RAPID RISK ASSESSMENT

Extreme rainfall and catastrophic floods in western Europe

29 July 2021

Summary

Extreme rainfall on 14 and 15 July 2021 and subsequent flooding in Belgium, Germany, Luxembourg and the Netherlands has taken a high number of human lives and caused substantial damage to community infrastructure and the environment.

This rapid risk assessment focuses on the most common infectious diseases and health risks associated with flood-affected areas, taking into account evidence from previous similar events in Europe.

In addition to food- and waterborne diseases, zoonoses, vector-borne diseases, vaccine-preventable diseases and other health hazards associated with previous natural disasters in Europe, the current risk assessment also considers the challenges of responding to such a complex crisis during the COVID-19 pandemic.

Risk assessment for the EU/EEA

The rapid responses put in place in the affected countries – such as providing access to healthcare, potable water and rescue shelters – has substantially mitigated the risk of infectious disease in the affected populations, as well as subsequent spread to other areas in the European Union and European Economic Area (EU/EEA).

In this rapid risk assessment, the risk of infectious diseases related to these events is stratified by population group (general population and vulnerable population) and by two levels of disease prevalence: very low or low (e.g. influenza, tetanus, measles, varicella, hepatitis A, *Legionella* and West Nile virus (WNV) infections, as well as other mosquito-borne diseases) and intermediate or high (e.g. SARS-CoV-2, *Escherichia coli*, *Salmonella* spp., *Cryptosporidium* spp. and norovirus infections).

Based on a combination of the probability of infection and the impact of infection, we assess the infectious disease risk that these events pose to the affected populations as ranging from very low or low for diseases that are uncommon in these countries and among otherwise healthy individuals, to moderate or high for diseases that are more probable among vulnerable individuals.

COVID-19 prevention is also given considerable emphasis, as the risk of SARS-CoV-2 infection spread in partially vaccinated or unvaccinated individuals is high, particularly among community members living in close contact with displaced people or among groups of displaced or evacuated people, due to overcrowding and the potential challenges of maintaining non-pharmaceutical interventions (NPIs). Although the risk of severe COVID-19 is low in fully vaccinated individuals, stringent implementation of NPIs is encouraged in all affected areas to prevent infection among partially vaccinated or unvaccinated individuals.

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Options for response

Floods are the most common type of natural disaster in Europe. Flash floods are significant emergencies that are challenging to predict and result in remarkable destruction. Such events have become more common in recent years and are expected to occur more frequently due to climate change.

Affected regions and countries have faced an immediate surge of injuries and trauma, and may – depending on the scale of disruption and public health capacity – consider setting up syndromic and event-based surveillance systems. Suspected cases of an agreed upon list of infectious diseases (including clusters of respiratory and gastrointestinal symptoms, rashes, etc.) would need to be reported to local and national public health authorities immediately to prompt a rapid response.

COVID-19 vaccination should remain a priority and disruptions to vaccine delivery in the flood-affected areas should be mitigated or resolved as quickly as possible. NPIs such as hand and respiratory hygiene, physical distancing and the wearing of face masks remain essential, particularly for displaced populations housed in shelters where physical distancing cannot be maintained. Testing and contact tracing should also remain a priority.

Collaboration between public health authorities and other local authorities (e.g. civil protection agencies, municipal governments) is needed to ensure access to clean water as soon as possible in the affected communities. Water management plans should minimise the risk for *Legionella* growth. Flooded areas also need to be monitored for increases in mosquito populations and control measures may need to be considered. Mechanisms to achieve early detection and awareness of disease clusters should be enhanced and availability of immunisations should be ensured.

Risk communication to the affected communities is a critical part of the response to the flood crisis and it should be undertaken in a structured way that clearly delivers core messages and listens to the affected communities' needs. Key principles of successful risk communication include the identification of a trusted spokesperson and the delivery of clear and actionable advice, with messaging tailored to the needs of the affected communities.

