Economic impact assessment of the climate change on the health sector: case of Montenegro

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Abstract. Considering that Montenegro does not have official data on the impacts of climate change and extremes on people's health, in this paper we prepared an assessment of the sensitivity to climate change in Montenegro for a longer period of time and their spatial distribution. The aim of this paper is to assess the future negative economic impacts of climate change on the health sector in Montenegro related to high temperatures. Due to the problem of establishing a clear correlation between the effects of climate change on health and specific diseases (for which there are no official data in Montenegro), the focus of our paper is on direct deaths under the influence of high temperature. Based on the processing and analysis of relevant statistical data, a projection of the future number of deaths caused by climate change in Montenegro was made. Then, we prepared an analysis of the value of life (VSL) concentrating on Montenegro and the world, in order to determine future statistical values, as a basis for damage assessment. Based on previously collected and processed data, we made a projection of economic damage in the health sector of Montenegro, according to 2 scenarios: Near Future Scenario (NF, until 2050) and Far Future Scenario (FF, until 2100). We estimated economic damage in the health sector of Montenegro, caused by high temperatures, at a cumulative amount of €30-60 million for the total observed period (NF, for a higher VSL), i.e. in a cumulative amount of €230-350 million for the total observed period (FF, higher VSL).

1 Introduction

Global rise in temperature, as well as the frequency of extreme weather events, have a significant impact on property and infrastructure, i.e. on the economy as a whole, but very strongly on people and human health as well. (Portier et al., 2010) Thus, studies began to assess the impacts of climate change on sectors that are not treated in the market (e.g. death due to extreme cold and heat, migration due to natural disasters, loss of comfort of life, etc.), stating that these sectors experience greater damage due to climate change, from sectors that are treated in the market. From the fact that many studies in the previous period (Portier et al., 2010; Hsiang et al., 2013; Patz et al., 2014; Waniyah et al., 2022) indicated a significant

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number of negative consequences of the impact of climate. changes to people's health and lives (e.g. mortality, morbidity, malnutrition, infectious diseases, cardio-vascular and respiratory diseases, etc.), even more worrying are the results of the latest studies (Watts et al., 2021) that warn of worsening and continued worsening of the impact in the future, in the absence of adequate planned and coordinated international response to climate change.

Heat waves, as extreme temperature events, already took a large number of human lives in Europe at the beginning of this century (Haines et al., 2006), which led to the worsening of certain diseases, whereby groups of elderly and socially isolated people were most exposed to climate impact risk (Argaud et al., 2007). When referring to climate change, deaths are mostly linked to heatwaves (Campbell et al., 2018), it can be stated that later research also confirmed the strong association of morbidity with heatwaves (Khader et al., 2015; Lian et al., 2015), which further result in strokes, as well as numerous cardiovascular and respiratory disorder (Amegah et al., 2016; Sun et al., 2018; Leyva et al., 2017; Moghadamnia et al., 2017). Although less studied than heatwaves, it can be concluded that low temperature, in a certain number of studies, is associated with morbidity due to climate impact (Xu et al., 2012; Yu et al., 2012), and consequently with the worsening of certain diseases (Bunker et al., 2016; Lian et al., 2015; Ghanizadeh et al., 2017). Also, numerous studies have attributed direct or indirect long-term morbidity to extreme weather events, such as floods (Alderman et al., 2012), droughts (Stanke et al., 2013), cyclons (Doocy et al., 2013), etc. Furthermore, some research points to the link of morbidity with air pollution (Leyva et al., 2017; Madaniyazi et al. 2015) or wildfire smoke (Liu et al., 2015; Youssouf et al., 2014), which further results in respiratory, cardiovascular and other health damage. Not a small number of studies suggest that climate change, which manifests itself as an increase in temperature, heat waves, extreme cold, extreme weather events, droughts, causes deterioration of mental health (Khader et al., 2015; Gao et al., 2019; Zuo et al., 2015), causing problems such as difficulty sleeping, fatigue, hospitalization due to impaired mental health, additional impairment of mental health, increase in suicides, etc. That is why a certain amount of research was focused on specific mental health problems (psychological distress, post-traumatic stress disorder, depression, anxiety, psychotropic medication use, alcoholism...), as a consequence of extreme weather events (Benevolenza and DeRigne, 2019; Veenema et al., 2017; Rataj et al., 2016), floods (Leyva et al., 2017; Fernandez et al., 2015), droughts (Stanke et al., 2013; Vins et al., 2015), etc [1-40].

Furthermore, a certain number of studies have indicated an increased problem of undernourishment and the risk of hunger, due to the negative impact of climate change on agricultural crops. Thus, Hasegawa et al. (2014) predict that, although the risk of hunger will vary by region (due to differences in caloric intake, climate change and land scarcity), climate change will have significant impacts, even in the strong emission mitigation scenarios. Nelson et al. (2014) in their study, integrating three types of models (climate, crop, and economic models), conclude that the greatest degree of variability in response to climate change is shown by agricultural production, cropland area and prices, and the lowest consumption. Ezzati et al. (2004) indicate the circumstance that undernourishment, as a result of climate change, as the main risk factor for death or disease (e.g. diarrhea and malaria), is a dominant problem, especially in low-income countries where the risk of disease increases in underweight children, or in the worst cases death occurs. Regaring this problem, Ishida et al. (2014) predicted a decrease in childhood underweight (DatU) per capita until 2050 in all regions and according to all the scenarios they developed, while Lloyd et al. (2011) predicted child stunting in South Asia and sub-Saharan Africa in 2050, due to undernutrition, due to the impact of climate change.

In addition to existing trends, estimates of future trends regarding negative outcomes associated with climate change, which are not at all optimistic, are of additional concern. Ciscar et al. (2011) in their study, which referred to Europe, estimated the range of annual

mortality caused by heat and lack of acclimatization at the level of 60,000 and 165,000 people, while the range of mortality due to extreme cold was estimated between 60,000 and 250,000 people. In a somewhat later study, Tol (2013) warns of the fact that climate change in the 20th century caused a significant number of premature deaths (on average 7.5 per million per year, or 90,000 people every 2000 years), while in the 21st century the number is constantly decreasing premature deaths due to extreme cold, but the number of heat-related cardiovascular deaths is rapidly increasing. Lloyd et al. (2014) even in the case of an optimistic scenario (high economic growth and with adaptation), predicted a negative impact of climate change on health, with about 250,000 estimated additional deaths per year, between 2030 and 2050, while the total climate impact on health was not considered. Furthermore, bearing in mind the undeniable and significant impact of climate change on health, the WHO (2018), based on relevant health outcomes, estimated that 250,000 excess deaths per year could occur between 2030 and 2050. Moreover, Paavola (2017) when determining the impact of social and health conditions on vulnerability to climate change in Great Britain indicates that age, existing health status and social deprivation are factors that influence people's greater or lesser vulnerability to the impacts of climate change. Therefore, Luber and Prudent (2009) warn that vulnerability to health effects due to climate change may increase if the trend of increasing the urban and elderly population, which typically has a lower ability to adapt, continues.

