A MICRODIS Report

Health impacts of floods in Europe

Data gaps and information needs from a spatial perspective

November 2010

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Principal investigator:
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List of Abbreviations

admin	administrative boundary
cCASHh	Climate Change and Adaptation Strategies for Human Health in Europe
CIRCE	Climate Change and Impact Research: the Mediterranean Environment
CISID	The Centralized Information System for Infectious Diseases
CRED	Center for Research on the Epidemiology of Disasters
DAFNE	Data Food Networking
DLR	German Aerospace Center
DMDB	European Detailed Mortality Database
ECHI	European Community Health Indicators
EDEN	Emerging Diseases in a changing European eNvironment
EEA	European Environment Agency
EFTA	European Free Trade Association
EM-DAT	Emergency Events Database
ENHIS	European Environment and Health Information System
EUGLOREH	The Global Report on Health in the European Union
EUHSID	European Health Surveys Information Database
FAO	Food and Agriculture Organization of the United Nations
GAUL	Global Administrative Unit Layers
GBE	The Information System of the Federal Health Monitoring
GDP	Gross Domestic Product
GHO	Global Health Observatory
GIS	geographic information system
HEN	World Health Organization Health Evidence Network
HES	Health Examination Surveys
HFA-DB	World Health Organization European Health for All Database
HIS	Health Interview Surveys
HMDB	European Hospital Morbidity Database
ICD10	International Statistical Classification of Diseases and Related Health Problems 10th Revision
IDB	European Commission European Injury Database
INTARESE	Integrated Assessment of Health Risks of Environmental Stressors in Europe
IRDES	Institute for Research and Information in Health Economics
ISTAT	Italian National Institute of Statistics
MDB	Mortality Indicator Database

MINDFUL	Mental Health Information and Determinants for the European Level
NHS	National Health Service
NUTS	Nomenclature of Units for Territorial Statistics
OECD	Organization for Economic Co-operation and Development
OFDA	Office of United states Foreign Disaster Assistance
PHEWE	Prevention of acute Health Effects of Weather conditions in Europe
PTSD	Post-Traumatic Stress Disorder
SDI	spatial data infrastructure
SERTIT	Service Régional de Traitement d'Image et de Télédétection
SHA	Strategic Health Authorities
UKL HD	University Hospital Heidelberg
USAID	The United States Agency for International Development
WDI	World Development Indicators
WHO	World Health Organization
WHOSIS	World Health Organization Statistical Information System

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1. Introduction

1.1 Background and Context of the Study

MICRODIS - Integrated health, social, and economic impacts of extreme events: evidence, methods, and tools

Recent natural disasters worldwide have highlighted the vulnerability of societies to extreme events. It is now internationally acknowledged that efforts to reduce disaster risks must be systematically integrated into policies, plans, and programmes for sustainable development and poverty reduction.

Within the MICRODIS project, research focuses on and in disaster-affected communities to assess the health, economic, and social impacts at the micro-level in Asia and Europe. Microdis focuses on the micro-level of disasters. The overall goal is to strengthen preparedness, mitigation, and prevention strategies to reduce the health, social, and economic impacts of extreme events on communities. The project objectives are as follows:

- to strengthen the scientific and empirical foundation of the relationship between extreme events and their health, social, and economic impacts;
- to develop and integrate knowledge, concepts, methods, tools, and databases towards a common global approach; and
- to improve human resources and coping capacity in Asia and Europe through training and knowledge sharing.

Natural disaster human impact data at the European level

The human impact-monitoring of natural disasters in Europe is particularly weak. This study aims to identify the current situation and explore possibilities of measuring human and health impacts of natural disasters in Europe.

The geographic location of people is a critical factor in their exposure to natural disasters and related health hazards. *"With the geographic information system, observations regarding the social, economic, political, and physical environments can be referenced to a common geospatial data framework. This permits varying organizations to share spatial data regarding these phenomena. Geographic information science has the potential to create rich information databases, linked to methods of spatial analysis, to determine relationships between geographical patterns of disease distribution and social and physical environmental conditions. As the core of a decision-support system, geographic information science also has the potential to change the way that allocations of resources are made to facilitate preventive health services and to control the burden of disease."* (Rushton, Elmes et al. 2000)

According to the European Commission, more evidence is needed on the impact of floods on public health. In Europe, the health care systems in general have a higher standard compared to developing countries (WHO 2000), even though there are differences among the Member States.

Floods are the most common natural disaster worldwide and in Europe and therefore a focus of research and decision makers, but the effort has been targeted more to early warning, physical impact, risk analysis, and infrastructure and population vulnerability and not so much to the health impact. The reason for this may be the generally high health status in Europe, the smoothly functioning first-aid assistance efforts in the case of a disaster, and a different level of problems in Europe than in less-developed countries. Even the complete evacuation of several hospitals, as happened during the 2002 floods in Dresden, Germany, did not cause a major disruption of the health system (Kirch, Bertollini et al. 2005).

Thus, in Europe, other flood-related health effects come to the fore and have a longer-term orientation, including chronic disease or mental health issues. Monitoring such effects and especially linking them to specific flood events is more difficult than establishing associations with short-term effects, such as injuries or an increase in waterborne disease.

Among the several approaches to assessing these effects are case studies related to a flood event that monitor the health status of the affected population. Another approach is using geographic information system (GIS) methods to analyse and link current data stored in disaster and health databases. Well-established reporting systems report certain health indicators in a reliable and standardized way, and reports on natural disasters such as floods are becoming increasingly detailed. The key issue is not availability but access to such data.

1.2 Goals and Objectives of the Study

Within MICRODIS, the present study especially emphasizes natural disasters in Europe. The overall goal is to strengthen the quality, accuracy, and completeness of disaster impact data in Europe. The main objective is to analyse the impact on human populations of recent disasters using both statistical and spatial data through generating geocoded maps of impact areas.

The main activities within the current study are as follows:

- analysis and simple mapping of natural disasters and their impact in the European Union (EU-27), using the Emergency Events Database (EM-DAT database), to provide a disaster profile;
- creation of geocoded maps using specialized data standard systems such as Global Administrative Unit Layers (the GAUL System of the Food and Agriculture Organization of the United Nations, FAO) and tools such as ARCGIS; and
- development of recommendations for statistical, spatial, and geo-referenced data required for measuring future natural disaster impacts for European countries.

The ultimate outcome is insight into the flooding situation in the EU27, what is available in terms of data and what the data indicate, and how countries may differ. We also present our ideas of how GIS analysis could be applied in disaster assessment.

Comprehensiveness is not the aim of this single study. Differences in health systems, health status, or reaction to floods within the EU27 vary too greatly for a single study to capture.

Therefore, we present more detailed work in the four MICRODIS countries: England, France, Germany, and Italy. We provide a thorough description of the flooding situation for each country and also select two health indicators per country that, according to our literature review, can be related to floods. It is important to note that this study draws no causal conclusions, as doing so was not possible with the data we used.

Thus, this study is intended to serve as a preliminary and descriptive investigation to reveal certain possibilities and serve as the basis for further research.

Geographic information systems

A GIS integrates hardware, software, and data for capturing, managing, analysing, and displaying all forms of geographically referenced information.

Practitioners also regard the total GIS as including the operating personnel and the data that go into the system. Spatial features are stored in a coordinate system, which references a particular place on Earth. Descriptive attributes in tabular form are associated with spatial features. Spatial data and associated attributes in the same coordinate system can then be layered together for mapping and analysis.

A GIS is a framework that allows the user to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts. Such visual outputs allow an understanding of problems and answering questions in a way that is quickly understood and easily shared.

It is useful to view GIS as a process rather than a thing. A GIS supports data collection, analysis, and decision-making and is far more than a software or hardware product. It can be used in many different disciplines and allows application of a geographic approach to the methods.

Floods as natural disasters

Floods refer to a situation of water accumulation in places that are not normally submerged. Heavy rainfall is the leading cause of inland flooding. Other natural hazards that cause inland flooding are melting snow, glacial outbursts, and dam break flows. Inland floods are classically categorized as either flash floods, in which the excess of water rapidly overwhelms the drainage capacity of (often small) river basins, or slow-rising riverine floods, during which water accumulates over longer periods of time, often in larger river basins. In addition to flash floods and slow-rising floods, a third category of floods is coastal floods. These are mainly caused by tidal waves, tsunamis (such as the Indian Ocean 2004 Tsunami), or storm surges (such as the New Orleans floods following Hurricane Katrina in 2005).

However, floods are a hazard and not a disaster. In many places, floods are events of annual occurrence. They may carry positive aspects, such as fertilization of fields, and be viewed as beneficial. Floods become disasters when they are of unusual proportion, occur in unusual places, or occur unexpectedly, thus exceeding the ability of the affected community or society to cope with the event.

Floods can cause extensive damage to infrastructure and crops. Their impact on agriculture depends in part on the timing in relation to the cycle of the crops in the region. The area affected by floods can be immense, depending to some extent on topographical features. The floods of 1998 in China submerged more than 21 million hectares of farmland, an area about seven times the size of Belgium.

It is important to remember that the severity of flood disasters is not solely linked to the intensity of the natural hazard but also to many human-driven factors that contribute to increasing the risk for flooding and magnifying the impacts, such as soil degradation, deforestation, urbanization, and poor urban drainage. Urbanization reduces the potential for lands to correctly absorb heavy precipitation and hence strongly contributes to the risk of flooding. This may also force people into unsafe and flood prone areas, notably impoverished people in the context of rural to urban migration. Examples include the unsafe peripheral areas of the cities of Manila, Kolkata, Dhaka, or Rio, where the poorest settle down in urban slums that are located in highly disaster-prone (and especially flood-prone) areas, on unstable slopes or in flood-prone basins.

Over the last 30 years, worldwide a total of 3,119 floods were reported in EM-DAT, resulting in the deaths of more than 200,000 people and affecting more than 2.8 billion others.

Floods are the most common natural disaster in Europe. In recent years, Europe has witnessed some of the largest flooding events in its history. Indeed,,7 out of the 20 most important floods ever recorded in Europe (in terms of the total reported number of affected people) occurred during the 2000–2009 decade. Recent major flooding events include the 2007 floods in the United Kingdom and the Elbe and Danube river floods during the summer of 2002. Over the last 10 years, floods in Europe have killed more than 1,000 people and affected over 3.4 million others.

2. Methods

2.1 Data Search

Our first approach to the data search was to identify key informants who could either provide us with data or link us to other sources, creating a snowball effect. We also used the Internet and especially websites of national and international health authorities as sources for data querying. Our search focused on two kinds of data: data on health indicators and data on floods. In both cases, the common denominator was attribution in geographic space of the data, the intended link between the datasets.

A similar systematic search was performed for health statistics reporting systems and available databases. The references in the identified sources were crosschecked to pinpoint further health reporting systems and databases (a further snowball effect). Datasets were downloaded for investigation of their scope and completeness.

For information on floods as natural disasters, we drew on the Centre for Research on the Epidemiology of Disasters (CRED) network. For information on health data, we used the MICRODIS partners and the network of the University Hospital Heidelberg (UKL HD), especially in Germany.

We conducted a literature search in the World Health Organization (WHO), PubMed, and Web of Science databases to identify studies that address the health impacts of flooding in Europe. The references in the identified papers were crosschecked to identify further studies (a further snowball effect). The search strategy included a combination of the following search words: “floo*, Europe (names of each country separated with OR, health impact*, disease, injury, health syste*)”. Inclusion criteria were set at studies discussing health and health systems impacts in Europe. We identified and reviewed 26 documents.

2.2 Data Sources

Our main source on floods in Europe was EM-DAT, hosted by CRED. The study addresses two levels. One level is geocoding of the dataset of 149 floods that were recorded in EM-DAT in the last 10 years to bring out more detail. At another level, we selected the four MICRODIS countries in Europe and searched for the most accurate health and flood data available.

We selected only floods that were classified as general floods because these have a bigger spatial extent and therefore are more likely to be mapped by satellite imagery. General floods are gradually rising inland floods due to high total depth of rainfall or snowmelt. General floods can be expected at certain locations (e.g. along rivers) with a significantly higher probability than at others. For each of the four MICRODIS countries, we identified the top two events in terms of the total number of people affected.

For four of these major events, we obtained flood footprints from the German Aerospace Center (DLR) and the Service Régional de Traitement d'Image et de Télédétection (SERTIT) in France. Although there are more providers for such data, such as the Dartmouth Flood Observatory, not all of their data are publicly available. We evaluated these flood footprints and found them spatially incompatible with the available health data.

Health data that would serve our needs in terms of temporal and spatial resolution are much more difficult if not impossible to acquire. Access to such data varies considerably from country to country and is strongly related to the structure of the health system and different privacy regulations.

Also, systematic collection of certain indicators has been initiated only in recent years, so that they are not yet available for the longer analysis periods that would be needed to assess the long-term health impact of floods. Through our data search, we contacted health authorities, insurance companies, and health data providers. Public health data are monitored at the sub-national level but are often not publicly available.

