Emerging Public Health Issues by Environmental Change and Heat Flushing

Aqsa Majeed[1], Muhammad Zubair-Ul-Hassan Arsalan[1], Majeeda Rasheed[1], Hafiza Amna Abdul Ghaffar[1], Hassan Ameen[2] and Areeba Aslam[2]

[1]Department of Life Sciences, Khawaja Fareed University of Engineering and Information Technology, Rahim Yar Khan, Pakistan 64200
[2]Institute of Molecular Biology and Biotechnology, Bahaudin Zakaria University, Multan, Pakistan 60800
*Corresponding author: aqsamajeed208@gmail.com

Abstract

Environmental change, particularly the growing intensity of global warming, is becoming a major driver of new and complex public health challenges. One of the most pressing concerns is the rise in extreme heat events, commonly known as heatwaves or heat flushes, which are occurring more frequently and with greater severity. These conditions are putting human health at significant risk, especially for older adults, children, outdoor laborers, and people with chronic illnesses. This chapter explores the wide-ranging health consequences linked to environmental change, with a focus on heat-related impacts. Direct effects include an increase in cases of heat exhaustion, heatstroke, and severe dehydration. Indirectly, rising temperatures are expanding the habitats of disease-carrying insects like mosquitoes and ticks, contributing to the spread of illnesses such as malaria, dengue, and Lyme disease. Moreover, elevated heat levels worsen air quality, leading to more respiratory and cardiovascular conditions. Mental health is also affected, as prolonged heat exposure and environmental stressors contribute to anxiety, depression, and sleep disturbances. Additionally, climate disruptions threaten food and water security, increase the risk of waterborne diseases, and place a heavy burden on healthcare systems already strained in many parts of the world. By examining these emerging threats, this chapter highlights the urgent need for adaptive public health strategies, heat-resilient infrastructure, and strong community awareness. Responding proactively to these challenges is essential to protect health and build resilience in a rapidly changing climate

Keywords: Climate change, Heat flushing, Chronic obstructive pulmonary disease (COPD), Heat Exhaustion, Vector-borne diseases, Weather events.

Cite this Article as: Majeed A, Arsalan MZUH, Rasheed M, Hafiza Amna Abdul Ghaffar, Ameen H and Aslam A, 2025. Emerging public health issues by environmental change and heat flushing. In: Abbas RZ, Akhtar T and Arshad J (eds), One Health in a Changing World: Climate, Disease, Policy, and Innovation. Unique Scientific Publishers, Faisalabad, Pakistan, pp: 378-384. https://doi.org/10.47278/book.HH/2025.468

A Publication of Unique Scientific Publishers

Chapter No: 25-053

Received: 15-Jan-2025
Revised: 19-Feb-2025
Accepted: 20-March-2025

Introduction

Environmental change encompasses a vast array of occurrences, i.e., pollution, urbanization, biodiversity loss, and climate change etc. These shifts are primarily driven by human activities, most notably the relentless growth of the human population and the ever-increasing demand for resources. Research shows that several environmental changes, i.e., extreme weather, for instance, or rising temperatures, pose serious threats to human health. Our well-being is endangered in a variety of ways; some of the most direct impacts are coming through these pathways: Heat waves and deteriorating air quality, for example, imperil human life as well as the health of the planet (Mackenbach, 2007).

Importance of Addressing Heat-related Health Issues in the Context of Climate Change

The biggest issue for Pakistan caused by climate change is rising temperatures and several heat waves. The country is vulnerable in this regard, as illustrated by the disturbingly high rate of increase we are witnessing in rash and heat-related issues and fatalities. The direct link between climate change and the dramatically worsening health impacts we have long associated with excessive heat can't be ignored. The effects of rising temperatures on health, including intense heat waves, are striking Pakistan with greater severity, especially in urban centers like Karachi. On June 21, 2022, and in 2017, the government officially announced a "state of emergency." Even temperature phenomena are transitioning to climate emergencies (Saleem et al., 2024) Meteorology predicts that the frequency, intensity, and duration of heatwaves will continue to increase due to climate change, compounding an already overstressed healthcare system (Khan et al., 2021).

