2005) and evaluation of diagnostic tests	Eightfold rise in 2005 after heavy rainfall and water-logging
3	North Kerala, India, July–October 2002[a,b]	Relation between pattern of daily rainfall and incidence of leptospirosis	Three peaks of disease after heavy rainfall peaking 7–10 days previously. The patients had no direct occupational exposure to animals, but 62.9% had fissures or wounds on their feet.
4	Slum residents, Salvador, Brazil[c]	Community-based survey of 3171 slum residents to estimate the prevalence of *Leptospira* infection and identify risk factors for infection	Overall prevalence of *Leptospira* antibodies 15.4% (14–16.8). Multivariate analysis: people who lived < 20 m from an open sewer and the lowest point in the valley had a 1.42 times (CI, 1.14–1.75) increased risk; those who lived < 20 m from accumulated refuse had a 1.43 (1.04–1.88) increased risk.

OR, odds ratio; CI, confidence interval

[a] Routine data (e.g. disease surveillance, hospital admissions, clinic attendance)

[b] Cohort study design

[c] Cross-sectional study design

References

1. Bhardwaj P, Kosambiya J, Desai V. A case control study to explore the risk factors for acquisition of leptospirosis in Surat City, after flood. *Indian Journal of Medical Sciences*, 2008, 62:431–438.
2. Maskey M et al. Leptospirosis in Mumbai: post-deluge outbreak 2005. *Indian Journal of Medical Microbiology*, 2006, 24:337–338.
3. Pappachan MJ, Sheela M, Aravindan KP. Relation of rainfall pattern and epidemic leptospirosis in the Indian state of Kerala [1]. *Journal of Epidemiology and Community Health*, 2004, 58:1054.
4. Reis RB et al. Impact of environment and social gradient on *Leptospira* infection in urban slums. *PLoS Neglected Tropical Diseases*, 2008, 2:e228.

Annex 2e. Results of literature search for studies of the association between flooding and the health effects of exposure to chemicals, 2004–2010

Reference	Location and year of flood	Study description	Main results
1	Hurricane Katrina, Mississippi, 29 August–30 September 2005, after hurricane period and during same period in 2001–2004[a]	Evaluation of patterns of exposure to potentially toxic chemicals. Comparison of repeated, retrospectively collected cross-sectional samples	During 12 weeks after Katrina, the number of calls increased by 13% over previous years (n=6669); 8% increase in calls about exposure and 25% increase in calls for information. Increased calls about exposure to lamp oil (n=8; OR, 13.4; 95% CI, 2.8–63.1), gasoline (n=44; 7.3; 4.3–12.4) and carbon monoxide (n=7; 7.8; 20–30.2)

OR, odds ratio; CI, confidence interval

[a] Cross-sectional study design

Reference

1. Cox R, Amundson T, Brackin B. Evaluation of the patterns of potentially toxic exposures in Mississippi following Hurricane Katrina. *Clinical Toxicology*, 2008, 46:722–727.

Annex 2f. Results of literature search for studies on the association between flooding and acute health effects, 2004–2010

Reference no.	Location and year of flood	Study description	Main results
1	Province of Taiwan, China, typhoon Haitang, 18 July 2005[a]	Comparison of presentations for lower limb cellulitis before and after typhoon and flood: 22 patients treated for cellulitis in 2 weeks before typhoon and 43 in 2 weeks after event	RR 2.0 (95% CI, 1.4–2.6). 12 (28%) reported immersing affected limb in flood-water; before event, people had imersed limbs only in tap water. Confounders evenly distributed between groups, except for limb immersion
2	Hurricane Katrina, 2005[a,b]	Effect of a natural disaster on diabetes: exacerbation of disparities and long-term consequences Observational study of random sample of computerized medical records from adults with HbA1C measured before and after hurricane in specific health care settings	Significant increase in mean HbA1c (0.1%, P < 0.01), mean systolic blood pressure (10.5 mm Hg, P < 0.01), mean diastolic blood pressure (3.9 mm Hg, P < 0.01) and mean low-density lipoprotein (6.0 mg/dl, P < 0.01). Also a significant decrease in mean high-density lipoprotein (–2.4 mg/dl, P < 0.01), but no change in mean triglycerides
3	Hurricane Katrina, 2005[a]	Comparison of 6-monthly mortality data for renal dialysis patients 1 year before and 1 year after the hurricane	Hurricane not significantly associated with mortality among patients in affected regions of Gulf Coast (n=5031, P = 0.75; 95% CI, 0.86–1.11) or those in 40 New Orleans clinics (n=2238; P = 0.28; 95% CI, 0.74–1.09)