For our study, we relied on freely accessible data and therefore decided to use the statistical data provided by the national health or statistical authorities. These data are usually annual in scope and provided at different administrative levels and can be accessed through institutional online databases.

We also used Eurostat for the regional information on the health system and economic status. Eurostat is the statistical institute of the EU. It provides various statistical indicators for the Member States in a way that allows their integration and comparison.

2.3 Data Selection and Preparation

The last decade, 2000 until 2009, was selected as the study period because detailed, good data such as flood footprints were more likely to be

found for this period. Also anticipated to be easier were gathering missing information, specifying the information in the EM-DAT location field, and acquisition of health data.

To give a more detailed overview of the flooding situation in Europe overall, EM-DAT records from the last 10 years were geocoded, which has previously been done only at the country level. Information stored in the location field in EM-DAT was used for the geocoding and verified and completed with the EM-DAT archives if necessary. As a reference dataset, the GAUL dataset provided by the FAO was selected. This is a standardized and annually updated dataset of administrative boundaries (admin) down to the admin2 level. In some countries, lower levels are also available. Admins refer to the official divisions of countries on different levels (admin0 = country; admin1 = state; admin2 = county). They can differ from other administrative units like for example the NUTS classification

To perform the geocoding, we referred to a geocoding protocol developed by CRED. In the final dataset, each flood in EM-DAT from the last 10 years could be assigned to the affected admin1s; we also tried to increase to the admin2 level for even better resolution, but this information was not consistently available for all floods.The start month from EM-DAT was always designated as the affected month. In some cases in which the flood occurred at the end of the month or lasted for a long period, the next month also might have been affected; however, only the start month was counted as affected.

Based on the literature review, two health indicators were selected for each country, one to represent respiratory disease and the other to represent mental health problems. To obtain an idea of the economic and health system status of the regions, we used the number of doctors standardized per 100,000 inhabitants and Gross Domestic Product (GDP) in EUR as a percent of the European average (from Eurostat).

All indicators were used as they occurred in the different databases without further processing, leading to differences in standardization and format. Because of these differences, an intercountry comparison except for the Eurostat indicators is not possible.

A large part of the following report involves addressing the shortcomings of data availability, which are described in detail within their context. The reporting of health data is strongly related to the organization of the underlying health system; however, the degree of data availability does not allow any conclusions about the quality or standard of the associated health system.

The International Disaster Database, EM-DAT

Since 1988, with the sponsorship of the United States Agency for International Development's Office of Foreign Disaster Assistance (USAID)/OFDA), CRED has maintained EM-DAT, its international disaster database. It contains core data on the occurrence and impacts of more than 18,000 natural and technological disasters worldwide dating from 1900 to the present. The database is compiled from various sources, including UN agencies, non-governmental organizations, insurance companies, research institutes, and press agencies. Priority is given to data from UN agencies, followed by OFDA, governments, and the International Federation of Red Cross and Red Crescent Societies. This prioritization is not only a reflection of the quality or value of the data but also reflects the fact that most reporting sources do not cover all disasters or have political limitations that can affect the figures. The entries are constantly reviewed for redundancy, inconsistencies, and incompleteness.

For each wdisaster that is entered into the database, additional information is provided, including dates, disaster types and subtypes, country, region, the number of people killed, injured, homeless, and otherwise affected, as well as estimates of infrastructure and economic damages.

The database's main objectives are to assist humanitarian action at both the national and international levels; to rationalize decision-making for disaster preparedness; and to provide an objective basis for vulnerability assessment and priority setting.

CRED defines a disaster as "a situation or event which overwhelms local capacity, necessitating a request to a national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering". For a disaster to be entered into the database, at least one of the following criteria must be fulfilled:

- 10 or more people reported killed;
- 100 or more people reported affected;
- declaration of a state of emergency; and/or
- call for international assistance.

"In EM-DAT, natural disasters comprise hydrological, geophysical, meteorological, climatological and biological disasters". The EM-DAT website (http://www.emdat.be/) provides free access to the disaster occurrence and impact data through country and disaster profile sections and an advanced data-search interface. Various analyses, trends, maps, and related documents are also available on the website.

3. Flood Occurrence and Human Impact Based on EM-DAT

This chapter gives an overview of the spatial occurrence of floods in Europe with a relevant human impact. It is important to keep in mind that in this report, the term "flood" always refers to the disaster, as defined in EM-DAT and not to the hydrological event.

3.1 Flood Occurrence in the EU27

The map in Figure 1 shows the occurrence of floods recorded in EM-DAT from 2000 to 2009 at a sub-national level. When the classification is chosen as the context for displaying the flood occurrence, the steps between the classes are inhomogeneous. The idea behind this choice was to separate the admins that were affected only once in the last 10 years from the other admins. One flood in the last 10 years is a relatively low rate, and we are more interested in the admins that were affected by floods recurrently. On the other end of the classification, the occurrence of more than six floods was limited to only a few admins.

Even at this rather raw admin1 resolution, some patterns become visible. Figure 1 shows that floods are concentrated to certain regions within Europe and that if regions affected only once are discounted, large parts of Europe are never affected by floods. This feature would be even clearer if the resolution were increased to admin2; some of the admin1 areas are very big, like Bavaria in Germany or Andalusia in Spain, but floods affected only a small area within them.

On the other hand, floods hit some regions in Europe very frequently, in some cases almost every year. On the top rank of this list are the regions in Romania that were affected up to 8 times, meaning a flood almost every year, followed by Peloponnese in Greece, which was affected 6 times in the last 10 years.

Table 1 lists the 10 most severe floods from the last 10 years in terms of total affected. The country that appears most often is Romania, although it is not among the top three on the list. The table also shows that the number of deaths is rather low relative to the number of people affected.

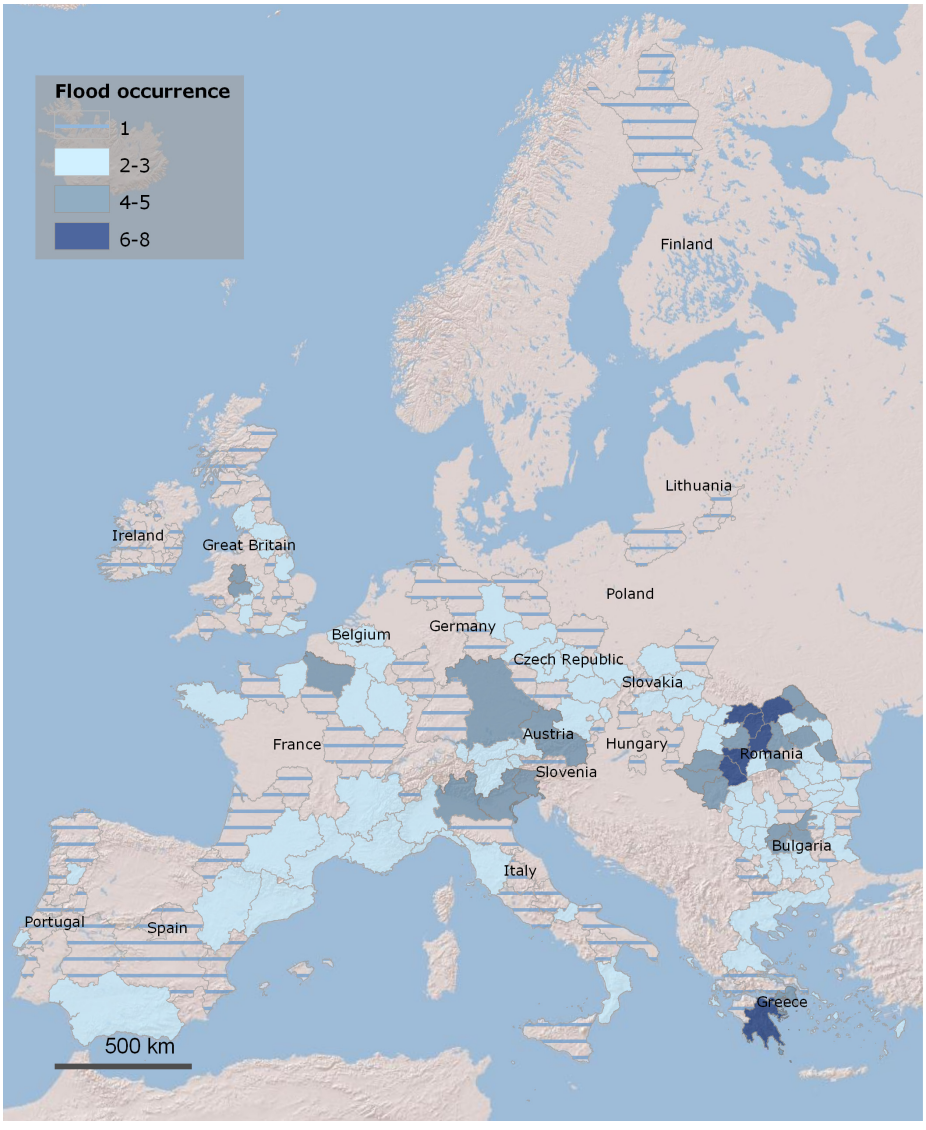

Figure 1 Flood occurrence in the EU27 from 2000–2009. Source: EMDAT

3.2 Seasonal Flood Occurrence in Europe

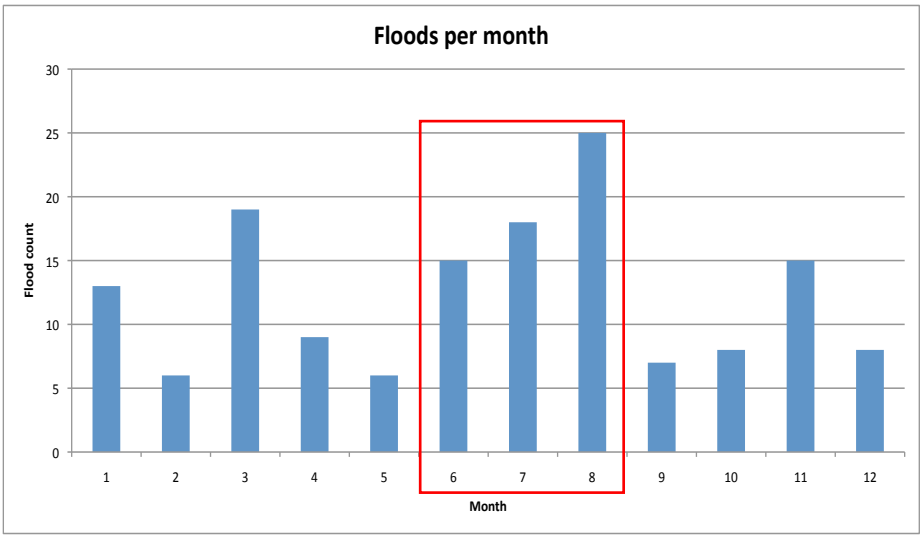

Figure 2 Flood occurrence from 2000–2009 recorded in EM-DAT, per month and admin1. Source: EM-DAT

Looking at the flood occurrence in the last 10 years and the months in which they occurred (Figure 3), some seasonality becomes visible. Of the 149 disasters recorded in EM-DAT in this period, 58 occurred during June, July, and August (Figure 2). Other months also had an elevated flood count, like March (19 floods) and November (15 floods). Examination of this distribution from a spatial point of view also shows a difference in the pattern of occurrence between the two seasons. In the months of June, July, and August, the "high season", floods occur in very specific regions of Europe: Central Europe with Austria in the middle and eastern Europe with Romania are the two most flooded regions at this time of the year, while the other parts of Europe remain mostly unflooded.

On the other hand, in the rest of the year, flood events are much more scattered over Europe because of the wider time span and the larger sample size. However, the Alps region is little or not at all affected during this

Year	Country	Start month	Number killed	Total number affected	Total damages (,000 US$)
2007	United Kingdom	July	7	340,000	4,000,000
2002	Germany	August	27	330,108	11,600,000
2002	Czech Rep	August	18	200,000	2,400,000
2000	Romania	April	9	60,431	100
2002	Austria	August	9	60,000	2,400,000
2006	Hungary	March	0	32,000	No data
2005	Romania	September	10	30,800	No data
2007	United Kingdom	June	6	30,000	4,000,000
2006	Romania	March	6	17,071	No data
2005	Romania	July	24	14,669	800

Table 1 Top 10 flood disasters in the EU27 from 2000–2009 according to total number affected. Source: EM-DAT

period in contrast to the Mediterranean region, which was not affected during the “high season”.

These seasonality patterns may also indicate different causes of floods during these periods, which are related to differences in regional climate. In the “high season”, snow melt in the mountains and increased run-off from glaciers delivers substantial water to the receiving streams together with the heavy rainfalls that can occur in this part of Europe at this time of the year, potentially triggering flood disasters (Smith and Ward 1998).

