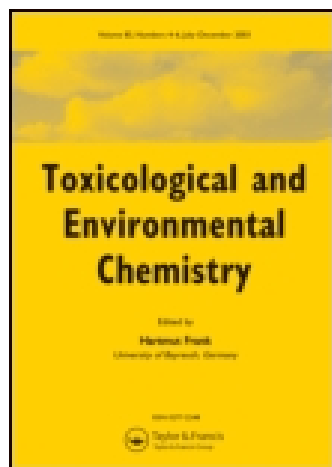


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### Risks of water-borne disease outbreaks after extreme events

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## Risks of water-borne disease outbreaks after extreme events

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Climatic changes are associated with heat waves, droughts, and floods which have significant impacts on human health. Floods enhance the effects of water-borne pathogens increasing the concentration of biological agents in surface water. On the basis of national statistics collected by the Italian Ministry of Health, this work illustrates preliminary observations concerning outbreaks of water-borne diseases after flood events in Italy and presents options for an administrative response. The water-borne infectious diseases taken into account are Legionellosis, Salmonellosis, Hepatitis A, cutaneous and visceral Leishmaniasis, Leptospirosis, and Infectious Diarrhea. An association between these infectious diseases and flood events seems to exist in Italy, although further analysis should be carried out to confirm this relationship. Flood impacts can be distinguished into: immediate, medium term, and long term. Several factors are involved in determining the intensity and the severity of effects. Some vector-borne infectious diseases are likely to become more frequent due to changes in vector distribution and lifecycle dynamics associated with climate change. Health care systems should develop new strategies for a more comprehensive understanding of the impact of changing weather conditions on human health.

**Keywords:** climate change; human health; floods; infectious diseases

### Introduction

Climatic changes cause modifications in frequency and intensity of weather events, and consequently often trigger heat waves, floods, and droughts in many regions of the world. An increase of water-borne disease outbreaks after extreme events has been observed both in developed and in underdeveloped countries (Curriero et al. 2001; WHO 2003; Wade et al. 2004). High precipitation rates increase the concentration of chemical and microbiological agents in surface water, causing an enhancement of gastrointestinal disease incidence as documented by several studies (Rose et al. 2001; Hajat et al. 2003; Eisenreich 2005). In the past 50 years, more than half of the waterborne disease outbreaks in the United States have been preceded by

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rainfall (Patz and Mc Geehin 2001). Floods are the most common natural disaster also in Europe. Floods are due to significant rise of water level in a stream, lake, reservoir, or coastal region. Floods can kill people and cause direct or indirect diseases. They can damage the environment, infrastructure, property (European Environmental Agency 2005), and cultural heritages. However, the relationships between human health and problems of water quality and quantity are complex, and predicting the potential impacts of climate change on water-related diseases is still difficult.

Weather extremes contribute to the persistence of a number of water-borne diseases in the developed world. Consumption of contaminated water represents the main human exposure pathway linking extreme events to human health risk. Despite improvements in public health and economic wealth, the incidence of intestinal infection still remains high and this situation could significantly worsen under the impact of climatic changes.

While the Fourth Assessment report of the IPCC (2007) is consistent with a general decrease of precipitation over the Mediterranean region, at the same time, rainfall events are expected to become more irregular and intense, with an increased likelihood of flood events.

Based on national statistics collected by the Italian Ministry of Health, this work illustrates preliminary observations concerning outbreaks of water-borne diseases after flood events in Italy and discusses options for an administrative response.

## Methods

The Ministry of Health publishes collected data related to illnesses that can represent an epidemiological risk, in the Italian Epidemiological Bulletin (Italia 1991). It provides data regarding “case number per year” of infectious diseases, both at regional and national levels, from 1993 up today.

In this study, from the bulletin we selected available data on infectious diseases with high frequency and/or liable to interventions of control (Class II, Italia 1991), related to water: Legionellosis, Salmonellosis, Hepatitis A, cutaneous and visceral Leishmaniasis, Leptospirosis, and Infectious Diarrhea. These diseases, occurring worldwide but most commonly in temperate or tropical climates, were related to poor sanitation and hygienic conditions and to extreme climatic events in developing countries. Infection and transmission of the epidemic illnesses may occur in different ways, such as accidental or natural transport related to water, air, and soil.

