RISK FACTORS FOR INFECTIOUS DISEASES IN FLOOD-AFFECTED AREAS: THE CASE OF CENTRAL GREECE

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Abstract

Floods account for the majority of catastrophic events resulting from hydrometeorological hazards. In September 2023, Greece was confronted with the Daniel flood phenomenon that led to the need to reconstruct Central Greece. Flooding alters the natural balance of the environment and often creates a favorable habitat for the occurrence of infectious diseases. The probability of occurrence and transmission of these diseases is multiplied due to the adverse living conditions formed by the occurrence of the phenomenon. The obligation of the state to safeguard the lives of citizens makes it necessary to take prevention, preparedness and intervention measures adapted to the profile and needs of society.

Keywords: *flood, waterborne diseases, civil protection, Daniel, Greece*

1. INTRODUCTION

The constant movement and interaction of the biosphere, which is the Earth's envelope and incorporates all living organisms and their relationships with the lithosphere, hydrosphere and atmosphere, leads to the manifestation of natural and expected phenomena. However, these phenomena, when they occur and affect the area where man operates and develops, can be catastrophic for human life, activity and property.

According to the EM-DAT database [1] natural phenomena are divided into:

• Geophysical (earthquakes, volcanic eruptions, movements of dry masses)

• Hydrological (floods, landslides, wave action)

• Meteorological (thunderstorms, fog, extreme temperature change)

• Climatological (drought, fires, glacier movement, glacial eruption)

• Biological (epidemics, insect or rodent invasions, transmission of diseases by vectors)

• Extraterrestrial or Interplanetary (asteroids, meteoroids, comets, solar flares)

The term "disaster" refers to "a situation or incident that exceeds local response capacity necessitating a request for external assistance at national or international level. An unforeseen and often sudden event that causes serious damage, destruction and human suffering" [2]. According to the United Nations Office for Disaster Risk Reduction (UNDRR) disaster brings about "a serious disruption of the functioning of a community or society associated with widespread loss of life and impact on human beings; material, economic or environmental level exceeding the capacity of the affected community or society to respond effectively by allocating its own resources" [3].

Catastrophic events and their consequences are recorded and registered in databases by organizations and research centers, in order, through cross-checking and statistical processing of data, to highlight global trends and threats worldwide and ways to effectively manage them. A disaster is the result of exposure to risk, the conditions of vulnerability recorded, and the inadequacy (measures and capacity) to reduce or reduce dealing with possible negative consequences [4].

Since 1988, the Centre for Research on Epidemiology of Disasters (CRED), a global organization that studies public health during emergencies, has maintained an Emergency Events Database (EM-DAT).

In order for a disaster event to be recorded in this database, at least one of the following criteria must be met [2]:

· 10 or more deaths

· 100 or more persons affected or injured or left homeless

· Declaration of a state of emergency in an affected area

· Call for help at international level

Phenomena such as floods, earthquakes, fires, etc. are more frequent and dangerous [5]. From available data, it was observed that between the time period 2000-2019, 44% of all disasters recorded involved floods that affected approximately 1.6 billion people worldwide, the highest percentage for any type of disaster [4]. In 2023, 399 catastrophic natural events were recorded worldwide that affected 93.1 million people. 164 of these were floods and affected 32.4 million people worldwide [1].

The term flood means the temporary covering of the ground with water that would not normally occur. Water from rivers, mountain streams, ephemeral streams or from the sea in coastal areas temporarily covers the territory causing impacts. Some of the impacts are determined in monetary terms while others are classified as intangible, such as loss of human life; the extent of an ecosystem affected and the psychological stress mainly after the event of a flood [6].

Unlike most types of disaster, the effects of floods can be prevented by primary prevention mechanisms such as dams, drainage systems, monitoring and early warning systems, followed by information systems and stakeholder coordination to manage outbreaks of infectious diseases that may occur after floods, as affected societies face unsanitary conditions living, overcrowding in emergency places, inability to access drinking water and medical care.

'Flood risk' means the combination of the likelihood of a flood occurring and the potential negative consequences for human health, the environment, cultural heritage and economic activities associated with that flood.

In Greece, floods are the second most frequent natural disaster. Floods between 2001 and 2011 accounted for 50% of the total, compared to other natural disasters [7]. A database of high-impact weather events in Greece: a descriptive impact analysis for the period 2001–2011. Nat. Hazards Earth Syst. Sci., 13, 727–736 In the period 2012-2018, a total of 1951 areas were recorded in Greece, which due to the severe effects of floods, were declared emergency [8].