On the other hand, conditions are usually dry in the Mediterranean climate at this time of the year (Strahler and Strahler 1994). Floods in this region are usually caused by heavy rainfall or, at the coast, storm surge events, and the single event is limited to a small area. Many of these small events occur at the same time in a specific region; however, because the same triggering event affects them, they are reported as one flood.

In Romania, the country that floods have most affected (27 times) in the last 10 years, the variation during the year is rather low. The number of floods per month, however, is greater during the “high season” compared to the rest of the year.

In Great Britain and Ireland, a specific pattern also emerges during these periods. In the “low season”, floods are equally distributed, but during the “high season”, there is a concentration on in a few British counties.

3.3 Flood Occurrence and People Affected

Currently, “total number of people af-

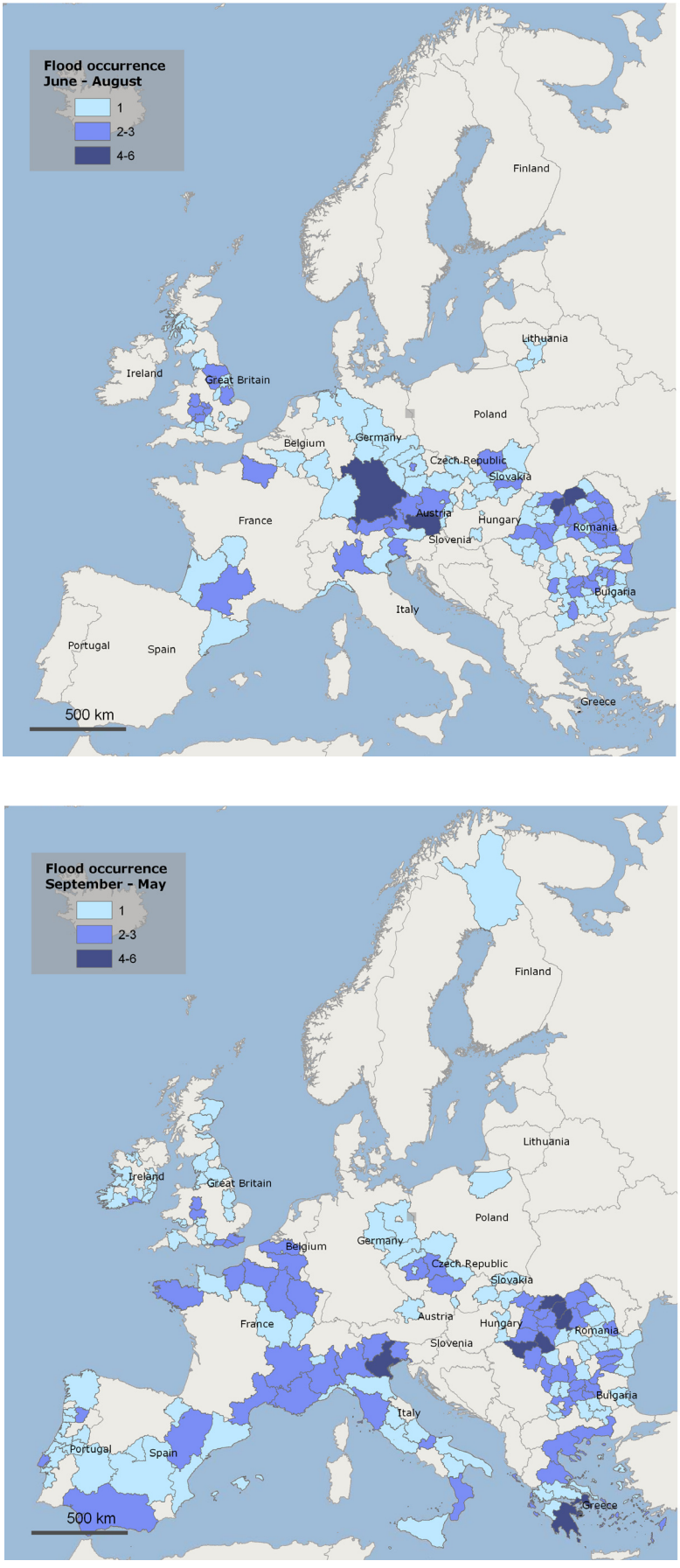

Figure 3 Flood occurrence from 2000–2009 recorded in EM-DAT, per month and admin1. Source: EM-DAT

fected" is reported at the country level in EM-DAT, so that the number affected cannot be shown on any other level. The map in Figure 4 shows the sum of the total number affected from 2000 to 2009 together with the flood occurrence for the same period.

Romania, the Czech Republic, Germany, and Great Britain have the most affected people. While this is not surprising for Romania, which is in the top rank in Europe for frequency and area affected, Germany, Great Britain, and the Czech Republic are not in this top rank. Even though the areas affected in Germany seem to be large, that appearance arises from a limitation of displaying these data at the admin1 level. In Great Britain, the only country for which we display the data at the admin2 level, the effects of this limitation are clearer. Neither Germany nor Great Britain experiences floods as frequently as Romania, and they also are two of the wealthiest countries in the EU27, yet they fall into the same class as Romania. Furthermore, the biggest share of the total affected respectively in Germany, Great Britain, and the Czech Republic has its cause in a single event in each country (Table 1), in contrast to Romania.

Figure 5 shows the population density together with flood occurrence. Several regions in the high-income countries have areas with a high population density and have been flooded more than once. In the lower-income countries, population density in general is lower, especially in the most often flooded regions in Romania and Greece. This difference in population density could be another reason for the high numbers of the total affected in Germany and Great Britain.

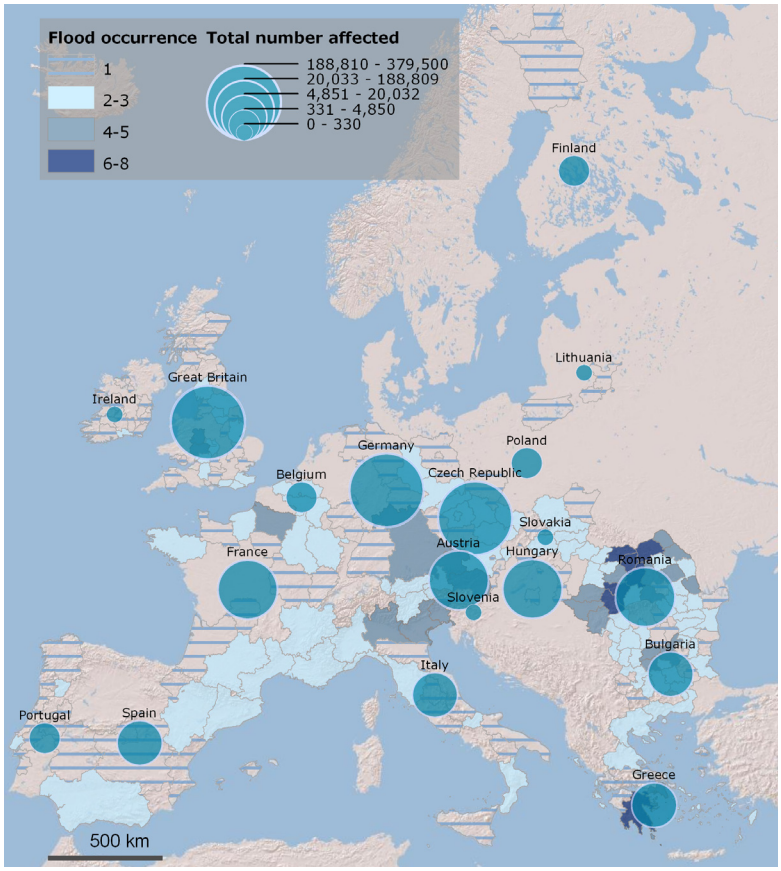

Figure 4 Flood occurrence from 2000–2009 per admin1 in the EU27 and total number affected from 2000-2009 per country. Source: EMDAT

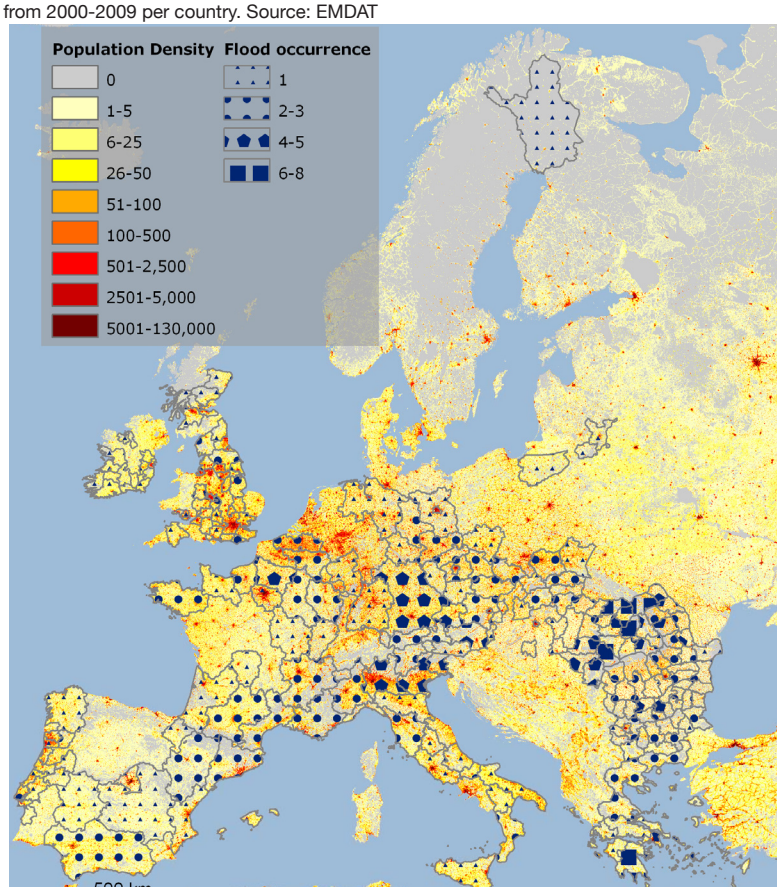

Figure 5 Flood occurrence in the EU27 from 2000–2009 on admin1 level and population density. Sources: EM-DAT, LandScan

4. Epidemiological Evidence of Health Impacts of Floods in Europe - Literature Review

The literature suggests that the health impacts of floods are far reaching and influenced by the close interplay between physical, social and other vulnerabilities, pre-existing health conditions, and flood characteristics including the speed of onset (flash floods more severe than slow onset), depth, and extent (Meusel and Kirch 2005). The vulnerable groups identified include the elderly, disabled, children, women, ethnic minorities, and those with low incomes (Hajat, Ebi et al. 2005). The speed of flood onset is the chief determining factor influencing the severity and frequency of the health impacts (Ahern, Kovats et al. 2005), and most health problems begin after the flood waters recede (Penning- Rowsell, Tapsell et al. 2005).

The literature on the health impacts of flooding in Europe is limited (Vasconcelos 2006), and often it is difficult to quantify the health impacts of floods and to attribute them specifically to the flood (Ebi 2006; Fewtrell and Kay 2008; WHO NA). Flood impacts have been best documented in the UK (Hajat, Ebi et al. 2005). Although studies differentiate the impacts into immediate and long-term effects then into direct and indirect impacts, respectively, we classify them here into health and health systems impacts.

4.1 Health Impacts

A small longitudinal study since 1998 carried out in the UK reports, that physical effects were observed in about 60% of the respondents and they lasted on an average about 12 months, whereas the mental health impacts were observed in 75% of the respondents and these lasted more than twice as long (Meusel and Kirch 2005). Thus both physical and mental health impacts and more important the interplay between them and the duration of symptoms are an important concern after disasters.

4.1.1 Mortality

The main reason for mortality is death by drowning/asphyxiation (Vasconcelos 2006). Jonkman et al. reviewed 13 flooding episodes with 247 reported deaths from Europe and the US for the causes and circumstances of flood-related deaths. Approximately two thirds of the deaths occurred because of drowning, and males were more vulnerable (70% deaths were males). Evidence was insufficient to draw conclusions on age-related vulnerability (Jonkman and Kelman 2005). Although the numbers of deaths are not comparable to those of developing countries, the nature, timing, and cause reported are similar. A great burden is attributed to heart attacks, hypothermia, trauma, and vehicle-related accidents (Few 2004), and the speed of the flood water is a determinant of the number of immediate flood-related deaths. Additionally, studies conducted by Bennet in Bristol and Lorraine et al. in Canvay Island in the UK reported a 50% increase in all-cause deaths in the flooded population in the 12 months following the floods (Bennet 1970; Ahern, Kovats et al. 2005). Most drownings are associated with wading into fast moving waters, and deaths by drowning in homes occur largely among the elderly (Ahern, Kovats et al. 2005).

In 1996, 86 deaths were reported from a flood in Biescas, Spain, when a stream of mud and water covered a campsite. Similarly, in 1998, between 147 and 160 deaths were reported from a river of mud that destroyed an urban area in Sarno, Italy (Hajat, Ebi et al. 2005).