However, although there is an evident growth trend in climate research. impact on human health, a detailed look at the literature can reveal some limitations of existing research (Rocque et al., 2021), such as: dominant preoccupation with the metrological impacts of climate change, primarily focus on physical health outcomes, uneven geographical distribution of research and the insufficiency of some types of research (e.g. the connection of climate change with the use of health services, adverse mental health outcomes, impaired nutrition, adverse outcomes of climate change at work, etc.) Therefore, regardless of the increase in research in the last 2 decades, a global understanding of the hitherto known multiple impacts of climate change on health is missing from several reasons: the study's focus on specific climate impacts (Alderman et al., 2012; Coates et al., 2019), focus on specific health consequences of climate change (Duan et al., 2019; Babaie et al., 2018), focus on the situation and outcomes at the level of individual countries (Chua et al., 2019; Lal et al., 2015; Li et al., 2018), out of date (Herlihy et al., 2016), etc. Similarly, based on detailed mapping and characterization of research on the impact of climate change on human health, Rocque et al. (2021) pointed out some of its gaps and limitations, such as: preoccupation with meterological impacts, primarily focus on physical health outcomes, uneven geographic distribution research and the insufficiency of some types of research (the relationship of climate change with the use of health services, adverse mental health outcomes, nutrition, adverse outcomes at work, etc.).

Additionally, efforts have been made in the literature to estimate the value of lives lost. Although lives should have the same value wherever and whenever, the fact is that people who live in wealth are more likely to value their lives than people who live in misery and poverty (Pearce 1978; Cropper et al., 2011; OECD, 2012). It is known that the OECD (2012) later developed a methodology for determining the Value of a Statistical Life (VSL), which represents a summary measurement of the willingness to pay (WTP) for a mortality risk.

On the other hand, a number of researches in the previous period were focused on the assessment of economic damage due to the impact of climate change on people's lives and health, because it is undeniable that these damages represent an important part of the total economic losses. Studies from the 90s of the last century estimated the total damage costs of climate change in the range of 1-3% of GDP, while the global economic value of loss of life due to climate change varied between 6 and 88 billion USD (Fankhauser and Tol, 1997; Fankhauser et al., 1997; Tol, 1995; Tol, 1996; Tol, 1992), with the loss of human life in total

economic losses from climate change varied from 6.5% to as much as 50%. Over time, the impacts, including the data on the impacts of climate change on human health, have expanded. Bosello et al. (2006) notes that the economic impacts of poor health are greater than the sum of health costs for various diseases, indicating that GDP, welfare and investment fall in regions with a net negative climate impact, and vice versa. Ciscar and Soria (2009) in the study related to the EU, predicts a net annual benefit of €25 billion in the 2020s due to the reduction of deaths due to cold. Trying to predict future trends, Watkiss et al. (2009) estimated the annual damage cost of between €70-139 million until 2040 in the EU, due to extremely high temperatures and heat (with an average cost of treatment of €3,500). Hutton (2011), mid-estimates health sector costs are approximately US$2-5 billion annually, when it comes to global adaptation costs. However, it is considered that these costs are underestimated because the literature still lacks estimates of the considerable economic damage due to climate change in other sectors, which should be occupied by future research. According to a study that referred to Europe (EU-27), which was carried out by Watkiss and Hunt (2012), the health costs of climate change from coastal flooding (with a focus on mental health, e.g. depression) are estimated at €1.5 million per year in the period 2071-2100, while the welfare costs for salmonellosis from climate change are estimated at potentially several million euros per year, in the same period. Later, Hasewaga et al. (2016) state that the economic value of the lost of a healthy life, due to the impact of climate change, is greater than the additional costs for health care and the reduction of the workforce. However, by reviewing the literature, it can be concluded that there is a significant difference in the estimated health damage costs, for several reasons, e.g. valuing only increased mortality, not valuing lost productivity, not valuing increased expenditures for health care, including a small range of diseases, valuing loss of life based on the country's GDP (Ackermana and Stanton, 2008), the valuation of impacts far into the future and selection of an adequate discount rate, etc [41-60].

Through a detailed review of the literature, it can be concluded that a number of studies (UNFCCC, 2009; Markandya and Chiabai, 2009a) have focused on estimating the costs of health adaptation measures, which reduce the impact of climate change on health, and implementing adaptation strategies in the context of National Adaptation Programs of Action (NAPA). According to the World Bank study (2010) the share of GDP in the total costs of adaptation decreases from 0.22% (2010-2019) to 0.12% (2040-2049), due to the increase in resistance to climate change, which ensures economic growth, while according to the UNFCCC report (2008) the share adaptation costs directly relevant to health care vary from 14% to 47% (depending on the estimated amount of costs). Regarding the aforementioned, Hutton (2011) indicates that climate risks can increase the costs of health adaptation to climate change, but on the other hand, also increase the potential health benefits of these interventions, which in total could result in unchanging overall efficiency, due to the effects of climate change. In general, it can be concluded that research has paid little attention to the relationship between benefits and costs of adaptation, with the aim of reducing the impact of climate change on health, on the one hand, and reducing health risks from climate. change, on the other hand. Such analyzes are necessary for making more effective decisions on health adaptation policies and adequate distribution of available resources. To that end, it is necessary to include multidisciplinary research on climate-health links, adaptation and mitigation measures in the health economic analysis (Haines, 2008), and to encourage the use of economic evidence through improved dissemination, communication, presentation and use of economic evidence (Rosenbaum at al., 2011) [61-88].

Additionally, it can be stated that unfortunately there is not enough research that has assessed the avoided costs of climate change adaptation. For example, a smaller number of studies evaluated reducing health damage costs, as a result of reducing GHG emissions (Barker and Bashmakov, 2007; European Commission, 2007; Nemet et al., 2010), while

Markandya and Chiabai (2009b) estimated health gains in the EU, China and India in the amount of US$145 billion in 2030, as a result of measures to reduce CO2 emissions in the electricity sector.

The aim of our paper is to assess economic damage in the health sector of Montenegro, caused with high temperatures, over a longer time period. The absence of an official methodology on the procedure for determining damage caused by climate change in Montenegro is a limitation for analyzes of this type. For this reason, the estimates so far, related mostly only to concrete estimates of material damage, caused by certain extraordinary events, which arise under the influence of a changed climate. As Montenegro lacks official statistical and research data on the direct impacts of climate change on human health and the Montenegrin health system, the authors of this paper assessed sensitivity to climate change by analyzing data and information from the previous period and their spatial distribution.

