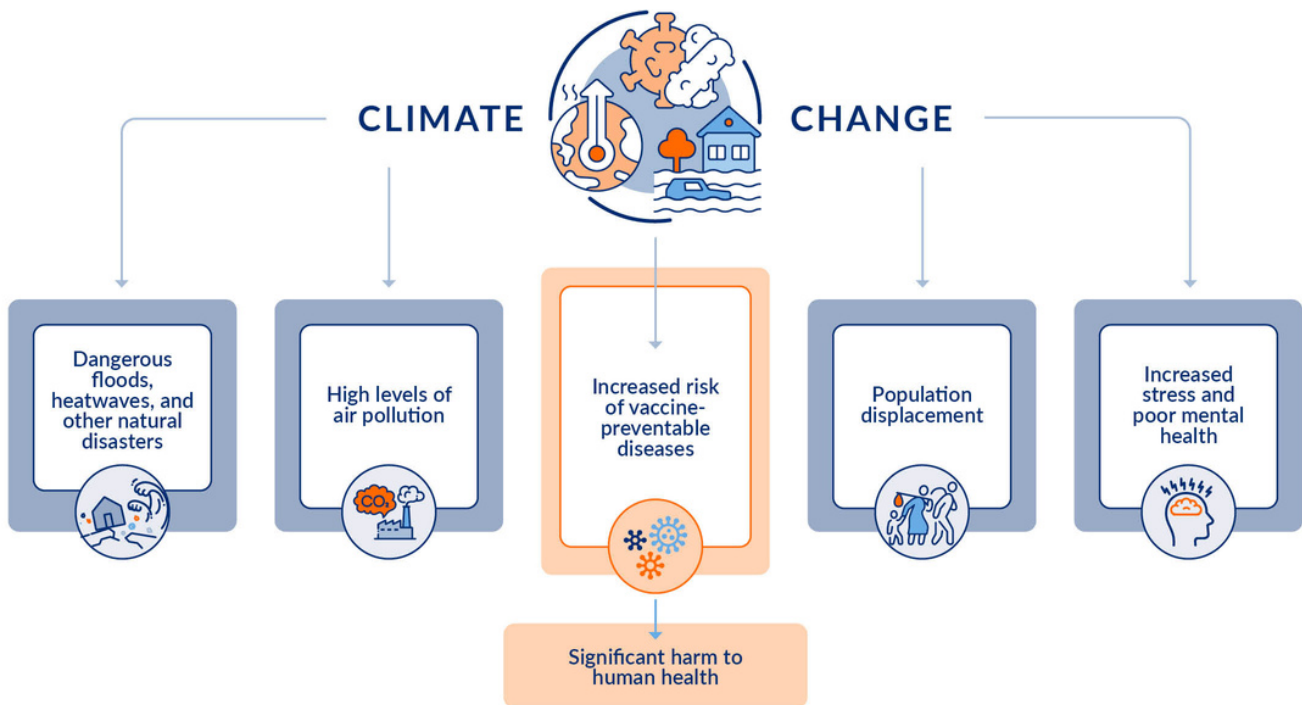


# A Warming World Means Vaccination is More Important Than Ever

*“The climate crisis threatens to undo the last fifty years of progress in development, global health, and poverty reduction, and to further widen existing health inequalities between and within populations.” (1)*

With July 2023 confirmed as the hottest month on record (2), the impacts of climate change are becoming impossible to ignore. In addition to rising temperatures, climate change is also responsible for increasingly frequent extreme weather events like intense storms, catastrophic floods, and record-breaking heat waves. A growing body of evidence suggests that the consequences of climate change pose a major threat not only to the planet, but also to human health.



