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REVIEW

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Climate change in Kazakhstan: implications to population health

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Abstract

Background Globally, climate change is one of the most pressing issues affecting the human race. The health of the Kazakh people is significantly impacted by climate change, which has made Kazakhstan one of the most vulnerable nations in Central Asia. This study reviews the impact of climate change on population health in Kazakhstan and provides recommendations to address these issues.

Main body of the abstract This review paper evaluated available evidence and resources, which included journal articles, country reports, World Bank reports, United Nations Development Program reports, and other findings and reports relevant to the issues of climate change and the quality of life of the Kazakh people. The impact of climate change on the country is becoming more pronounced. Floods, deterioration of water quality, melting of glaciers, and extremes of temperature are some of the direct impacts of climate change observed in the country. These changes were shown to affect the health of the population.

Short conclusion This review revealed mounting proof of how climate change is having an increasing impact on the lives of people in Kazakhstan. There is now an urgency to address the impact of climate change by implementing various mitigation and adaptation strategies.

Keywords Climate change, Population health, Impact, Kazakhstan

Background

Kazakhstan is known for being landlocked and for its great distance from large water bodies such as the Caspian Sea. From an income level standpoint, it is an upper-middle income country with a population of 18.7 million and the ninth largest country by land mass (Atakhanova 2021). The high mountains in the country are found in the Southeastern and Eastern regions, while the rest of the terrain is 90% flat. The country is the largest economy in Central Asia and accounts for 60% of the region's gross domestic product (GDP). The country has a rich natural resource base, including coal, oil, and natural gas. However, the country's reliance on coal and oil strongly correlates to its greenhouse gas (GHG) emissions. The majority of GHG related to climate change and global warming result from carbon dioxide emissions. With

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nearly 366 million tons of carbon dioxide equivalent, Kazakhstan has Central Asia's highest per-capita output of GHG (Primbetova et al. 2022). Kazakhstan also has the largest carbon emissions per-capita in Central Asia, and its carbon emissions increased by more than 80% between 2000 and 2014 (Primbetova et al. 2022). The major sources of pollution in Kazakhstan originate from industries, transport vehicles, agriculture, and municipal sources. According to a World Bank assessment, 75% of the country is increasingly at risk from the negative effects of climate change (The World Bank Group 2021). Currently, the country experiences extreme summers and harsh winters with temperatures varying depending upon the latitude where certain areas in Kazakhstan are located. For instance, northern areas of Kazakhstan experience much colder winter temperatures, whereas the southern part experiences relatively extremely hot summers. The level of precipitation also varies in each area. For example, in desert areas, the level of precipitation is only 100–200 mm annually, while mountains may receive rainfall between the ranges of 500 mm–1600 mm per year (The World Bank Group 2021).

In recent decades, deforestation, significant crop loss, ozone layer deterioration, rising sea levels, loss of habitat, floods, droughts, storms, and earthquakes have all brought climate change to the public's notice (Primbetova et al. 2022). Most scientific predictions state categorically that every nation on earth will be impacted by climate change, but not all countries will be impacted equally. For example, three extremely severe weather events struck Japan in 2018; the country experienced heavy rainfall in July that was daily measured as being twice greater than what was previously believed to be the wettest day on record. Similarly, in the same year, the Philippines was devastated by Typhoon Mangkhut (Somvichian-Clausen 2020). More recently is the occurrence of wildfires in the UK and USA which results in many injuries and fatalities. Examples of typical climate-related disasters in central Asia include the 2008 flooding in Kazakhstan, which resulted in the displacement of 13,000 people and the death of 24 people (Fay et al. 2010). In Tajikistan, two further floods occurred in 2002 and 2007, resulting in 21 fatalities (Fay et al. 2010). Forest fires are also currently raging in the Abay region of Kazakhstan accounting for 14 deaths so far (Satubaldina 2023). According to the Kazakh Emergency Minister, there were 800 forest fires and 111 steppe fires documented in the nation in 2022 alone, a 2.2-fold increase in the number of forest fires over the previous five years (Satubaldina 2023). Statistics from the Kazakh government also showed that 122 forest fires have been reported in Kazakhstan since the beginning of 2023, with the fires covering an area of more than 19,000 hectares and resulting in damage to properties of more than $114,619 (Satubaldina 2023). Climate change effects go beyond environmental impact thereby rendering the identification and assessment of health effects due to climate change exceedingly challenging and complex. Its effects may be direct or indirect which could also last for longer terms (Cianconi et al. 2020).