This paper is organized as follows. In the introduction, the relevant aspects concerning the impact of climate change on the health sector in Europe and the world, and the numerous consequences that are the result of this impact, are presented. The second section of the paper presents the national circumstances related to the health sector in Montenegro and the impact of climate change on this sector. This section presents the annual trends in mortality and its specific causes in Montenegro, as well as the presentation of environmental factors that have a direct influence on climate change vulnerability of the health and health sectors in Montenegro. The third section of the paper presents the methodological framework used for the analysis and assessment of the economic damage to the health sector of Montenegro due to climate change, caused with high temperatures, over a longer time period. The negative impacts of climate change on the health sector in Montenegro were analyzed based on the projection of the additional number of premature deaths caused by climate change in Montenegro and determined unit values of VSL in Montenegro. For the basic scenario - the "no climate change" scenario, the benchmark was the target number of deaths taken from the national program for adapting the health system to climate change in Montenegro for the period 2020-2022. In the conclusions of the work, the final results and recommendations were announced, but certain limitations of this work were pointed out, which can be overcome in future research of this and similar types in this field.

2 Curent status/overview: baseline health profile of Montenegro

In this section of the paper, we provide basic information regarding the health status and the health sector in Montenegro. We presented the basic annual mortality trends, as well as the specific causes of death of the population in Montenegro. At the same time, a review of intestinal and transmissible infectious diseases, as a consequence of the manifestation of climate change, was given. The last part of the section presents basic environmental factors that have a direct influence on climate change vulnerability of the health and health sectors in Montenegro, such as air pollution, water quality and food quality.

2.1. Annual trends of all-cause and specific mortality data in Montenegro

The all-cause mortality of the population in Montenegro in the last 10 years has an increasing trend from 5922 deaths registered in 2012 to 7301 deaths in 2021, as presented on Figure 1. Of this number, the largest percentage (75% in 2012 and even 79.8% in 2021) belong to the age category over 65 years, which is considered the most vulnerable to climate change. In the country's structure of all-cause mortality, the percentage of deaths is higher in men with an increasing trend from 50.5% in 2012 to 53.4% in 2021, unlike women whose death rate decreases from 49.5% in 2012 to 46.6% in 2021 (Figure 2). According to statistical data, in

the most vulnerable age group population (over 65 years) mortality is higher among women, having a decreasing trend from 53.4% in 2012 to 50.5% in 2021.

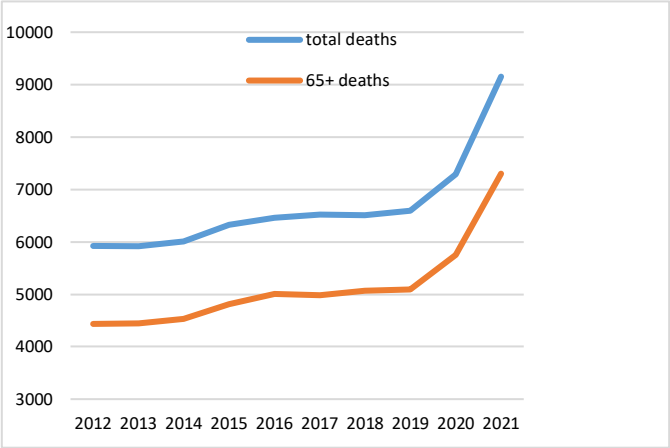

Fig. 1. All-cause mortality in Montenegro, Montenegro (%), MONSTAT, MONSTAT, 2021

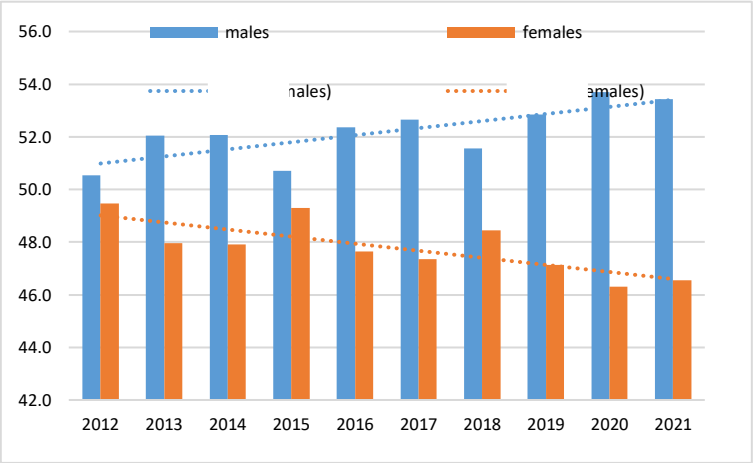

Fig. 2. All-cause mortality in 2021

2.2. Causes of deaths in Montenegro population

Noncommunicable diseases are the cause of most deaths in Montenegro, especially cardiovascular diseases and cancer. In 1990, those two causes (diseases) accounted for an estimated 80% of all deaths and in 2019 for more than 82 %. Of course, the older population groups are at much higher risk. Women over 50 in Montenegro have a significantly greater risk of dying from cardiovascular diseases than men (62.5% and 51.8% of total deaths respectively in 2019). Furthermore, 86% of the deaths from these diseases were among the population group over 60 of age. The opposite is with cancer as the second leading cause of death. Men over 50 are affected to a greater extent (25.9% and 18.4 % of total deaths respectively in 2019), as presented on Figure 3 and 4.

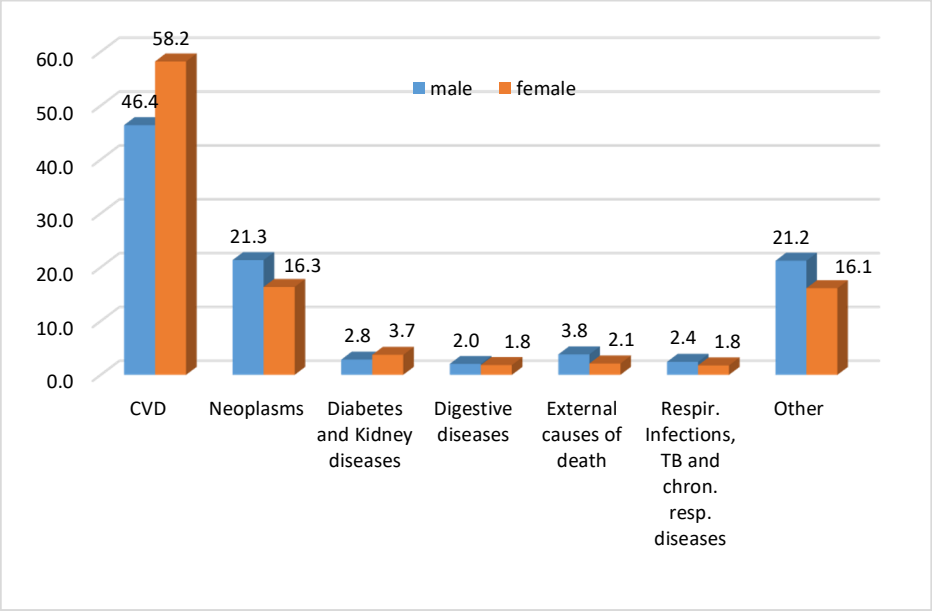

Fig. 3. Cause-specific mortality (%) in MNE (1990), age group 50 and over, Source: IHME database 2019