In order to highlight possible associations between an increased number of cases of Hepatitis A, Infectious Diarrhea, Legionellosis, and flood events in Italy, we reported the trends at a regional level of ministerial data on these infectious diseases, during the years and in the regions affected by floods. Main flooding events, recorded in the 20 Italian regions from 1951 to 2003, were reported in the Environmental Data Yearbook of the Agency for Environmental Protection and Technical Services (APAT 2004). The main flooding events were those that induced socio-economic effects such as victims and/or damages. The eventual association between the number of cases of the seven selected infectious diseases and flood events in Italy was highlighted using regional level data from 1993 to 2003, taking into consideration the location and the years of registered cases and the flooding events.

## Results

Disease trends at a national level (number of cases per year) of Legionellosis, Salmonellosis, Hepatitis, Leishmaniasis (cutaneous and visceral), Leptospirosis, and Infectious Diarrhea in the decade 1993–2003 are reported in Figure 1. During this study decade, 24 main flood events were registered in Italy. We reported the trends of these infectious diseases in some specific Italian regions for the periods of time including the years characterized by main flood events in term of victims and damages. An increase in the number of cases of Hepatitis A was observed in Piemonte, Lombardia, and Liguria between 2000 and 2003, in coincidence with flooding events registered in 2000 and 2002 in these regions (Figure 2). A similar concurrence between increased number of disease cases and flood events was pointed out also for Legionellosis in Piemonte, Lombardia, and Liguria between 2000 and 2002 (Figure 2).

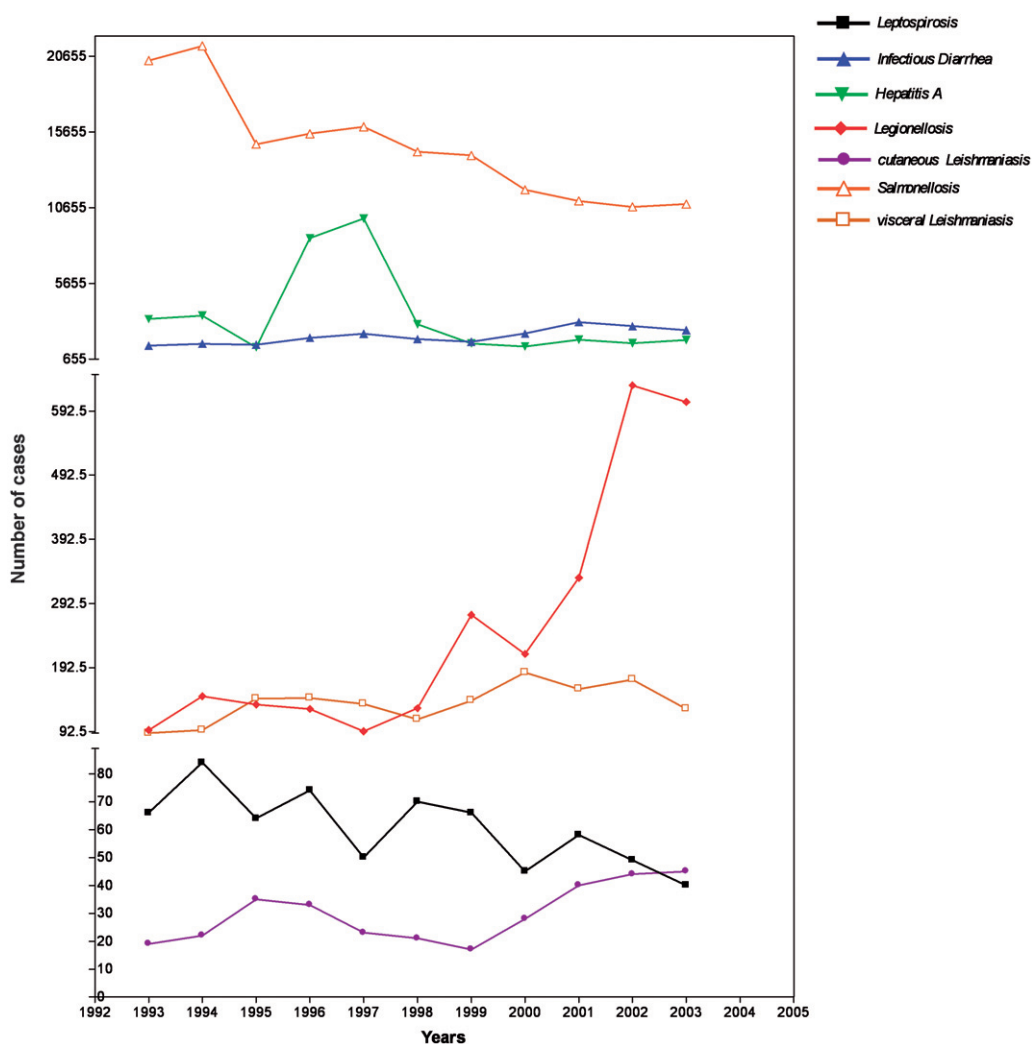


Figure 1. Yearly dynamics of some infectious diseases associated to weather extremes.