Event background

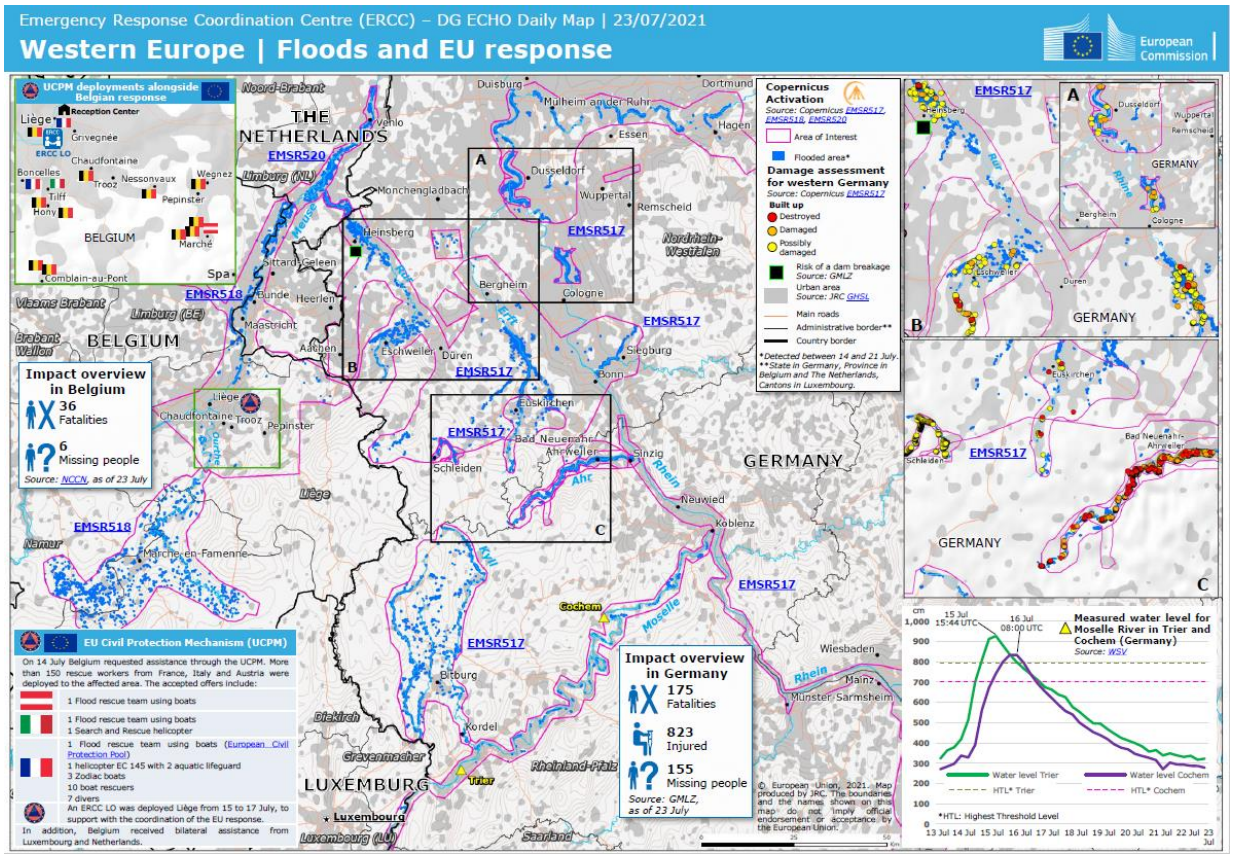
Heavy rainfall leading to disastrous floods in Belgium, Germany, Luxembourg and the Netherlands on 14 and 15 July 2021 has affected a large population and caused devastating destruction to infrastructure [1-5] (Figure 1). The worst-affected areas are in the western regions of Germany (Rhineland-Palatinate and North Rhine-Westphalia), as well as eastern Wallonia in Belgium. As of 27 July 2021, at least 212 deaths have been documented, of which 175 were reported in Germany and 37 in Belgium, with an additional 155 people in Germany and six people in Belgium who are still missing [6,7]. Much of the telecommunications network in these regions has been destroyed, further complicating attempts to reach all affected people.

Due to the floods, thousands of people have been evacuated, including from larger cities such as Liège in Belgium, and Limburg, Roermond and Venlo in the Netherlands [2]. Some of the disrupted areas are considered uninhabitable; therefore, people have been provisionally housed in various types of emergency accommodations, especially in Germany and the Netherlands. Initial reports indicate that about 1 000 people have been displaced in Luxembourg. Many evacuated or displaced people are currently housed with friends or relatives in multi-family homes or temporary accommodations. According to anecdotal reports in Germany, some people remain quasi-camped out outside of their homes without running water, sanitation or electricity in the vicinity. However, accurate data on the numbers and conditions of displaced populations are not yet available.

Given the disruption to wells and water supply infrastructure, tap water is considered unsafe to drink in most of the affected regions [10-12].

Just before, during and after the events described above, flooding also occurred in Austria [11], France [2], Italy [12], Poland [2], Romania [2] and Switzerland [12], as well as parts of the Bavarian region of Germany [11]; however, the destruction to infrastructure and disruption to populations was not as extensive.

Figure 1. Extent and impact of the floods in western Europe, as at 23 July 2021 [6]



Source: European Commission (EC) Emergency Response Coordination Centre (ERCC)

Disease background

Floods are considered the most common natural disaster worldwide and in Europe, and occur when water accumulates in places that are not normally submerged, usually due to heavy rainfall [13]. Generally, floods are categorised as fluvial (river inundation), pluvial (caused by heavy rainfall) or coastal (caused by sea-level elevation). Flash floods are a subset of pluvial floods that occur suddenly (with less than six hours warning), usually because of intense rainfall over a relatively small area, and are accompanied by widespread destruction. According to a recent report by the European Court of Auditors (ECA), serious floods have become more frequent in Europe. More than twice as many flash floods of medium to large magnitude have been registered in recent years, as compared with the late 1980s, particularly in Mediterranean countries and in the mountains [14]. Flash floods are difficult to predict and considerable research is underway in EU/EEA countries to develop better early warning systems [15]. Flood events are recorded in the Emergency Events Database (EM-DAT), under certain criteria that qualify them as disasters [16].