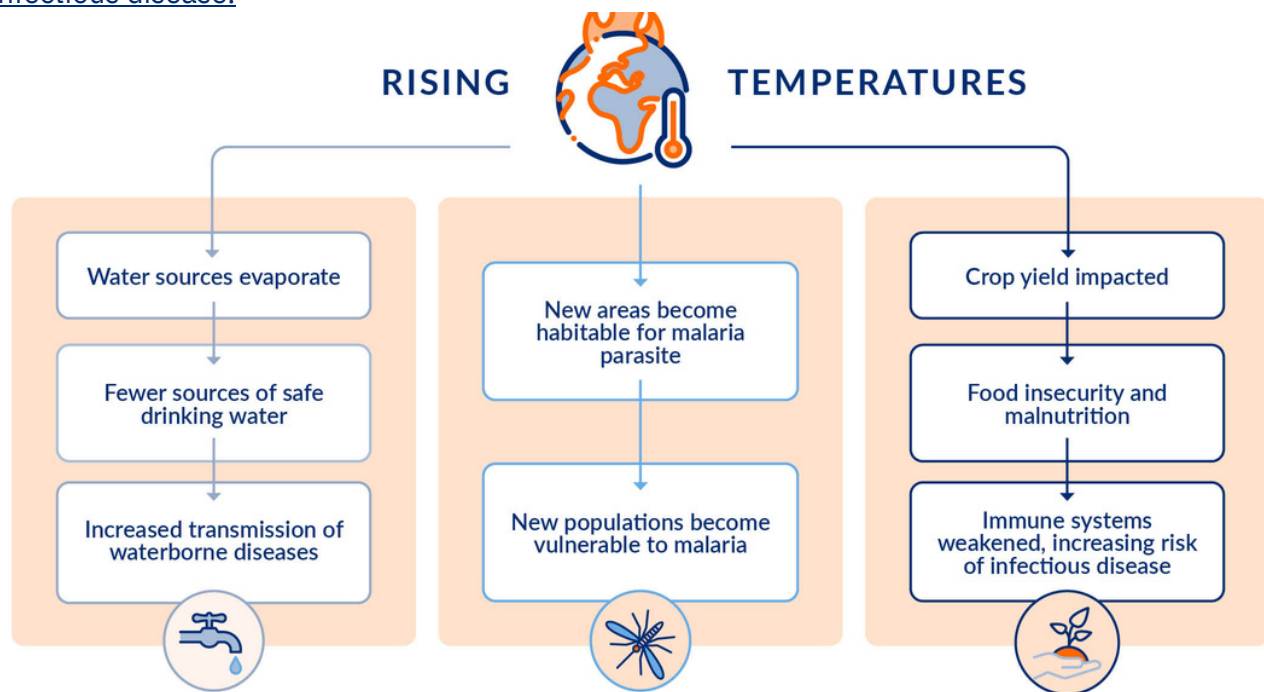
Altogether, climate change is expected to cause around 250,000 excess deaths per year between 2030 and 2050 due to malnutrition, malaria, diarrhea, and heat stress alone (1). In addition to the excess mortality that is *directly* attributable to natural disasters, the wide-ranging effects of climate change can also *indirectly* contribute to illness and death through several pathways. Warm, dry conditions trigger more frequent wildfires (3), which in turn contribute to dangerous levels of air pollution (4). The stress of living through an extreme weather event and the resulting loss of critical resources has been linked with poor mental health (5). Furthermore, climate change is expected to increase the prevalence of several vaccine-preventable diseases, such as malaria, cholera, and typhoid, thanks to the expansion of mosquito habitats, scarcity of clean water, and disruptions to routine immunization, among others (6).

No one is safe from the effects of climate change, but its impact reflects deep inequities. Already marginalized communities – particularly those in developing countries – will be disproportionately affected due to existing health disparities and insufficient health system infrastructure (7). To minimize climate change-related health impacts, equitable access to vaccines must be a priority, especially for those who will be most affected in the years to come.

## Rising Temperatures Increase Disease Transmission

In August 2023, global temperatures were approximately 1.5°C above preindustrial levels (8). In addition to the illnesses and deaths caused directly by these dangerously high temperatures, such as those related to heat stroke (9), collateral effects also include increased transmission of a number of vaccine-preventable diseases.