Climate change leads to decreased social mobility and imposes significant changes in the lives of people (Padhy et al. 2015). The impact on mental health due to climate change is substantial. For example, the worldwide economy loses almost one trillion US dollars annually due to lost productivity brought on by depression and anxiety, two of the most prevalent mental illnesses (Chisholm et al. 2016). Disasters due to climate change may result in people becoming homeless leading them to migrate from one place to another. Migrating to a different place could also result in acculturation stress and influence the perspective and lifestyle of people (Celik 2020; Padhy et al. 2015). Aside from that, climate change also induces an emotional response from people describing ecological grief as a mental health response of an individual toward climate-change-related loss (Cunsolo & Ellis 2018). As climate change progresses, it is anticipated that the impact of poor air quality on mortality and respiratory illnesses in different cities will get worse (Russell et al. 2018). Evidence from studies also revealed that increased temperatures tend to increase the rates of violent behaviors, including aggression and violent suicides. Droughts and disasters can lead to stress and post-traumatic stress disorder and depression (Padhy et al. 2015). Although there has been no clear and direct explanation that could link mental health and climate change, it is still imperative to shift our attention to the possibility of the indirect impact of climate change on population health.

Method

This review evaluated available evidence and resources, including journal articles, country reports, World Bank reports, UNDP reports, and other reports that are relevant to the issues of climate change on the population health of Kazakh people. Search for relevant literature was carried out on databases such as Google Scholar and PubMed with the following keywords: "climate change," "impact," and "Kazakhstan." Paper selections were carried out by reviewing their titles and abstracts. No date restriction was considered during the literature search.

Main text

Climate change in Kazakhstan

Climate change is a global issue observed as extreme weather events and tends to raise average monthly temperatures both seasonally and annually. Kazakhstan is one of the countries in Central Asia, situated

in desert regions, most vulnerable to climate change (Kaliyeva et al. 2021). The geographic characteristics of this country contribute to its vulnerability to climate change. Also, the country's economy greatly depends on fossil fuels and to some extent on agriculture. However, the latter factor contributes to the greenhouse effect continuously presented by the emission of GHG. Furthermore, droughts are a common occurrence in Kazakhstan, and they are exacerbated by the rising average annual air temperature brought on by climate change. The annual precipitation in the country is nearly two times less than its projected evaporation, with an exception in areas with high mountains (Zubairov et al. 2019). Northern Kazakhstan experiences around 250 mm-350 mm mean annual precipitation while its Southern part is around 100 mm-120 mm (Zubairov et al. 2019). According to Zubairov et al. (2019), the average range of temperature experienced in January is around -40 °C to -15 °C. Moreover, the authors concluded that the maximum average temperature of 40 °C is experienced in July. Based on a previous report, it was observed that the average annual mean temperature of Kazakhstan from 1901–2020 has been increasing, jumping from its average of 5.68 ˚C in 1901 to 8.32 ˚C in 2020 (The World Bank Group 2021). The temperature is still on the rise, and the Northern Tien Shan glaciers have seen changes like retreating glaciers that are losing some of their bulk (Wang et al. 2013).