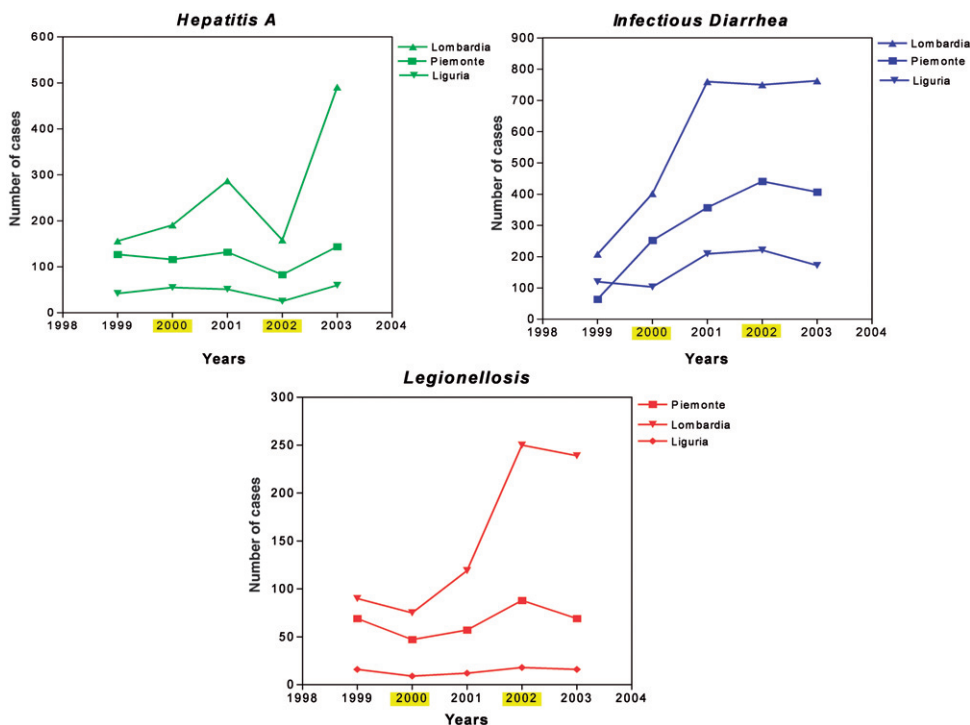


Figure 2. (Colour online). Yearly dynamics of selected diseases in three Italian regions for the periods of time including the years characterized by main flood events in term of victims and damages (APAT 2004). In yellow are highlighted the years with main flood events.

A tentative relationship between an increase in the number of disease cases and flood events can be pointed out also for Infectious Diarrhea in Piemonte, Lombardia, and Liguria between 2000 and 2002 (Figure 2).

## Discussion

In Italy, floods represent a serious threat. In fact, floods hit some 319,000 people in 2003, causing damage amounting to over 2000 million euro. During the same year a heat wave struck the Mediterranean as well as most of Europe causing over 40,000 deaths among elderly people. Such an unprecedented extreme condition underlined the lack of preparation shown by national health care systems in relation to unexpected weather changes.

Floods provide a relevant cause–effect link between climate change and human health by producing a number of impacts, which can be distinguished into: immediate, medium term, and long term (Figure 3).

The dynamic of infectious diseases shown in Figures 1 and 2 belongs to the medium-term category of impacts, with a potential for causing long-term effects depending on the persistence and relative importance of the disease epidemic. Increased incidence of infectious diseases tends to be associated to flood events, probably due to the increase in the concentration of microbiological agents in surface