Objectives of the Chapter

To find out both the direct and indirect health implications of climate change, especially on Pakistan's heat-related disorders. Demonstrate populations, such as the elderly, children, and outdoor workers that are disproportionately affected by heat-related health issues. Examine the wider public health ramifications of climate change, like effects on infectious diseases, air quality, food security, and mental health. Critically analyze existing public health measures targeting the health risks associated with extreme heat and offer evidence-based recommendations for new

strategies to improve resilience in communities vulnerable to heat events. Support integrated policies addressing climate change and public health to safeguard at-risk groups. Emphasize the importance of further research and cross-disciplinary action to deal with heat-related health issues.

2. Understanding Environmental Change

Ecological change refers to major changes in Earth's ecosystems and climate that affect the natural environment and human health. Meaningful alterations in land use, large temperature fluctuations, and large biodiversity loss are caused by many natural forces; in addition, human activities are also responsible for these changes (Vitousek, 1992).
Key factors contributing to environmental change:

Climate Change

The greenhouse gas emissions caused by human activity, such as burning fossil fuels and clearing forests, are the primary drivers of climate change. It is driving extreme weather, rising temperatures around the planet, and shifts in the patterns of precipitation. Increased heat brings more heat-related illness, and poor air quality contributes to more respiratory disease; changing ecosystems transmit infectious disease, so these changes have a direct impact on human health (Luber, 2009).

Urbanization

The urbanization process is coming fast as it converts pristine territories into man-made land it contributing to habitat loss and pollution. Urban settings have also been observed to be hotter (urban heat islands) as well as having worse air quality, causing respiratory diseases and heat-related illnesses. Urbanization in Pakistan has added to health issues from air pollution and heat exposure (Riaz et al., 2022).

Deforestation

Deforestation is the removal of forestland for timber, agricultural, or urban use. This has serious consequences: it reduces biodiversity and disrupts ecosystems, which increases carbon emissions and worsens climate change. Deforestation impacts local climates and can amplify vulnerability to natural disasters, and in the present work (Filippini et al., 2024).

Pollution

Pollution from industry, transportation, and agricultural runoff poisons air, water, and soil. It can cause serious health problems like respiratory diseases, cardiovascular diseases, and cancer. In Pakistan, current or future morbidity and mortality from different health conditions are correlated with high levels of air pollution (Rocque et al., 2021). Figure 1 elaborates factors causing environmental changes.

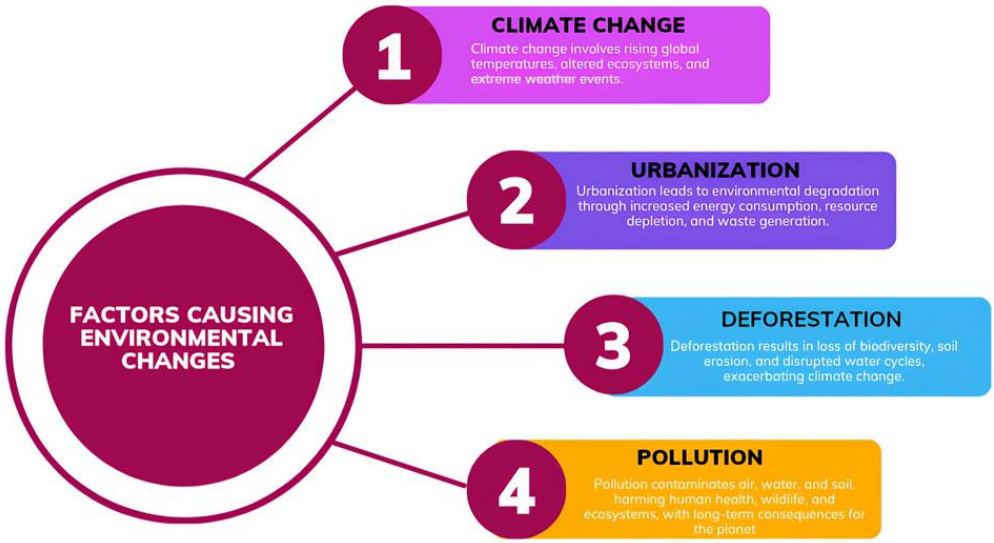

Fig. 1: Factors causing Environmental Changes

3. The Health Impacts of Heat Flushing

3.1 Mechanisms of Heat Flushing

Flushing heat or hot flashes is a sudden sensation of warmth, sometimes accompanied by perspiration, flushing, and anxiety. This could last from a few seconds to several minutes, and at times is most frequent during menopause because of the hormonal changes, primarily due to the reduction of estrogen levels (Comparetto & Borruto, 2023).