The search for catastrophic flooding events over the past five years showed that in June 2019 the Ghat region of southwestern Libya was hit by flash floods following heavy rains resulting in four deaths, the displacement of more than 4,000 people [9] and the deprivation of drinking water and electricity in parts of the city for two days [10].

On September 18, 2020, 644 mm of daily rain was recorded on the Greek island of Kefalonia hit by Medicane Ianos and the sudden floods and landslides brought about by the phenomenon [11]. Four people died, about 5,000 homes were affected by the floods, and the total estimated cost of the storm was over US$100 million [12].

In May 2023, an area of about 540 km of Italy was covered by floods that occurred when 23 rivers flowed from their banks. Fifteen people died and about 36,000 people were displaced [13].

In August 2023, two-thirds of Slovenia was affected by floods with high flows at 31 stations resulting in six deaths and the evacuation of 8,000 people [13].

At the beginning of July 2023, more than 250mm of rain fell in Turkey in 24 hours, causing flash floods that led to the loss of a human life, the rescue of 500 people and the evacuation of the population of flooded villages of Duzce province [14].

In September 2023, Storm Daniel caused extreme rainfall and subsequent flooding affecting Turkey, Bulgaria, Greece and Libya. In Bulgaria, Tsarevo, a resort town on the Black Sea, suffered most of the damage. Multiple rivers overflowed, destroying a series of bridges that disrupted the lives of

thousands of people [15]. In Turkey, The floods damaged many buildings and roads as they hit Istanbul's northern districts and Kirklareli province. On September 11, 2023 this weather system evolved in intensity into "Medicane", a storm of stormy winds that hit the Libyan coast and brought about a national disaster in Libya, as it caused two dams to explode in the city of Derna leading to at least 5,000 deaths. More than 16,000 people were internally displaced, 876 buildings were destroyed, health services were disrupted and there was a shortage of safe and drinking water [16].

In Greece, the bad weather "Daniel" hit the region of Thessaly (Central Greece) causing rivers and tributaries to overflow. Based on available statistics and IDF curves, it was a very extreme event that can be considered rare (monitoring stations recorded up to 750 millimetres of rain over 24 hours [17] and brought about effects that can last from months to years [18].

Due to failures in the embankments of the largest river in the region (Pinios), massive floods were caused in the eastern part of the plain of Thessaly, around Lake Karla. As significant amounts of water flowed to the easternmost part of the plain, these quantities of water accumulated in the artificially dried (in the 1960s) area of Lake Karla, creating the largest lake in the country, flooding large agricultural areas [18]. About 40,000 residents of the flooded areas were directly affected and 18 people died. The area flooded was more than 1,300,000 acres and it was estimated that over 200,000 animals drowned [18].

In the later stages of Storm Daniel, flooding from disasters in the western part of the plain began to subside, with the exception of the area where the rivers Enipeas, Mega and Kalentzis converge and flow into the Pinios River. As embankments of Pinios were being repaired, the flow to Lake Karla stopped, initially reducing and later stopping the rate of increase of the water stage in the lake preventing additional destruction for the villages surrounding the lake. In less than a month a second storm named "HLIAS" hit the region of Thessaly, leading to widespread flooding around Mount Pelion again [18].

2. MATERIALS AND METHODS

Natural hazards have the potential to have serious impacts on the natural and built environment and often on human life and areas of daily life. The high risk to public health in both developing and developed countries combined with the fact that the bad weather "Daniel", which hit Central Greece, was a very extreme event, which can be considered rare, and had effects that can last from months to years, gave the impetus for the investigation and detailed presentation of infectious diseases related to the Daniel flood phenomenon in Greece and the mapping of the state intervention to manage the high risk to public health. Bad weather Daniel created unprecedented conditions in Greece that led to studies on the "Reconstruction of Thessaly" and complex emergencies that shaped challenges in disaster management and disaster risk reduction. The state apparatus was called upon to implement the public civil protection policy with the assistance and coordination of all stakeholders based on the recent legislation in force. The ultimate goal is to safeguard human life and property through the effectiveness and efficiency of organizations in cooperation and with the assistance of volunteers and civil society.

In the present study, data related to the occurrence of floods and the risk of waterborne infectious diseases were searched in scientific databases (SCOPUS, Web of Science, etc.). The search then targeted catastrophic flooding phenomena of the last five years and focused on data on the Daniel flood phenomenon that occurred in September 2023 with particular targeting in the region of Central Greece.