4.1.2 Morbidity

4.1.2.1 Injury

Flood-related injuries are caused when individuals are evacuating from flood waters or attempting to save family and valuables. These injuries are usually minor in nature and include soft-tissue injuries such as contusions, lacerations, abrasions, cuts, bruises, sprains, strains, and puncture wounds. A total of 6% of the 108 households surveyed after the Nîmes, France, flooding reported contusions, cuts, and sprains (Ahern, Kovats et al. 2005). A few cases of burns, electrocutions, and sprains are also reported (Vasconcelos 2006), as are wound infections and dermatitis; however, tetanus is not a concern (Few 2004; WHO 2006).

4.1.2.2 Communicable diseases and infections

Although there are no reports of vector-borne diseases such as malaria and dengue from Europe, studies reported outbreaks of West Nile fever after the floods in Romania 1996–1997, Czech Republic 1997, and Italy 1998 (WHO 2006). Leptospirosis, an emerging threat in most developing countries following flooding, is also of concern in Europe because it has been reported after recent outbreaks in Portugal (1969), the Russian federation (1997), and the Czech Republic (2003) (Reacher, McKenzie et al. 2004; Ahern, Kovats et al. 2005; WHO 2006).

A study of the Lewes, UK, floods of 2001 reported an associated increase in self-reported cases of acute gastroenteritis and stomach upsets from

flooded households. The impact was also associated with the depth of the flood waters (Reacher, McKenzie et al. 2004). One of the reasons identified for these outbreaks was disruption of sewage disposal and water treatment infrastructure. However, these instances are rare, and no deaths were reported (Vasconcelos 2006). There is evidence of an increase in diarrhoeal disease after flooding in the former Czechoslovakia and Norway (Few 2004; Ahern, Kovats et al. 2005), but none of the reviewed studies quantify or report these cases explicitly. Studies in Finland reported a total of 14 flood-induced outbreaks between 1998–1999 resulting in 7,300 registered cases of waterborne disease (Hajat, Ebi et al. 2005). In contrast, no increase in infectious diseases was reported after the Nîmes flooding (Duclos, Vidonne et al. 1991), nor were there any cases of gastroenteritis after the 1995 flooding in Norway (Hajat, Ebi et al. 2005).

General infections resulting from direct contact with flood waters include skin irritation and infection (dermatitis), conjunctivitis, and ear, nose, and throat infections (Penning- Rowsell, Tapsell et al. 2005; WHO 2006; European Commission NA). Respiratory symptoms reported include colds, coughs, flu, headaches, acute asthma, and pleurisy (European Commission NA).

4.1.2.3 Chronic diseases

Cardiac complaints, high blood pressure, cardiac arrest, kidney or other renal infections, erratic blood sugar levels, and heart attacks are reported from most high-income countries after flooding (Penning- Rowsell, Tapsell et al. 2005). Increases in chronic respiratory illnesses, especially worsening asthma, are also reported in most cases (Hajat, Ebi et al. 2005; European Commission NA).

4.1.2.4 Poisoning and animal bites

Some of the other health impacts reported include a few cases of snake bites as snakes tend to take refuge in households after flooding (Vasconcelos 2006). Following the 1988 flooding of Nîmes, 12 cases of carbon monoxide poisoning were reported among civilians and rescue personnel who were pumping waters from flooded basements. Additionally, there is the risk of potential contamination with chemicals of river soils and beds when factories or storehouses holding chemicals are flooded, but no verifiable correlation has been reported (European Commission NA). After the 2000 flooding of the Danube in which cyanide compounds were introduced into the river, environmental impacts but no human health impacts were reported (WHO NA). There is also the potential threat of toxic fungal spread both in homes and in agricultural lands following floods (Hajat, Ebi et al. 2005).

4.1.3 Mental health impacts

Most of the literature for mental health impacts from floods comes from high- and middle-income countries (Ahern, Kovats et al. 2005). The mental health impacts result mainly from the destruction during the event itself, loss of life and/or property, problems in the recovery period, geographic displacement, anxiety about event recurrence, and stress in dealing with builders and repair people in the aftermath (Meusel and Kirch 2005; WHO NA). Several studies report common mental disorders such as anxiety, panic attacks, increased stress levels, mild/moderate/severe depression, irritability, nightmares, sleeplessness, Post-Traumatic Stress Disorder (PTSD), anger, tantrums, mood swings, increased tensions in relationships (e.g., arguing), difficulty with concentration, suicidal thoughts, alcohol dependence, and psychosomatic disorders (Duclos, Vidonne et al. 1991; Verger, Rotily et al. 2003; Ahern, Kovats et al. 2005; Hajat, Ebi et al. 2005; Penning- Rowsell, Tapsell et al. 2005; Vasconcelos 2006; Mason, Andrews et al. 2010).

A study by Bennet of the 1968 Bristol floods reported a significant increase (18% in flooded vs. 6% in non-flooded) in the number of new psychiatric symptoms (anxiety, depression, irritability, and sleeplessness). The study also reported that the effect of flooding on mortality and morbidity patterns was largely a result of the stress and psychological impacts of the disaster (Bennet 1970). A more recent comparative study conducted by Reacher et al. in the UK reported a four-fold increase in psychological distress among adults from flooded households even four years after the flooding. Risk estimates for physical illness in the study were lower when adjusted for psychological distress, and the psychological distress remained strongly associated with flooding after adjustment for physical illness. Thus, psychological distress may actually explain some of the excess physical illness (Verger, Rotily et al. 1999; Reacher, McKenzie et al. 2004; Tunstall, Tapsell et al. 2006).

Verger et al. reviewed the prevalence of psychological symptoms 5 years after the 1992 floods in southeast France to establish exposure to floods. For about 80% of the respondents, the researchers established an exposure–effect relationship (Ver-

ger, Rotily et al. 2003). This finding demonstrates that the long-lasting mental health impacts require further investigation. Other studies have reported an increased incidence of aggression, bedwetting, depression, and PTSD among children (11–20 y) following flooding in the Netherlands and Poland (Bennet 1970; Ahern, Kovats et al. 2005; Vasconcelos 2006; Bokszczanin 2007).

4.2 Health Systems Impacts

The most commonly reported health system impact after floods is disruption of health care services (European Commission NA). Bennet et al. report a 76% rise in males visiting General Practice more than three times from flooded households compared to those not flooded. Additionally the hospital referrals amongst the flooded more than doubled in the year following the floods (Bennet 1970). The use of primary or secondary health care has not been intensively documented anywhere (Hajat, Ebi et al. 2005), so very little information is available about health systems impacts. One exception is the 2002 Dresden flooding in Germany, where evacuation was the main challenge and an absence of standard operating procedures together with a lack of communication between the rescue and relief workers and the administrative authorities led to confusion. Another important lesson learned from this event was that key factors in running hospitals, such as the power supply, should be sited in places that are not prone to flooding (Meusel and Kirch 2005).

Research issues and gaps identified

1. Only large events are studied and small events are ignored
2. Most studies from Europe are not recent and date back to early 90's or even earlier with a few reviews in 2005-06
3. Studies dominated by slow onset floods in Europe, which may not represent flash flood impacts which are more severe
4. Most of the studies are retrospective, and may involve recall bias
5. Dearth of good quantitative data on health effects of flooding
6. Unclear how long the various health effects both mental and physical last after the floods
7. Longer-term impacts particularly mental health
8. Mortality in the period following the floods are rarely studied
9. Relatively limited evidence about morbidity and no injury database available
10. No studies reporting trends in mortality and morbidity from routine surveillance data during and after floods for example- number of ambulatory visits and primary and secondary consultations Standardized methodology for reporting morbidity and mortality is missing

Table 2 Summary of the health impacts of flooding in Europe

Impact	Features
Mortality	Main cause is drowning, other causes inadequately studied and include heart attacks, hypothermia, trauma, and vehicle-related deaths. Mud and water rushing in also caused some deaths in camping sites.
Injuries	Mainly soft tissue injuries (contusions, lacerations, abrasions, cuts, bruises, sprains, strains, puncture wounds), minor in nature
Communicable diseases	No malaria or dengue, some arbo-virus disease, West Nile virus, leptospirosis. Oro-faecal infections include diarrhoeal diseases and gastroenteritis. General infections include ear, nose, and throat infections; conjunctivitis; skin irritations; skin rashes; and dermatitis. Respiratory symptoms reported include colds, coughs, flu, headaches, acute asthma, allergies to moulds, and pleurisy.
Chronic diseases	Asthma worsening, high blood pressure, cardiac arrest, heart attacks, kidney or other renal infections, joint stiffness, and erratic blood sugar levels
Mental health impacts	Anxiety, panic attacks, increased stress levels, mild/moderate/severe depression, irritability, nightmares, sleeplessness, PTSD, anger, tantrums, mood swings, increased tensions in relationships (e.g., arguing), difficulty in concentration, suicidal thoughts, alcohol dependence, and psychosomatic disorders. Aggression, bedwetting, depression, and PTSD in children ages 11–20 years
Miscellaneous	Carbon monoxide poisoning, toxic fungal spread, insect or animal bites, earache, lethargy, spontaneous abortions mainly due to mental and physical stress
Health systems impacts	Increased referrals more than double in flooded households for the year following the floods; system disruptions such as electricity, lack of standard operating procedures, lack of communication between relief and rescue workers and administrative authorities

5. Health Statistics Reporting Systems and Available Data EU Wide

5.1 Introduction

Health reporting can be defined as *"... a system of different products and measures aiming at creating knowledge and awareness of important public health problems and their determinants (in different population groups) among policy makers and others involved in organisations that can influence the health of a population"* (Rosén 1998).

Public health research can benefit from data sharing in the scientific community and beyond (Lancet 2010), and the European context can serve as a useful tool for making comparisons. Most comparisons of health data in Europe take place at the national level[1]. There is, however, increased interest in looking at health data at a sub-national level. Producing health indicators at a sub-national level allows identification of epidemiological patterns that national averages might otherwise hide (Wilkinson,Berghmans et al. 2007).

This chapter provides an overview of currently existing health data reporting sources at the European-wide, national, and sub-national levels in Europe. It is not meant to be comprehensive but to address major data sources, their description, and their possible link to natural disasters, floods in particular.

1 See also: http://ec.europa.eu/health/ph_information/reporting/systems_en.htm

5.2 Results

5.2.1 Databases

Several databases provide health data at the European and national levels. Data at the sub-national level are often not available. Within the context of the present study, the following databases were identified:

5.2.1.1 European Community Health Indicators (ECHI)[2]

The European Community Health Indicators (ECHI) database encompasses a core set of more than 40 indicators and contains data on demographic and socio-economic factors (population, birth rate, total unemployment); health status (infant mortality, HIV/AIDS, road traffic injuries); health determinants (regular smokers, consumption/availability of fruit); and health interventions, such as health services (vaccination of children, hospital beds, health spending). The resolution of data in the ECHI database is at the EU and country levels covering a time span of 1995 to 2007. Data are available through the ECHI tool on the website.

5.2.1.2 Eurostat[3,4]

Eurostat provides data at the EU, country, and sub-national levels. The database can be queried through different sections: data on general and regional statistics, data on population and social conditions, and additional data on sustainable development indicators, such as human health protection and lifestyles, food safety and quality, handling of chemicals, and health risks due to environmental conditions. Data reach back to 1960 and up to 2009, but the data availability and time span varies per indicator.

2 http://ec.europa.eu/health/indicators/indicators/index_en.htm

3 http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/regional_statistics/data/database

4 http://epp.eurostat.ec.europa.eu/portal/page/portal/health/public_health/database

5.2.1.3 Organisation for Economic Co-operation and Development (OECD) Stat Extracts[5]

Organisation for Economic Co-operation and Development (OECD) Health Data 2010[6], jointly developed by OECD and the Institute for Research and Information in Health Economics (IRDES), offers statistics on health and health systems across OECD countries at the country level. It is a tool for comparative analyses and draws lessons from international comparisons of diverse health care systems. The data comprise some 1200 series, with selected long-term series from 1960 onwards. Most data cover the 1980s and 1990s, with many series up to 2007 or 2008, and selected data up until 2009.

5.2.1.4 WHO-Euro[7]

The WHO European Health for All Database[8] (HFA-DB) is a selection of core health statistics covering basic demographics; health status; health determinants and risk factors; and health care resources, use, and expenditures for the 53 Member States in the WHO European Region. Data are provided at the country level. The HFA-DB allows queries for country, inter-country, and regional analyses

5 http://stats.oecd.org

6 http://www.ecosante.fr/index2.php?base=OCDE&langh=FRA&langs=FRA&sessionid=

7 http://www.euro.who.int/en/what-we-do/data-and-evidence/databases

8 http://www.euro.who.int/en/what-we-do/data-and-evidence/databases/european-health-for-all-database-hfa-db2

and displays results in tables, graphs, or maps that can be exported for further use. The data are compiled from different sources, including a network of country experts, WHO/Europe's technical programmes, and partner organizations such as agencies of the UN system, Eurostat, and the OECD. The database is updated twice annually.