Figure 1 shows the summary of a recent evidence-based study in Kazakhstan comprising the observed average annual mean temperature of the whole of Kazakhstan from 1990 to 2021 (The World Bank Group 2021). The study illustrated rising air temperature data and a slight declining tendency in the average rainfall over the study period, which exemplifies the shambolic weather conditions in Kazakhstan. In another study, Salnikov and colleagues buttressed how climate change accounts for the trend of air temperature and precipitation in the whole of Kazakhstan from 1941 to 2011 (Salnikov et al. 2015). The study revealed that there was a steep rise in the daily maximum temperature, on an increasing number of days with an air temperature over 35 °C, and a decline in the number of days with a daily minimum temperature below 0 °C. Furthermore, Zhang et al. (2020) collected 99 samples of Schrenk spruce tree rings in Almaty and established tree-ring width and δ13C chronologies to infer climate change. The study showed that climate data from the tree ring of 13 °C recorded the highest climate signal for summer mean temperature. In addition, the authors showed that over the previous 166 years, the temperature in southern Kazakhstan has increased at a pace of around 0.27 °C each decade, and over the past 30 years, the rate has risen approximately by 0.44 °C per decade. According to the analysis of temperature and precipitation data, the study concluded that in the previous 166 years, the

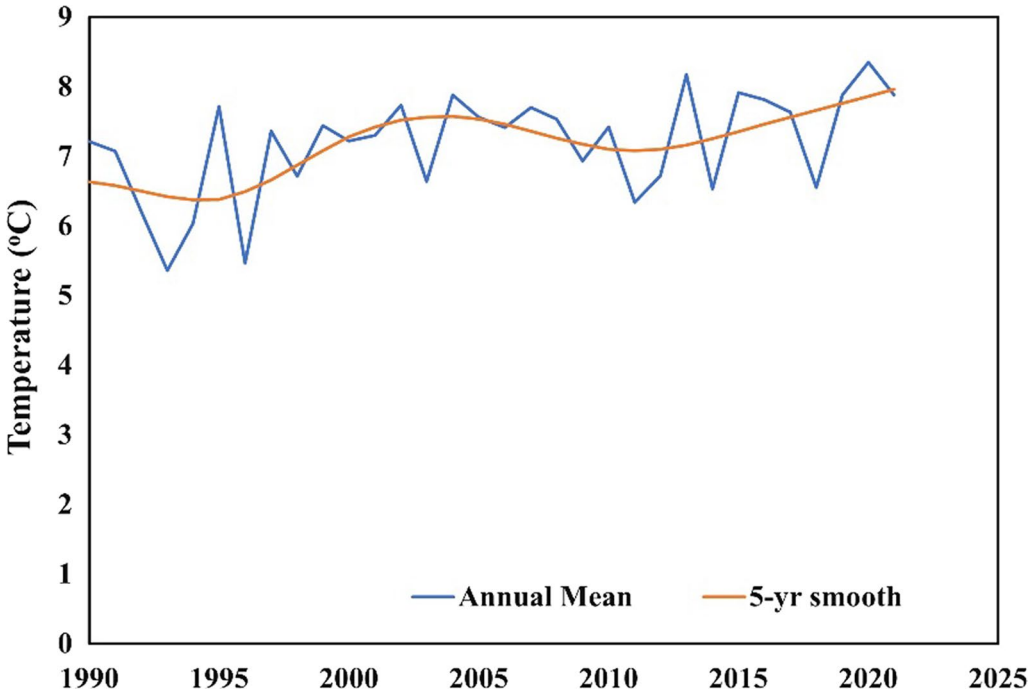

Fig. 1 Observed average annual mean temperature of Kazakhstan in 1990–2021. Source: (World Bank Group and Asian Development Bank 2021)

climate has fluctuated between hot and cold weather, and increasingly high temperatures and decreased precipitation contributed to the severe droughts of 1879, 1917, and 1945 (Zhang et al. 2020). Irrespective of the hot or cold seasons, they can have negative effects on mental health due to heightened ambient temperatures, but there may be seasonal variations in the underlying mechanisms that cause higher unfavorable mental health consequences.

