**Urban Flood**

**Overview**

Urban floods can arise from extreme thunderstorms or from river overflow. Both rapid rise and slow rise floods can have a significant impact on public health in an urban area.1 Between 1995 and 2015, 3,062 flood events were recorded2. Floods were responsible for the majority (56%) of natural disasters; affecting 2.3 billion people worldwide2. While the adverse health effects of flooding include direct impacts on human health, the pathways can be complicated and indirect.

**Health impacts**

**Disruption to essential health care.** Treatment for serious illnesses, such as cancer, can be disrupted by flooding, due to transport infrastructure being knocked out for prolonged periods of time.3 Lack of availability of routine prescription medicines due to flooding may also impact health.4 Health care practitioners may also become overwhelmed by the increased demand for services.1

**Drowning or physical trauma.** Rapid rise floods can cause sudden changes to the environment, increasing the risk of drowning and injuries.5 Slow rise floods can also be deadly when there is a lack of preparedness.1

**Illnesses.** Diseases can be spread from undisinfected groundwaters by the onset of flooding.6 Increased instances of cholera7, diarrheal diseases7, hepatitis A and E7, leptospirosis7, melioidosis8, respiratory infections9, and typhoid7 have been observed after floods in urban areas.

**Malaria.** Epidemics in the wake of flooding in tropical regions can occur due to clogging of storm water drains, causing stagnant water to allow genesis of vectors of malaria.9,10

**Malnutrition.** Damage to infrastructure caused by flood, and disruption to food systems can cause appropriate food to be unavailable for prolonged periods, with children and the elderly particularly in developing countries vulnerable.11

**Psychological distress.** The mental health effects of a flood can last long after the flood itself, with reports of increased prevalence of psychological morbidity (including depression, anxiety, PTSD) in residents up to 1 year after floods, particularly if residents are displaced at short notice.12,13

**Key deliverables**

**Clear messaging of probability, lead times and spatial scales.** Improving ‘believability’ of flood forecasts can and must be improved upon by having clearer messaging on the predictability and processes of weather systems. The trustworthiness of flood forecasts can increase the changes of appropriate action and response by a vulnerable population.14,15 Such ways to improve trustworthiness are diffuse, but include clearer explanation of uncertainty in forecasts, validation of hazards, among other aspects.

**High resolution hazard-exposure mapping** As flood hazard forecasts become more reliable at a higher resolution and longer timescales, hazard-exposure maps (similar to <https://coast.noaa.gov/floodexposure/#/splash)> with detailed overlay of vulnerable groups in flooding (e.g. the elderly, the poor)16 would help to provide targeted aid. This may rely on forecasts of flooding areas being made on the neighbourhood level (~1km resolution for overlay with gridded population datasets like <http://ec.europa.eu/eurostat/data/database)>.

**Vector-borne disease.** Advanced techniques are available for infectious disease mapping with the onset of precipitation, with a one month preparation lead time to adequately prepare medical treatment.17 Working with epidemiologists and infectious disease modellers more closely to understand their needs and wishes would greatly improve their ability to inform medical and emergency services.

**‘Warn on forecast’.** If the forecast skill is significantly improved in a case such as Hurricane Sandy to advance to further days in advance, essential preparations, especially for those less able to move from place-to-place, would be easier and less disruptive. This would require a consistent long-term forecast ensemble, as one of the main reasons Hurricane Sandy was so devastating was due to the conflicting information from competing model forecasts. [ref] This would be especially true for trapped members of the populations, for example those who are stuck in a house to ensure that they have an appropriate amount of food and/or remote medical treatment.

**Improved downscaling of flood forecasts to improve early warning systems.** A study experiment set in Japan demonstrated the benefits improving resolution of flood forecasts for early warning systems.18 This demonstrated that a dramatic improvement in flood forecast downscaling could have significant returns in the preparedness of a population from flood early warning systems.

**Tolerance levels of buildings and drainage systems.** Overflowing sewers and storm drains can lead to flooding and collections of stagnant water, which will both have significant health impacts.1 Under climate change and increasing urbanization, the maximum flows resulting from floods can and should influence design capacity for tolerance of urban storm water. Designing the appropriate drainage system in urbanized areas will depend upon hydro-meteorological characteristics.19 Predictability of long-term maximum estimated flows is therefore an important input of future urban design.