The Mortality Indicator Database[9] (MDB) allows age- and sex-specific analysis of mortality trends by broad disease groups, as well as disaggregated into 67 specific causes of death, EU wide and at the country level. Data reach back to 1980.

The European Detailed Mortality Database[10] (DMDB) contains mortality data by cause of death, age, and sex, submitted to the WHO by the European Member States. Data are provided EU wide and at the country level. The DMDB allows flexible and user-friendly access to the mortality data at the three-character ICD code level. It supplements the MDB, which provides mortality data only for predefined, aggregated causes of death.

The European Hospital Morbidity Database[11] (HMDB) contains hospital discharge data by detailed diagnosis, age, and sex, submitted by European countries to the WHO Regional Office for Europe. HMDB is a tool for the analysis and international comparison of morbidity and hospital activity patterns among countries. Data are provided EU wide and at the country level.

The Centralized Information System for Infectious Diseases[12] (CISID) collects, analyses, and presents data on infectious diseases in the WHO European Region. Data are provided at the country level and EU wide. The database contains the WHO/Europe infectious disease data set, compiled from reports submitted by Member States; accurate and current population data for the WHO European Region; confirmed outbreaks of infectious diseases; and links to partners and other sources of information on infectious diseases.

The European Environment and Health Information System (ENHIS) website[13] has been developed by a project co-financed by the European Commission, coordinated by WHO/Europe[14], and involving partner institutions from 18 European countries. The website hosts comparable data and information on priority environment and health issues, selected on the basis of international policy frameworks on environment and health.

The WHO Statistical Information System (WHOSIS) is incorporated into the Global Health Observatory (GHO)[15]. GHO is WHO's portal providing access to data and analyses for monitoring the global health situation. It provides critical data and analyses for key health themes, as well as direct access to the full database. Data are provided at the country level.

The WHO Global InfoBase[16] is a data warehouse that collects, stores, and displays information on chronic diseases and their risk factors for all WHO member states. Data are provided worldwide and at the country level.

The WHO Global Health Atlas[17] contains standardized data and statistics for infectious diseases worldwide at the country, regional, and global levels.

5.2.1.5 The World Bank

The World Bank's Open Data initiative[18] is a data catalogue with a listing of available World Bank datasets, including databases and pre-formatted tables and reports. The World Development Indicators (WDI) dataset provides a comprehensive selection of economic, social, and environmental indicators, drawing on data from the World Bank and more than 30 partner agencies. The database covers more than 900 indicators for 210 economies with data back to 1960.

The "Health, Nutrition and Population Statistics" covers health systems, disease prevention, reproductive health, nutrition, and population dynamics. Data are from the United Nations Population Division, WHO, United Nations Children's Fund, the Joint United Nations Programme on HIV/AIDS, and various other sources. Gender Statistics provides data on key gender topics. Themes included are demographics, education, health, labour force, and political participation. Data are provided worldwide and at the country level.

9 http://www.euro.who.int/en/what-we-do/data-and-evidence/databases/mortality-indicators-by-67-causes-of-death,-age-and-sex-hfa-mdb

10 http://www.euro.who.int/en/what-we-do/data-and-evidence/databases/european-detailed-mortality-database-dmdb2

11 http://www.euro.who.int/en/what-we-do/data-and-evidence/databases/european-hospital-morbidity-database-hmdb2

12 http://data.euro.who.int/cisid/

13 http://enhiscms.rivm.nl/object_class/enhis_home_tab.html

14 http://www.euro.who.int/en/what-we-do/data-and-evidence/environment-and-health-information-system-enhis

15 http://www.who.int/gho/en/

16 who.int/infobase/

17 www.who.int/globalatlas/

18 http://data.worldbank.org/data-catalog

5.2.2 Reports

In addition to databases allowing data querying, some recent reports are linked to datasets. The report, 'Health in the European Union' within the European Observatory on Health Systems and Policies, presents health data and public health policies in the EU, focusing in turn on each of the main causes of mortality and morbidity (Mladovsky, Alin et al. 2010). Much of the statistical information is drawn from WHO's Health for All database. Where available, supplementary sources were used to report data.

Within the context of The Global Report on Health in the European Union (EUGLOREH) project, a report[19] has been developed, with the main objectives of:

assessment of the status of health through selected indicators and their trends mainly over the last 10 years and, when possible, over a longer period;

analysis of the health determinants underlying the evolution of health indicators and related community and national policies; and

provision of data and information to facilitate the identification of priority issues for future investigations or actions and, when possible, of valuable relevant practicable approaches and policies.

The report addresses health-context–related items, mortality and morbidity, population ageing, health status, health determinants such as health systems and services, public health policy, and control tools at the EU-wide level.

Furthermore, several EU health reports have been produced by the European Commission within the context of the Community Public Health Programme[20].

5.2.3 Other main projects

Several other projects in Europe focus on health-reporting systems. The WHO Health Evidence Network (HEN)[21] is an information resource and platform on health evidence primarily for public health and health care policy-makers in the WHO European Region. HEN provides summarized information from a wide range of existing sources: websites, databases, technical and policy documents, and national and international organizations and institutions.

The European Commission European Injury Database (IDB)[22] is based on a systematic injury surveillance system that collects accident and injury data from selected emergency departments of Member State hospitals, providing a complement to and integrating existing data sources, such as routine causes of death statistics, hospital discharge registers, and data sources specific to injury areas, including road accidents and accidents at work.

The Mental Health Information and Determinants for the European Level (MINDFUL) mental health indicator database[23] comprises a set of 35 mental health indicators for all of the 25 EU Member States. The database covers the period from 1990 to the present, or to the latest year for which data are available. The data availability varies significantly among indicators and countries. In the case of health statistics data, the sources are principally international databases, such as the Eurostat Dissemination Database and WHO European Health for All Database. Additional data are provided by national statistical institutions. Survey indicator data originate mainly from survey reports and articles.

The European Commission HIS/HES database[24] was developed within the context of the European Health Surveys Information Database (EUHSID) project and presents an inventory of national or multi-country health surveys implemented in EU Member States as well as European Free Trade Association (EFTA) countries, EU Candidate Countries, and the USA, Canada, and Australia. The types of surveys incorporated into the database include Health Interview Surveys (HIS), Health Examination Surveys (HES), and combined HIS/HES Surveys. The HIS part of the database covers interview questions (in the national language and an English translation). The HES part covers health status components and measurements, e.g., collection and analysis of blood samples. The methodological information in both the HIS and HES parts refers to information on the sampling frame, numbers of persons or households participating, response rates, mode of data collection, standard instruments used, contact person, inclusion of institutionalized persons, and availability of data for analysis, among others.

The Data Food Networking (DAFNE)[25] initiative is a joint European effort to

19 http://euglorehcd.eulogos.it/DEFAULT.HTM

20 http://ec.europa.eu/health/ph_information/reporting/community_en.htm

21 http://www.euro.who.int/en/what-we-do/data-and-evidence/health-evidence-network-hen

22 https://webgate.ec.europa.eu/idb

23 http://info.stakes.fi/mindful/EN/database/overview.htm

24 https://hishes.iph.fgov.be/

25 http://www.nut.uoa.gr/dafnesoftweb/

exploit and compare food, demographic, and socio-economic data collected in the national household budget surveys to develop a cost-effective database that allows monitoring of food availability within and between European populations.

Disaster-related public health information in Europe

Few initiatives focus on the reporting of disaster-related public health data in Europe. EU projects to improve public health knowledge on extreme weather include[26]:

EURO HEAT: Improving public health responses to extreme weather/heat waves

EU 2003 Heat Wave Project: 'Etude de l'impact de la canicule d'août 2003 sur la population européenne'

PHEWE: Prevention of acute Health Effects of Weather conditions in Europe

cCASHh: Climate Change and Adaptation Strategies for Human Health in Europe

INTARESE: Integrated Assessment of Health Risks of Environmental Stressors in Europe

CIRCE: Climate Change and Impact Research: the Mediterranean Environment

EDEN: Emerging Diseases in a changing European eNvironment

The European Environmental Agency (EEA) published a report on 'Mapping the impacts of recent natural disasters and technological accidents in Europe' (European Environment Agency 2003)[27], bringing together information about natural disasters and technological accidents that have occurred across Europe in recent years and their impacts on the environment and societ1.

5.3 Discussion and Conclusions

This chapter lists the main reporting systems for public health data in Europe. In addition to regional or Europe-wide initiatives, many public health reporting efforts are undertaken within the European countries. However, the availability of and access to sub-national public health data across European countries remains challenging.

Few projects focus on promoting disaster-related public health information in Europe, making it difficult to investigate public health effects of natural disasters, such as floods, throughout Europe. The standardized compilation and sharing of disaster-related public health impact data in Europe at the national and sub-national levels should be reinforced to pinpoint the health effects of disasters on communities in Europe.

26 http://ec.europa.eu/health/ph_information/dissemination/unexpected/unexpected_2_en.htm

27 http://www.eea.europa.eu/publications/environmental_issue_report_2004_35

6. Country Profiles of England, France, Germany and Italy

This chapter illustrates the situation in the four European MICRODIS countries. The spatial distribution of the indicators is shown together with flood occurrence at the admin1 level. This approach will give an idea of the current situation as well as of the possibilities of approaching this topic spatially.

It is important to keep in mind that drawing a direct causal relationship between the indicators and the flood occurrence shown in the following maps is not possible. The intention rather is to show the status of a specific phenomenon that is also affected by floods and therefore should be of concern when dealing with floods.

While the indicators that were taken from Eurostat are comparable throughout the countries, the definitions for the health indicators can differ from country to country.

6.1 England

In England, there are different boundaries for different purposes, and they do not necessarily correspond to each other. In EM-DAT, the disasters in Great Britain are reported at the admin2 level, designated as counties in England, as the admin1 areas in the GAUL dataset, are England, Wales, and Scotland. These boundaries do not correspond, however, to the different Nomenclature of Units for Territorial Statistics (NUTS) divisions from Eurostat or to the Strategic Health Authorities (SHAs) that are used for national health indicator reporting.

In England, the ICD10 definitions from the WHO are used to classify the indicators, and the health reporting is very detailed in spatial and health indicator terms.

In total, there were 10 flood events reported in England from 2000 to 2009. The two most affected counties were Hereford and Worcester (5 times) and Salop (4 times).

6.1.1 Health and flood occurrence

Figure 6 shows the total admissions for asthma and the flood occurrence in England. As mentioned before, the floods are displayed at the admin2 level, while the health indicators are reported by the 28 SHAs. The 5 SHAs of London were aggregated into one unit.

Asthma does not seem to be an issue in all the counties that are affected more often by floods. The counties of Hereford and Worcester and Salop, which were affected the most by floods in England, also lie in an SHA where the asthma admissions were high.

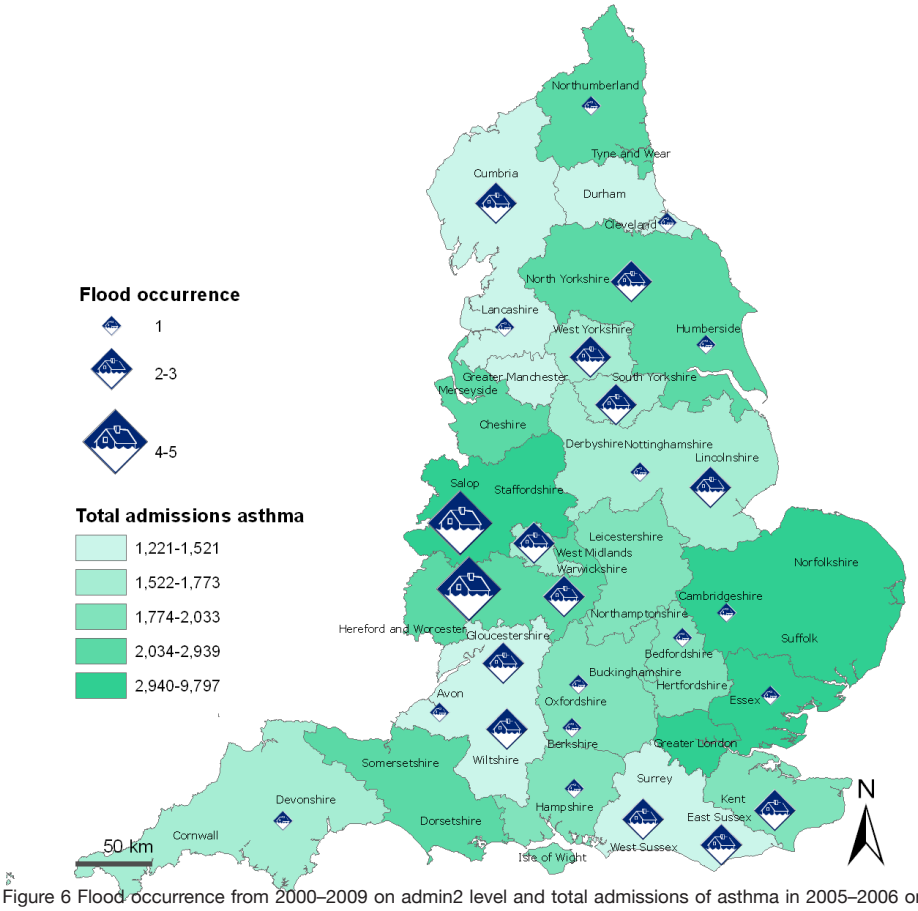

Figure 6 Flood occurrence from 2000–2009 on admin2 level and total admissions of asthma in 2005–2006 on SHA level. Sources: EM-DAT, NHSage, on NUTS2 level. Sources: EM-DAT, Eurostat

6.1.2 Health system and flood occurrence

Figure 7 shows flood occurrence at the admin2 level, while the number of doctors is reported at the NUTS1 level. The difficulty in England lies in the difference in the reporting boundaries. The idea of this indicator is to have a way of showing the standard of the health system. In general, one can assume that in many of the regions with many floods, the number of doctors is low. Regardless, the difference between the highest (328.4 doctors/100,000 people) and lowest (211.4 doctors/100,000 people) classes is quite small, and in general both are lower compared to, for example, Germany.