Flood-affected communities often suffer injuries and loss of lives, significant economic loss, as well as damage to the environment and cultural heritage. Floods may also lead to long-term health effects [13,14]. The most common infectious disease groups and health risks associated with flood-affected areas are outlined below.

Food- and waterborne diseases and zoonoses

Severe floods can lead to higher immediate, medium- and long-term risk of food- and waterborne infections and zoonoses. In areas that are prone to annual fluvial floods (e.g. due to snowmelt or excessive rain), the risks are mainly related to animal excreta in the soil and on land being flushed into buildings and water supplies through elevated river water. In urban settings, pluvial floods often cause street flooding, which is sometimes combined with sewage overflow [17]. When floods lead to severe disruption of infrastructure and sewage systems, the direct or indirect risk of gastrointestinal diseases increases due to the possibility of immediate exposure to waterborne and zoonotic faecal bacteria, viruses and parasites. Further, disruption of electrical, refrigeration and cooking systems may facilitate the transmission of food-borne illness, in particular during warm summer months [18]. In general, floods increase the risk of viral infections such as norovirus, hepatitis A and rotavirus; infections caused by parasites *Cryptosporidium* spp. and, to a lesser extent, *Giardia*; and bacterial infections due to *Campylobacter* spp., pathogenic *E. coli,* different *Salmonella enterica* serotypes and, to a lesser degree, *Shigella* spp.

In addition, there is an increased risk of leptospirosis transmission through skin abrasions and mucous membranes coming into contact with floodwater, damp soil or mud that has been contaminated with urine or tissue from infected animals, most commonly rats [21,22]. Occasionally, transmission occurs through drinking or inhalation of tiny droplets (aerosols) of contaminated water.

Medium- and long-term risk of gastrointestinal diseases due to floods have been described in several EU/EEA countries. In 2013, an outbreak of *Cryptosporidium hominis* infections was detected in Germany among children who had been playing on a floodplain after it dried out. As a response measure, authorities recommended that people avoid playing, swimming and having picnics in the flood-affected area [21]. This risk could be relevant to the recent flooding, e.g. along the Moselle and Rhine rivers, where the flood was less severe and therefore the area may dry out sooner, though flood-related risks could still be present due to the persistence of pathogenic microorganisms. In 2005, Austria reported a norovirus outbreak due to direct exposure to sewage water that occurred because of flooding [22]. A study in the Netherlands showed a significant association between contact with floodwater and gastrointestinal complaints during a four-week observation period after pluvial flooding [23]. In a follow-up study from the same country, contact with floodwater was significantly associated with acute gastroenteritis (AGE) (adjusted odds ratio (aOR): 4.2; 95% confidence interval (CI): 2.1-8.4). Risk factors for AGE were skin contact with floodwater (aOR: 4.0; 95% CI: 1.8-9.0), performing post-flooding cleaning operations (aOR: 8.6; 95% CI: 3.5-20.9) and cycling through floodwater (aOR: 2.3; 95% CI: 1.0-5.0) [17]. In 2010, river water contaminated a tap water system in Belgium, causing a large multi-pathogen waterborne outbreak that included isolations of norovirus, rotavirus, *Campylobacter* spp. and *Giardia lamblia* in stool samples from clinical cases [24].

Legionellosis

Legionella bacteria are environmental organisms found in soil and water, such as lakes, streams and artificial water reservoirs. Typically, they are transmitted to humans via the inhalation of contaminated aerosols and can cause pneumonia or Pontiac fever [25]. In late summer, after seasonal rainfall, sporadic cases of legionellosis are common in Europe. After heavy flooding, disturbances in the water supply, damages to water infrastructure, use of temporary water piping and tanks, and failure to follow the appropriate water management plans increase the risk of sporadic cases and outbreaks of *Legionella* pneumonia [26]. People in the affected area, including recovery workers, are at risk of exposure to aerosols generated from soil or sediment containing *Legionella* bacteria while flooded areas are cleaned (e.g. flushed with water) [27]. Moreover, an elevated legionellosis risk can be associated with poorly designed or incorrectly maintained water infrastructure (e.g. water piping and tanks) in temporary shelters or healthcare facilities. There is also evidence that the risk of *Legionella* infections may increase when there is warm weather following heavy rain [30-32].

It is important to highlight that *Legionella* pneumonia, leptospirosis and COVID-19, as well as a number of other viral respiratory infections, can present with similar clinical symptoms and signs, characteristically as an influenza-like illness.

COVID-19 and other vaccine-preventable diseases

COVID-19

The overall case notification rate for COVID-19 in the EU/EEA was 151.0 per 100 000 population in week 28 2021. This has been increasing in the past three weeks, mostly due to the spread of the Delta variant of concern (VOC) and relaxation of NPIs in some regions [31].

