

Health protection and risks for rescuers in cases of floods

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Floods can pose a number of safety and health hazards for flood-affected populations and rescuers and bring risk of injuries, infections, and diseases due to exposure to pathogenic microorganisms and different biological and chemical contaminants. The risk factors and possible health consequences for the rescuers involved in evacuation and rescuing operations during the May 2014 flood crisis in Croatia are shown, as well as measures for the prevention of injuries and illnesses. In cases of extreme floods, divers play a particularly important role in rescuing and first-response activities. Rescuing in contaminated floodwaters means that the used equipment such as diving suits should be disinfected afterwards. The need for securing the implementation of minimal health and safety measures for involved rescuers is paramount. Data regarding injuries and disease occurrences among rescuers are relatively scarce, indicating the need for medical surveillance systems that would monitor and record all injuries and disease occurrences among rescuers in order to ensure sound epidemiological data. The harmful effects of flooding can be reduced by legislation, improvement of flood forecasting, establishing early warning systems, and appropriate planning and education.

KEY WORDS: *contamination; decontamination of diving equipment; disinfection; displaced animals; flood-related health hazards*

Floods have significant adverse impacts on human health and the environment causing damage to infrastructure, livestock, and crops (1-3). Floodwater can cause a range of significant health impacts and risks, including deaths and injuries, contamination of drinking water, loss of electricity, increased populations of disease-carrying insects and rodents, community disruption, and displacement (2, 3). Rescuing displaced animals from floodwaters may present high risks and health hazards for involved responders (4, 5). A study on rescuers' exposure showed that chemicals and pathogenic microorganisms in contaminated floodwater also pose hazards (6). People who perform rescue operations in polluted water are faced with problems of exposure to hazards from flood water and cleaning and disinfecting their wet and dry suits (7). Among the general population, the main health impacts during a flood event include deaths by drowning and injuries such as sprains, strains, lacerations, abrasions, contusions, etc. (8, 9). Although the negative impact of a disaster on the health of the general population is widely known, data regarding rescuers are relatively scarce (6). Recently conducted studies after several major disasters, showed significant increases of dermatological, diarrhoeal, and respiratory diseases among rescuers workers (10-12).

General hazards

Apart from the fact that hazardous objects may float along the stream of a flood, floodwaters may also conceal sharp objects, such as wood, glass or metal fragments, and even large holes created by collapsed buildings and roads. Floods can also lead to an abundance of various specific hazards comprising biological and chemical (or even radiological) contaminants.

Biological hazards

One of the most significant risks comes from faecal contamination, due to the mixing of floodwater with raw human sewage, septic tanks, waste water from stables and animal manure (13, 14).

The presence of bacteria (e.g., *Escherichia coli*, *Campylobacter spp.*), viruses (e.g., polioviruses, Hepatitis A), parasitic protozoa (e.g., *Cryptosporidium parvum*, *Giardia lamblia*), and helminths (e.g., *Ascaris*) in floodwater can cause health problems such as gastroenteritis, diarrhoea and vomiting, respiratory diseases, hepatitis, dysentery, anaemia, poliomyelitis and ascariasis (13, 15). Free-living amoebae found in aquatic environments cause diseases such as encephalitis, keratitis, and meningoencephalitis (13). The pathogenic *Leptospira* species cause leptospirosis with symptoms from mild flu-like illness to a severe form including kidney failure and haemorrhage that can be fatal. Entering floodwater in regular diving gear does not prevent the exposure of rescuer divers to faecal contamination via the nose, ears, mouth and open wounds, because the wet

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suit does not protect the skin and mucosa (16). Additionally, there is risk of inhaling contaminated water through the regulator, which creates small droplets of water (13, 14). Algae and cyanobacteria present a potential health risk through the production of poisonous toxins (17). Cyanobacteria produce three types of toxins. Microcystins are the most frequent causing liver damages and their main exposure route is through inhalation. Exposures to cyanobacterial neurotoxins cause suffocation, cramps, tremor, diarrhoea, vomiting and paralysis, but their concentrations in freshwaters are rarely high enough to cause death (13, 18). Cytotoxins cause kidney and liver failures. Divers who use regular diving gear can be exposed to these toxins through ingestion, skin contact, and inhalation (13, 14).