Physiological Mechanisms

The physiological response in the heat flush involves several mechanisms:
Vasodilation: The primary physiological response is peripheral vasodilation, wherein the size of the vessels increases to accommodate more blood flow toward the surface of the skin, allowing more heat to escape and hence raising the skin temperature with a sensation of warmth (Padilla et al., 2018).

Thermoregulatory Dysfunction: In individuals experiencing hot flashes, there is a narrowing of the thermoneutral zone, the range of core body temperatures within which thermoregulatory responses (like sweating or shivering) do not occur. Small increases in core temperature can trigger exaggerated heat dissipation responses, leading to hot flashes (Grodzinsky & Sund Levander, 2020).
Neuroendocrine Factors: The hypothalamus plays a role in body temperature regulation. Changes in the hormonal environment, especially decreases in estrogen, affect hypothalamic function and lead to inappropriate activation of thermoregulatory mechanisms. Several studies have indicated that neurokinin B signaling within the hypothalamus mediates the initiation of these flushing episodes. Increased sympathetic nervous activity has also been suggested in the etiology of hot flashes. This activation increases responses such as sweating and an increase in heart rate during an episode (Freedman, 2013).

3.2 Vulnerable Populations

Identification of Populations at Higher Risk

Elderly Individuals

Elderly individuals are particularly susceptible to heat-related illnesses due to the physiological changes that accompany aging. Their ability to efficiently cool in extremely hot temperatures is diminished as a result of their thermoregulatory systems becoming less effective. It has been proposed that older adults have lower critical limits of environmental strain that they can withstand without losing thermal balance than younger people, which may be a factor in the higher rates of heatwave-related illness and mortality. Additionally, older adults frequently suffer from chronic illnesses and pharmaceutical treatments, which may exacerbate their sensitivity to heat (Fastl et al., 2024).

Children

Additionally, children are more susceptible to heat-related illnesses. Because of their significantly larger relative surface area to volume, they heat up more quickly when the outside temperature rises. Furthermore, they could not recognize the signs of heat stress or be unable to articulate why they feel overheated. Recent research has also shown that children's physical and cognitive abilities are negatively impacted by hot temperatures, and that heat waves increase their risk of heat-related illnesses (Xu et al., 2014). Workers outside because they labour outside for extended periods, sometimes in hot weather, outdoor workers are at a considerable risk of heat exposure. Many are exposed to direct sunlight and lack enough access to cooling resources or hydration methods. Studies have revealed that their incidence rates of heat-related disorders, such as heat exhaustion and heat stroke, are significantly greater than those of indoor workers as extreme heat events increase (Ioannou et al., 2022). For this population to be aware, it takes the implementation of workplace safety and the education of identifying symptoms of heat stress.

People with Preexisting Medical Conditions

Individuals who experience chronic diseases, particularly those dealing with cardiovascular or respiratory ailments-are much more prone to these extreme heat incidents that further exacerbate the presence of these very diseases and trigger an increase in hospitalizations along with the toll on deaths. This shows the effects are dramatic, even as temperature rises reach lower levels; targeting vulnerable individuals could prevent significant consequences, from mild temperature rises alone (Leach et al., 2024).

3.3 Types of Heat-related Illnesses

Heat Exhaustion

Heat exhaustion is a condition in which excessive perspiration causes the body to lose too much water and salt, resulting in weakness, light-headedness, nausea, and headaches. Heat exhaustion can cause heat stroke, a dangerous health risk, if left untreated. Despite frequently having a higher-than-normal body temperature, heat exhaustion victims are typically aware and responsive (Yeo, 2004).

Heat Stroke

Heat stroke is a medical emergency since it is thought to be the most dangerous heat-related sickness. It happens when the body is unable to maintain homeostasis and when the core body temperature rises incredibly quickly, frequently well above 106°F or 41°C. Confusion, changes in a person's mental state, hot and dry skin or intense perspiration, seizures, and coma are typical signs of heat stroke. Your essential organs may sustain irreversible damage if you do not receive prompt medical assistance from doctors. This could result in severe impairment or even death from heat stroke (Savioli et al., 2022).

Other Heat-Related Conditions

Other conditions, aside from heat exhaustion and heat stroke, include:
Heat Cramps: This is the mildest kind of heat illness that is characterized by painful muscle cramping. This is usually brought about by electrolyte imbalances from excessive perspiration. These cramps usually occur during or after intense physical activity in hot conditions (Gauer & Meyers, 2019).
Heat Rash: This is the inflammation of the skin, mainly because of excessive sweating and blocked pores. It usually presents itself with several small red pimple-like lesions, and/or blister-like blisters that normally appear on a surface that creates friction (Uter & Kanerva, 2019).