During week 28, the COVID-19 14-day notification rate per 100 000 population was 147.0 in Belgium, 17.0 in Germany, 276.0 in Luxembourg and 670.4 in the Netherlands, with increasing trends observed in all four affected countries in recent weeks. COVID-19 vaccination rates for cumulative uptake of full vaccination among adults (18 years and older) in the affected countries in week 28 were 60% (Belgium), 55.5% (Germany), 59.2% (Luxembourg) and 56.3% (the Netherlands) [32]. The majority of new COVID-19 infections in the EU/EEA, including in the affected countries, are occurring among unvaccinated, younger individuals [33].

Evacuated or displaced people from flood-affected communities will need to either be housed in shelters (e.g. community buildings, hotels, etc.) or with friends and relatives in multi-family homes. In both cases, overcrowding can occur, making it difficult to implement the recommended NPIs. This, in conjunction with the overall low full vaccination coverage of the general population and the increasing circulation of the Delta VOC, increases the risk of local outbreaks.

For information on the latest scientific evidence relating to COVID-19 and SARS-CoV-2 – including virus transmission, diagnostic testing, infection, clinical characteristics, risk factors and risk groups, immunity, treatment and vaccines – please visit ECDC's dedicated COVID-19 web page: https://www.ecdc.europa.eu/en/covid-19/latest-evidence and the Weekly COVID-19 country overview.

Tetanus

The risk of tetanus does not rise with simple contact with floodwater. However, when cleaning flooded places there is an increased risk of suffering injuries and open wounds from contact with debris. Such cases should be treated according to the type and depth of the wound, as well as tetanus immunisation status. Tetanus prophylaxis should be offered according to existing national guidelines [34].

In 2019, 64 cases of tetanus have been reported in the EU/EEA, none from the four flood-affected countries. Belgium reports that 62% of the adult population has received a tetanus booster in the past 10 years [35]; for Germany, this is reported at 72% [36]. In the Netherlands, protective antibodies against tetanus are reported for >90% of the population [37]. No data on tetanus seroprevalence are available for Luxembourg [38].

Hepatitis A

Hepatitis A is transmitted primarily by the faecal-oral route, mostly through contaminated food or water. All four flood-affected countries (Belgium, Germany, Luxembourg and the Netherlands) were categorised as having very low incidence rates for hepatitis A, according to data from 2000 to 2014, and none of them include immunisation against hepatitis A in their national immunisation schedules (though it is administered to special high-risk groups or travellers) [39]. Therefore, it is likely that these populations have substantial levels of susceptibility to hepatitis A outbreaks [40]. As the detection of hepatitis A outbreaks or clusters is usually delayed due to the long incubation period of 15 to 50 days, this may represent a medium-term concern.

Other vaccine-preventable diseases

If displaced individuals and families are temporarily housed in close proximity in shelters, there is an increased risk of transmission of vaccine-preventable diseases such as varicella, measles, meningitis and influenza, in addition to COVID-19.

Outbreaks of vaccine-preventable diseases like measles, varicella or meningitis are of immediate concern in displaced populations, albeit the risk is higher in countries with limited resources and suboptimal vaccination coverage [42].

Reported vaccination coverage for measles (two doses of measles-containing vaccine (MCV)) in the four affected countries ranges from 85 to 93% (Belgium (85%), Germany (93%), Luxembourg (90%), the Netherlands (90%)), thus below the 95% target. Furthermore, the COVID-19 pandemic has negatively impacted national immunisation programmes in the EU/EEA, as regular vaccination visits have been delayed or postponed for many young children [43]. This could lead to a higher proportion of children being susceptible to vaccine-preventable diseases.

Vector-borne diseases

Stagnant water remaining after floods (e.g. in basements, gardens, parks, agricultural and rural areas) could create suitable sites for mosquito breeding; therefore, heavy rainfall and floods increase the risk of mosquito-borne diseases. A higher density of mosquitoes may primarily increase nuisance levels, while the risk of mosquito-borne diseases may increase if mosquito-borne pathogens are present and competent mosquito vectors of those pathogens are also present in the flooded areas.

Outbreaks of mosquito-borne diseases associated with floods or heavy rainfall have mainly been reported in tropical areas (e.g. outbreaks of malaria, dengue fever, Rift Valley fever [40,41]). In Europe, extreme rainfall and flooded basements have been linked to the occurrence of chikungunya [46] and West Nile virus (WNV) infections [47]. The circulation of WNV in Europe has been documented since the 1950s, and it appears to be expanding its geographical range [48]. However, WNV circulation has not been documented in the affected regions. The principal vector, the common house mosquito *Culex pipiens*, is widespread in Europe [49]. Other mosquito-borne viruses (e.g. Usutu virus, Sindbis virus, Tahyna virus, Inkoo virus) are also endemic in some European countries, but have low prevalence and pathogenicity in humans.

Imported cases of exotic mosquito-borne diseases (e.g. malaria, dengue fever, chikungunya, Zika virus disease, yellow fever, Rift Valley fever) occur regularly in Europe. However, autochthonous transmission of these pathogens requires competent mosquito vector species.