The aim of the study was to identify scientific knowledge and data on waterborne diseases, their correlation with the occurrence of a flood phenomenon following a literature review, the search and correlation of general scientific knowledge with data from the study of the case of the Daniel flood phenomenon that hit Greece.

3. RESULTS

3.1. Central Greece and flooding phenomena

The lower parts of Thessaly lie on a paleolake, the existence of which is dated to several thousand years ago and is also mentioned by the Greek historian Herodotus (who lived during the 5th century BC) in his book Histories (7.129). Herodotus also reveals the exposure of Thessaly to floods in the following quotation [19]:

[7.130.1] Xerxes asked if Peneus had another outlet to the sea, so his guides, who knew these places well, said to him: "King, this river has no other outlet leading to the sea than the one you see. for the whole of Thessaly is surrounded by a crown of mountains." And they say that Xerxes answered: "Wise men are the Thessalians."

[7.130.2] This, then, was the reason why they were measured and submissive: close to everything else they set in mind that they had a country that the enemy could easily and quickly conquer. His only difficulty would be to turn the waters of the river and direct them towards their country, blocking the furrow with a dam of earth and diverting the river from the bed where it flows today, so that the whole would sink under the waters — only the mountains will remain on the surface.

According to the last census (2021), the Region of Thessaly includes the two major urban centers of Larissa (147886 inhabitants) and Volos (118610 inhabitants), smaller dynamic urban centers such as Trikala (61017 inhabitants), Karditsa (36618 inhabitants) and Tyrnavos (12378 inhabitants), as well as 32 semi-urban, directly related to developments in rural areas. The total area of the apartment is 13,377 km2 [20]. Based on the recording of incidents in the period 2012 – 2018 shows that at country level 210 days of flooding occurred, of which 125 have led to the issuance of emergency decisions for the affected areas. A total of 2368 locations have been affected by these phenomena (settlements, municipalities, municipal units, regions depending on the recording data), of which 1951 concern areas for which emergency decisions have been issued [18]. In relation to the time distribution of episodes, the largest number of historical floods recorded occurred during the period 2001-2010 with one hundred twenty-eight (128) historical events (87.1% of the total), from 1991 to 2000 fifteen (15) historical events have been recorded (10.2% of the total) and finally from 1981 to 1990 four (4) historical events (2.7% of the total).

According to Directive 2007/60/EU of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks, Greece had to publish by 22/12/20215 a flood risk management plan (Article 7 of the Directive), taking into account the specific characteristics of the areas covered and providing appropriate solutions. The plans Flood risk management should focus on prevention, protection and preparedness. According to Article 14 of the Directive, flood risk maps had to be reviewed and updated by 22/12/2019 and every six years thereafter. [21]

The modern flood map of Thessaly was compiled based on a study from 2016 based on the worst rainfall in the last 100 years and was posted in 2018 [22] (Figure 1). The areas flooded by Daniel are almost exactly the same as scientists' predictions [23].

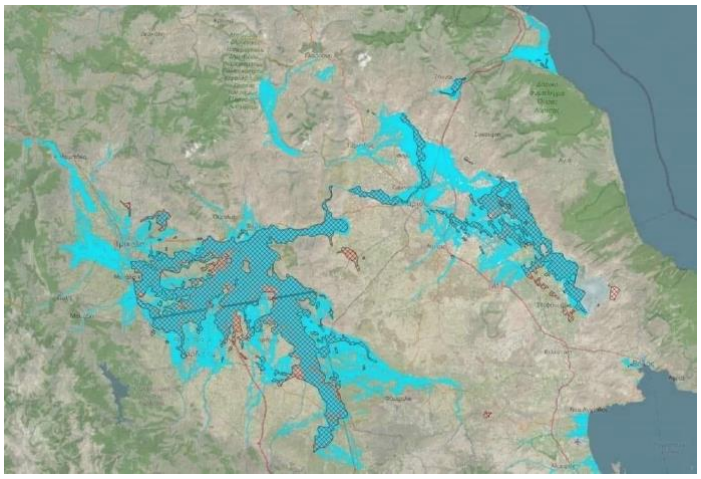

Fig. 1. Thessaly Water District (EL08) Potentially High Flood Risk Zones (October 2019)

(Note: darker blue are the areas flooded by Daniel)

Source: Special Water Secretariat of Water, Ministry of Environment and Energy, 2024

The scientists' scenario differed only in the fact that it assumed that it would drop the same large volume of rain throughout Thessaly at the same time, when in fact Daniel affected half of the geographical district.