Long-term Health Consequences of Repeated Exposure to Heat

Numerous potential challenges are additionally brought on by prolonged exposure to heat. Heat stress-related cardiovascular disorders,

severe dehydration-induced kidney failure, and the exacerbation of long-term respiratory disorders are among the potential long-term consequences of heat. Similarly, people who are frequently exposed to excessively high temperatures experience cognitive impairment, which makes them (Leon & Kenefick, 2012).

4. Broader Public Health Consequences of Climate Change

4.1 Infectious Diseases

Changes in Vector-Borne Diseases

Climate change continues to have a significant impact on the dynamics of VBD transmission, including dengue fever and malaria. Temperature increases have created the perfect conditions for vectors to expand their previously inappropriate border areas. As a result, diseases that are not often found in previously thought to be endemic areas are exposed to them more frequently, which leads to an increase in outbreaks of those diseases. By 2070, models predict that 4.7 billion more individuals would be at risk for dengue fever and malaria as a result of changes in vector habitats and transmission seasons brought on by climate change (Mojahed et al., 2022).

Changes in Waterborne Diseases due to Flooding and Contamination

Waterborne illnesses are also promoted by climate change due to increasing flooding and contamination. Floods or excess precipitation from extreme weather events can overwhelm sanitary systems, allowing infections to migrate to water supplies and raising the risk of cholera, leptospirosis, and other diseases, particularly for individuals without access to clean water. In addition to mosquitoes, floods can create pools or collections of still water that are perfect breeding grounds for disease vectors, further raising the potential of public health issues (Chaminade et al., 2018).

4.2 Air Quality Deterioration

Effects of Increased Temperatures on ground-level ozone and Particulate Matter

Furthermore, there is a general correlation between PM exposures and mortality. The air contains a mixture of solid objects and droplets of liquid that are known as particulate matter (PM). These particles may consist of smoke, soot, dust, and dirt. Some particles are so tiny that they can only be seen under a microscope, while others are big or black enough to be seen. Indeed, the significant impact that air quality can have on public health does inspire a strong desire for appropriate, short-term solutions.

Ground-Level Ozone Formation

High temperatures are ideal for the production of dangerous ground-level air pollutants, such as ozone, which is created when NOx and VOCs undergo photochemical interactions with sunlight. High concentrations, particularly during the sweltering summer months, are the result of these chemical processes, which have been demonstrated to accelerate with temperature. For example, it has been calculated that its concentration increases by up to 16% for every 5°C increase in temperature. The sensitivity of surface ozone concentration to the various characteristics of climatic oscillations is supported by this relationship, which is especially pertinent to urban areas (Sicard, 2021).

Air Quality and Associated Health Effects

Poor air quality is linked to various major health impacts, such as particulate matter and ground-level ozone. Exposures to elevated ozone levels lead to respiratory ailments such as asthma, wheezing, and COPD, as well as a rise in hospitalizations that ultimately seem to surpass the threshold (Ebi & Semenza, 2008).

4.3 Food and Water Insecurity

How Climate Change affects Agricultural Productivity and food Supply Chains

Because of rising temperatures, unpredictable rainfall, and an increase in extreme events, climate change has an impact on agricultural productivity. Some key crops have shown severe yield losses as a result of rising temperatures and erratic rainfall. For example, under some climate change scenarios, rice yields are predicted to be decreased by 14%, while wheat yields could be depressed by up to 17.6% due to a combination of heat stress and changed precipitation. Food security is now in danger due to changes, especially in areas like South Asia, where agriculture has been highly vulnerable to environmental factors (Zhang et al., 2024).

Risks Associated with Contaminated water Sources during Extreme Weather Events

In this sense, flooding and heavy rains are also regarded as exceptional events since they contaminate water sources and overflow sanitary systems. Such contamination affects agricultural production, breaks up food supply systems, and raises the risk of water-related diseases. In addition to impeding irrigation and lowering crop productivity, contaminated water sources pose a health danger to farming communities. The interaction between flooding brought on by climate change and water point pollution indicates that efficient water management is recommended if food security and safety are to be guaranteed in the face of climate change.

