Editorial

El Niño, Climate Change and Public Health: Emerging Challenges and the Need for Health-System Preparedness in Pakistan

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Introduction

Climate change has emerged as one of the most significant global public-health challenges of the twenty-first century. Rising global temperatures, shifts in rainfall intensity and distribution, heatwaves, prolonged droughts, sea-level rise, wildfires, and the increasing frequency and intensity of extreme weather events are affecting human health through multiple pathways. These include heat-related illnesses such as heat exhaustion and heatstroke, infectious diseases such as dengue and malaria, food and water insecurity, malnutrition, and disruptions to essential healthcare services. These consequences are particularly concerning for developing countries such as Pakistan, which are highly vulnerable to climate-related hazards and often have limited capacity to effectively prepare for and respond to environmental emergencies.[1] Among the climate phenomena influencing global weather patterns, El Niño is particularly important because its effects on temperature, rainfall and other weather conditions can have significant implications for communities, economies and healthcare systems.[2]

Understanding El Niño

El Niño, meaning “the Christ Child” in Spanish, was named by Peruvian and Ecuadorian fishermen because the phenomenon often occurs around Christmas. Pronounced approximately “el NEEN-yo,” it represents the warm phase of the El Niño–Southern Oscillation (ENSO), a naturally occurring climate phenomenon characterized by periodic warming of sea-surface temperatures in the central and eastern equatorial Pacific and associated changes in atmospheric circulation.[3]

El Niño is characterised by unusually warm sea-surface temperatures in the central and eastern equatorial Pacific. During this phenomenon, the normally prevailing easterly trade winds, which blow from east to west across the tropical Pacific Ocean, become weaker than usual. Under normal conditions, these winds push warm surface water towards the western Pacific, allowing colder, nutrient-rich water to rise along the coast of South America. However, during El Niño, the weakening of trade winds disrupts this pattern, allowing warmer water to spread eastward and altering atmospheric circulation, rainfall distribution and temperature patterns across different parts of the world.[4]

There are three phases of ENSO: El Niño (warm phase), La Niña (cool phase) and neutral conditions. El Niño events recur irregularly every two to seven years, typically lasting several months to over a year. Although their effects are most pronounced in tropical regions, they influence weather patterns globally through changes in atmospheric circulation, with varying intensity and geographical impacts from one event to another.[5]

El Niño and Climate Change

Although El Niño and climate change are distinct phenomena, they can interact and influence their respective effects on global climate and public health. El Niño, driven by interactions between the ocean and atmosphere, represents a naturally occurring component of Earth's climate variability rather than a consequence of human-induced climate change. In contrast, contemporary climate change is primarily driven by rising atmospheric concentrations of greenhouse gases, such as carbon dioxide (CO_2) and methane (CH_4), resulting from human

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activities, particularly fossil fuel combustion, deforestation, and industrial processes. Global warming raises the baseline temperature of the planet, while El Niño can temporarily intensify global temperatures and modify regional patterns of rainfall and extreme weather, with implications for water resources, agriculture and public health.[6]

Impact on Public Health

Changes associated with El Niño can have extensive implications for public health. Higher temperatures increase the risk of heat-related illnesses, including heatstroke, heat exhaustion and dehydration, as well as adverse cardiovascular outcomes. These risks are particularly high among older adults, children, outdoor workers, pregnant women and individuals with pre-existing illnesses. Deteriorating air quality can adversely affect not only individuals with chronic respiratory conditions, such as asthma and chronic obstructive pulmonary disease (COPD), but also the general population, potentially increasing respiratory illnesses, hospital admissions and workdays lost due to illness. Changes in rainfall and temperature can alter the geographical distribution and seasonal transmission patterns of vector-borne diseases, including malaria and dengue. Similarly, floods and large-scale population displacement may increase the risk of communicable diseases and waterborne infections such as hepatitis, cholera, typhoid, diarrhoeal diseases, amoebiasis and giardiasis. Disruptions to water supplies can compromise food production and contribute to malnutrition, thereby increasing the economic burden on affected populations. In addition to physical health consequences, climate-related disasters can adversely affect mental health, contributing to anxiety, depression, psychological distress, and post-traumatic stress. They can also disrupt essential healthcare services by damaging health facilities, interrupting medical supplies, and limiting access to routine and emergency care. These impacts often disproportionately affect vulnerable and socioeconomically disadvantaged populations, further deepening existing health inequalities.[7]

Public Health Implications for Pakistan

Pakistan's geographical diversity, high population density, socioeconomic inequalities and dependence on climate-sensitive sectors such as agriculture make it particularly vulnerable to climate variability and climate change. Recurrent heatwaves, floods, droughts and changing monsoon patterns, alongside climate-sensitive infectious diseases, pose significant public-health challenges and further strain the healthcare system. Extreme heat, particularly in densely populated and arid regions of Punjab and Sindh, is an important health concern. Water scarcity and unequal distribution of available water further escalate these risks by limiting access to safe drinking water and adequate sanitation, potentially increasing the burden of waterborne diseases, as mentioned above.[8,9]

Changes in temperature and rainfall patterns may also influence the transmission and geographical distribution of vector-borne diseases, particularly malaria and dengue. The situation following the 2022 floods illustrates these concerns: more than 33 million people were affected, while stagnant floodwater, damaged sanitation systems and disrupted healthcare services created favourable conditions for infectious disease transmission. There were nearly 400,000 confirmed malaria infections in 2021, a figure that increased to approximately 2.7 million in 2023. Although cases declined in 2025, Pakistan continued to report approximately 1.8 million cases, demonstrating the potentially prolonged public-health consequences of climate-related disruptions.[10]

Beyond infectious diseases, climate-related changes also threaten food security, nutritional status and mental well-being. Floods and droughts can damage agricultural production, disrupt livelihoods, displace communities and increase food insecurity, with particularly serious consequences for children, pregnant women and economically disadvantaged households. Displacement and damage to healthcare facilities can also interrupt maternal and child health services, routine immunisation, treatment of chronic diseases and access to essential medicines.[11] These challenges can have long-term effects on population health and the availability of essential healthcare services in Pakistan.