167 communities in Thessaly were affected by the floods and damage was caused to 12,235 of the 12,671 buildings affected. Regarding infrastructure, it was estimated that 40.7% of the affected infrastructure (rail, roads, bridges) was destroyed or suffered heavy structural damage. During Daniel's development, the Volos Nursing Home and the Argalasti Community Health Center were evacuated. Part of the old wing of the Volos nursing home collapsed, the Fire Brigade in the community of Palamas, Karditsa, storage areas of the Army Officers School in Trikala and 79 school units were flooded. At the same time, there was extensive damage to the Electricity Distribution and Power Supply Network as well as to the fixed telecommunications infrastructure in the flood-affected areas. According to data from the Hellenic Association of Insurance Companies, 4,307 losses were related to property insurance including:

- 1,714 residential properties;
- 2,032 businesses;
- 69 industrial facilities;
- 116 infrastructure projects;
- 376 solar parks

The remaining 1,699 were related to motor insurance and 5 to boat insurance [24].

From 5 to 24 September 2023, 10,357 people called the Fire Service for assistance to the Region of Thessaly due to the flooding phenomena. 3,576 people were rescued and transported to safety by various means (vehicles, excavators, lifeboats, helicopters). With the assistance of emergency services and volunteers, food, water, medicines and other necessities such as tents and beds were transported by various means, including drones [18].

3.2 Health effects of flooding events

According to Yang et al. between 2000 and 2019 in 761 communities from 35 countries affected by floods up to 0.10% of all cause deaths, 0.18% of cardiovascular deaths, and 0.41% of respiratory deaths were attributed to flood. The effect of flooding on cardiovascular mortality persisted for up to 50 days while mortality correlations were modified by climate type. It was found that mortality was

strongest in low-income countries, that cardiovascular and respiratory mortality was strongest in communities with low socioeconomic status, and that respiratory mortality was stronger in communities with a high proportion of older people. Population density and flood severity had little correlation with mortality. The mortality risk was most evident about 25 days after flood exposure and lasted up to 60 days [25].

Waterborne diseases are inextricably linked to water quality, since their manifestation indicates the penetration of viruses into the water by infecting urine or feces of humans or animals. The risk of viruses entering exponentially increases the risk in cases of flooding, as happened in the floods that followed the destruction of the Nova Kakhovka dam in Ukraine where drinking water was contaminated with pathogenic bacteria 28,000 times above the maximum permitted limits [26]. There were 20 infrastructure and industrial facilities in the area with a high risk of flooding that could lead to the release of chemicals including pesticides [27]. By drinking, washing or eating food that has been exposed to contaminated water, or washing the human body with it, physical health is potentially threatened by waterborne viruses with the most common being hepatitis, norovirus and rotavirus.

Access to safe drinking water and disinfection are vital in flood management situations. The occurrence of flooding events leads to infrastructure disasters by contaminating water in water supply systems, springs, streams, rivers and wells. The dead animals, the turbulence of the waters that carry sediment, sewage and carry away everything that is found in their path (rubble of buildings, Green waste, household equipment and waste, electrical appliances, cars, hazardous waste such as pesticides and fertilizers, waste from evacuation centers) in combination with the damaged water supply network are very likely to carry pathogenic microorganisms, chemicals and pollutants contaminating the water and thus threatening people's public health. Flooding of roads and/or flooding of combined sewage systems causes rainwater to mix with waste water resulting in contamination of flood water with excrement. Consequently, pathogenic microorganisms, such as noroviruses, enteroviruses and campylobacter, are very likely to be detected in flood waters. These microorganisms, as they are causative agents of gastrointestinal and respiratory diseases, make the manifestation of infectious diseases possible [28]. At the same time, flooded water may contaminate neighbouring areas, as microbes from surface water can enter groundwater and affect drinking water wells and municipal water systems using groundwater.

The most commonly reported symptoms of waterborne diseases are diarrhea and vomiting, however other infections of the skin, ear, respiratory tract or eyes are also found [29]. Children, pregnant women, the elderly, the unvaccinated or inadequately vaccinated, and people with weakened immune systems are more vulnerable to diseases caused by pathogens [30].