5. Extreme Weather Events and Public Health

5.1 Types of Extreme Weather Events

Overview of Hurricanes, Floods, and Wildfires

Weather extremes, including hurricanes, floods, and wildfires, are becoming more common and powerful due to climate change. Research has shown that hurricanes are becoming more powerful and frequent as a result of climate change, with warmer water temperatures increasing the storms' intensity and precipitation (Amirkhani et al., 2022). Figure 2 types of extreme weather events.

5.2 Direct Health Impacts

Injuries, Fatalities, and Mental Health Issues Resulting from Extreme Weather Events

Severe weather conditions can directly affect health, resulting in injuries or even death. Hurricanes, for example, can result in immediate bodily harm due to high winds and flooding, which can lead to structural damage or drowning deaths. The psychological effects of such traumatic events increase the likelihood of negative long-term effects on mental health, such as sadness, anxiety, and PTSD (Rorie & Poole, 2021). According to a study, those who have experienced catastrophic weather disasters had greater rates of mental health illnesses due to the anxiety brought on by property loss, displacement, and future uncertainty (Ummenhofer & Meehl, 2017)

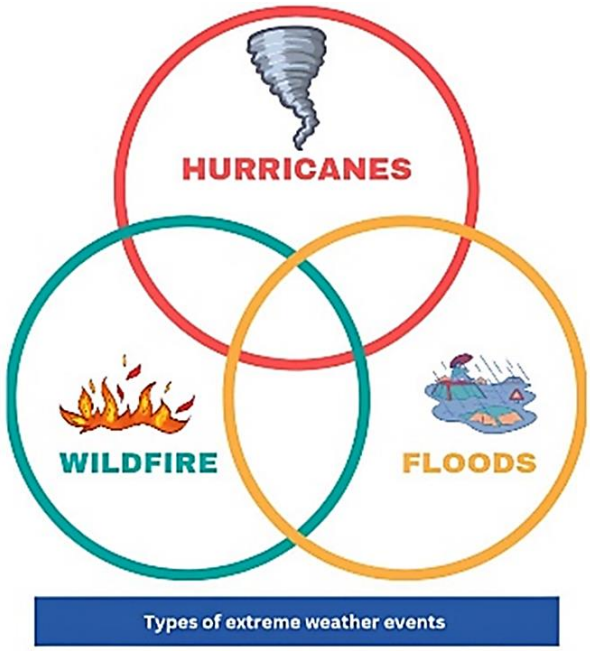

Fig. 2: Types of extreme weather events.

5.3 Infrastructure Challenges

Damage to Healthcare Facilities and Emergency Response Systems during Disasters

The infrastructure of healthcare is seriously hampered by extreme weather occurrences. Communities are unable to receive the necessary care during emergencies as a result of medical services being disrupted after hospitals and clinics are devastated by hurricanes and floods. According to the study, severe weather can occasionally overwhelm emergency response systems, leading to delays in treatment delivery and higher death rates. Flooding can exacerbate health issues in communities by making it more difficult to evacuate and provide emergency supplies.

6. Addressing the Challenges: Public Health Responses

6.1 Policy Interventions

Recommendations for local, national, and global policies aimed at mitigating the public health impacts of environmental changes.

Local Policies on Mitigation of Public Health Effects

Green urban spaces must be implemented in order to lessen the effects of environmental change locally. For example, urban green spaces, such as parks and gardens, offer residents in urban areas a number of advantages, including better air quality and a reduction in the effects of urban heat islands. Essentially, current public parks and their physical environments must be maintained by local governments. This will consistently allow for the highest quality. Because it functions as a climate moderator and reduces soil impermeability, which affects stormwater management and air purification, the addition of vegetation to an urban landscape has a favourable impact on environmental outcomes and citizen health.

National Policies on Public Health Impact Control

To promote and preserve green places, national policies must be put into place nationwide. To encourage local governments to prioritize funding the construction and long-term upkeep of parks, gardens, and other types of green infrastructure that can further enhance environmental quality as well as the general health and well-being of the urban community, specific funding streams and incentive programs must be established.

Global Policies to Counter Public Health Impacts

Addressing the negative effects of environmental change on public health necessitates international coordination and collaboration. In order to develop an integrated cross-country plan and approach that permits the interdependencies between environmental and public health challenges, policymakers must collaborate. Urban green space design, planning, and management are driven by international development principles and norms. Additionally, it should include funding for international projects that enable.