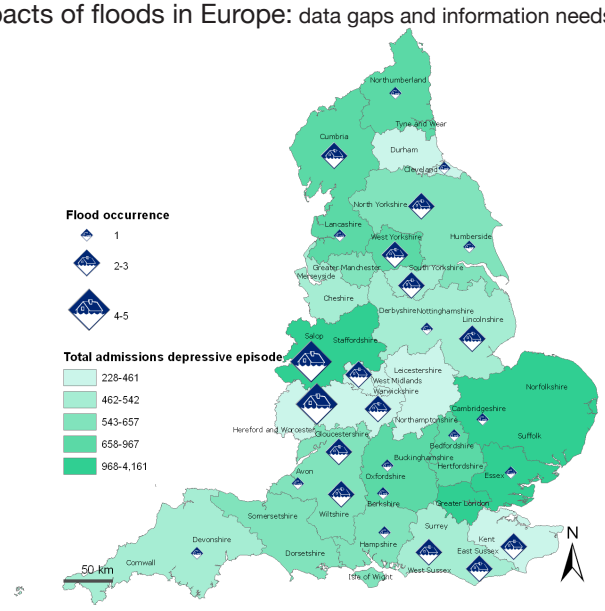

Figure 7 Flood occurrence from 2000–2009 on admin2 level and total admissions for depressive episode 2005–2006 on SHA level. Sources: EM-DAT, NHS

6.1.3 Economic status and flood occurrence

An examination of the GDP level in Figure 8 shows that some of the counties frequently affected by floods are located in regions with a low GDP. On the other hand, floods occurred in some regions with a high GDP. Again, the situation in the two areas most affected is in contrast: Salop falls into the lowest GDP class while Hereford and Worcester falls into the mid-range group.

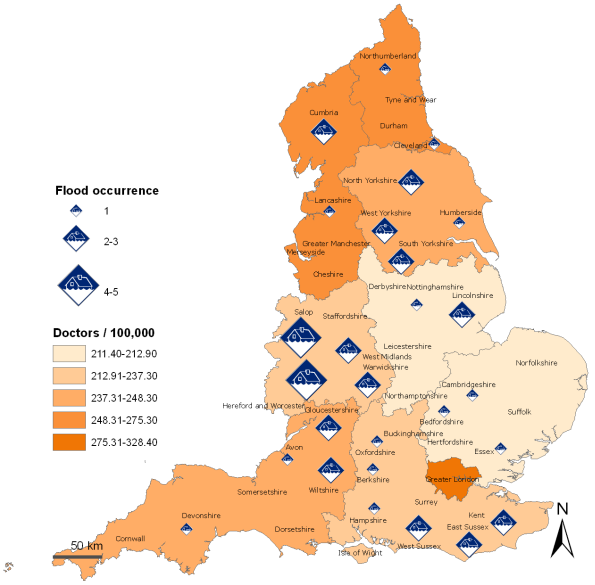

Figure 8 Flood occurrence from 2000–2009 on admin2 level and number of doctors per 100,000 inhabitants (2006) on NUTS1 level. Sources: EMDAT, Eurostat

The GDP level can be helpful for determining if a region can cope with the aftermath of floods, as economic damage usually is the most important factor in high-income countries and the impact of floods is often measured in economic terms. Thus, poor regions will need more assistance than wealthy regions; on the other hand, more economic damage can be caused where there is more to damage.

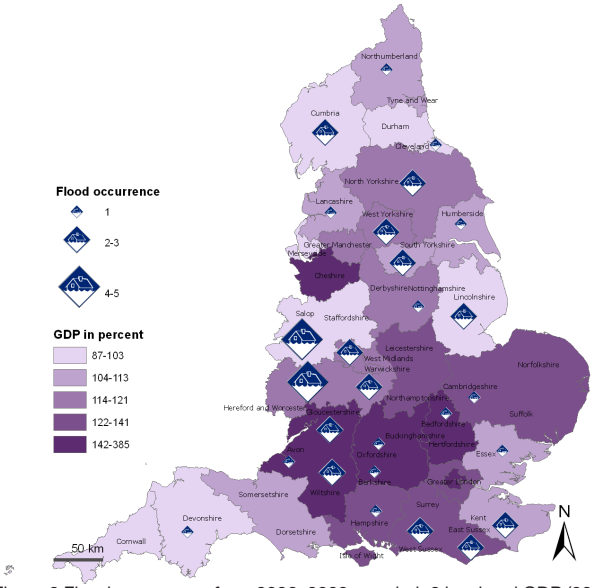

Figure 9 Flood occurrence from 2000–2009 on admin2 level and GDP (2007) as a percentage of the EU average, on NUTS2 level. Sources: EM-DAT, Eurostat

6.2 France

In France, health indicators are reported nationwide down to the admin2 level for many diseases and the health system. The data are available from the Institute Eco-Santé, and the institute also provides definitions of the indicators. For some indicators like asthma cases, data are available even on a weekly basis.

There were 14 flood disasters in France recorded in EM-DAT from 2000–2009. The most affected admin1, called "regions" in France, was Picardie.

6.2.1 Health and flood occurrence

In France, the rate of respiratory disease, shown in Figure 10, in general is low. The region of Picardie, which was most affected by floods, has a low rate of respiratory disease. Indeed, the rate of respiratory disease was elevated only in three of the second most-affected regions: Bretagne, Provence-Alpes-Cote d'Azur, and Languedoc-Roussillon. As the distribution of psychiatric disease in Figure 11 indicates, the pattern is similar to that for respiratory disease, with a low number of cases in general. Only in two provinces, ones that were also affected by floods more than once, was psychiatric disease an issue.

6.2.2 Health system and flood occurrence

In France, there is a clear difference between the north and south in the number of doctors available per 100,000 inhabitants (Figure 12). In the north, the coverage is much lower compared to the south, and the Picardie region, which was most affected by floods, falls into the lowest class.

6.2.3 Economic status and flood occurrence

The economic status of the French regions, shown in Figure 13, in general is considered to be high, with the lowest value at 7% below the EU average. The disparities within France are big, however, and Picardie, the most affected region, is classified as having the lowest GDP in France.

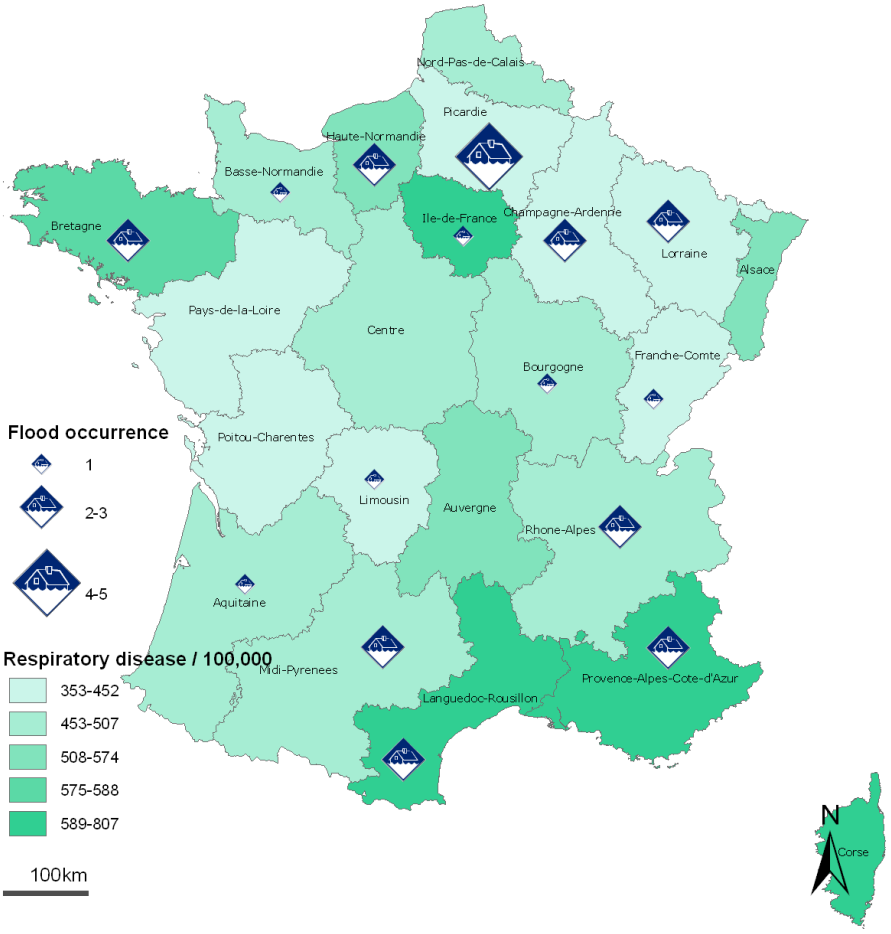

Figure 10 Flood occurrence from 2000–2009 on admin1 level and respiratory disease per 100,000 inhabitants (2008). Sources: EM-DAT, Eco-Santé

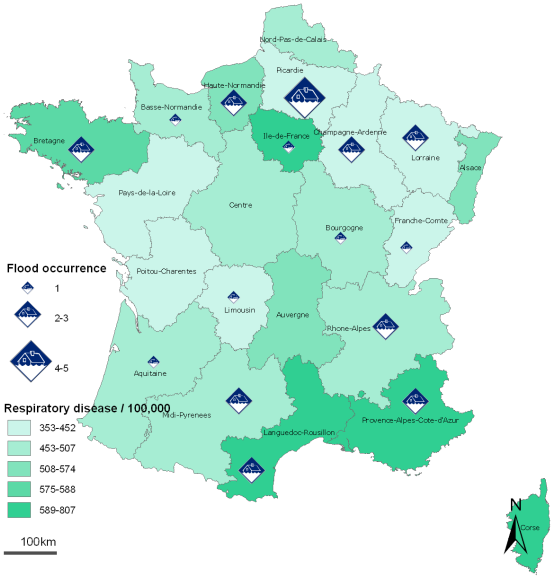

Figure 11 Flood occurrence from 2000–2009 on admin1 level and psychiatric disease per 100,000 inhabitants (2008). Sources: EM-DAT, Eco-Santé

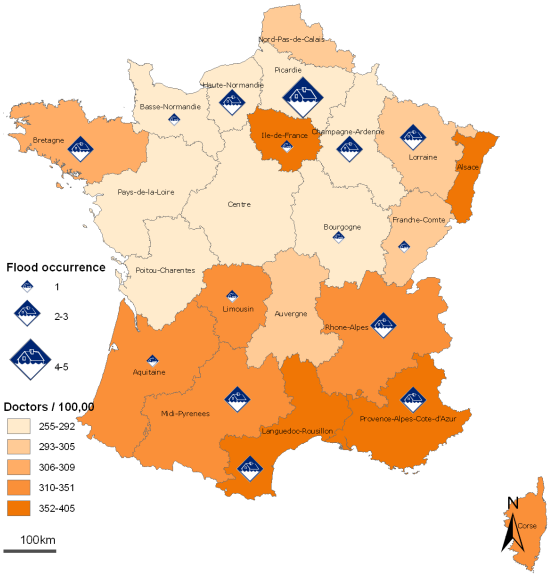

Figure 12 Flood occurrence from 2000–2009 and number of doctors per 100,000 inhabitants (2006) on admin1 level. Sources EM-DAT, Eurostat

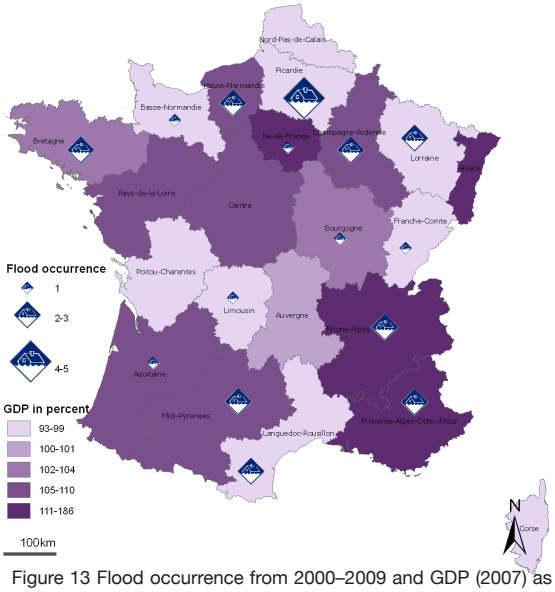

Figure 13 Flood occurrence from 2000–2009 and GDP (2007) as a percentage of the EU average on admin1 level. Sources EM-DAT, Eurostat

6.3 Germany

In Germany, health and health system indicators are reported annually to a national database (the GBE) at the admin1 level, which in Germany are the federal states. In this database, the ICD10 definitions are used. Data on lower levels is available from the databases of the health ministries from the different federal states but vary considerably among them.