RR, relative risk; CI, confidence interval; HbA1C, glycosolated haemoglobin

[a] Routine data (e.g. disease surveillance, hospital admissions, clinic attendance)

[b] Cohort study design

References

1. Lin HJ, Hsu CC, Guo HR. Lower limb cellulitis after a typhoon and flood [1]. *Epidemiology*, 2007, 18:410.

2. Fonseca VA et al. Impact of a natural disaster on diabetes: exacerbation of disparities and long-term consequences. *Diabetes Care*, 2009, 32:1632–1638.

3. Kutner NG et al. Effect of Hurricane Katrina on the mortality of dialysis patients. *Kidney International*, 2009, 76:760–766.

Annex 3. WHO weekly morbidity monitoring and reporting forms

WHO weekly morbidity monitoring form (Available at: http://www.who.int/infectious-disease-news/IDdocs/whocds200317/4hsforms.pdf**)**

Governorate/Province: …… District/Area: ……

Town/Village/Settlement/Camp: ……

Health facility: …… Agency: ……

Reporting period: From Saturday ……/……/…….. To Friday ……/……/…….

Population covered: …… Under 5 population: ……

Name of reporting officer: ……..

DISEASE/SYNDROME	NEW CASES	
	Under 5 years	5 years and over
* Acute watery diarrhoea		
* Bloody diarrhoea		
* Measles		
* Meningitis – suspected		
* Acute haemorrhagic fever syndrome		
* Acute jaundice syndrome		
Upper respiratory tract infection		
Acute lower respiratory tract infection/pneumonia		
* Malaria		
* Acute flaccid paralysis (suspected poliomyelitis)		
Neonatal tetanus		
Fever of unknown origin		
* Other communicable diseases		
* Unknown disease occurring in a cluster		
Trauma/injury:		
Landmine/UXO injury		
War-related other than landmine/UXO		
Road traffic accident		
Other		
Severe malnutrition		
Mental health/stress-related problems		
Other noncommunicable diseases		
TOTAL NUMBER OF CONSULTATIONS		

* Diseases with outbreak potential – report as soon as possible to your health coordinator using outbreak alert form. See alert thresholds in "guidelines for use of health surveillance forms".

For use by data management office

Form received: __/__/__ Validated ☐ Entered ☐ Record number: _

WHO weekly reporting form (Available at: http://www.who.int/infectious-disease-news/IDdocs/whocds200317/4hsforms.pdf**)**

Governorate/Province: …… District/Area: ……..

Town/Village/Settlement/Camp: …… Health facility (Hospital/ Health centre): ……..

Reporting period: From Saturday..……/……../…….. To Friday..……/……../……

Population at the end of the week: ……. Under 5 population at the end of the week: …….