Chemical hazards

Chemical hazards include inorganic and organic contaminants, but the impact of organic contaminants on health in the event of floods is far more important. Organochlorine pesticides and polychlorinated biphenyls (PCBs) are extremely toxic and persistent environmental pollutants (19, 20). PCBs are also known as potential carcinogens (21, 22). The widely used pesticides glyphosate and atrazine (and its metabolites), as well as various organophosphates and carbamates (neurotoxic pesticides), can be found in high concentrations, but are less persistent and unlikely to reach concentrations in open waters that would be high enough to cause a risk (15). Floodwater may also influence that other chemicals and solvents used in agriculture are transferred from farm storages into the surrounding area causing very high concentrations of pollutants.

Hydrocarbons include solvent, oil, fuel and polycyclic aromatic hydrocarbons (PAHs). PAHs are heavy molecules capable to evaporate and dissolve in water (23). Some hydrocarbons may also damage neoprene protective wear, which is why neoprene diving suits are not recommended when diving in areas likely to have high concentrations of hydrocarbons (16, 24).

Displaced animals

Displaced pets and domestic animals pose a number of health hazards to rescue workers. Unpredictable or aggressive behaviour caused by fear and panic are usual in displaced animals and put rescuers at risk of being injured or contracting rabies and other zoonoses such as toxoplasmosis (25). Contact with animals and exposure to their dander, hair, fur, saliva, all of which contain allergens can cause both respiratory and dermatologic disorders, allergies, and asthma (4). When handling animals, cages, and equipment, it is important to use appropriate personal protective equipment (protective face mask, rubber boots, and disposable protective suits) that provide a protective barrier between the skin and the contaminants and are made

from materials that reduce exposure to allergenic substances, as well as adhere to procedures and prevention measures. Wounds, cuts or animal bites should be immediately cleansed with soap and clean water and rescuers should ask for medical evaluation, including post-exposure rabies and tetanus treatment according to country-specific public health regulations (26-28).

Divers as a particularly vulnerable population in cases of flooding

In cases of extreme floods, divers play a particularly important role in rescuing and first-response activities. Divers usually wear dry or wet suits. Wet suits do not protect the rescuers as those wearing them are totally immersed and exposed through the ears, nose, and mouth. The wet suit also creates a micro-environment that may enhance contact between chemical contaminants and skin (13). If the use of a wet suit cannot be avoided, it is important to fill the suit with clean water or mixed weak disinfectant immediately before diving to reduce water-flow by contaminated water (8). A better and safer option for rescuers is to use dry suits, which minimizes exposure.

Diving in contaminated waters means that the equipment (protective suit, mask and snorkel, and other) should be disinfected afterwards, especially following diving in sewage or other faecal-contaminated waters (6). Disinfection of diving equipment can be general or partial. General and complete disinfection generally takes place after the purchase of new equipment, after long storage or repair, or after diving in contaminated water. Partial disinfection includes only one piece of equipment, usually those parts in close contact with the individual (29, 30). As a first step in protecting the health of rescuers and preventing exposure and possible transmission of disease, it is necessary to wash the dry suits with clean running water and remove mud immediately following rescue, which will limit the formation of moulds and bacteria. After rinsing, suits should be air-dried.

Contaminated suits should be disinfected with an appropriate disinfection solution, whose safety for skin must be assessed as some solutions, for example bleach and iodine solution, are very effective for biological or chemical contaminants, but are harmful for divers' skin and dive gear (30). The dry suit should not be cleaned with solvents or strong detergents, because this may damage them (31-34).

The May 2014 floods in Croatia

Croatia is a country prone to flooding and estimations are that approx. 15 % of its territory is under constant potential threat (35, 36). In May of 2014, continuous heavy rainfall raised the water levels of the Sava River Basin and extensively affected areas in Bosnia and Herzegovina, Croatia, and Serbia (36). In the affected region, more than 100,000 homes, 230 schools, businesses, roads, and railways were flooded. In the eastern part of Croatia, 8,500

hectares of agricultural land, around 3,000 houses, and 588 agricultural households were stricken (37-41). The Croatian Government declared a disaster and state bodies and agencies such as the National Protection and Rescue Directorate, Ministry of internal affairs, Croatian Mountain Rescue Service, Croatian Red Cross, and other rescue services and organizations (firefighters, civil defence, state administrative agencies) as well as the Croatian Armed Forces took part in salvaging the area and evacuating more than 13,000 residents of the flooded villages (39-41). According to preliminary reports, over 4,000 officials and an even larger number of volunteers were active in the rescue and evacuation of people and animals (38). The duties and activities of the abovementioned agencies were governed by national legislation and were aimed at alleviating the risk of epidemics/outbreaks. By introducing measures through the mobilisation of health workers and others involved in rescue operations, requisition of equipment, drugs and medical products, transport equipment, and temporary use of office spaces for providing health care, the Crisis Headquarters of the Croatian Ministry of Health coordinated the activities of all of the involved health services. According to preliminary results obtained from the medical records of the Crisis Headquarters, collected in the period from May to June 2014, 179 emergency medical interventions, 1878 medical treatments, 1209 vaccinations, and 122 transports to medical facilities were performed (41).