Warmer winters and hotter summers are expected to increase the evaporation of water sources, endangering the availability of safe, clean water and increasing the risk of diarrheal diseases (10). This includes cholera, which has recently seen a global surge: The WHO reported 472,697 cases of cholera in 2022, nearly double the number reported in 2021 (11). Rising temperatures reduce the availability of high-quality crops (12), threatening food security and leading to dangerous malnutrition that weakens a child’s immune system and increases the risk of infectious disease.



An analysis of 14 countries in sub-Saharan Africa (13) demonstrated that for every 1°C increase in average maximum temperature, the prevalence of diarrhea increased by about 1%. The reasons for this association are not entirely clear, but researchers point to the impact of heat on the growth and survival of diarrhea-causing bacteria, as well as the potential for heat-related changes in hygiene or food storage. This increase in disease burden may significantly impact vulnerable populations, especially young children, as diarrhea is currently the second most deadly infectious

disease worldwide and kills over 480,000 children under 5 each year (14). We already have the means to prevent rotavirus infection, the leading cause of diarrhea-related mortality among children around the world – a 2018 analysis estimated that if 100% of children globally had access to rotavirus vaccination, more than 83,000 child deaths could be prevented in a single year (15) – yet millions of children around the world are still unprotected against this disease (16). As global temperatures continue to rise, efforts to increase access to lifesaving rotavirus vaccines will remain critical.

Temperature changes are also expected to impact transmission of vector-borne diseases, including malaria. About 80% of the world’s population lives in a region that is at risk of at least one vector-borne disease (17), and this number could grow as temperatures continue to rise. The malaria parasite develops more quickly at higher temperatures, increasing the chance that a mosquito will survive long enough to transmit the disease (18). Additionally, areas that are presently too cold for malaria transmission may warm up enough to allow malaria parasites to survive, exposing new populations to this deadly disease. One recent analysis estimated that around 1.4 billion additional people will be at risk of malaria and dengue in urban areas in Africa and southeast Asia due to changes in climate (19). On the other hand, areas where malaria is currently being transmitted may become too warm, which could actually decrease incidence of the disease. Controlling malaria is already complex, but additional climate-related factors such as temperature, rainfall, and humidity may be important considerations for preventing outbreaks.

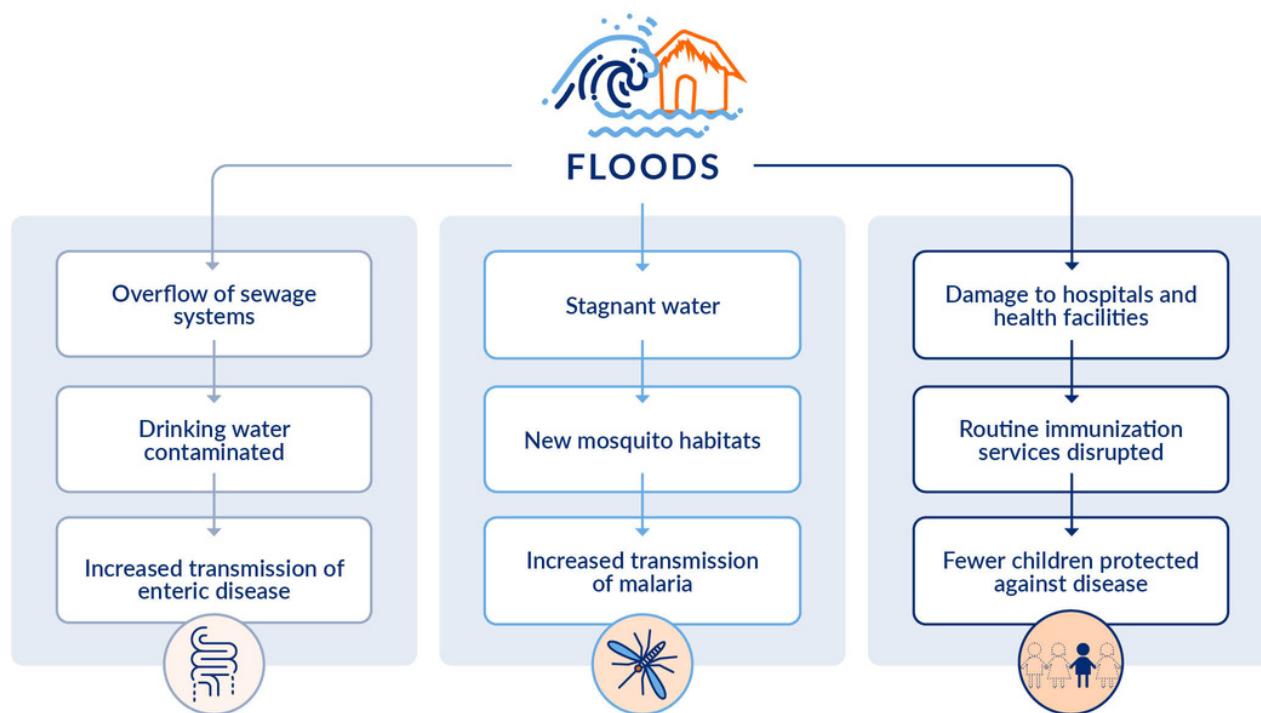
## The Dangerous Consequences of Floods and Droughts