Strengthening Health-System Preparedness

Although the extent to which individual El Niño events influence Pakistan's regional climate

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patterns varies, their potential effects on temperature and rainfall highlight the importance of public-health planning and preparedness. Pakistan's healthcare system must be equipped not only to respond to emergencies but also to anticipate emerging threats, protect vulnerable populations and maintain essential health services during climate-related disruptions. This requires coordinated efforts by federal and provincial health authorities, healthcare institutions, disaster management agencies and environmental organisations. There is a need to strengthen climate-informed disease surveillance and early-warning systems by integrating temperature forecasts, rainfall patterns and flood predictions to anticipate disease outbreaks and enable timely public-health responses. Priority should be given to addressing common climate-sensitive diseases, particularly malaria, dengue and waterborne infections. These warnings should be communicated promptly to healthcare facilities and vulnerable communities through improved data sharing, digital technologies and coordinated efforts among the Pakistan Meteorological Department, public-health authorities and disaster management agencies to facilitate timely interventions and optimise resource allocation.[12,13]

Healthcare infrastructure, including primary healthcare facilities in high-risk areas, needs to be upgraded to ensure the availability of emergency response plans, reliable electricity and water supplies, adequate stocks of essential medicines, trained emergency personnel and arrangements for continuity of care during floods and heatwaves. Particular attention should be given to routine immunisation, treatment of chronic diseases and provision of maternal and child health services during emergencies. Climate-resilient infrastructure and appropriate emergency logistics are vital to prevent environmental hazards from becoming prolonged healthcare crises.[11]

An important priority is the development of a climate-informed healthcare workforce by integrating climate change, environmental health, disaster medicine and climate-sensitive health conditions into medical and public-health education. Doctors, nurses, pharmacists and public-health practitioners should be trained to recognise and manage climate-related health risks and participate in emergency preparedness. Equally important are community engagement and effective risk communication to help people understand early warnings and adopt appropriate protective measures. Strategies for managing climate-related health challenges should be an integral component of national and provincial health planning rather than being limited to occasional responses to natural disasters.[11]

The Way Forward

For Pakistan, preparedness for climate variability, including El Niño, and long-term climate change should be integrated into national health planning and sustainable development rather than treated solely as an emergency management responsibility. This requires adequate budgetary allocation, intersectoral collaboration, evidence-based policymaking and investment in public-health research, supported by a coordinated One Health approach that recognises the interconnectedness of human, animal and environmental health. Such an approach can facilitate the early identification and prevention of emerging health threats and strengthen the country's capacity to develop a more responsive, equitable and climate-resilient healthcare system.

Universities, research institutions and healthcare professionals also have an important role in advancing this agenda. They should promote research on climate-sensitive diseases, heat-related morbidity, environmental health risks and the effectiveness of public-health interventions. Medical and allied health curricula should incorporate climate change and disaster preparedness to develop a workforce capable of responding to emerging environmental health threats. Healthcare professionals, through enhanced clinical preparedness and community education, can contribute to this effort.

Individual and Community Responsibility

Although individuals cannot prevent natural climate phenomena such as El Niño, they can contribute significantly to reducing climate-related health risks and strengthening community resilience. In Pakistan, individual responsibility and community participation are vital to addressing extreme heat, water scarcity, air pollution and flooding. Several practical

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measures can be adopted at the household and community levels.

Conserving water through responsible domestic use, repairing leaking taps, harvesting rainwater where feasible and avoiding unnecessary wastage can help reduce pressure on already stressed water resources. During heatwaves, individuals should maintain adequate hydration, avoid unnecessary outdoor activities during peak temperatures, use shaded areas and check on vulnerable members of their communities, particularly children, older adults, pregnant women and people with chronic illnesses. Following weather forecasts and advisories issued by the Pakistan Meteorological Department and the National Disaster Management Authority can also help communities prepare for heatwaves, floods and other extreme weather events.[14] Tree plantation, along with the expansion and protection of existing green spaces, should be promoted at the national level, particularly in urban areas, roadsides, hospitals, schools, parks and residential areas. Trees provide shade, improve air quality and help regulate the urban microclimate. They also absorb carbon dioxide and reduce surrounding temperatures. Planting saplings without ensuring their survival provides limited environmental benefit. Communities, educational institutions and local authorities should therefore promote sustained plantation programmes, protect mature trees and discourage unnecessary deforestation.[15]

Building climate resilience in Pakistan requires collective responsibility, informed individual actions, sustained community engagement and coordinated efforts across sectors. Recognising El Niño and climate change as major public-health challenges and strengthening preparedness through political commitment, intersectoral collaboration and international cooperation are essential to protecting population health, ensuring health security and safeguarding future generations.

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