Kazakhstan faces severe air pollution difficulties as a result of its substantial reliance on fossil fuels, which results in GHG emissions (The World Bank Group 2021). The nation's GDP has a carbon intensity twice the global average and triple that of the European Union. In 2019, Kazakhstan was ranked 14th globally and first in Central Asia in terms of carbon dioxide emissions, with the emissions amounting to 313.80 million metric tons (The Astana Times 2021). The country's major sources of air pollution are fossil oil burning, gas exploration, large-scale mining activities, transport vehicles (gasoline and diesel), energy, industrial, and agricultural sources (Kerimray et al. 2020).

There are also concerns about the constant interaction of socioeconomic, organizational, and technical activity leading to environmental degradation. This degradation refers to an alteration or disruption to the environment that is deemed harmful or unwanted and that worsens the environment by causing the depletion of resources, including air, water, and soil; the annihilation of ecosystems; and the demise of wildlife. Different factors, such as economic expansion, growing populations, urbanization, increasing energy use, improvement of agriculture, and transportation, may be responsible for these environmental changes. Other factors include economic expansion over the past ten years and rising traffic volumes. Exposure to radiation from nuclear testing sites, the shrinkage of the Aral Sea, and the degradation of former agricultural areas are among other severe environmental problems that Kazakhstan is currently dealing with (Sain 2015). Energy, economic growth, and globalization are all contributing to Kazakhstan's current environmental problems, which have been linked to the country's declining environmental quality (Primbetova et al. 2022). Previous studies indicated that people living around the Aral Sea areas, industrial areas and nuclear testing zones are at risk of exposure to different dangerous chemicals leading to detriments in health (Sakiev et al. 2017; Semenova et al. 2019; Zhumalina et al. 2019). Even though there is a dearth of information on environmental degradation and its impacts in Kazakhstan, the available information indicates that some areas in Kazakhstan are experiencing problems associated with it.

Impact of climate change on population health

Generally, numerous ways exist in which climate change impacts affect the lives and health of people. It poses a threat to fundamental components of health, including access to clean air, safe drinking water, wholesome food, and a secure place to live, and can impede the advancement of global health for decades. It is well recognized that 17–20% of a person's health status is predetermined by their external surroundings, natural circumstances, and climate, 48–53% by their lifestyle, 18–22% by their heredity, and 8%–10% by their access to healthcare (Lin et al. 2017). Climate change affects our physical and mental health via direct and indirect means (see Fig. 2). While it is known that healthcare systems play an integral part in fighting climate change, they are ultimately affected by the impact of climate change. This includes hospitals, health centres, and other healthcare providers caring for those affected by the health impact of climate change. In addition, healthcare facilities are often unable to provide quality healthcare due to interruptions such as power outages or floods (UNDP 2022). The regions with inadequate healthcare infrastructure, particularly in developing nations, will struggle to survive in the absence of preparedness and response support. Knowledge of these relationships is critical for this study to provide adequate and effective recommendations.

Heat waves

The human body's capacity to regulate temperature has a threshold of 35 °C, above which even a relatively brief exposure can increase the risk of serious illness and death (Im et al. 2017). Much lower temperatures below the 35 °C "survivability" threshold can nevertheless pose a serious threat to human health. Climate change might bring global temperatures closer to this temperature 'danger zone' both through slow onset warming and amplified heat waves. Honda et al. (2014) estimated that absent adaptation, annual heat-related mortality in the Central Asian region might rise by 139% by 2030 and 301% by 2050 using the A1B emissions scenario from CMIP3 (Honda et al. 2014). Previous studies reported that extreme heat is associated with higher rates of mental health-related visits to the emergency department (Nori-Sarma et al. 2022), increase risk of psychiatric disorders (Li et al. 2022) and increase suicide counts (Grjibovski et al. 2013). Increasing surrounding temperature increases the number of deaths due to cardiovascular disease and strengthens mental disorders (UNDP 2022). Exposure to high temperatures can cause a range of harmful physiological reactions in humans, including