					Direct causes of death													**Underlying causes of death**					
No.	First and middle names	Family name	Sex	Age (mos/ yrs)	Bloody diarrhoea	Acute watery diarrhoea #	Measles	Meningitis- suspected	Acute haemorrhagic fever syndrome	Acute jaundice syndrome	ALRI/pneumonia	Communicable diseases (others) #	Trauma/ injury #	Noncommunicable diseases (others) #	Specify cause	Unknown	Neonatal death § (0-28 days)	Maternal death §	Malnutrition	Other (specify)	Date of death dd/mm/yy	Location of death HF= health facility C = community	Lab S= sample taken C= confirmed
1																							
2																							
3																							
4																							
5																							
6																							

§ see case definitions list **#** If this box is ticked, **also** specify cause in the "*specify cause*" column. Example, if cholera is suspected as the cause of the acute watery diarrhoea death, tick the acute watery diarrhoea column **and** write "cholera" in "*specify cause"* column. For "**Trauma/injury** deaths: "*specify cause"* column should indicate1=mine/ UXO, 2= war-related other than mine/UXO, 3=RTA (road traffic accident), or 4=other.

Annex 4. United States natural disaster morbidity surveillance tally sheet

Available at:
http://www.bt.cdc.gov/disasters/surveillance/pdf/NaturalDisasterMorbiditySurveillanceTallySheet.pdf

Natural Disaster Morbidity Surveillance Tally Sheet

For Active Surveillance with Medical Staff

Form v1.9
Rev.09/29/2009

Part I: GENERAL INFORMATION

Name of Facility:

City_____ State____
Date of Visit ____/___/_____
Reporting Period START____:_____ AM PM
Reporting Period END ____:_____ AM PM

	Tally (𝍸)	Total(#)
Patients Seen		
Workers/Volunteers		

Part II: PATIENT INFORMATION

		Tally (𝍸)	Total(#)
Race	White		
	Black		
	Hispanic		
	Asian		
	Unknown		
Gender	Male		
	Female		
Pregnant	Yes		
Age Category	< 1		
	1 to 17		
	18 to 64		
	65+		

Part III: REASON FOR VISIT (For each client, place a tick mark next to the corresponding injury or illness. A single client may have more than one condition ticked)

	Tally (𝍸)	Total(#)
TYPE OF INJURY		
Any Injury (cut, amputation, concussion, fracture, sprain, etc.)		
MECHANISM OF INJURY		
Bite/sting (all types)		
Burn (chem., fire, sun)		
Cold/heat exposure		
Electric shock		
Fall, slip, trip		
Foreign body		
Hit by or against object		
Motor vehicle crash		
Near drowning, submersion		
Poisoning – CO exposure		
Poisoning – other		
Use of Machinery, tools, or equip.		
Violence/assault		
TOTAL Mechanism of Injury		
ACUTE ILLNESS/SYMPTOMS		
Conjunctivitis/eye irritation		
Dehydration		
Dermatologic/Skin (includes *all* dermatologic/skin conditions)		
Fever (≥100°F or 37.8°C)		
Gastrointestinal (nausea, vomiting, diarrhea)		
Jaundice		
Meningitis/encephalitis		
Neurological (includes *all* neurological conditions)		
OB/GYN (includes *all* OB/GYN conditions)		
Pain (includes *all* pain symptoms/conditions)		
Respiratory (includes *all* respiratory conditions)		
Sore throat		
TOTAL Acute Illness/Symptoms		
Influenza-Like-Illness (ILI) - Fever (temperature of 100°F [37.8°C] or greater) AND a cough or a sore throat in the absence of a KNOWN cause other than influenza		

	Tally (𝍸)	Total(#)
EXACERBATION OF CHRONIC DISEASE		
Cardiovascular (hypertension, congestive heart failure)		
Diabetes		
Immunocompromised		
Neurological (seizure, stroke)		
Asthma		
COPD		
TOTAL Chronic Disease		
MENTAL HEALTH		
Agitated behavior		
Anxiety or stress		
Depressed mood		
Drug/alcohol intoxication/withdrawal		
Previous mental health diagnosis		
Psychotic symptoms (i.e. paranoia)		
Suicidal thoughts or ideation		
TOTAL Mental Health		
ROUTINE/FOLLOW-UP		
Medication refill		
Blood sugar check		
Blood pressure check		
Vaccination		
Wound care		
TOTAL Routine/Follow-up		
Other		
All "other"		
Disposition		
Discharge to self care		
Refer to other care (e.g., clinic or physician)		
Admit/refer to hospital		
Left before being seen		
Deceased		
TOTAL Disposition		