At the same time, participation in post-flood clean-up work was associated with the occurrence of flu-like symptoms or the occurrence of either acute gastroenteritis or acute respiratory infection [28]. Walking or cycling through floodwaters was also associated with the development of flu-like symptoms [31] or the occurrence of acute gastroenteritis [28].

After a systematic review of 32 studies, the occurrence of waterborne diseases dominated by leptospirosis is related to natural water as the main water source, exposure to flood waters, contact with mud and stagnant water, and water-related recreational activities. At the same time, an increased risk is observed due to contact with animals (rats, pigs, etc.) [32].

The length of time it takes for an affected area to be considered hygienically safe depends on factors such as the time it will take to remove water, clean the area of sediment, mud, dead animals, etc., restore the water supply and sewage system of the area. In research conducted by Mavroulis et. al. (2022), following a literature review of 61 articles of health risks related to flood-affected regions in Europe, concluded that difficult post-flood conditions favoured the emergence and transmission of water-borne diseases and vectors. In particular, 70.5% of cases are related to the occurrence of waterborne diseases with water, 19.7% of studies are related to the occurrence of rodent transmitted diseases and 9.8% are related to vector-borne diseases [29].

Due to the Daniel flood phenomenon that hit Greece, an electronic platform was created for the recording of clinical syndromes in the context of the operation of a syndromic surveillance network of

cases of gastroenteritis, respiratory tract infections and other infectious diseases related to flooding phenomena [33]. By 11/12/2023, 115,724 visits to the Emergency Departments of health units under surveillance, 3,068 cases of gastroenteritis and 12,027 cases of respiratory infection had been recorded on the platform.

Regarding leptospirosis, a zoonotic disease that occurs or increases after heavy rainfall or flooding, especially in areas with poor housing and hygiene conditions, and is associated with increased contact of the population with stagnant water or mud resulting from floods, 55 laboratory cases of leptospirosis were confirmed in Thessaly from the onset of the phenomenon until 11-12-2023. In the period 2004-2022, the average annual average of recorded cases of leptospirosis in the Region of Thessaly amounted to 47 cases. Most cases were recorded in August, September and October each year [34].

According to surveillance data of the National Health Organization

- in September 2023, 7 out of 18 leptospirations had a reported place of exposure in the Region of Thessaly, with a date of onset of symptoms after 4/9 (date of onset of bad weather Daniel)
- in October 2023, 32 of the 35 leptospirations had a reported place of exposure in the Region of Thessaly
- in November 2023, 6 out of 7 cases of letospirosis had a reported place of exposure in the Region of Thessaly
- in December 2023, 1 out of 2 leptospirations had a reported exposure site in the Region of Thessaly

Regarding the number of reported cases of foodborne – waterborne confluence in the Mandatory Notification System of the National Public Health Organization:

- in September 2023, 0 out of 9 cases of foodborne – waterborne disease had a reported place of exposure in the Region of Thessaly
- in October 2023, 2 out of 6 reported cases of foodborne – waterborne disease had a reported place of exposure in the Region of Thessaly
- in November 2023, no case of foodborne-waterborne disease was reported
- in December 2023, 0 out of 3 reported cases of foodborne – waterborne disease had a reported place of exposure in the Region of Thessaly

Regarding cases of Campylobacter infection

- in September 2023, 11 out of 54 declarations of campylobacter infection had a reported site of exposure in the Region of Thessaly
- in October 2023, 32 out of 114 declarations of campylobacter infection had a reported site of exposure in the Region of Thessaly
- in November 2023, 12 out of 64 declarations of campylobacter infection had a reported site of exposure in the Region of Thessaly
- in December 2023, 9 out of 57 declarations of campylobacter infection had a reported site of exposure in the Region of Thessaly

From the day after the outbreak of the flood phenomenon, following relevant instructions, the residents of the affected areas drank only bottled water and did not use the water of the network for their personal hygiene. With the assistance of public bodies, private initiatives and voluntary organizations, an effort was made to supply bottled water to all affected areas [34].

3.3. State intervention

Although the impact of a natural disaster on a country or community cannot be accurately predicted, it is nevertheless possible to reduce the impact through management strategies that focus on risk reduction [35] require the cooperation of many public services to protect public health, control for outbreaks of infectious diseases, disease surveillance, management of dead and missing persons, environmental health, food security and nutrition, and information to the affected population.