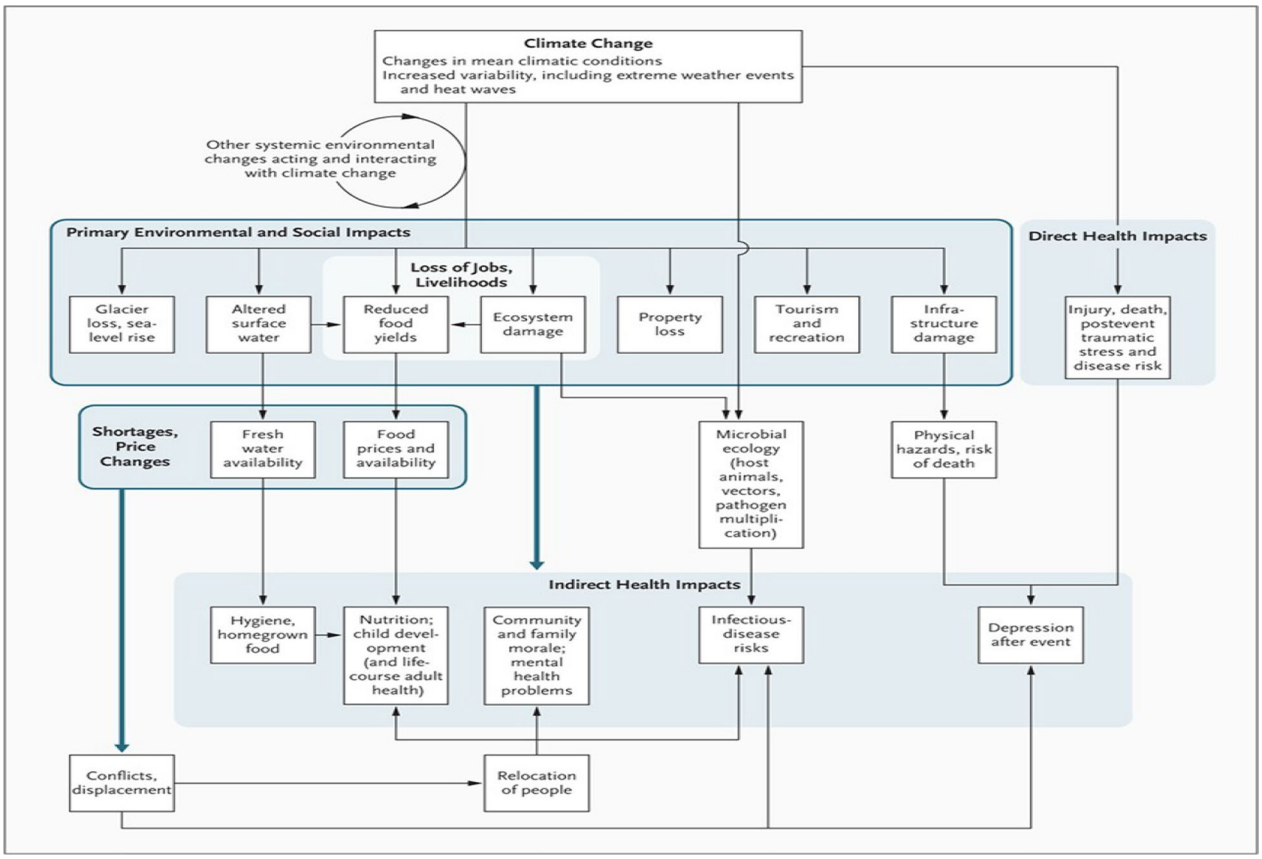

Fig. 2 Shows the impact of climate change on health. Source: (McMichael 2013)

heat rash, cramping in the muscles, exhaustion, and the potentially fatal condition known as heat stroke along with other negative consequences on physical health (CDC 2022). Without serious action, these events will only increase in size and frequency.