Natural disaster line listing

Available at:
http://www.bt.cdc.gov/disasters/surveillance/pdf/NaturalDisasterMorbiditySurveillanceLineList.pdf

Natural Disaster Morbidity Surveillance Line List

For use in hospital or shelter with medical staff

Form v1.9
Rev.09/29/2009

Facility Name:

City & State:

Date (mm/dd/yy):

Total Patients seen:

Report time frame (12hour clock am/pm):

PREG = Pregnancy

RACE/ETH: W=White, non-Hispanic; B=Black, non-Hispanic; H=Hispanic; A=Asian

INJURY	MVC	Motor vehicle crash
	Fall	Fall (from height or same level)
	CO	Carbon monoxide exposure
	Vio	Including assault, sexual assault, suicide attempt, & self-inflicted injury
	Other	All other injuries not listed above
ACUTE ILLNESS	Derm	Including rash, infection, & infestation (e.g., lice, scabies)
	Fever	Fever ≥100 °F or 37.8 °C
	GI	Gastrointestinal illness including nausea, vomiting, & diarrhea
	OB/GYN	Including preg check, preg complications, in labor, & other gynecologic conditions
	Pain	Including abdominal, chest, angina, earache, headache, muscle or joint, & oral/dental
	Resp	Respiratory illness including congestion, cough, shortness of breath, pneumonia (susp)
	ILI	Fever (temperature of 100 °F [37.8 °C] or greater) AND a cough or a sore throat
	Other	All other acute illnesses not listed above
CHRONIC	Card	Exacerbation of hypertension, congestive heart failure
	Diab	Exacerbation of diabetes
	Resp	Exacerbation of chronic respiratory illness including asthma & COPD
	Other	All other exacerbations of chronic diseases not listed above

MH	Mental health including agitated behavior, anxiety or stress, depressed mood, drug/alcohol intoxication or withdrawal, previous mental health diagnoses, psychotic symptoms, and/or suicidal thoughts/ideation
ROUTINE	All routine and follow-up care including medication refill, blood pressure/sugar check or assessment, wound care/dressing change, vaccination
OTHER	All other illness, injury or conditions not fitting into one of the above categories

	Age (years)				Sex		Preg	Race/Eth				INJURY					ACUTE ILLNESS								CHRONIC				MH	ROUTINE	OTHER
	<1	1-17	18-64	65+	M	F	Yes	W	B	H	A	MVC	Fall	CO	Vio	Other	Derm	Fever	GI	OB/GYN	Pain	Resp	ILI	Other	Card	Diab	Resp	Other	MH	Routine Care	Other
1																															
2																															
3																															
4																															
5																															
6																															
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15																															
16																															
17																															
18																															
19																															
20																															
	TOTAL				TOTAL		TOTAL	TOTAL				TOTAL					TOTAL								TOTAL				TOTAL	TOTAL	TOTAL

Annex 5. WHO recommendations for routine immunization

Available at:
http://www.who.int/immunization/policy/immunization_tables/en/

(updated 3 February 2012)

Table 1: Summary of WHO Position Papers - Recommendations for Routine Immunization