The Asian tiger mosquito, *Aedes albopictus*, may serve as a vector for several viruses and has been expanding its range in Europe in recent decades [50]. *Aedes albopictus* has been implicated as the vector of outbreaks of dengue fever, chikungunya and Zika virus disease in southern Europe, but it is not considered established in the affected regions.

Malaria is not endemic in Europe. Considering the ecology and epidemiology of malaria, the probability that the recent floods would facilitate vector-borne autochthonous transmission from any imported malaria infections in the affected regions is very low.

Other health risks

Injuries and soft tissue wounds that come into contact with the debris that is associated with flooding can lead to soft tissue infections. Bacteria that are often responsible for soft tissue infections are *Staphylococcus*, *Streptococcus* and *Vibrio* spp. (e.g. *Vibrio vulnificus*); fungi are also implicated in soft tissue infections [51].

Wild animal bites (e.g. from rodents) are frequently reported after floods, as animals may seek refuge in flooded houses and become aggressive upon contact with humans [52,53]. Similarly, domestic animals can become aggressive in stressful situations like floods when people approach them (e.g. to rescue them).

Studies have reported fungal growth in homes that have been flooded and in household goods that have been submerged, particularly when waters recede gradually. The extent and type of fungal growth depends on the local climate and the type of building structure. Pulmonary and systemic fungal infections (usually airborne and dust-borne *Aspergillus*) and mycotoxin exposure have been reported following flooding [20,49]. People can be exposed through skin, ingestion or inhalation. Immunocompromised people are more vulnerable to fungal infections after inhalation, which can be localised or disseminated. Prolonged exposure to mould (usually occupational exposure) can cause rhinitis, hypersensitivity pneumonitis (e.g. farmer's lung) and asthma [50,51].

While this risk assessment focuses on infectious disease risks after the extensive flooding in western Europe, as per ECDC's mandate, it is important to note that these do not represent the biggest risks to the health and well-being of the flood-affected communities in the current crisis. Several other health risks are mentioned in the literature – including disruption of healthcare (particularly chronic care), other environmental hazards (e.g. carbon monoxide poisoning, exposure to dangerous chemicals) and psychological stress – and may be accompanied by long-lasting health effects and an increase in all-cause mortality [13,57].

ECDC risk assessment for the EU/EEA

This assessment is based on information available to ECDC at the time of publication and, unless otherwise stated, the assessment of risk refers to the risk that existed at the time of writing. It follows the ECDC rapid risk assessment methodology, with the overall risk determined by a combination of the probability of an event occurring and its consequences (impact) for individuals or the population [58].

Risk assessment questions

What is the risk of infectious disease in the population affected by catastrophic floods in Belgium, Germany, Luxembourg and the Netherlands?

The degree to which infectious disease outbreaks occur after a natural disaster like floods is associated with the regional incidence of specific diseases, the nature and scope of the event, the robustness of public health infrastructure in place both before and after the event, and the efficacy of the disaster response [45].

In this particular event, the relatively limited geographical areas of destruction and the proximity of unaffected areas has facilitated disaster response and access to rescue shelters and potable water, possibly mitigating the risk of infection.

In this assessment, we stratify the population affected by this event into two groups: the general population and the vulnerable population. The latter group is defined as those who are at higher risk of exposure to and/or severe outcomes of infectious disease, including elderly people, pregnant women, children, immunocompromised and disabled individuals, and those who were displaced into temporary shelters, due to their higher possibility of exposure to infectious disease pathogens in communal accommodations and the disruption of their regular healthcare provision.

We stratified the infectious diseases potentially connected to flooding events into two groups according to their epidemiology in the four affected countries, taking into consideration the types of post-flood outbreaks reported in the literature. Therefore, for the purposes of this assessment, we considered vector-borne infections (e.g. WNV infection, *Aedes*-borne infections) and influenza, tetanus, measles, varicella, hepatitis A and *Legionella* infections as having a very low or low baseline prevalence and COVID-19, foodborne infections (e.g. from pathogenic *E. coli*, *Salmonella* spp., *Cryptosporidium* spp.) and leptospirosis as having an intermediate or high baseline prevalence.

Based on a combination of the probability of infection and the impact of such an infection, should it occur in the two population groups described previously, we assess the infectious disease risk posed by this event as ranging from **very low** to **high** (Table 1).

Table 1. Probability, impact and overall risk of infectious diseases for the general population and vulnerable population affected by flooding in western Europe

Population	Very low or low prevalence diseases*	Intermediate or high prevalence diseases†
General population	Probability: Very low Impact: Low **Risk: Low**	Probability: Moderate Impact: Low **Risk: Moderate**
Vulnerable population	Probability: Very low Impact: High **Risk: Moderate**	Probability: Moderate Impact: High **Risk: High**

** Very low or low prevalence diseases include tetanus, hepatitis A, measles, varicella, meningitis, influenza, legionellosis and vector-borne diseases.*
† Intermediate or high prevalence diseases include FWD, COVID-19 and leptospirosis.