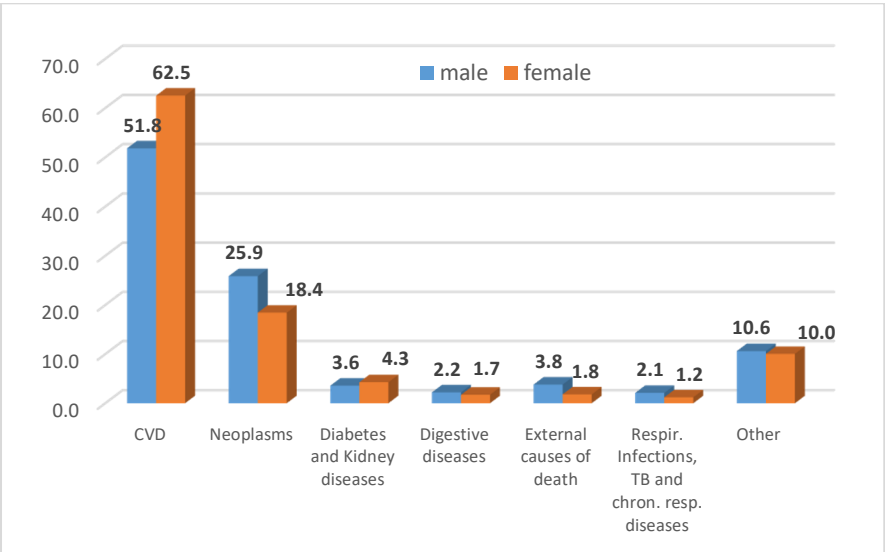

Fig. 4. Cause-specific mortality (%) in MNE (2019), age group 50 and over, Source: IHME database 2019

2.3. Intestinal and transmissive infectious diseases

Diarrheal diseases, like salmonellosis and campylobacter, are more common when temperatures are higher or can occur more frequently in conjunction with usually high or low precipitation. Furthermore, an increase in vector-borne (transmissive) infectious diseases

such as malaria, dengue, Lyme diseases, etc have been linked to climate variability and are expected to increase further as a result of climate change. Observed by groups of infectious diseases, in 2018 in Montenegro the number of reported cases was highest in the group of respiratory infectious diseases (78%, without influenza), followed by intestinal infectious diseases (11.5%) and parasitic diseases (7.8%). Similar findings could be observed when analysing NIPH annual report on infectious diseases for the period 2018-2021. Of the disease that could be linked with climate change events, Salmonellosis and Enterocolitis acuta were among the most frequent intestinal infectious diseases with visible seasonal variations in 2018 and 2019 (more frequent in the hot periods of the year), as presented on Figure 5.

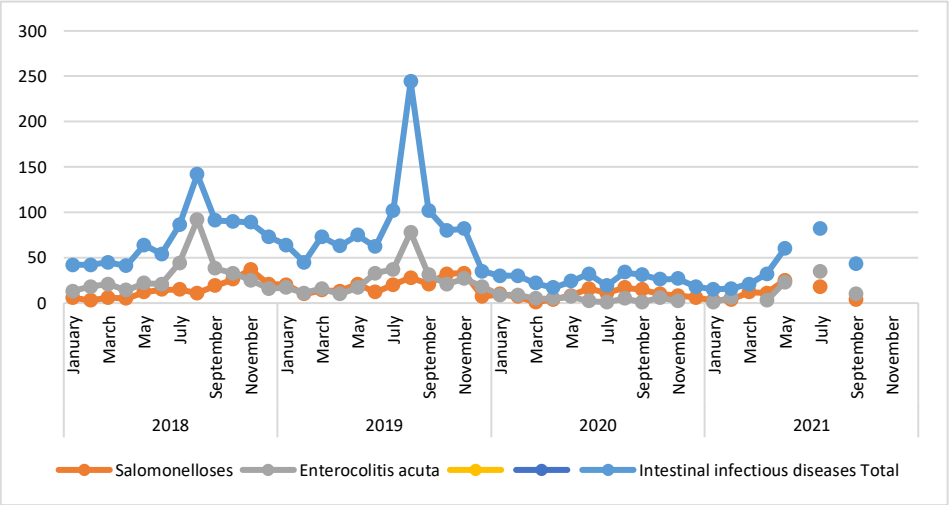

Fig. 5. Intestinal infection diseases in Montenegro in 2018-2021, seasonal variations, Source: NPHI. Annual reports on infectious diseases in Montenegro, 2018-2021.

Some zoonoses like Leishmaniasis could be also impacted by climate change. Aiming to determine the ecological and epidemiological characteristics of Leishmaniasis in Montenegro in the extensive timeframe 1945-2011, Medenica (Sanja Medenica, Epidemiological and ecological characteristics of Leishmaniosis in Montenegro, Doctoral dissertation, University of Niš, 2016) found a trend of a significant decline in the number of cases by 3.1% annually for the whole country in the period 1945-1981, while during 1981-2014 trend of a significant increase in a number of cases by 4.0% per year was recorded. Pre-school and school age children accounted for 79.1% of the total number of cases. A positive correlation between the number of patients, a 1°C increase in temperature (on annual basis in all three areas) and a 1 mm increase in precipitation was registered in all geographical regions of the country (the number of patients increased by 0.150).

Climate change is likely to have short and long-term effects on vector-borne infectious disease transmission and infection patterns, affecting both seasonal and geographic changes in disease occurrence over long periods. Since there are also many other factors to interact in this process it is difficult to predict the real effects of climate change on vector-borne diseases.