Six floods in Germany were reported in EM-DAT from 2000 to 2009. Only three federal states were affected more than once by floods in the last 10 years, and only one, Bavaria, has been affected four times. Because these admin1 units are still very big, especially Bavaria, which is the biggest state in Germany, interpretation of the available information remains difficult.

6.3.1 Health and flood occurrence

In Germany, the distribution of asthma cases (Figure 14) seems to be very balanced, with only Baden-Württemberg and Berlin standing out with very low numbers. The states that have been affected by floods more often have a slightly higher number of asthma cases, especially Bavaria, which has been affected the most but is also the biggest state. Thus, it would be of interest to have more data at the admin2 level to better resolve the detail.

Although Figure 15 again gives the impression of a very equal level of depression cases, the differences are somewhat greater than with asthma when looking at the classification. Nevertheless, the three states of interest because of being most affected by floods are on the lower end of the classification, and a better-resolved visualization below the admin1 level would be of interest here. of the distribution of flood and health indicators.

6.3.2 Health system and flood occurrence

The standard of the health system (Figure 16) is considered to be high in Germany, as the numbers indicate. For example, the lowest level with 305 doctors per 100,000 inhabitants would fall into the mid-range in France or England. Bavaria, the most flood-affected state in Germany, falls into the class with the most doctors available per 100,000 inhabitants.

6.3.3 Economic status and flood occurrence

When it comes to the distribution of wealth (Figure 17), the effects of the former separation of Germany are still clearly visible. All poorer states are si-

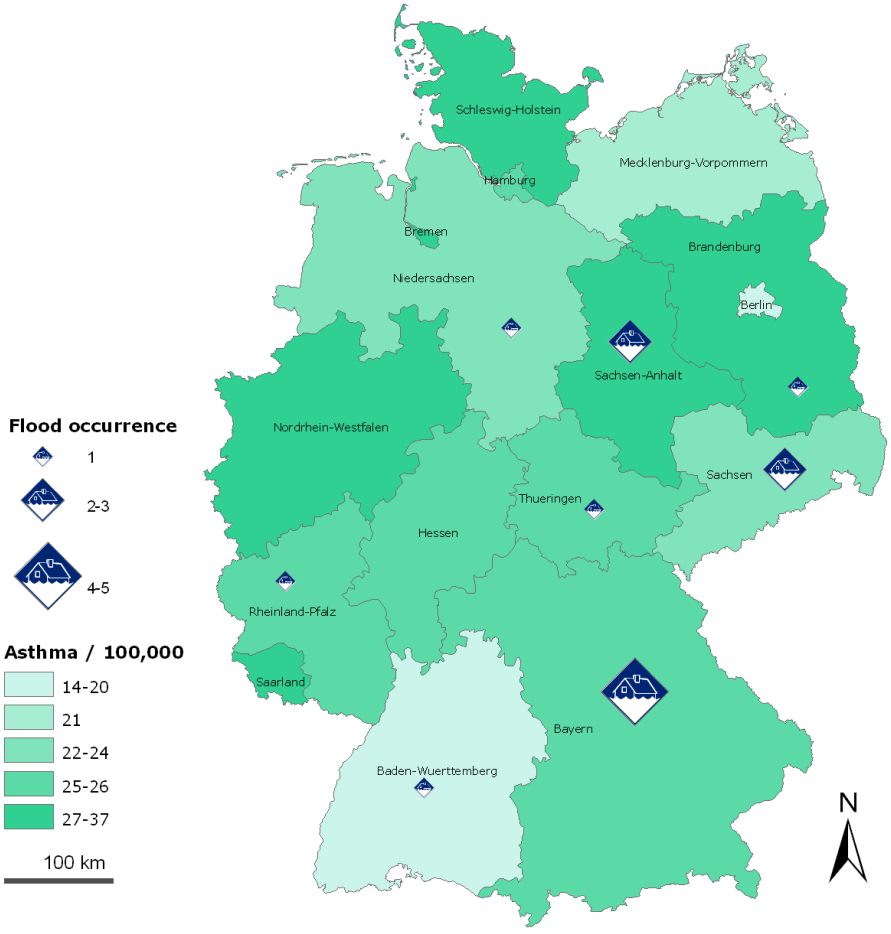

Figure 14 Flood occurrence from 2000–2009 and asthma cases per 100,000 inhabitants (2008) on admin1 level. Sources: EM-DAT, GBE

tuated in the former Eastern Germany, where the two biggest floods of the Elbe River, in 2002 and 2006, took place. On the other hand, Bavaria, with 139% of the EU average, is one of the wealthiest states in the nation.

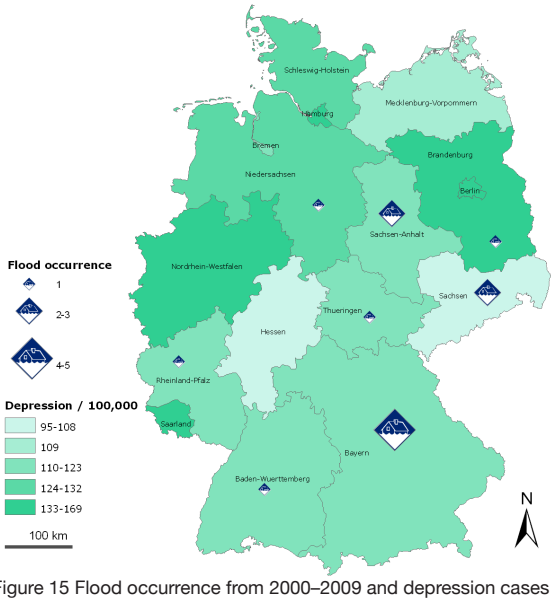

Figure 15 Flood occurrence from 2000–2009 and depression cases per 100,000 inhabitants (2008) on admin1 level. Sources: EM-DAT, GBE

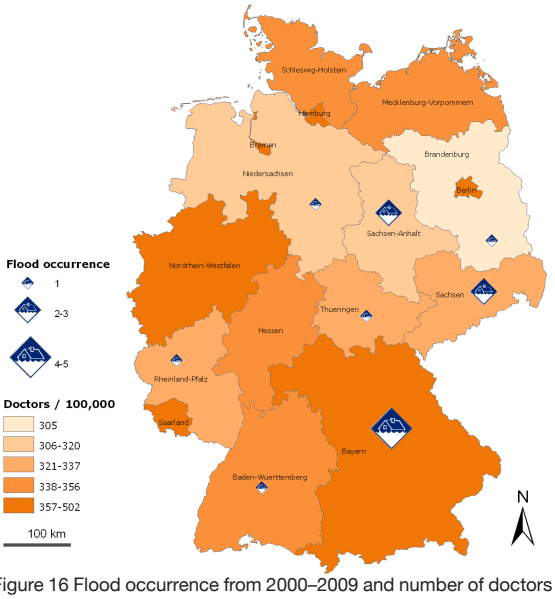

Figure 16 Flood occurrence from 2000–2009 and number of doctors per 100,000 inhabitants (2006) on admin1 level. Sources: EM-DAT, Eurostat

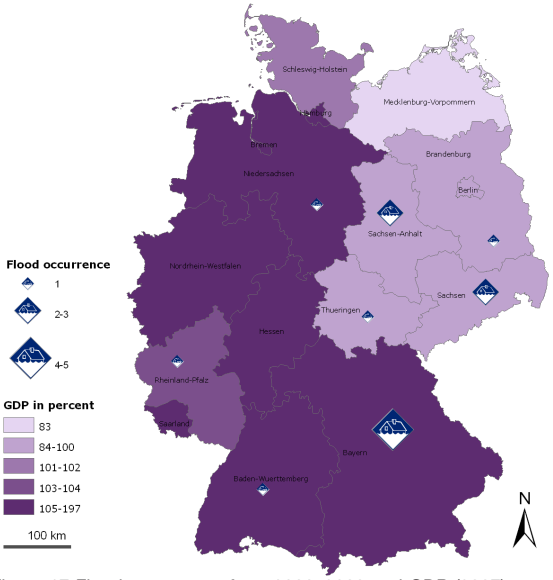

Figure 17 Flood occurrence from 2000–2009 and GDP (2007) as a percentage of the EU average on admin1 level. Sources: EM-DAT, Eurostat

6.4 Italy

Health data are available from the national statistics institute on an annual basis and on a regional basis, but the more detailed documentation as well as the definitions of the indicators are in Italian.

In Italy, 13 floods have been reported in EM-DAT for the study period. The north is under the influence of the Alpine region while the south is more influenced by the Mediterranean. Italy thus experiences both of the flood seasons described in Chapter 2.2, with the north more affected from June to August and the other parts affected in the rest of the year. In total, the north has been affected more often by floods than the south.

6.4.1 Health and flood occurrence

The most cases of bronchial asthma (Figure 18) are reported in the middle west of Italy, a region that has not been affected by floods as frequently as the north. There are more cases of bronchial asthma in the north than in the south of Italy.

Regarding chronic depression, shown in Figure 19, the picture is even more heterogeneous in Italy. In the admins that floods have affected several times, the number of cases per 100 inhabitants is quite low compared to the rest of Italy.

6.4.2 Health system and flood occurrence

When it comes to the number of doctors per 100,000 inhabitants, Italy is the country with the biggest differences among the four countries we examined (Figure 20). In Italy, the lowest class starting at 246 doctors is also the lowest among all four countries; on the other hand, the highest class with a maximum of 678 doctors is the highest number of doctors available per 100,000 inhabitants among the four countries. The admins with the highest number of doctors are situated in the middle western region of Italy while the numbers are lower in the north and south.

6.4.3 Economic status and flood occurrence

The north–south gradient typical for Italy emerges also with the distribution of the GDP (Figure 21). The three most flood-affected regions also lie in the north of Italy and belong to the wealthiest regions in the country.