Antigen		Children (see Table 2 for details)		Adolescents	Adults	Considerations (see footnotes for details)
Recommendations for all						
BCG[1]		1 dose				Exceptions HIV
Hepatitis B[2]		3-4-doses (see footnote for schedule options)		3 doses (for high-risk groups if not previously immunized) (see footnote)		Birth dose Premature and low birth weight Co-administration and combination vaccine Definition high-risk
Polio[3]		3 doses, with DTP				OPV birth dose Transmission and importation risk criteria Type of vaccine
DTP[4]		3 doses	Booster (DTP) 1-6 years of age	Booster (Td) (see footnote)	Booster (Td) in early adulthood or pregnancy	Delayed/interrupted schedule Combination vaccine
Haemophilus influenzae type b[5]		3 doses, with DTP				Single dose if 12-24 months of age Delayed/interrupted schedule Co-administration and combination vaccine
Pneumococcal (Conjugate)[6]	Option 1	3 doses, with DTP				Vaccine options; Initiate before 6 months of age
	Option 2	2 doses before 6 months of age, plus booster dose at 9-15 months of age				
Rotavirus[7]		Rotarix: 2 doses with DTP RotaTeq: 3 doses with DTP				Maximum age limits for starting/completing vaccination Rotarix with DTP1 and DTP2
Measles[8]		2 doses				Combination vaccine; HIV early vaccination; Pregnancy
Rubella[9]		1 dose (see footnote)		1 dose (adolescent girls and/or child bearing aged women if not previously vaccinated; see footnote)		Achieve and sustain 80% coverage Combination vaccine and Co-administration; Pregnancy
HPV[10]				3 doses (girls)		Vaccination of males for prevention of cervical cancer is not recommended at this time

Refer to http://www.who.int/immunization/documents/positionpapers/ for most recent version of this table and position papers.

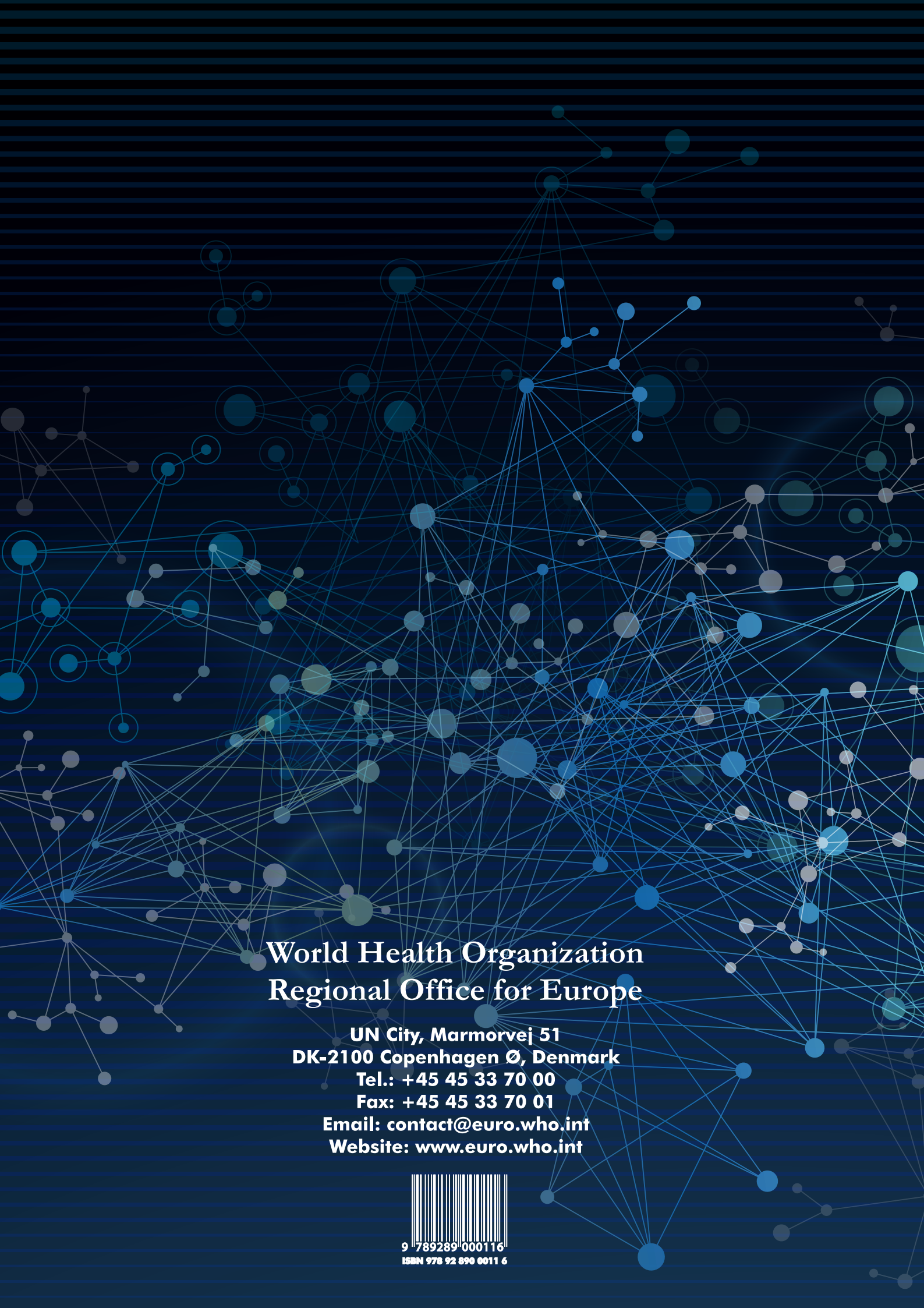
This table summarizes the WHO child vaccination recommendations. It is designed to assist the development of country specific schedules and is not intended for direct use by health care workers. Country specific schedules should be based on local epidemiologic, programmatic, resource and policy considerations.