6.2 Community Resilience Strategies

Importance of Community Engagement in Developing Heat Action Plans

Public health is seriously threatened by the frequency and severity of heat waves increasing as a result of climate change, particularly for the most vulnerable. To lessen the detrimental effects of extreme heat events on local populations' health, effective heat action plans that address their unique requirements and operate at the local level are desperately needed. A key element of effective heat action planning is community involvement. Additionally, by actively engaging the community, policymakers and urban planners can better understand the unique vulnerabilities, needs, and resources of a given area. This helps them develop strategies and interventions that are more likely to be implemented and successfully adopted because they speak to the local population. Heat Action Plans must be founded on a reliable assessment of community-level vulnerability and be integrated into larger enhancements to urban and regional planning, according to a comprehensive evaluation of heat wave studies and policies in South Asia. Furthermore, studies on mapping community-determinants of heat susceptibility revealed that socioeconomic level, age, health, and access to cooling resources are some of the crucial elements to consider when creating heat mitigation strategies.

6.3 Innovations in Healthcare Delivery

Use of Technology in Monitoring Heat-related Illnesses

Heat-related illnesses are becoming increasingly prevalent as a result of rising global temperatures and their effects on climate change. According to research, exposure to high temperatures impairs the body's capacity to cool itself, which can result in several heat-related illnesses, such as heat exhaustion and hyperthermia, exacerbations of chronic illnesses, and heat stroke, which can result in death from exposure to high temperatures. Since the severity of these conditions varies from the relatively minor rash of heat rash to the potentially fatal heat stroke, close observation and prompt treatment are crucial to halting the onset of other heat-related disorders. We can enhance our capacity to monitor and respond to heat-related illnesses with the help of emerging technologies. Particularly in developing countries where the healthcare system is less equipped to handle the negative effects of extreme heat waves, there is a growing need for governmental organizations to create improved heat warning systems that can notify citizens to take precautions and request the activation of heat-health intervention measures. Enhancing current risk assessment methods could enhance survival rates during periods of excessive heat and assist emergency personnel in providing critical resources during emergencies. The use of geospatial approaches to combine several heterogeneous data sources and produce a thorough understanding of the geographical and temporal dimensions of heatwave hazards in cities is are example of how to enhance heat disease surveillance.

Development of Early Warning Systems for Extreme Weather Events

Building robust early warning systems has been a top priority for the majority of governments, disaster management organizations, and communities worldwide due to the rising frequency and severity of extreme weather occurrences. Building resilience to and reducing the catastrophic effects of natural hazards, such as floods, storms, droughts, and heat waves, depends critically on the efficient implementation of early warning systems (Villani et al., 2024). Four interrelated parts make up the common early warning system: awareness of catastrophe risk, danger detection and monitoring, warning dissemination, and response readiness. The first step in creating an early warning system is carrying out a comprehensive risk assessment, which includes mapping the vulnerabilities and dangers in a specific location. This serves as the foundation for comprehending regional risks and dangers, upon which the other elements are based. The ability of early warning systems to identify, track, and evaluate the antecedents of extreme weather events has significantly risen due to advancements in sensor technology, data processing, and forecasting models (Perera et al., 2020). Better accuracy and timely predictions are made possible by such technical advancements, which enable earlier activation of warning systems and more efficient public dissemination of important information. To ensure that the most susceptible groups receive the information, strong early warning systems also need effective channels of distribution and a well-defined communication plan.

Conclusion

In light of climate change, the connection between environmental change and public health is becoming more and more significant. Key findings show that a growing number of heat-related illnesses, respiratory conditions, and vector-borne diseases are linked to temperature increases and climatic extreme occurrences. Children, the elderly, and outdoor laborers are more vulnerable for physiological and situational reasons. These health issues are exacerbated by environmental degradation, such as pollution and deforestation, which deteriorate food safety and air quality. In order to change integrated policies on topics that concern or link to both environmental sustainability and public health, public health practitioners should be advocates for climate-related concerns that influence health. Raising awareness of the negative health effects of climate change, improving community resilience against heat events, and implementing targeted treatments for at-risk populations are all part of this. For initiatives to effectively protect vulnerable groups, health care providers, legislators, and community organizations must work together. With an emphasis on regions that will be most affected by climate change, more studies should be done on the long-term health effects of environmental change. Interdisciplinarity will be crucial to developing novel policy frameworks to address the dual challenges of public health and climate change. As a result, sustainability becomes the main focus of policy creation in order to improve public health infrastructure while simultaneously reducing climatic consequences. It will involve funding sustainable energy, raising air quality standards, providing safe and wholesome food, and forming international alliances to pool resources and expertise to address these problems successfully.

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