The first important step in preventing an infectious disease epidemic is to identify it and clarify the most important risk factors for its occurrence, such as:

a) poor economic situation and living in flood-prone areas;

b) destruction of infrastructure, disruption of services of general interest and disruption of essential public health services;

c) direct natural exposure to floodwaters contaminated by waste water;

d) lack of sufficient drinking water, water supply from polluted lakes and pipe wells, lack of distribution of water purification tablets

e) deterioration of environmental conditions (rapid cooling of the environment - increased humidity);

f) population displacement resulting in densely populated and overpopulated areas;

g) adverse living conditions in emergency shelters;

h) inadequate and inadequate hygiene or lack of access to clean water and sanitation;

i) multiplication and sudden increase of vector and rodent populations following floods; and

j) contamination of water, wet soil, mud or vegetation caused by rodent urine, dead animals and overflow of latrines [18].

Given these factors, preparedness at all levels of government of the state for natural disasters is critical, imperative and urgent.

The "Dardanos" plan was issued in 2019 by the General Secretariat for Civil Protection of the Ministry of Climate Crisis and Civil Protection and is the General Plan for emergency response and immediate/short term management of the consequences of flood events, implemented in cooperation with stakeholders at local, regional and central level. Based on this, in Emergency Response and Immediate/Short Term Consequence Management The Flood Event involves the bodies of the Central Administration of the state, the bodies of Local Government (Regions, Municipalities), Decentralized Administrations of the country, voluntary organizations [36].

In case of any catastrophic phenomenon that could alter the regularity of water quality, Local Government Organizations and water suppliers proceed ex officio to an immediate health control of the water supply and sewerage systems (according to Joint Ministerial Decision JMD 46399/1352/1986) and in case of damage detection, inform the competent local services of the Fire Brigade and the Hellenic Police and the local authorities.

After Daniel's attack, the entire water supply network of the Region of Thessaly was recorded and mapped, and sampling was carried out. Immediately after the flooding phenomenon, out of a total of 25 municipalities, 11 were deemed with unsuitable water for human use. The necessary drinking water quality standards are set in Greece by Joint Ministerial Decision 46399/1352/1986 [37]. Required quality of surface waters intended for: 'drinking', 'bathing', 'freshwater fish living' and 'shellfish farming and fishing', measurement methods, sampling frequency and analysis of the surface waters intended [37].

During the first 24 hours, the stakeholders ensure the immediate temporary distribution of people whose homes have been affected by the flooding phenomenon and the transfer and coverage of all the basic needs of citizens who have been temporarily evacuated from an area threatened by an ongoing disaster to protect their lives and health. According to law 4662/2020 [38], the General Secretariat for

Civil Protection is responsible for coordinating the work of Civil Protection, informing public opinion, providing instructions at central level, activating geotargeted warning of citizens through a message "112" for the occurrence of phenomena and raising citizens' awareness for taking self-protection measures from potentially catastrophic events Phenomena. The Regional Governor and the Mayors are respectively responsible for informing the public on issues related to response actions – short rehabilitation.

The Ministry of Health is responsible for informing the public about health protection measures when public health issues arise from the occurrence of flooding phenomena, and about the impact of flooding on citizens' health.

The Ministry of Interior, through the Welfare Services of the Municipalities, supports the social protection of citizens affected by natural disasters by financially supporting them to cover basic living needs, deal with simple repair works and/or replace household effects.

On the day of the occurrence of the rainfall (September 5, 2023) that led to the flooding phenomenon, the Greek Fire Service announced self-protection measures for the population during a storm-flood. The next day, the General Secretariat for Civil Protection announced self-protection measures against extreme weather events. The Ministry of Climate Crisis and Civil Protection aired a TV spot with flood protection measures [39].

12 days after the phenomenon, the Fire Brigade Headquarters issued an order with instructions for the protection of personnel from the consequences of the flooding phenomenon, for personal hygiene, personal protective equipment, the process of clothing and removal of clothing, washing clothes, care of open wound / wound, cleaning of firefighting equipment and the need for immediate medical assessment in case of malaise and / or shortness of breath or other symptoms. At the same time, the Fire Brigade supplied the Administrative Fire Services of the Prefectures of the Region of Thessaly with washers – dryers.

The National Public Health Organization carried out a risk assessment based on the methodology developed by the European Centre for Disease Prevention and Control (ECDC) according to which waterborne and foodborne diseases, zoonoses (mainly leptospirosis), respiratory infections, mainly in high-risk individuals, as well as vaccine-preventable diseases (such as Hepatitis A, in some populations e.g., Roma) have a higher risk of causing epidemics in both the short and long term [33].