The suitability for transmission of many infectious diseases is influenced by shifts in temperature and precipitation. Dengue is a mosquito-borne disease that can cause febrile illnesses and, in severe cases, organ failure and death, with children under five, particularly at risk. With temperatures changing across the globe, this indicator tracks how this is

affecting the climate suitability for these infections. The Lancet countdown (2021) indicator tracks the environmental suitability for the transmission of arboviruses (dengue, chikungunya, and Zika), malaria, and Vibrio bacteria. For arboviruses, it uses an improved model to capture the influence of temperature and rainfall on vectorial capacity and vector abundance and overlays it with human population density data to estimate the R0 (the expected number of secondary infections resulting from one infected person). The findings say that the R0 for all arboviral diseases tracked has increased, and, in 2020, was 13% higher for transmission by A. aegypti and 7% higher for transmission by A. albopictus than in baseline years (Lancet 2021)

The climate-sensitive vector-borne infections include viral infections such as Dengue, Zika and Hantavirus infections; bacterial infections such as Lyme disease, plague, and tularemia; or parasitic infections such as malaria and leishmaniasis. Lyme borreliosis is the most important vector-borne disease in temperate zones of the northern hemisphere in terms of the number of cases. In Europe, at least 85,000 cases are reported every year and the prevalence is greater eastwards. The disease is prevalent in Bosnia and Herzegovina, Serbia, and Montenegro (Climate Change Post, 2023). When temperature increases, rainfall and moisture also increase, water-borne infections such as cholera, as well as leptospirosis, and Weil's disease or leishmania infections are more frequent in the relevant regions and mosquitos get more abundant to transmit infections such as malaria or Dengue fever. When temperature increases but rainfall and moisture decrease, meningococcal meningitis and West Nile virus infection can get more frequent. Balkan countries including Montenegro are also endemic to Crimean Congo Hemorrhagic Fever (caused by Norovirus transmitted to humans by Hyalomma ticks) with a high fatality ratio (Kayacan and Akgul, 2022).

There is no systematic mosquito surveillance currently done or published in Montenegro. The Lovćen project is the only project that published the findings of a few mosquito species in Montenegro that are pathogen vectors for transmission of certain diseases like Malaria, Chikungunya, Dengue, West Nile viruses and Leishmania. The Asian tiger mosquito (Aedes albopictus) has become established in many parts of Europe since its introduction at the end of the 20th century. It can vector a range of arboviruses, of which Chikungunya and Dengue are the most significant in Europe. Montenegro is also among those countries at risk. In 2018, a study was conducted on analysing the expected climate change and the related shift in the climate zones for Montenegro and its impact on the establishment of Ae. Albopictus. The results pointed to a significant increase in suitability for the mosquito and a vertical shift to higher altitudes by the end of the century. The contribution of this change is most significant for the northern mountains, while for the coastal areas where the annual temperature was high CC did not induce insignificant changes in suitability. Similarly, the expected drop in precipitation does not significantly affect the suitability since the annual precipitation is still above the threshold for egg survival. The contribution of this change is most significant for the northern highlands, while for the coastal areas where the annual temperature was high CC did not induce significant changes in suitability (Petrić et al., 2018). While vulnerabilities to arboviruses transmitted by A. albopictus and A. aegypti have decreased across all countries in the world since the year 2000, countries in the low Human Development Index group remain on average the most vulnerable (Ministry of Health of Montenegro, 2020).

Even though malaria's current main location is Africa, the European Environment Agency (EEA) projected that different countries including Turkey and some of South-Eastern Europe will be affected due, among other factors, to the changing climate. According to the data presented in the national program (Ministry of Health of Montenegro, 2020), in Montenegro, the share of patients with vector-borne infectious diseases in 2013 was 0.2% of the total number of patients with infectious diseases. That year 13 vector cases of infectious diseases were registered in Montenegro (1 case of imported malaria, 4 cases of Lyme disease) diseases, 4 cases of leishmaniasis, and four cases of West Nile fever. However, in the latest

NIPH reports on transmissive infectious diseases in Montenegro, those groups of diseases did not have an increasing trend. Given the very small number of these diseases, some specific seasonal or regional matrix of their occurrence in Montenegro could still not be found, as seen on Figure 6.

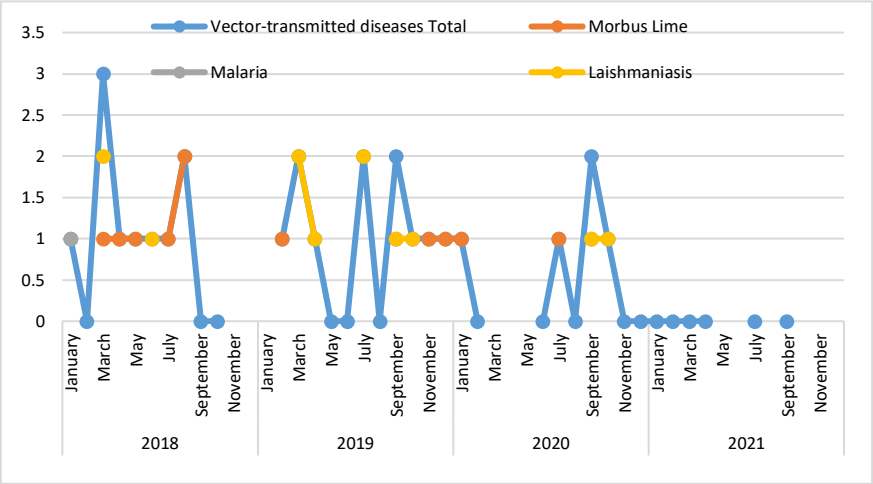

Fig. 6. Vector-transmitted diseases in Montenegro in 2018-2021, seasonal variations. Source: NPHI. Annual reports for infectious diseases in Montenegro, 2018-2021

3 Data and Methodology

Climate change is one of the greatest threats to human health and health workers around the world are already responding to the damage to health caused by this evolving crisis. The following can be expected in the near future:

- economic, social and health consequences of loss of ability to work and reduced productivity;
- increasing the incidence of respiratory diseases due to higher concentrations of ground-level ozone and particulate matter in urban areas, related to climate change;
- increased risk of illness and death caused by more intense heat and extreme heat waves and higher risk of injury and death from multiple fires;
- increasing the impact of floods on health due to heavy rainfall;
- increased number of infectious diseases through ticks, mosquitoes, rodents and tropical and foodborne diseases;
- increasing the number of water-borne diseases in populations where water, sanitation and personal hygiene standards are low.

Moreover, vulnerability to weather and climate change depends on people's levels of exposure, their personal characteristics, and their access to resources. The following population groups are particularly vulnerable: the elderly, chronically ill people, children, exposed workers, socially vulneraable and homeless people. Older people are particularly vulnerable, and their vulnerability stems from a complex mix of factors such as: multiple chronic diseases, poverty, isolation, lack of access to transportation, etc. Children are

particularly vulnerable because of their physiological and cognitive abilities of immaturity and their greater potential for long-term exposure.

The health risks associated with heat increase with the level of physical strain. Heat stress is a problem for those who work indoors, in environments that are not under temperature control. Heat exhaustion and heat stroke are the main health effects associated with heat, which pose a risk to outdoor workers and outdoor occupations (e.g. agricultural and construction workers, workers who are working in the tourism sector, etc.).

In evaluating the impact on health, n the literature there are three elements that are considered when assessing the overall effects of the impact on the well-being of society. These elements are:

- Resource costs, i.e. medical expenses;
- Opportunity costs, i.e. costs in terms of lost productivity, and
- Lost enjoyment of life by to premature mortality, plus the pain and suffering of the loved ones.