SARS-CoV-2 is endemic in the community throughout the EU/EEA, including in the flood-affected areas. Considering the increasing prevalence of the Delta VOC and the fact that substantial proportions of the population are unvaccinated, the probability of increasing circulation of SARS-CoV-2 in the flood-affected areas is high. Additional factors that may contribute to the increased risk of COVID-19 include the potential disruption of testing and tracing programmes and the difficulties of implementing isolation and quarantine measures. The disruption of the COVID-19 vaccine rollout and obstacles to maintaining NPIs in the community or in multi-family dwellings add to this risk.

There are immediate, medium- and long-term risks of food- and waterborne infections and zoonoses (e.g. leptospirosis) connected to flooding. Due to full disruption of sanitation and drinking water systems in some areas, there is a moderate risk of infections with various enteric pathogens that tolerate environmental conditions well, such as norovirus, rotavirus, pathogenic *E. coli*, *Salmonella* spp. and *Cryptosporidium* spp. The risk of infection with other food- and waterborne pathogens is low. Therefore, the probability of food- or waterborne disease clusters or outbreaks is considered moderate in areas where access to clean water and good hygiene practices cannot be ensured. Due to the possible contamination of water used for agricultural purposes, there is limited risk of contamination of fresh fruits and vegetables with enteric pathogens, if they were grown in the vicinity of the affected areas. Children are particularly at risk, due to higher direct or indirect oral transmission of pathogens from contaminated water or surfaces affected by floodwater.

The risk of leptospirosis is assessed as moderate, as the scattering of garbage, debris and food may contribute to the amplification of rodent populations [59].

Sporadic *Legionella* infections can be expected after summer rainfall, but the flooding has added to this risk, mostly through occupational exposure for people cleaning or maintaining piping in flooded buildings, particularly if mud or dust is aerosolised.

Considering the likely low natural immunity levels, outbreaks of hepatitis A may occur in the affected areas through consumption of contaminated food or accidental swallowing of sewage-contaminated water [60]. Occupational exposure to hepatitis A virus during construction of sanitation systems in cleaning workers has also been reported [61].

Finally, although mosquito nuisance is likely to increase due to the existence of abundant breeding sites in the flooded areas, mosquito-borne diseases are included in the very low or low prevalence group. WNV circulation has not been documented in the affected regions and *Aedes albopictus* – which could transmit several *Aedes*-borne viral diseases – is not considered to be established there. Autochthonous transmission of malaria in the affected regions from imported cases is also considered unlikely.

What is the risk of infectious diseases spreading from the affected areas to other areas of the EU/EEA?

For most of the diseases considered in this assessment, the probability of spread to other areas of the EU/EEA is considered very low and, should such risk materialise, its impact is assessed as low. However, the probability of SARS-CoV-2 and food- and waterborne infections and outbreaks spreading is considered higher than that of the other diseases discussed previously.

SARS-CoV-2 is circulating in the communities of all four flood-affected countries with a 14-day case notification rate per 100 000 population ranging from 17.0 in Germany to 670.4 in the Netherlands. At the same time, full vaccination among adults (18 years and older) in the affected countries ranges from 56% in the Netherlands to 60% in Belgium. Therefore, there is a risk that any localised increase in transmission resulting from disruption to

healthcare delivery or less stringent adherence to NPIs in the flooded areas could result in increased spread of SARS-CoV-2 to neighbouring communities. The need to prioritise COVID-19 vaccination deployment in flood-affected areas and among both displaced populations and volunteers in these areas is highlighted, together with stringent implementation of NPIs for all.

The probability and impact of food- and waterborne infections spreading to other populations is considered very low. However, there is a theoretical risk if exported fresh fruits and vegetables have been irrigated with contaminated surface water, which could then lead to outbreaks outside of the flood-affected areas.

Options for response

Floods are the most common type of natural disaster in Europe and extreme weather events like the flash floods in Belgium, Germany, Luxembourg and the Netherlands are expected to increase in frequency, as outlined in the latest Intergovernmental Panel on Climate Change [62]. Consequently, preparedness planning for the management of the health effects of climate-related disasters needs to be strengthened [62,63].

The recent flood-affected areas may experience a disruption of healthcare services and an initial increased demand to respond to injuries, trauma patients and the management of fatalities. As EU/EEA countries are still responding to the needs of the COVID-19 pandemic, this can cause additional strain on the healthcare system and support may be needed from unaffected areas nearby.

To rapidly detect and respond to possible infectious disease threats in the affected areas, national authorities should consider setting up syndromic and event-based surveillance systems.

Syndromic surveillance systems are based on the ongoing reporting of clinical presentations/syndromes (e.g. diarrhoea with/without fever, fever with rash, cough with fever, etc.) to public health authorities. Depending on existing surveillance infrastructure, the reporting can be real-time, daily or weekly, using simple reporting methods and forms. Due to the disruption of networks (e.g. electricity, internet, etc.) alternative ways of reporting (e.g. by phone) should also be considered until the situation stabilises and regular reporting methods are available again. Alternative communication pathways may cause delays in reporting, thereby delaying recognition of a new health event (e.g. a new cluster). Regular analysis of incoming syndromic data could allow for the rapid detection and control of outbreaks.