**Preparedness for after the flood** Hurricane Sandy failures in the post-hurricane flood show that more understanding is required by authorities into how the flood will affect infrastructure in the weeks after the flood itself.[ref] Improving modelling of water flows after the flood will result in better infrastructure planning, potentially saving many more lives, and certainly avoiding prolonged distress by a population of displacement without knowledge of return.

**Potential projects with improved forecasting**

**Working with food and medicine supply infrastructure in a developing country with early warning system to map pathways to vulnerable communities** Vulnerable members of Pakistan’s population suffered malnutrition from the devastating floods of 2011.11 Working with authorities there, high resolution flood mapping with adequate lead times could aid planning for stockpiling of food.

**Project to create high resolution disease mapping simulations based on prediction of flood.** In early January 2015, devastating rains hit Malawi, resulting in massive floods across the country. This affected an estimated 638,000 people. There were 79 deaths associated with the floods. An outbreak of cholera resulted in 693 cases and 11 deaths. Advanced techniques are available for infectious disease mapping with the onset of precipitation, with a one month preparation lead time to adequately prepare medical treatment.17

**Long-term hospital infrastructure planning using high resolution flood modelling.** During the 2010 flood emergency in Pakistan, more than 500 hospitals and clinics were damaged or destroyed. High resolution extreme flood modelling could aid the planning of new flood-resistant hospitals and clinics, and help shore up existing treatment centres to enable them to continue to run.

**Education and workshops of key disaster relief stakeholders into understanding how forecasting of floods can be reported.** Often a key reason that appropriate action is not taken by a vulnerable population is that there is not sufficient belief that the flood warning will result in a flood. This is true even in industrialised countries like the USA. A key goal could be to work with practitioners who deploy resources in flood warnings to better understand what kind of information they need with regards to

**Wildfire**

**Overview**

Uncontrolled spread of wildfire can originate from bush, vegetation, forest, heath and grass. Wildfires predominantly occur in countries with warmer climates, they have been known to occur from uncontrolled burning of vegetation in temperature climates such as in the UK.20 Many health impacts result from the inhalation of burnt organic material, but other direct effects are evident.

**Health impacts**

**Burns.** Direct flame and thermal burns can result from a wildfire. The great increase in burns victims in a short time puts significant pressure on health care burns units, which can overwhelming these specialist centres.20

**Carbon monoxide poisoning.** This is mainly a risk to those who are in the immediate vicinity of the fire, such as firefighters. It can cause hypoxic injury, nervous system damage, and death.

**Eye irritation.** Those living close to the wild fires can experience eye irritation, as well as reduced general visibility due to ambient smoke, which can make vehicular accidents more likely.21 Corneal abrasions can also result from the eyes’ exposure to wildfire smoke.22

**Heat-induced illness.** Working in hot and humid conditions can cause many health issues (see ‘Urban Heat Waves and Pollution’). Firefighters can be particularly vulnerable when attempting to deal with the controlling the extent of the fires.

**Particulate matter inhalation.** Burning of organic material can produce several varieties of particulate matter. PM10 (particles under 10µm in diameter) can pass through the upper respiratory tract and are deposited in airways.20 PM2.5 (particles under 2.5 µm in diameter) can penetrate even deeper into the lungs and deposited where gaseous exchange takes place.20 Short-term exposure leads to increases in hospital admissions for respiratory conditions.23 Exposure to particulate matter will cause long-term health problems, and is a known risk factor for cardiopulmonary and lung cancer mortality.24,25

**Psychological distress.** Wildfires can cause the complete destruction of homes and livelihoods. This in turn can lead to depression, anxiety, and PTSD.26

**Respiratory complications.** Breathing in bushfire smoke will exacerbate breathing problems for both children and adults. [ref]

**Water and land contamination.** Large concentrations heavy metals (such as arsenic, cadmium, copper, and lead) have been found deposited in soil from ash debris after a wildfire, which can cause various long-term health effects.27

**Deliverables**

**Potential projects with improved forecasting**

**Example of Manitoba, Canada.**

**Localised Extreme Wind**

**Overview**

28 **Health impacts**

**Injuries from debris** Buildings and trees

**Road accidents**

**Psychological distress**

**Sea spray**

**Deliverables**

**Potential projects with improved forecasting**

**Disruptive Winter Weather**

**Overview**

**Health impacts**

**Deliverables**

**Potential projects with improved forecasting**

**Urban Heat Waves and Air Pollution**

**Overview**

**Health impacts**

**Deliverables**

**Potential projects with improved forecasting**

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