In the beginning, many people refused to evacuate, and one of the main reasons was their concern about the pets and domestic animals that could not be evacuated simultaneously. A similar phenomenon was confirmed by research after hurricane Katrina, which also reported that people were unwilling to evacuate and leave their animals behind (42). Approximately 9,148 livestock (cattle, pigs, horses, sheep, goats, poultry, rabbits, etc.) and an unknown number of dogs, cats, and other pets were rescued. According to preliminary results, the total number of deceased animals was 10,189, while over 237,845 kilogrammes of animal carcasses were collected until mid-June and promptly and properly disposed (41).

Animal rescue operations were primarily managed by the members of the Croatian Mountain Rescue Service, specially trained to perform search and rescue and equipped with boats, dry suits, and other essential equipment. They were assisted by untrained volunteers from animal welfare groups. Rescuers and volunteers crossed the flooded areas on boats, entered into floodwater contaminated by sewage and animal waste in wet and dry suits; some volunteers entered the water in bathing suits. However, to protect the health of the rescuers and volunteers and possible spreads of disease, the Ministry of Health banned entry into the water shortly after. Animal rescue continued only from boats. Among the rescuers, sharp injuries from submerged objects and injuries mostly from dogs and pig were recorded. Considering that most rescuers used proper

protective equipment, and were trained, injuries were not frequent.

Among the many rescuers, divers were vital for most of the rescuing operations. In disinfecting their suits, the divers used the facilities, equipment, and disinfectant of the Nuclear-biological-chemical Defence Battalion of the Croatian Armed Forces at two decontamination stations in flooded area (39).

Concluding remarks

Floods cause great damage to both personal property and public infrastructure and ultimately have negative consequences on the economic growth of a country. They often result in humanitarian crises and emergencies, as well as an increased need for emergency medical care, food, shelter, and access to water and sanitation, which is why preventive public health measures are of immense importance. The harmful effects of flooding can be reduced by legislation, improvement of flood forecasting, establishing early warning systems, and appropriate planning; however, countries must invest additional effort into designing medical surveillance systems that would monitor and record all injuries and diseases among rescuers and volunteers in order to ensure sound epidemiological data, which at the moment is lacking.

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Zdravstvena zaštita i rizici za spasioce u poplavljenim područjima

Na poplavama pogođenom području mogu se kriti brojne opasnosti za sigurnost i zdravlje stanovništva i spasilaca, među kojima ozljede, infekcije i bolesti zbog izloženosti patogenim mikroorganizmima i raznim biološkim i kemijskim onečišćivačima. U radu su prikazani čimbenici rizika i moguće zdravstvene posljedice za spasioce koji su bili uključeni u evakuaciju i spašavanje tijekom poplava u Hrvatskoj u 2014. te mjere sprečavanja ozljeda i bolesti. U slučaju ekstremnih poplava ronionici imaju važnu ulogu u spašavanju. Akcije spašavanja iz potencijalno onečišćenih poplavnih voda dovode do potrebe dezinfekcije rabljene opreme, pri čemu je najvažnije da se spasiocima osigura provedba minimalnih zdravstvenih i sigurnosnih mjera. Vrlo je malo podataka o njihovim ozljedama i bolestima, što upućuje na potrebu da se uspostavi zdravstveno praćenje svih ozljeda i bolesti spasilaca kako bi se dobili odgovarajući epidemiološki podaci. Štetne posljedice poplava mogu biti umanjene zakonodavnim odredbama, unapređenjem sustava za predviđanje poplava, uspostavljanjem sustava za pravodobno upozoravanje te odgovarajućim planiranjem i edukacijom.

KLJUČNE RIJEČI: *dekontaminacija ronilačke opreme; dezinfekcija; napuštene životinje; zaraza; zdravstveni rizici uslijed poplava*