Montenegro doesn't have an official statistic and research data or the direct health effects (impacts) of climate change and climate extremes on the human health and the health system in Montenegro. Having in mind the lack of official data, in this paper we assessed the climate change sensitivity by analysing data/information from the previous (historical) climate change events and their spatial distribution. As aforementioned, the task defined within the scope of this paper, is to assess future adverse economic impacts caused by climate change on the health sector in Montenegro, caused with high temperatures, over a longer time period.

A trend of increasing temperature in each decade since 1970-th was observed in each region of Montenegro (Ministry of Ecology, Spatial Planning and Urbanism of Montenegro and UNDP, 2021). The valley of River Zeta has the hottest summers in Montenegro and the highest average summer temperature was recorded in Podgorica (29.2 C). as well as the highest daily temperature of up to 44.8 C in August 2007. In relation to this, the heat waves also became an increased climate hazard for the country, having in mind that they occur more frequently and last longer in comparison with the past data. Urban areas like Podgorica and southern (coastal) cities like Bar are at the highest risk. Heatwaves with longest duration are usually observed in August, but there are also short heatwaves in June and July.

The average length of the heatwave in the coastal region of Montenegro is 28.5 days per year, in the central region it is 23 days, and in the northern region 18.4 days. In 2012, a strong heatwave hit Montenegro, affecting more than 4,500 people (Ministry of Ecology, Spatial Planning and Urbanism of Montenegro and UNDP, 2021), while the maximum duration of the heatwave of 128 days was recorded in 2018 in Bar.

Increasing concentrations of greenhouse gases lead to an increase in the average but also extreme temperatures and other extreme climatic events. As health consequences that will lead to increased rates of deaths, heat stress, and diseases, which will especially affect the sensitive population groups like children, elderly, pregnant woman, physically, socially and economically disadvantaged groups, people working outside, and the homeless. They can also worsen chronic conditions such as cardiovascular diseases and respiratory and cerebrovascular diseases. People over 65 are the most vulnerable to heat-related illnesses since they live in some degree of constant dehydration, regardless of the weather conditions. As a result, their circulatory system and their cooling system no longer works as well, making them predisposed to heat exhaustion and heat stroke.

Lancet countdown (2021) indicator of climate change impacts and vulnerability can also be used to assess the heat vulnerability in the country and the region. This indicator tracks a population's vulnerability to heat using a composite index ranging from 0 to 100, which combines data on the proportion of the population older than 65 years; the prevalence of

chronic respiratory disease, cardiovascular disease, and diabetes in this population, and the proportion of the total population living in urban areas. Tracking the Heat Vulnerability Index in some countries of Southeast Europe, including Montenegro (Romanello et al., 2021), is presented in Table 1.

Table 1. Tracking the Heat Vulnerability Index in some countries of Southeast Europe

Country/year	1990	2019
Montenegro	31	38
Serbia	33	39
Albania	26	34
North Macedonia	36	39
Greece	39	42

Although vulnerability to heat in the low and medium Human Development Index (HDI) country groups is 27–38% lower than in the very high HDI group, it is increasing in all groups and, since 1990, it has increased by 19% in the low HDI group and by 20% in the medium HDI group. For Montenegro, the increase is 19.5 %. It should be emphasized that this indicator does not capture the existence or the absence of effective adaptation measures, such as early warning systems for heat waves, cooling devices, and green areas in cities.

Regarding the mortality linked with climate extremes, in the absence of specific cause of deaths mortality data and according to the modelling data from national documents, in "baseline climate change scenario", annual high-temperature mortality was estimated at 55 deaths (Ministry of Health of Montenegro, 2020).

As aforementioned, the aim of this paper is to to assess future adverse economic impacts caused by climate change on the health sector in Montenegro, caused with high temperatures, over a longer time period. Methodologically, it perhaps the most difficult to assess the negative economic impacts of climate change in the health sector. Although the health effects of climate change are obvious or proven, it is not easy to establish a clear correlation between climate change and specific diseases where, thereby official statistical data on that are nowhere to be found in Montenegro. For this reason, when assessing the negative impacts for this area, the focus was exclusively on direct death cases, which will occur due to climate change, caused with high temperatures. This assessment required to:

- Collect relevant statistics on the number of deaths due to climate change caused with high temperatures;
- Process and analyse collected data, as a basis for further projections;
- Project the future number of deaths caused by climate change;
- Perform an analysis of the value of statistical life (VSL - Value of Statistical Life) in Montenegro and in the world and determine future values, as a basis for damage assessment;
- Based on previously collected and processed data, calculate and project the economic damage caused by climate change in health sector of Montenegro.

An important step in this work for the assessment of economic damage due to climate change in the health sector, caused with high temperatures, was defining the time frame for performing the analysis. The negative effects of climate change cannot be assessed for shorter periods of time because climate changes occur slowly, which is why the effects are not noticeable in shorter periods of time, as is usual for different types of economic analysis. That is why the authors of this paper guided by the recommendations from relevant international

documents (WMO and UNEP, 2000), decided to assess the economic damage due to climate change in the health sector in Montenegro according to 2 scenarios:

a) Near Future scenario, until 2050, and
b) Far Future scenario, until 2100.

Due to the impossibility at this moment to precisely define how much impact on the climate will occur in these defined periods, and therefore what negative consequences these changes will cause, as part of the further analysis, we decided to look at two scenarios – a more favorable and a less favorable scenario, within both defined periods. Although the number of these scenarios could have been higher, we believe that in order to determine the preliminary level of adverse effects of climate change on the health sector, this number of scenarios is sufficient.

As there is a problem of scarcity of adequate statistical data and scientifically verified results and evidence for the area of Montenegro and the region, the data and initial assumptions used in this analysis were taken from analyzes and research in Europe and the world (Table 2), and can be considered relevant to our analysis.

Table 2. Initial assumptions from relevant sources and analysis for the assessment of economic damage due to climate change

Document name	Initial assumptions for the assessment of economic damage due to climate change
"The Economic Impact of Climate Change in Montenegro", UNDP, 2010.	- Fear Future scenario, until 2050: losses of 3% and 8%; - Far Future scenario, until 2100: : losses of 8% and 15%.
"The Economics of Climate Change: No Action not an Option", Swiss Re Institute, April 2021.	- Decrease of GDP of 2.8%, if the goals of the Paris Agreement are achieved (increase in temperature well below 2 ° C); - Decrease of GDP of 7.7%, if further mitigation measures are taken (temperature increase of 2 ° C); - Decrease of GDP of 8.1%, if some mitigation measures are taken (2.6 ° C increase in temperature); - Decrease of GDP of 10.5%, if mitigation measures are not taken (temperature increase of 3.2 ° C).
"Long-Term Macroeconomic Effects of Climate Change: A Cross-Country Analysis", International Monetary Fund, October 2019.	- For the period up to 2050: losses of 2.18% and 3.11%; - For the period up to 2100: losses of 6.05% and 8.25%.