Public health authorities should also consider defining a list of serious events (event-based surveillance) that require immediate notification by phone in order to prompt rapid investigations and implementation of prevention and control measures (e.g. suspected cases of measles or meningitis, cases of unusually severe respiratory or gastrointestinal illness) [64,65].

COVID-19 response measures

Response to the ongoing COVID-19 pandemic should follow the options outlined in the latest ECDC Rapid Risk Assessment 'Assessing SARS-CoV-2 circulation, variants of concern, non-pharmaceutical interventions and vaccine rollout in the EU/EEA, 15th update' [66], as well as the Threat Assessment Brief 'Implications for the EU/EEA on the spread of the SARS-CoV-2 Delta (B.1.617.2) variant of concern' [67].

COVID-19 vaccination campaigns should remain a priority for the flood-affected countries. In these areas, given the increased risk of further spread of COVID-19 due to local conditions, efforts to ensure the provision of COVID-19 vaccines and to facilitate access to vaccination should be prioritised, particularly if the communities are displaced into communal shelters or multi-family homes. Initiatives can include mobile vaccination units (e.g. the vaccination buses deployed in affected areas in Germany [68]), drop-in vaccination, flexible scheduling and community delivery strategies. If capacity is reduced, prioritising risk groups, including elderly people and those with underlying medical conditions, will have the biggest impact on reducing severe COVID-19 and COVID-19-related mortality. Humanitarian workers and volunteers in the affected areas should be included in the priority risk group. In addition, a risk assessment of the cold chain for transportation and maintenance of COVID-19 vaccines should be undertaken in the affected areas, due to the severe damage to utility networks, to ensure they are functioning properly.

Some preventive measures are currently being taken to curb the spread of COVID-19 in the affected regions, as the risk of disease spread in emergency housing is increased given the proximity of large groups of people. For example, in Germany [69], buses are providing testing and offering vaccination without appointment, and temporary medical infrastructure has replaced many of the destroyed or unusable medical establishments. In addition, in Belgium a dedicated website has been created to inform citizens what to do if the floods have disrupted vaccination or testing appointments [70].

Non-pharmaceutical interventions

To reduce the risk of SARS-CoV-2 transmission, it is essential to maintain or re-establish NPIs (i.e. physical distancing, use of face masks where physical distancing cannot be maintained, hand and respiratory hygiene, etc.) in areas where flooding has resulted in increased crowding or disruption to health services, as part of the public health response. Such measures should be implemented particularly among displaced populations, taking into consideration the local epidemiological situation, the vaccination coverage in the general population and the prevalence of VOCs. Face masks should always be worn while volunteering, assisting, or staying in shelters, and hand and respiratory hygiene measures should be practised meticulously.

Testing and contact tracing

Testing and contact tracing of SARS-CoV-2-positive cases remain important. This is crucial in areas where populations have been displaced or health services have been interrupted. The spread of SARS-CoV-2 can be minimised by expecting and planning for potential outbreaks or clusters of cases, particularly in congregate settings. A robust system for contact tracing should remain a priority.

Other flood-related infectious disease response measures

Other flood-related infectious disease response measures that public health authorities should consider in the short and mid-term include:

- Ensuring the rapid detection of potential clusters or outbreaks of vaccine-preventable diseases (e.g. establish alerts from surveillance systems), particularly in displaced individuals, and ensuring availability and access to the immunisations necessary for outbreak control.
- Ensuring that the affected communities have access to clean water by collaborating with other local authorities in areas where water and sanitation systems have been damaged. Water quality monitoring systems are needed and water quality results should be communicated to the affected communities through appropriate information pathways.
- Ensuring that water management plans minimise the risk of growth or exposure to *Legionella* and other waterborne pathogens.
- Providing hand hygiene stations or facilities throughout shelters and in community spaces.
- Providing information to humanitarian workers, first responders, construction workers and anyone else involved in recovery and cleaning of flooded edifices and debris, including that they should wear appropriate personal protective equipment to avoid potential exposure to pathogens.
- If water removal is not possible within the next few weeks, public health authorities should monitor mosquito populations in the flooded areas. If intensive mosquito breeding is detected, deploying control measures (such as larvicide treatments) should be considered.

Risk communication

Communication among all the stakeholders is very important in the response to such complex emergencies. A large part of public health authorities' involvement in managing the health effects of flooding has to do with risk communication to the affected population, which should address the risks outlined in this document. Risk communication during the response to a disaster is considered a critical function and should be carefully planned, focusing on three key principles: use of a trusted voice or representative as a spokesperson; provision of clear, actionable advice; and tailoring of messages and communication methods to the communities' needs [71].

Communicators should focus on expressing empathy, explaining risks, promoting action and describing response efforts. In addition, community engagement should be prioritised to address rumours, misinformation or misunderstandings [72]. At the same time, the listening aspect of risk communication should be developed by regional and national authorities to enable better community engagement and gathering of feedback on how messages are received. Examples of such activities include organising hotlines, monitoring social media and organising community meetings where community members can provide feedback on their needs and the response to the crisis [72,73].