The Ministry of Health proceeded to the epidemiological surveillance of all infectious diseases in all affected areas and the establishment of a coordinating team to supervise actions for surveillance of cases of gastroenteritis, respiratory tract infections and other infectious diseases related to flooding phenomena, control and restoration of the water supply network in the Region of Thessaly, entomological surveillance in the affected areas, bathing water quality control program and shellfish safety programme [33].

At the same time, the Ministry of Health, in order to ensure the smooth operation of its supervisory bodies, issued circulars to inform and sensitize medical staff and other health professionals, for the early diagnosis and epidemiological recording of diseases, the occurrence of which is favored by flooding phenomena, in the context of disease declaration, their vigilance in cases of treatment of wound contamination by bacteria, such as staphylococcus and streptococcus and fungal infections, the need for special attention for the health care of people belonging to vulnerable groups of the population, such as pregnant women, people with chronic diseases, mobility or other difficulties, elderly people, etc., the need to provide the population of the area with precautionary and health protection instructions. At the same time, a circular instructed the competent Services of the Region of Thessaly to prepare a Mosquito Management Plan in the areas affected by the floods, given that a plethora of widespread mosquito breeding sites that increase the risk of transmission of mosquito-borne pathogens, such as West Nile virus, was identified and insect repellent products were distributed to strengthen personal protection measures [30, 33].

In addition, the Ministry of Health instructed the competent Services of Regional and Local Government to provide by all appropriate means information and timely warning to the affected

population in order to minimize the consequences on the health and safety of citizens after the flooding phenomena. Detailed instructions were given for the movement of citizens in flooded areas, water and food consumption, ways to prevent illness and injury, instructions related to animals (domestic or farmed), as well as child safety. Subsequently, instructions were given on the protection measures that employees and residents must take when cleaning and disinfecting outdoor areas such as streets, courtyards of houses, courtyards, etc., in cities and villages affected by flooding phenomena and there is a risk of exposure of people to infectious agents. These instructions stressed that any contact (without protective equipment) with flood water and objects/surfaces exposed to it should be avoided. In case of any skin exposure to flood waters, the area should be washed with soap and water and contact a doctor immediately [30].

In addition, the diagnostic capacity of Health Units for the diagnosis of visceral leishmaniasis (endemic in the country, transmitted by gnats) was strengthened with the emergency availability of rapid leishmaniasis tests in all local Health Units of the Region, which have the ability to perform laboratory testing [33].

The National Public Health Organization distributed 4,300 protective glasses and 1,000 protective masks and door-to-door interventions were made by the Mobile Health Units of the Organization to prevent and limit the number of cases of leptospirosis. At the same time, insect repellents and information leaflets were distributed by the Mobile Health Units of the Organization, for protection against mosquitoes and West Nile virus [33].

Finally, the Ministry of Health proceeded with vaccination against tetanus (2,524 vaccinations) to shield the people of the affected areas, the human resources of the public administration and the volunteers who managed the flood phenomenon and vaccination against Hepatitis A (188 vaccinations) in children of special populations in the Region of Thessaly, to avoid the occurrence of an influx of cases of diseases prevented by vaccination [33].

The Public Health Coordination Center of Thessaly held an awareness webinar on infectious diseases related to flooding phenomena for those involved in crisis management.

From the day after the outbreak of the flood phenomenon, following relevant instructions, the residents of the affected areas drank only bottled water and did not use the water of the network for their personal hygiene.

4. DISCUSSION

Disaster occurs when risks meet weakness. Weakness means vulnerability, exposure to risk, inadequacy of means and organization to deal with potential risk. Thus, a natural hazard will never result in a natural disaster in areas where there is no weakness (e.g. a strong earthquake in an uninhabited area). Floods and extreme weather events can have serious impacts on public health as they often lead to damage to basic infrastructure, such as water supply and the electricity grid.

Water contamination and degradation of sanitation systems create favorable ground for pathogenic microorganisms. The lack of access to clean water and proper sanitation further enhances the vulnerability of affected populations, particularly in densely populated areas and communities with limited resources. After floods, the most likely health risks to the population include viral gastroenteritis, bacterial and figurative etiology (norovirus, rotavirus, Cryptosporidium, etc.), hepatitis A, respiratory diseases (Covid-19, legionella, etc.), as well as diseases transmitted through vectors and through rodents or other animals (leptospirosis, West Nile virus, malaria, etc.) [18, 33].