From the data presented in Table 2, it is obvious that the assessment of economic damage due to climate change depends on the initial assumptions, which differ from document to document. In order to provide a broader time frame of analysis for the assessment of economic damage due to climate change in the health sector in Montenegro, in this paper the following assumptions are accepted within the framework of the considered scenarios:

→ Near Future 1 (NF1), damage level by 2050 – 5%,
→ Near Future 2 (NF2), damage level by 2050 – 10%,
→ Far Future (FF1), damage level by 2100 – 10%,
→ Far Future (FF2), damage level by 2100 – 15%.

Projections of individual economic categories are made relying on certain growth rates based ither on historical data, or on the fluctuations of a certain category in the past period, or using official GDP growth rates, or certain sectoral rates or a combination of all mentioned

above with appropriate estimates of sectorial experts. In this particular case, some historical rates are not fully relevant due to the atypical 2020. This also applies to the GDP growth rate, which dropped significantly in 2020. For that reason, it was decided to follow the precautionary principle with moderate growth rates, in relation to the initial state. For health sector we decide to consider 1% per year.

As for the health sector in Montenegro, the benchmark was the target number of deaths taken from the aforementioned program for adapting the health system to climate change in Montenegro for the period 2020-2022 (Ministry of Health of Montenegro, 2020).

In order to better understand and monitor the analysis of the impact of climate change and the assessment of economic damage to the health sector in Montenegro, caused whith high temperatures, in the continuation of the work, Figure 7 shows a methodological flowchart.

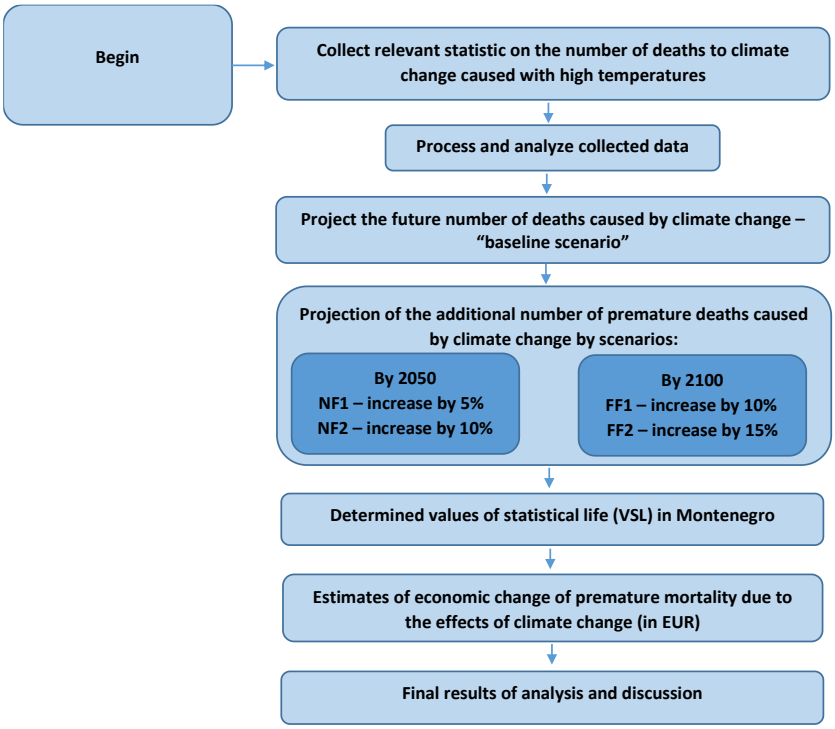

Fig. 7. Methodological flowchart.

4 Analysis and results: Calculating economic damage in Montenegro from premature deaths from climate change, caused by high temperatures

As stated earlier, the future impacts of climate change on health are difficult to quantify, due to the complex interplay between climate and non-climate drivers and the health effects of adaptation to climate change. However, climate change is the dominant driving force in forecast trends, accounting for more than 90% of the increase in risk to humans. Monitoring and evaluation of the climate in Montenegro show that heat waves are becoming more

frequent, and their length shows high variability from year to year. From a long-term perspective, there is a visible trend of continuous growth in the duration of heat waves.

Heat waves represent a particularly pronounced risk for the elderly and people suffering from respiratory and cardiovascular diseases. Air quality often deteriorates during heat waves, further exacerbating health problems. The elderly are particularly sensitive to the impact of climate change on health. There is a direct correlation between mortality and temperature, which varies by climate zone and geographic area. High air temperature is associated with mortality caused by heatstroke, cardiovascular, renal and respiratory diseases, metabolic disorders, etc. The effect of temperature on mortality is greater for respiratory and cardiovascular diseases than for other causes of death. The most vulnerable are people over the age of 65, pregnant women, children and chronic patients.

Considering that in Montenegro, but also in Europe, there is not enough input data and clear principles and methodologies to determine the correlation between these cost categories and climate change, an assessment of economic damage from premature mortality due to the effects of climate change, caused by high temperatures, was made in this paper.

In this paper, the cost of premature mortality caused by high temperatures was calculated based on projections of the additional number of deaths due to climate change and the established Value of Statistical Life (VSL). As stated in Section 3, according to official data from national documents (Ministry of Health of Montenegro, 2020), in the „baseline scenario“, it was determined annual mortality of 55 deaths caused by high temperatures. Projections of the number of deaths caused by climate change for „baseline scenario“ are shown in Table 3.

Table 3. Projections of the number of deaths caused by climate change – „baseline scenario“

Year	Number of deaths	Year	Number of deaths
2025	57	2065	84
2030	60	2070	89
2035	63	2075	93
2040	66	2080	98
2045	69	2085	103
2050	73	2090	108
2055	76	2095	114
2060	80	2100	120

After that, an expert assessment of the impact of climate change on the number of premature deaths was performed, for different projected time periods, as well as for the corresponding climate scenarios. Four scenarios were considered:

→ Near future, an increase in the number of deaths by 2050 by 5% (NF1),
→ Near future, an increase in the number of deaths by 2050 by 10% (NF2),
→ Far future, an increase in the number of deaths by 2100 by 10% (FF1),
→ Far Future, an increase in the number of deaths by 2100 by 15% (FF2).

The projection of the additional number of premature deaths caused by climate change, for 4 scenarios, is shown in Table 4.