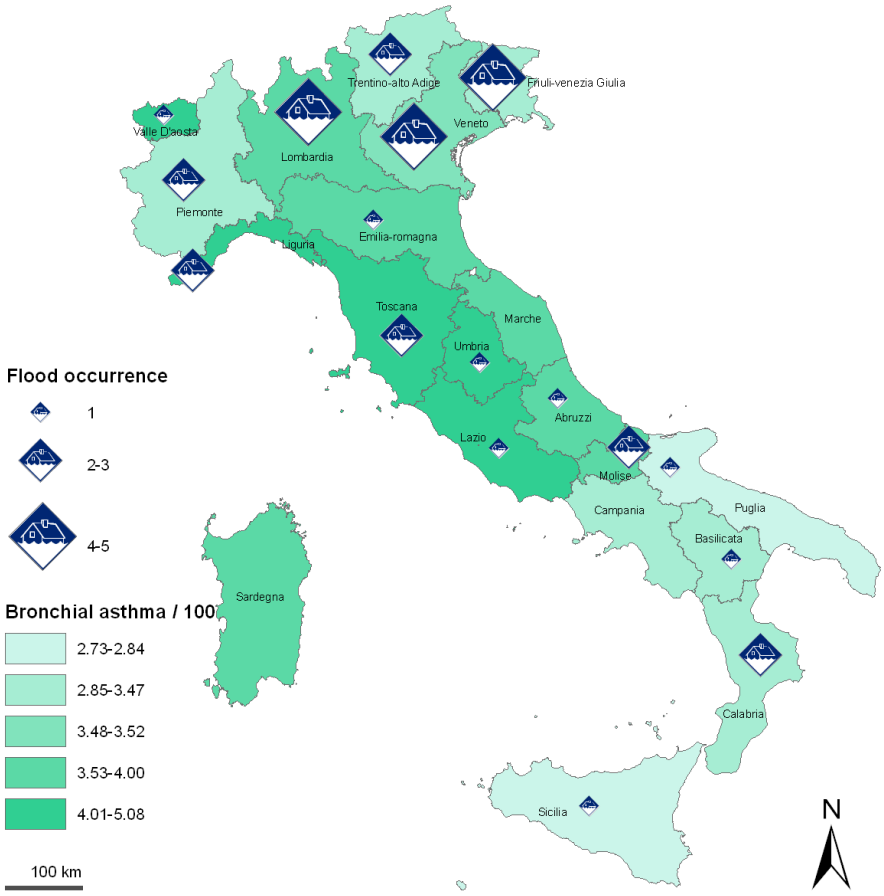

Figure 18 Flood occurrence from 2000–2009 and bronchial asthma per 100 inhabitants (2004–2005) on admin1 level. Sources: EM-DAT, ISTAT

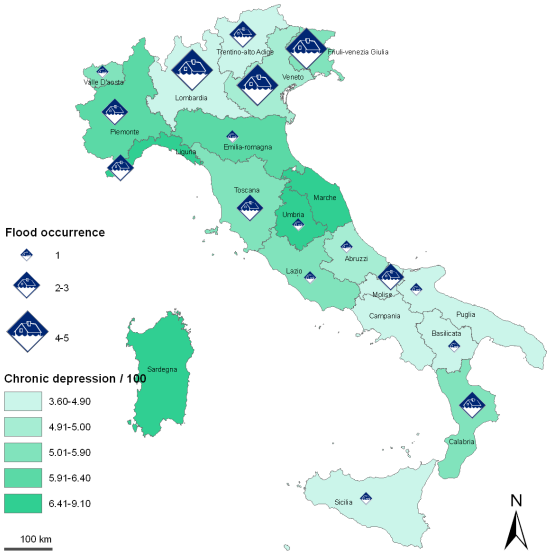

Figure 19 Flood occurrence from 2000–2009 and chronic depression per 100 inhabitants (2004–2005) on admin1 level. Sources: EM-DAT, ISTAT

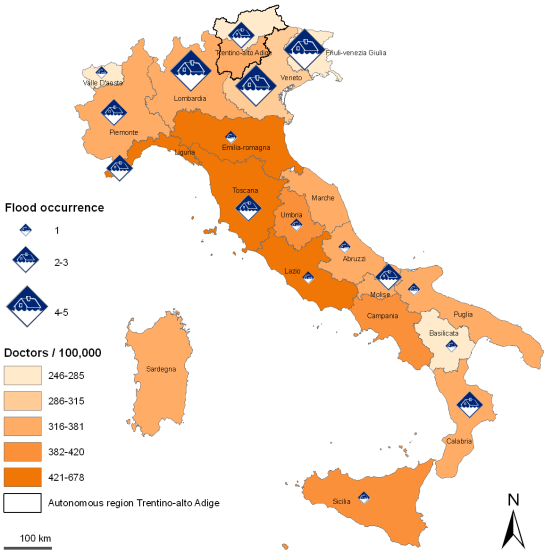

Figure 20 Flood occurrence from 2000–2009 and number of doctors per 100,000 inhabitants (2006) on admin1 level, except the autonomous Region Trentino-alto Adige, which is displayed on admin2. Sources: EM-DAT, Eurostat

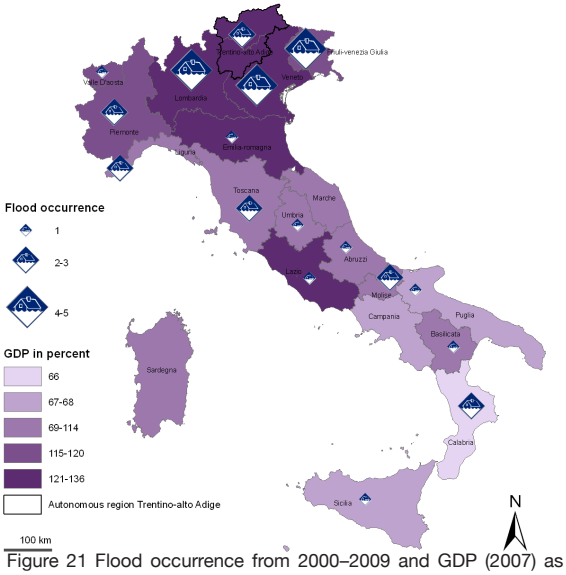

Figure 21 Flood occurrence from 2000–2009 and GDP (2007) as a percentage of the EU average on admin1 level, except the autonomous Region Trentino-alto Adige, which is displayed on admin2. Sources: EM-DAT, Eurostat

6.5 Summary

This exploration of these four very different countries helps to elucidate what the difficulties can be when trying to develop a study that assesses the health impact of floods. The health sector is managed very idiosyncratically by each country and the structure, the regulations, limitations, and associated data are never the same; indeed, even within the countries, there can be differences.

In Germany, for example the federal states administer health care, with the result that there are big differences among the states in the reporting, in addition to some indicators that are reported centrally. In the United Kingdom, the different regions also have a great deal of responsibility for the health services as well as for the reporting. In France, on the other hand, the structure and administration are centrally organized throughout the country.

Thus, not only are there differences in health data reporting among the countries, there also are differences within each nation, factors that must be considered in conducting research on an intercountry level.

Besides structural features of a decentralised health system like in Germany, confidentiality is of high value when it comes to data reporting and storage. One can basically rely only on highly aggregated data that is usually stored not longer than four years

Based on these observations, a study at the European level requires a sufficient timeframe and human resources. Also, we recommend collaboration with the official health administration bodies to facilitate access to the necessary health data. Another source of detailed health data could be insurance companies, but this approach also requires establishing collaborations.

The most common issue we encountered involved high-level aggregation of health data on the temporal and spatial levels while facing restrictions due to privacy regulations. In some countries, only a few indicators that could be related to floods are reported or are aggregated to a broader level of categorization (e.g., as respiratory disease instead of asthma).

Access to a lower level of health data in England and France is easier than in Germany where regulations governing access to such data are more strict, although the reporting is very detailed. In France, however, some indicators are publicly available on a weekly basis.

Gaining access to lengthy timelines of historic health data can also be difficult because of the storage time. In Germany, for instance, insurance companies may delete their data after several years.

Research linking flood occurrence and the health status of the EU population is hindered by difficulties in data access to health registries at the sub-national level and poor comparability among indicators, health reporting systems, and disaster reporting, as well as a general lack of monitoring of flood-related impacts.

7. Ways Forward

As described in the preceding chapters, some available data can be used to assess the effects of floods on public health in Europe, although difficulties exist, such as access to the data or its quality and resolution.

This study involved no application of analytical methods because of the shortcomings described earlier. We do, however, want to outline some ideas about how analysis could be done.

In Figure 22, the footprint of the 2002 Elbe flooding is shown together with the highlighted admin1 boundaries. This depiction gives an impression of the gap between the real hazard and the currently available data. The real impact area is somewhere between the hazard and the administrative boundary. Assessing this real impact area is a matter of great interest.

An interesting approach could be the use of spatial products, like disaster footprints derived from satellite imagery that show the hazard, to assess the spatial reach of the disaster that is still detectable in the health data. Such an approach could estimate the real range or impact that flood driven disasters have on public health and health systems. Such results then could be implemented in models to develop scenarios of the health impact and to improve planning and preparedness. Many more GIS-related methods exist that could be applied, such as spatial statistics or surface interpolations.

For such analysis, spatial resolution is crucial. The ideal scenario would be to have the relevant health indicators by collecting institution (e.g. hospital) as point data and at a sufficient temporal resolution to capture the long-term effects. The estimated impact area mask could then be used to select the affected institutions. This could contribute to linking health data to disasters as well as the continous monitoring of the health effects

An important step to achieving this approach would involve setting up a spatial data infrastructure (SDI) for health data. SDI is a framework of technologies, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve the use of geospatial data across multiple public and private organizations (ESRI online GIS Dictionary). An important initiative to mention in this context is the INSPIRE initiative from the European Commission, which has the goal of setting up a European SDI although it has no specific focus on health data.

For a better understanding of the health impacts of natural disasters, the collection of health data directly linked to natural disasters should be reinforced, given the scarcity of recent research focused on Europe. This goal could be accomplished with the application of a geographic approach, and such research would help focus the monitoring of health impacts on the right indicators.

Geocoding of available disaster databases like EM-DAT is also an important step so that better interoperability with other datasets, in this case health data, will be enabled. This step also includes the concept that reported impact data (i.e., people affected) should be available on levels other than the country level.

One advantage of a more geospatial approach such as this, in addition to the improvement in methodology, is the possibility of communicating the results in the understandable and straightforward medium of maps. These graphic products can help considerably in imparting a better understanding of a situation if the data are accurate and they are cartographically well done.

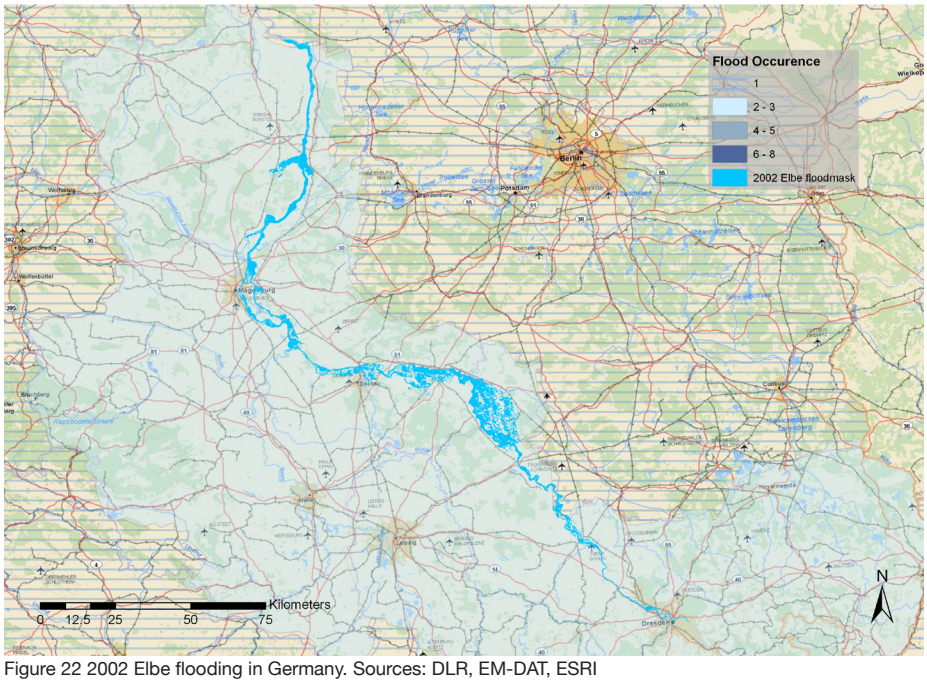

Figure 22 2002 Elbe flooding in Germany. Sources: DLR, EM-DAT, ESRI

8. Conclusions

Floods are the most common natural disaster in Europe and have a significant impact on the health and mental status of the community. Dealing with the aspects of health in connection with natural disasters, in this case floods, implies a detailed knowledge of health as well as of geosciences.

The main human impact indicators for flood events are monitored at the national level in the EU-27; however, these human impact data are not available consistently at a higher resolution. Considerable potential exists for further research in the combination of health and the geosciences in the field of disaster assessment.

Flood occurrence and impacts are currently recorded in EM-DAT, with worldwide coverage and a national resolution. Providing flood occurrence and impact data at the sub-national level can serve policy-makers and the international community in disaster management and mitigation. Descriptive analysis and mapping of flood occurrence statistics in the EU-27 is shown in this study to be feasible at subnational (admin1) level, hereby increasing the applicability of disaster statistics for policy measures.

Although research has addressed the health impacts of floods, the results are not very conclusive, especially concerning the long-term effects. This issue is one of several that are attributable to shortcomings, like poor data access, described in this report. Even though evidence exists regarding the health impacts of floods in developing countries, the health impacts of floods in Europe differ because of the different health, social, and economic context. To capture the more subtle and longer-term health effects of floods in Europe, more research is needed to link health data, spatial data, and flood occurrence data and to establish the direct impact on health of floods in Europe.

We identified some interesting starting points for such research and also demonstrated some of the possible advantages that, for example, an increased reporting resolution can have.

The biggest issue at the moment is access to and availability of health data at the sub-national level. On a positive note, many efforts are in progress to standardize health reporting in Europe at the national level and at the sub-national level and to overcome structural differences in administrative and health reporting systems. However, few initiatives currently exist to collect and share health data related to natural disasters, including floods. Furthermore, health and disaster data provision across Europe at the sub-national level remains challenging.

These initiatives require reinforcement with the inclusion of disaster impact statistics to strengthen the scientific body of evidence on the effect of disasters on health, to identify gaps, and to establish priorities for intervention.

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