In addition, the possible movement of the population due to flooding often leads to temporary settlement in shelters with high overcrowding, increasing the likelihood of spreading infectious diseases. The close proximity of people in such environments increases the risk of respiratory infections, vector-borne diseases (e.g. mosquitoes, ticks, fleas) and more generally the overall deterioration of public health conditions.

The likelihood of an infectious disease occurring after floods is related to the frequency of the disease, the type, extent and intensity of catastrophic flooding, the resilience of public health infrastructure, and the effectiveness of existing emergency and immediate disaster management plans [18]. Disease surveillance and early warning systems, combined with effective prevention and response capabilities; they can reduce current and future vulnerability to infectious diseases after floods.

The possibility of an epidemic of infectious diseases is related, inter alia, to the economic situation of the affected country, the ability of those affected to have access to public health services, public utilities and access to clean water and sanitation, as well as to informing and educating the population on emergency management, prevention and preparedness for natural disasters.

Taking into account the risk factors of infectious diseases, bodies of all levels of administration (central government, local government of first and second degree) must respond to the needs of strategic management of natural disasters. In the context of operational planning based on well-prepared plans, it is necessary to identify prevention, preparedness and intervention measures based on the needs of society to prevent the outbreak of waterborne epidemic infectious diseases. To prevent, for example, an outbreak of leptospirosis, the general public should be given information about the symptoms of the disease, the importance of early diagnosis by a healthcare professional as well as protective measures (avoiding contact with water using disposable gloves – rubber boots/boots, washing/disinfecting hands regularly, avoiding eye touch, nose and mouth, boiling drinking, etc.). It has been found that proper hand washing can reduce episodes of diarrhea by one third [40]. Measures must be communicated in a timely and effective manner to the general public, with a particular focus on the elderly population, persons with disabilities, children, people on low incomes, homeless people, migrants as well as personnel involved in emergency prevention and management. [18, 33, 38] The concern of the administrative bodies should be at the same time the disinfection of flooded buildings in the areas affected by the flood as well as of the machinery, vehicles, etc. involved in the management of the flood phenomenon.

It is crucial to prevent outbreaks of infectious diseases to record information on flood-affected areas, affected population, displaced population, risk factors for infectious diseases and disruption of public health infrastructure, in order to make a rapid risk assessment, establish an appropriate disease surveillance system and identify appropriate interventions to manage and mitigate adverse diseases impact of outbreaks of infectious diseases.

It is necessary to immediately provide emergency shelters for evacuees and those in need after the flood and to distribute essential emergency supplies. At the same time, the implementation of a vaccination program in vulnerable and vulnerable areas is important for the prevention and control of infectious diseases after a flood event. The chlorination of public water works by hitting and flushing water pipes to eliminate pathogenic microorganisms adhering to pipes allows effective disinfection of public water works [4, 18].

Social and environmental parameters are two of the important components of the relationship between climate and waterborne diseases, as they dynamically influence the occurrence of diseases and epidemics. At the same time, they provide the community with levers to address the future impacts that may be caused by the climate crisis [40]. At the same time, a better understanding of the relationship between the climate crisis and waterborne diseases will help assess the potential impacts of human interventions to control the catastrophic phenomenon [4, 18, 33].

The vulnerability of a community to the climate crisis and, by extension, to a catastrophic phenomenon is also a function of sensitivity and capacity in the adaptability of a society. Social vulnerability to climate change is a function not only of exposure to severe weather events, but also of vulnerability (e.g. with maintenance and treatment of water and sanitation systems, home hygiene) and adaptive capacity of a society (government, education, social responsibility) [18].

5. CONCLUSIONS

Disaster risk reduction and disaster management over the past five years has faced many challenges. The extensive and severe impact on the population, the natural environment and the built environment, as indicated by the relevant literature, created fertile conditions for the occurrence of post-flood infectious diseases. The effective management of hydrometeorological risks, including floods, and biological health risks, requires interdisciplinary approaches, planning, training, information, prevention – preparedness – resilience actions, interventions for immediate response and rapid recovery in order to ensure public health. Under these conditions, guarantees of effectiveness and efficiency of each service provided for the protection of people's lives and property are formed. A typical example is the rare and extreme Daniel flood phenomenon that hit Greece in September 2023, creating ideal conditions for the outbreak of waterborne diseases without, however, leading to an outbreak of infectious diseases.

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