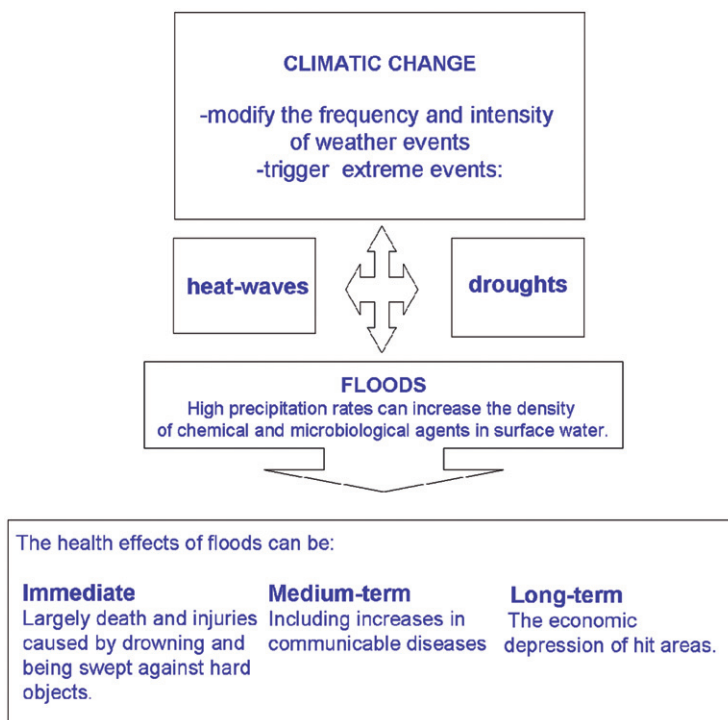


Figure 3. Process linkage between climate change and human health.

waters. However the overall effect is likely to be mediated by a large number of factors bearing a significant influence on the consequences of floods.

The peaks of considered diseases showed a delay if compared to flood events, due to the occurrence of floods at the end of the previous year and the relative incubation and transmission period of the disease. For example, Hepatitis A, a serious liver disease caused by the Hepatitis A virus (HAV), has an incubation period comprised between 15 and 50 days, with an average time of 28 days. Hepatitis A is highly contagious and transmitted by fecal–oral contact, including ingestion of contaminated water.

Also Legionellosis can be a very serious disease that can cause death in up to 5–30% of cases. It is an infection with aerosol transmission caused by the bacterium *Legionella pneumophila*, and other *Legionella* species, ubiquitous aquatic organisms that thrive in warm environments (32–45°C) and found naturally in the environment, usually in water. Infectious diarrhea is the most common cause of diarrhea worldwide and is transmitted through water contaminated with human or animal feces.

Higher temperatures will accelerate the maturation of the protozoal parasite, thereby increasing the risk of infection (Rioux et al. 1985). McMichael et al. (2001) report the current state of epidemiological research on the health impacts of global warming. In particular, the authors describe the indirect consequences on Leishmaniasis. There are two principal clinical types of Leishmaniasis—visceral and cutaneous—which are caused by a range of species of *Leishmania* parasites. The parasites are transmitted by sandflies, among which the two most important genera are *Phlebotomus* in Europe and Asia and *Lutzomyia* in America. In Central Asia and

Europe, Leishmaniasis has become an important co-infection with Human Immunodeficiency Virus (Alvar et al. 1997; WHO/UNAIDS 1998). Sandflies are very sensitive to temperature, and increases in temperature also may increase daily mortality rates. Phlebotominae are sensitive to sudden temperature changes and prefer regions with small differences between maximum and minimum temperatures. A study on Leishmaniasis in Italy indicates that climate change may expand the range of one vector (*Phlebotomus perniciosus*) but decrease the range of another (*P. perfiliewi*) (Kuhn 1997).

## Conclusions

As illustrated by a recent report issued by the Italian Environment Agency (APAT/WHO 2007) flood impact on human health is not exclusively related to flood intensity or duration. Other factors such as land use, occurrence of anthropogenic stressors and efficiency of early warning systems play a significant role.

However, studies trying to establish a correlation between climatic conditions and health are at their beginning. Much effort needs to be done to try and collect adequate data and establish an adequate frame of meteorological exposure to interpret causes and effects correctly.

While damage due to weather extremes is likely to rise in the near future, much can be done to prevent impacts on health by implementing early warning systems following the example of EuroHEAT, a successful project set-up to improve public health responses to weather extremes, in particular to heat waves (WHO 2008). An appropriate response to climatic changes and weather extremes will require health services to adapt to the changing scenario by increasing their reaction capacity.

The relevance of these approaches will increase in parallel to the increasing variability of weather conditions predicted by the dominant climate change scenarios.

In the developed countries, like Italy, despite several improvements in public health and economic wealth, the incidence of intestinal infections remains high and continues to be an important clinical problem, although mortality has been falling sharply during recent decades. A relationship seems to exist between these infectious diseases and floods in Italy, although further analyses should be carried out to confirm this correlation.

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