Air pollution

In recent years, some researchers set out to bridge the gap on poorly investigated air quality trends in Kazakhstan, and thus, 21 cities in the country were selected. It was found that nine (9) cities had per-capita mortality rates due to ambient air pollution (per 10^5 adults per year) below 150, another nine (9) had per-capita mortality rates between 150 and 204, and three industrial cities (Balkhash, Temirtau, and Zhezkazgan) had per-capita mortality rates between 273 and 373 (Kerimray et al. 2020). A recent evidence-based study also analyzed the relationship between air pollution and the prevalence of breast cancer in Aktobe region. The study revealed that there is a strong correlation between the prevalence of breast cancer and air pollution emissions (Batyrova et al. 2021). According to a risk assessment of the level of air pollution carried out in 26 cities across Kazakhstan, there was a high risk of immediate negative consequences from suspended particles, oxides, and nitrogen and sulfur-containing dioxides in almost all of the analyzed cities (Kenessary et al. 2019). This risk level is highly unacceptable and can endanger human health. Figure 3 shows the air pollution level in Kazakhstan, and it can be inferred that the current PM2.5 concentration in Kazakhstan is below the recommended limit given by the WHO 24-h air quality guidelines value (AQI 2022). Thus, when the air quality deteriorates, it leads to an increase in various respiratory disorders, allergies, and cancer.

Floods and droughts

The World Bank Group (2021) elucidated that Kazakhstan is vulnerable to climate-related disasters citing some major natural disaster events that occurred between 1985 and 2013. Notable examples include floods (6 major events), drought (8 major events), and pests and diseases (6 major events). The article further buttressed that floods are more frequent in the south and east of Kazakhstan, the most recent flood happened in 2010, killing over 40 people and destroying property worth millions of dollars. This is a little of the various health

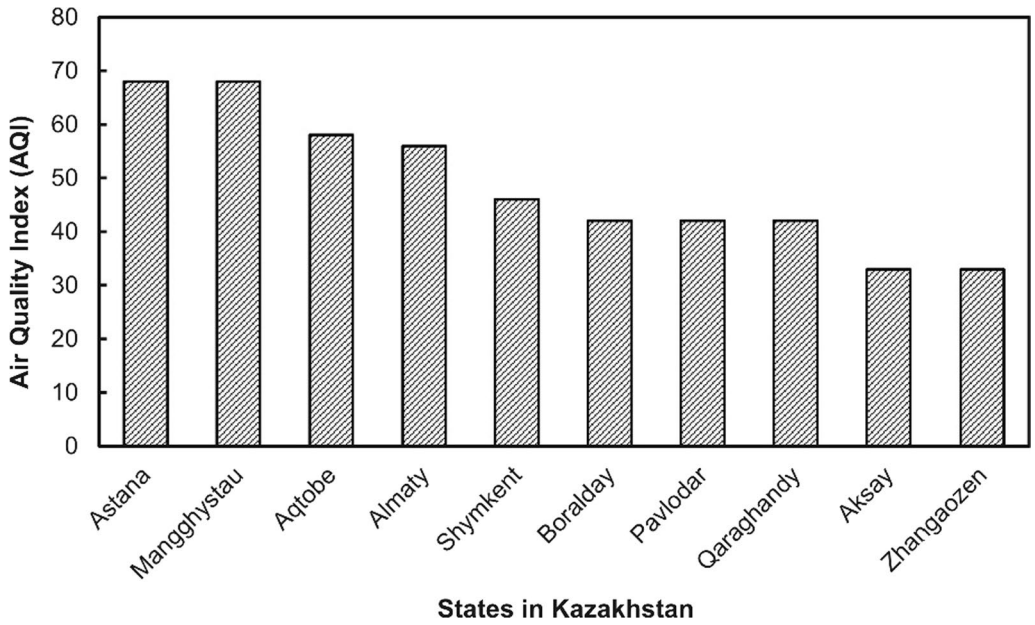

Fig. 3 Kazakhstan—States Air Pollution Level. Source: (AQI 2022)

