

Exacerbating Crises: The Devastating Impact of Climate Change and Antibiotic Resistance on Human and Animal Health in Pakistan

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ABSTRACT

Antimicrobial resistance (AMR) in Pakistan and other comparable regions may be indirectly impacted by changes in the climate. The relationship between AMR and climate change is complex and multidimensional, as both factors can influence temperature and precipitation patterns, thereby affecting the distribution and incidence of infectious diseases. Pakistan is ranked seventh among countries that are most vulnerable to the unpredictable effects of climate change. Policymakers, healthcare professionals, and researchers must consider how climate change may affect AMR and develop strategies to mitigate these risks. Such strategies may include improved AMR surveillance, promoting the judicious use of antibiotics, strengthening healthcare systems to withstand climate-related challenges, and implementing measures to enhance water and food safety amidst climate change.

Key Words: Antimicrobial resistance, Zoonotic diseases, Waterborne diseases.

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Climate change can have indirect effects on antimicrobial resistance (AMR) in Pakistan and other similar regions. The connection between AMR and climate change is intricate and multifaceted, as it can lead to changes in temperature and precipitation patterns, thus affecting the distribution and prevalence of infectious diseases.¹ For instance, increased temperature variations and altered precipitation patterns can facilitate the spread of infectious illnesses, particularly neglected tropical disease pathogens that will likely reappear in different regions, potentially leading to increased antibiotic use and AMR development.² Pakistan ranks seventh among countries most susceptible to the unpredictable effects of climate change. With each passing year, the country is experiencing hotter summers and milder winters.³

Moreover, seasonal variation can affect both the quality and availability of water, as contaminated water sources contributed to the spread of waterborne diseases, necessitating costly prevention and treatment with antibiotics.⁴ Similarly, climate-related events, such as floods or droughts, can affect food production and safety, potentially increasing the use of antibiotics in agriculture and aquaculture, thereby contributing to the development of AMR.¹

Likewise, climate change can have significant effects on infectious diseases by altering the distribution, prevalence, and transmission dynamics of various pathogens — such as ticks, sandflies and mosquitoes.⁵ Rising temperatures and shifting precipitation patterns can expand the geographic range of these vectors, resulting in the spread of illnesses such as Lyme disease, dengue fever, malaria, and the Zika virus. In Pakistan, vector-borne diseases pose a serious threat to public health.⁶ Malaria, a vector-borne disease, is a major health problem in Pakistan, particularly in the rural areas. The disease is transmitted by the *Anopheles* mosquito. Moreover, *Plasmodium falciparum* and *Plasmodium vivax* are the predominant malaria parasites in the country. During the 2022 floods, 1.2 million malaria cases were reported.⁷ The country has also seen periodic outbreaks of dengue fever, particularly in urban areas during the monsoon season when mosquito breeding sites proliferate.⁸ Chikungunya, another mosquito-borne viral disease transmitted by the *Aedes* mosquito, has been reported in Pakistan. Symptoms include fever, joint pain, and rash. As of 31 May 2024, a total of 459 cases of Chikungunya had been reported in the country.⁹ Cutaneous and visceral forms of Leishmaniasis (a parasitic disease transmitted by the bite of infected sandflies), are endemic in different parts of Pakistan.¹⁰ In Khyber Pakhtunkhwa, nearly 25,300 cases of Leishmaniasis were registered in 2023. Crimean-Congo haemorrhagic fever (CCHF) is a tick-borne viral disease that can also be transmitted to humans through contact with infected livestock. Cases of CCHF have been reported in various regions of Pakistan. In 2023, a total of 101 cases were recorded, with a fatality rate of 25%.¹¹

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The availability and quality of water can be affected by rising temperatures and changes in precipitation patterns, which raises the likelihood of waterborne illnesses such as cryptosporidiosis and cholera.¹² Flooding incidents have the potential to contaminate water supplies, accelerating the spread of diseases and posing a serious threat to public health in the country. Cholera, a bacterial infection caused by the bacterium *Vibrio cholera*, is a common waterborne disease in Pakistan. Between January and 20 May 2024, a total of 18,318 cases were reported.¹³ Cholera outbreaks have occurred across the country, typically caused by contaminated food and water. These outbreaks are more common in places with inadequate sanitation and limited access to clean drinking water.¹⁴ Typhoid fever, caused by *Salmonella typhi*, is very common in Pakistan, particularly in heavily populated urban areas and is transmitted through contaminated food and water consumption. About 4,518 cases of Typhoid fever have been reported in the first 11 weeks of 2024.¹⁵ Moreover, Hepatitis A, a viral infection, is commonly spread through the consumption of contaminated food and water, poor sanitation, and poor hygiene practices. Various diarrhoea diseases, including those caused by bacteria, viruses, and parasites, are prevalent in Pakistan due to unsafe water sources and inadequate sanitation facilities. These diseases can lead to dehydration, particularly dangerous for young children. Individuals can protect themselves from waterborne diseases by drinking safe and clean water (boiled, filtered, or treated), practicing good hygiene (washing hands with soap), and avoiding consumption of raw or undercooked food. Additionally, improving water quality and sanitation infrastructure at the community level are crucial for preventing waterborne diseases in Pakistan. Public health education campaigns promoting safe water practices are also essential.¹⁶