Table 4. Projection of the additional number of premature deaths caused by climate change

Year	NF1	NF2	FF1	FF2
2025	0	1	0	0
2030	1	2	1	1
2035	1	3	1	1
2040	2	4	1	2
2045	3	6	2	3
2050	4	7	3	4
2055			3	5
2060			4	6
2065			5	7
2070			5	8
2075			6	9
2080			7	11
2085			8	12
2090			9	14
2095			11	16
2100			12	18
Total	**48**	**95**	**367**	**546**

In the next step of the analysis, it is necessary to determine the Value of Statistical Life (VSL) for Montenegro. The value of statistical life (VSL) is the rate of local compromise between the risk of death and money. When compromise values are performed in market contexts, VSL serves both as a measure of the willingness of the population to pay for risk reduction, but also as a marginal cost of increasing security. Given its fundamental economic role, analysts have adopted VSL as an economically sound measure of the benefits that individuals derive from improving their health and safety. Estimates of VSL values vary by country, given the positive elasticity of VSL to GDP. Due to the emphasis on reducing the risk of mortality, as a justification for a particular measure, VSL is also used as an essential component in cost-benefit analyses. VSL is also fundamentally related to the concepts of statistical age valuesand statistical injury values, which also permeate the literature on occupational and health economics.

There are no special studies conducted in Montenegro to determine the VSL. However, authors used EU methodologies and relevant publications which describe the procedures of determining this value. Unit values of VSL were determined on the basis of two models from the professional literature. The first model is based on iRAP document (2016), which provides recommendations for determining these values based on a comprehensive analysis and on an established formula correlated with GDP per capita. The second model is based on guidelines from the EC Handbook (European Commission, 2019), which defines these values for the EU28 average, and then proposes their correction for each country in accordance with the relationship between GDP per capita. These values are presented in Table 5.

Table 5. Determined Values of Statistical Life (VSL) in Montenegro

Description/Source	IRAP[1]	Handbook[2]
Value of Statistical Life – VSL	542,010	630,206

[1] International Road Assesment Programme, The true cost of road crashes-valuing life and the cost of a serious injury, 2016.
[2] European Commisssion. Handbook on the External Costs of Transport, European Commission, Version 2019 – 1.1.

Based on projection of the additional number of premature deaths caused by climate change in Montenegro and determined unit values of VSL in Montenegro, we prepared an assessment of economic damage due to climate change in the health sector in Montenegro, caused with high temperatures. Estimates of economic damage of premature mortality due to the effects of climate change are shown in Table 6 and 7.

Table 6. Estimates of economic damage of premature mortality due to the effects of climate change in EUR (VSL – IRAP document)

Year	NF1	NF2	FF1	FF2
2025	160,978	315,251	112,797	165,546
2030	453,144	891,126	317,103	466,060
2035	777,309	1,535,030	543,238	799,564
2040	1,136,135	2,253,104	792,970	1,168,810
2045	1,532,482	3,051,983	1,068,197	1,576,752
2050	1,969,421	3,938,841	1,370,951	2,026,566
2055			1,703,411	2,521,661
2060			2,067,913	3,065,698
2065			2,466,958	3,662,605
2070			2,903,222	4,316,598
2075			3,379,575	5,032,200
2080			3,899,086	5,814,261
2085			4,465,039	6,667,984
2090			5,080,950	7,598,945
2095			5,750,577	8,613,120
2100			6,477,943	9,716,915
Cumulative Total 2025 – 2050/2100	25,972,704	51,573,065	198,703,933	296,118,329

Table 7. Estimates of economic damage of premature mortality due to the effects of climate change, in EUR (VSL – EC Handbook)

Year	NF1	NF2	FF1	FF2
2025	187,172	366,548	131,151	192,483
2030	526,879	1,036,130	368,702	541,897
2035	903,793	1,784,811	631,633	929,670

2040	1,321,008	2,619,729	922,002	1,358,999
2045	1,781,848	3,548,603	1,242,014	1,833,322
2050	2,289,885	4,579,770	1,594,032	2,356,330
2055			1,980,591	2,931,987
2060			2,404,405	3,564,549
2065			2,868,382	4,258,585
2070			3,375,636	5,018,996
2075			3,929,501	5,851,041
2080			4,533,546	6,760,359
2085			5,191,592	7,753,000
2090			5,907,723	8,835,447
2095			6,686,313	10,014,649
2100			7,532,036	11,298,054
Cumulative Total 2025 – 2050/2100	30,198,988	59,965,047	231,037,086	344,302,776

As can be seen from the results of our analysis, the economic damage of premature mortality due to the effects of climate change in Montengro could be significant. In the first variant of the VSL value, in the near future scenarios, these damages could be around EUR2 to 4 million per year in the final year of observation, which would be cumulatively around EUR25 to 50 million for the total observed period. In the far future, these damages in the final years would be from about EUR6.5 to about 10 million per year, so the cumulative amount of these damages for the total period up to 2100 would be from about 200 to 300 million EUR. In the second variant of the VSL value, the amount of these damages is proportionally higher and can reach a cumulative level of around EUR 350 million.

5 Conclusion

Results of our analysis confirmed that there is a significant health risk for the population from climate change, especially from certain climatic extremes. Although sufficient quality health data covering a longer historical period have not been obtained, nor have specific studies on the direct connection of climate change with health have been developed, the indirect indicators and existing models – predictions confirm that the occurrence of high temperature and heat waves, especially in the summer period, is the highest climate change risk for the population in Montenegro. Cardio-respiratory morbidity and mortality are the main health outcomes to expect as a result of extreme temperatures and heat waves.

The results presented in section 4 indicate a significant estimated economic damage in the health sector of Montenegro, caused with high temperatures, which is estimated at a cumulative amount of about €30-60 million for the total observed period (NF scenario, for a higher value of VSL), i.e. in the cumulative amount of around €230 to 350 million for the total observed period (scenario FF, higher value of VSL).

Certainly, not all population groups are equally at risk, so the focus of the risk is on the old population above the age of 65, the chronically ill, homeless, workers who work outdoors (which includes agricultural workers, fishermen and tourism workers) and socially marginalized groups that live in substandard conditions. Climate change's negative impacts

are affecting everybody, although there is strongly related gender-based negative health consequences from the climate extremes. In terms of the geographical region, it seems that the coastal region and the urban zones of Montenegro (mainly Podgorica) are the most threatened by this climate extreme.

In the climate projections (Ministry of Ecology, Spatial Planning and Urbanism and UNDP, 2021), the future climate change is primarily characterized by a further increase in the temperature, which will also cause changes in extreme weather and climate anomalies, so that we can expect a decrease in the number of temperature extremes with low temperatures and an increase in the number of warm extremes, i.e., a significant increase in very hot days and an extended duration and increased frequency of heat waves. Health risks especially to older people and chronically ill patients will be extremely high and the capacities and medical staff in the health care services including emergency care must be well prepared to work in climate extreme circumstances.

The main areas for intervention for addressing the gender driven climate related vulnerabilities of the health sector of Montenegro are divided on policy level actions, health care infrastucture and health protection actions and specific actions for monitoring and addresing climate-driven vulnerabilities and gender and solcially disaggregated impacts.

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