impacts of natural disasters, as there are numerous scenarios, such as infestations of locusts that are sporadic in Kazakhstan due to temperature increases, and they are more severe in the northern regions where wheat is grown (World Bank Group and Asian Development Bank 2021). These recent catastrophes destroyed 200,000 hectares in 2008 (out of a total of 12.9 million hectares). Contaminants from industry, mining, agriculture, and floods washed into water resources could have a severe impact on drinking water quality. The risk of gastrointestinal illness, which is already a leading cause of death in Kazakhstan, could grow as a result of this (Arystambekova et al. 2019). Additionally, a report by the United Nations Development Program (UNDP) claims that the direct and indirect effects of climate change in Kazakhstan could result in more than 30 adverse health outcomes. Among the direct impacts of climate change are natural disasters, such as earthquakes, floods, landslides, forests, wildfires, which pose a greater risk to citizens' lives and health (World Bank Group and Asian Development Bank 2021). According to experts, the lack of water resources in Kazakhstan is due to natural conditions, inefficient and irreplaceable consumption, and the fact that almost half of the wastewater is generated on the territory of neighboring countries (Abuduwaili et al. 2018). The Aral Sea disaster serves as a sobering lesson about the consequences of climate change on population health and how anthropogenic activities are fueling the occurrences of these disasters (Wæhler and Dietrichs 2017). There are reports of poor health, increased mortality, a high prevalence of chronic diseases, and delayed physical and cognitive development among children living in the Aral Sea region (Crighton et al. 2011). A major concern for the Aral Sea region is the disappearance of rivers that flow into it. This shortage of water in the Aral Sea areas is an important factor that is fueling the fecal-oral transmission of diseases (Semenova et al. 2019). Irrigation projects, which left behind plains drenched in salt and poisonous chemicals that produce dangerous dust, have resulted in an 88% decrease in the Aral Sea's surface area since 1960 (Russell et al. 2018). Aquatic lives and the communities that relied on the sea for food perished as the Aral Sea dried up. Pesticides and fertilizers also damaged the water, making the sea more and more saline. A public health risk was then created by the flying dust from the exposed lakebed that was polluted with agricultural pesticides (Lioubimtseva 2015).

Infectious diseases

Climate change is said to increase the emergence of respiratory and urinary tract diseases which is facilitated by the accumulation of toxic compounds in the air and also leads to prolonged drought which disturbs the processes of nutrition and metabolism as well as creates disorders of the gastrointestinal tract (Khaibullina et al. 2022). Increased temperatures also accelerate the spread of infectious diseases like Crimean-Congo hemorrhagic fever, which are transmitted by ticks, mites, and rodents (Arystambekova et al. 2019). The burden of diseases linked to severe temperatures is

anticipated to rise as climate change increases the number of days with extreme temperatures. Due to these conditions, there is a predominant transmission of several infectious diseases that endanger human health. For example, Kazakhstan experienced a Crimean-Congo hemorrhagic fever outbreak in 2009 that resulted in 30 fatalities (Nurmakhanov et al. 2015). Climate warming affects the spread of naturally occurring infectious diseases such as cholera, hepatitis A, dysentery, tick-borne encephalitis, and malaria as can be seen in Table 1. According to estimates, climate change is expected to cause an additional 250,000 deaths per year from malnutrition, malaria, diarrhea, and heat stress between 2030 and 2050 (WHO 2021). The annual cost of direct health care will range from $2 billion to $4 billion by 2030. However, in Kazakhstan, the estimated expenditure on health as of 2019 was $296 per person and this figure is expected to fairly rise to $410 by 2050 (IHME 2019). Based on the following, Kazakhstan currently takes a proactive role in establishing international rules for chemical safety and environmental protection. Many international agreements and conventions in this area have been ratified by the nation. The national legislation of the Republic of Kazakhstan also seeks to implement measures to protect the environment and combat climate change. The Environmental Law of the Republic of Kazakhstan, which was approved on January 2, 2021, is the primary regulatory legal document in the area of environmental protection (Abuduwaili et al. 2018). The report emphasizes the severity of climate change and its effects on the health Kazakhstani population, from rising natural disasters, and increased mortality rates to deteriorating food security. Immediate and effective action must be taken to avert the worst-case scenario. Currently, there is still a paucity of studies that could comprehensively explain the impact of climate on population health making this research relevant to be conducted.