Furthermore, weather changes can influence food production and storage conditions, increasing the risk of foodborne infections caused by bacteria such as *Escherichia coli* (*E. coli*) and *Salmonella*.¹⁷ Fluctuations in temperature and humidity can influence the growth and spread of these pathogens in food products. Foodborne infections are a significant public health concern in Pakistan, as various pathogens cause illnesses through contaminated food. *Salmonella* bacteria is a common cause of foodborne illness in the country. The sources of *Salmonella* infection are often contaminated poultry, eggs, and dairy products. Ingestion of food contaminated with *Campylobacter* bacteria can lead to campylobacteriosis, a common cause of bacterial diarrhoea in Pakistan.¹⁸ Common sources of *Campylobacter* infection include raw or undercooked poultry, unpasteurised milk, and contaminated water. Certain strains of *E. coli* bacteria can cause foodborne illnesses in Pakistan. Contaminated food — particularly undercooked ground beef and raw vegetables — is a common source of *E. coli* infections. In Sindh, a 2018 cross-sectional study involving 800 participants reported a prevalence of *Salmonella* at 19%, *Listeria monocytogenes* at 28.99%, and *Campylobacter jejuni* and *E. coli* at 8%.¹⁹ Similar to many other low-income nations, Pakistan has a high incidence of hepatitis E, primarily caused by the Geno-

type 1 virus, which is disseminated through contaminated water supplies. Establishing adequate sanitation and ensuring access to clean drinking water remain significant challenges in these places. HEV outbreaks are more common in areas experiencing conflict and humanitarian crises — such as war zones, flood-prone areas, refugee camps, and among internally displaced populations.²⁰ Individuals can reduce their risk of foodborne infections by following safe food handling practices — such as washing hands before food preparation, properly cooking food, preventing cross-contamination between raw and cooked foods, and storing food at safe temperatures. Public awareness campaigns on food safety and hygiene can also help in preventing foodborne infections in Pakistan.

Extreme temperature and humidity levels can influence the survival and transmission of respiratory viruses, potentially altering patterns of disease spread and favouring the emergence of new infectious diseases or the re-emergence of old ones.²¹ Pakistan is vulnerable to severe influenza epidemics and influenza-related consequences due to its poor immunisation coverage. In the country, influenza is a year-round illness that peaks in January and February.²² Environmental changes can disrupt ecosystems, bringing humans into closer contact with wildlife and increasing the risk of zoonotic disease spillover, which poses a significant public health concern globally. Pakistan has reported cases of CCHF, which is a tick-borne viral disease, particularly in rural areas where individuals have close contact with animals / livestock and ticks.⁹ In addition, livestock workers and individuals in Pakistani rural areas are at higher risk of contracting leptospirosis.²³ A viral infection known as Avian influenza, an infection that mainly affects birds, can also be transmitted to people. In Pakistan, cases of avian influenza have been reported in poultry, posing a risk of transmission to individuals who work in close contact with infected poultry.²⁴ In particular, humans can get brucellosis by consuming contaminated dairy products or through contact with affected animals. In Pakistan, livestock workers and individuals involved in animal husbandry are at risk. Between 2000 and 2020, the sero-prevalence of brucellosis in Pakistan was recorded in non-ruminant species such as camels, horses, dogs, and humans, with ranges of 0.5-21%, 16.23-62.6%, 9.2-63.8%, and 2.0-70%, respectively.²⁵ Nipah virus is another zoonotic virus, which is transmitted to humans from fruit bats or through contact with infected animals. Although cases of the nipah virus have been reported in neighbouring countries, there have been concerns about the potential emergence of this virus in Pakistan. Efforts to address emerging zoonotic infections in Pakistan include surveillance of animal and human populations, promotion of good agricultural practices, implementation of biosecurity measures in livestock farming, public health education, and collaboration between human and animal health sectors.²⁶

It is important for individuals in Pakistan — especially those working with animals or in rural areas — to take precautions to reduce the risk of zoonotic infections. These precautions included wearing protective clothing, practising good hygiene, and seeking prompt medical care if symptoms of zoonotic

disease develop. Policymakers, healthcare providers, and researchers in Pakistan must consider the potential impacts of climate change on AMR and to develop strategies to mitigate these risks. These strategies may include improved surveillance of AMR, promoting the judicious use of antibiotics, strengthening healthcare systems to withstand climate-related challenges, and implementing measures to enhance water and food safety in the face of climate change.

COMPETING INTEREST:

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AUTHORS' CONTRIBUTION:

MK: Conception and design of the study, data collection, data analysis, writing, and editing.

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