While vaccines are universally recommended, some children may have contraindications to particular vaccines.

(updated 3 February 2012)

Table 1: Summary of WHO Position Papers - Recommendations for Routine Immunization

Antigen		Children (see Table 2 for details)	Adolescents	Adults	Considerations (see footnotes for details)
Recommendations for certain regions					
Japanese Encephalitis[11]		*Live attenuated vaccine*: 1 dose Booster after 1 year *Mouse brain-derived vaccine*: 2 doses Booster after 1 year then every 3 years	*Mouse brain-derived vaccine*: booster every 3 years up to 10-15 years of age		Vaccine options
Yellow Fever[12]		1 dose, with measles			Co-administration
Tick-Borne Encephalitis[13]		3 doses (> 1 yr FSME-Immun and Encepur; > 3 yrs TBE-Moscow and EnceVir) with at least 1 booster dose (every 3 years for TBE-Moscow and EnceVir)			Definition of high-risk Vaccine options; Timing of booster
Recommendations for some high-risk populations					
Typhoid[14]		*Vi polysaccharide vaccine*: 1 dose; *Ty21a live oral vaccine*: 3-4 doses. Booster dose 3-7 years after primary series			Definition of high-risk Vaccine options
Cholera[15]		*Dukoral (WC-rBS)*: 3 doses ≥ 2-5 yrs, booster every 6 months; 2 doses adults/children > 6 yrs, booster every 2nd year; *Shanchol & mORCVAX*: 2 doses ≥1 yrs, booster dose after 2 yrs			Minimum age Definition of high-risk
Meningococcal[16]	**MenA conjugate**	1 dose (1-29 years)			Definition of high-risk; Vaccine options
	MenC conjugate	2 doses (2-11 months) with booster 1 year after 1 dose (≥12 months)			
	Quadrivalent conjugate	2 doses (9-23 months) 1 dose (≥2 years)			
Hepatitis A[17]		2 doses			Definition of high-risk
Rabies[18]		3 doses			Definition of high-risk; Booster
Recommendations for immunization programmes with certain characteristics					
Mumps[19]		2 doses, with measles			Coverage criteria > 80% Combination vaccine
Influenza (inactivated)[20]		First vaccine use: 2 doses Revaccinate annually: 1 dose only (see footnote)	1 dose from 9 yrs of age. Revaccinate annually (see footnote)		Priority targets Definition of high-risk Lower dosage for children



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