Recommendations to mitigate climate change

Addressing the impact of climate change on population health will require a combination of mitigation and adaptation-based initiatives. This approach can be effectively developed and implemented through collaboration with ministries of health and the environment. Primary care interventions, individual and group therapy, cognitive-based interventions, and crisis counselling are a few examples of broad strategies to manage population health issues linked to climate change. More generally, pursuing interests in the arts, literature, and spirituality can help one maintain emotional resilience. This adaptation strategy should be advanced to promote population-level mental health in a changing climatic environment.

Building community resilience should be prioritized as the severity of the global climate catastrophe intensifies. In contrast to passive recipients of external aid or support, community-based approaches encourage people affected by emergencies to participate actively and lead initiatives to improve their mental well-being. Government officials, climate change players, and experts must collaborate to advance community-based climate action that fosters resilience and targets the underlying causes of the issue, such as advocacy campaigns to reduce greenhouse gas emissions and residential air pollution. Youth are well-positioned to advocate on this front and have done so in numerous settings. Everyone has a part to play in strengthening community resilience and handling the crisis.

To develop a more comprehensive and well-coordinated response, more study is required to pinpoint best practices, measure the severity of the impact, and expand on the body of available knowledge. More importantly, Kazakhstan must commit to full implementation of the Paris Agreement which would significantly speed up the process of reducing both the severity of the climate catastrophe and its destructive effects on population health. Also, flooding can be a real problem for riverfront residents. Homeowners who live too low and too close to the banks may suffer

Table 1 Impact of Climate on population health in Kazakhstan

Climate hazard	Direct impact	Potential impact on health
Rising temperatures	Severe weather, extreme heat or cold, heatwaves, snow, and wildfires	Injuries, heat-related stress, frostbite heart failure, and mental health impact: Anxiety, depression, post-traumatic stress disorder (PTSD), limited social mobility
Increasing levels of CO_2 and pollutants	Air pollution, allergens, social and economic instability	Asthma, respiratory diseases, heart diseases, violence, poverty, and forced migration
Drought, Floods, and storms	Environmental degradation, food, and water insecurity	Civil conflict, forced migration, mental health impact, malnutrition, and water-borne infections
High sea levels and melting glaciers	Change in vector ecology, decrease in water quality, increasing allergens	Injuries, increase in tropical disease transmission, respiratory diseases, fatalities, respiratory allergies, cardiovascular crisis

flood damage regardless of how sophisticated flood control measures are in place. Seasonal changes in water levels may affect low-lying and close-to-the-bank homes. It is therefore imperative to discourage people from building underground houses or near the riverfront.

Conclusions

There is mounting proof that there are numerous ways through which climate change affects population health. Climate change negatively impacts several determinants of mental health, including environmental, social, and economic factors in addition to physical injuries that result from climatic events. Efforts to address the effects of climate change on population health must be drastically accelerated by countries. If Kazakhstan is to address the devastating impact of climate on the population health of its people, it must urgently implement various mitigation and adaptation strategies. Climate awareness and adequate adaptation techniques must be put into practice to address the societal impact of climate change in Kazakhstan.

Abbreviations

GHG Green House Gas
GDP Gross Domestic Product
UNDP United Nations Development Programme

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Author contributions

TOO, UAH, HOA, JA, MSS, ISA, and ZE all contributed to the writing of the paper. FOB did the data-based analysis and drew the graphs. ASS and DLPE did the final review and arrangement of the paper. All authors read and approved the final manuscript.

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