Messages and advice that public health authorities should communicate to target groups (communities, health professionals, volunteers and humanitarian workers in the flood-affected areas) as part of their risk communication activities are outlined in the following sections.

General hygiene messages

Public health authorities should consider suggesting the following general hygiene practices to those in the flood-affected areas:

- Practicing careful hand hygiene with soap and clean water or using appropriate alcohol-based hand rub solutions, particularly after handling any item or material that may have been contaminated by floodwater or using the toilet and before preparing food, eating, drinking or smoking.
- Only drinking clean, safe water and only eating food that has not come into contact with floodwater directly or indirectly (e.g. by touching surfaces that have come into contact with floodwater or sludge).
- Not using floodwater, well water or water that has been contaminated with floodwater for:
  - personal hygiene (e.g. washing or brushing teeth);
  - to wash dishes, vegetables or fruits;
  - to cook food; or
  - to prepare baby food.
- Waiting for official announcements or advice regarding when tap water is safe to drink.
- When in doubt, throwing away any food or water that may have come into contact with floodwater.
- Not eating fruits, vegetables or any other plants from gardens that have been flooded, unless they are well washed with clean water.
- Not eating refrigerated food that has been exposed to warm temperatures for more than two hours (e.g. due to electricity disruption).
- Not swimming in floodwater or lakes and rivers that have been flooded, and not picnicking in or allowing children to play in recently flood-affected areas.
- Practicing proper respiratory hygiene (coughing and sneezing into the elbow, using and disposing of tissues properly), particularly in shared accommodations.
- Being aware of immunisation status for tetanus and other vaccine-preventable disease pathogens.
- Seeking prompt medical advice when having clinical symptoms (according to surveillance needs regionally).
- Removing stagnant water (as part of recovery and reconstruction work) by draining flooded areas and removing debris that could act as water containers.

Specific messages for healthcare professionals could also include:

- Increasing awareness of reporting to the event-based surveillance system, if applicable, or increasing awareness of a specific list of diseases, according to local management decisions (e.g. gastrointestinal, respiratory, rash, etc.).
- Increasing awareness of the detection of clusters of communicable diseases, particularly for health professionals serving displaced populations (e.g. food- or waterborne diseases, vaccine-preventable diseases, *Legionella* pneumonia, etc.).
- Increasing awareness of the similarities between the clinical presentations of COVID-19 and other respiratory syndromes that should be included in the differential diagnosis (e.g. *Legionella* or *Leptospira* infections).
- Providing advice on the management of wounds and reminders about tetanus prophylaxis.
- Increasing awareness of potential vaccine-preventable diseases (e.g. hepatitis A, measles, varicella) that may emerge in the displaced population, as well as their management and notification procedures, according to national guidelines.

General messaging on disasters

- Disease outbreaks happen due to the destruction of infrastructure (e.g. sanitation systems).
- Corpses do not pose a public health risk for disease outbreaks because most pathogens can no longer survive in a dead body, and microorganisms involved in putrefaction (decay processing) are not pathogenic [74].

Limitations

This assessment is undertaken based on facts and data known to ECDC at the time of publication.

Source and date of request

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Consulted experts

ECDC experts (in alphabetic order): Leonidas Alexakis, Xanthi Andrianou, Agoritsa Baka, Tamas Bakonyi, Olivier Briet, Orlando Cenciarelli, Nishi Dave, Silvia Funke, Josep Jansa, Teija Korhonen, Katrin Leitmeyer, Lara Payne, Anastasia Pharris, Emily Scott, Ettore Severi, Johanna Takkinen, Maria Tseroni, Angela Wirtz, Andrea Würz.

External reviewers:

Belgium: Valeska Laisnez (Sciensano)

Germany: Christina Frank, Nadine Zeitlmann (Robert Koch Institut (RKI))

Luxembourg: Anne Vergison (Health Directorate)

Netherlands: Eelco Franz (National Institute for Public Health and the Environment (RIVM))

WHO Europe: Enkhtsetseg Shinee, Paula Vasconcelos, Simon van Woerden

All experts have submitted declarations of interest and a review of these declarations did not reveal any conflict of interest.

Disclaimer

ECDC issues this risk assessment document based on an internal decision and in accordance with Article 10 of Decision No 1082/13/EC and Article 7(1) of Regulation (EC) No 851/2004 establishing a European Centre for Disease Prevention and Control (ECDC). In the framework of ECDC's mandate, the specific purpose of an ECDC risk assessment is to present different options on a certain matter. The responsibility on the choice of which option to pursue and which actions to take, including the adoption of mandatory rules or guidelines, lies exclusively with the EU/EEA countries. In its activities, ECDC strives to ensure its independence, high scientific quality, transparency and efficiency.

This report was written with the coordination and assistance of an Internal Response Team at the European Centre for Disease Prevention and Control. All data published in this risk assessment are correct to the best of our knowledge at the time of publication. Maps and figures published do not represent a statement on the part of ECDC or its partners on the legal or border status of the countries and territories shown.

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