*“Climate change is exacerbating both water scarcity and water-related hazards (such as floods and droughts), as rising temperatures disrupt precipitation patterns and the entire water cycle.” (20)*

Between 2001–2018, nearly two-thirds of natural disasters were water-related (21), and floods and droughts are only expected to become more intense and more frequent as climate change worsens. These events threaten the availability of safe drinking water and can increase transmission of enteric diseases. For example, both droughts and floods have been found to be significantly associated with cholera outbreaks in sub-Saharan Africa (22); in this region, a cholera outbreak can be expected in 1 out of every 3 droughts. During a drought, communities searching for water can be forcibly displaced, often to overcrowded refugee camps with poor sanitation and limited access to cooking tools, increasing the risk of contamination and disease transmission.

Floodwater can overflow sewage systems and contaminate drinking water (23). This contaminated water can also destroy WASH facilities, further putting communities at risk of disease transmission. Additionally, the heavy rainfall and stagnant water associated with flooding can create new mosquito habitats and increase breeding. In 2007, for example, areas in China impacted by flooding saw significantly higher numbers of cases of both malaria and diarrhea than non-flood-affected areas (24). Lastly, floods and other disasters can seriously disrupt the delivery of health services, including vaccination (25). Not only can flood water damage hospitals and health clinics, making it difficult or

even impossible to provide routine immunization services, but it can also block roads, potentially leading to supply chain gaps that can impact the availability of vaccines and other medical supplies.



## Disproportionate Impact to Disadvantaged Populations

Every year, approximately 21.5 million people around the world (26) are forced to leave their homes due to climate-related disasters like floods, storms, wildfires, and extreme temperatures, and this number is only expected to continue growing (27). These individuals are often referred to as “climate refugees”, though this includes those internally displaced within their own countries as well as those pushed across borders to seek safety. Climate-related displacement disproportionately impacts those living in low-resource settings, who are less able to prepare for and withstand natural disasters. Even within low- and middle-income countries (LMICs), climate change is more likely to impact those who are already most deprived. According to an analysis in Pakistan, the regions with worse socioeconomic conditions are also the most vulnerable to climate change (28). The same analysis also found that some regions which *should* be most exposed to climate change due to their precipitation and temperature patterns are actually less vulnerable, most likely because their populations have higher socioeconomic status and thus a higher capacity to adapt, suggesting that strengthening a community’s resilience is one potential solution to fight the impacts of climate change.

In addition to equity considerations, forced migration can also lead to increased risks of vaccine-preventable disease outbreaks. Disruption to health services, malnutrition, overcrowded settlements, and insufficient sanitation resources all contribute to infectious diseases, such as pneumonia and

diarrhea, which are the leading causes of death during humanitarian emergencies (29). Vaccination programs that target measles, *S. pneumoniae*, *H. influenzae* type-b, and rotavirus have already been recognized as critical tools for reducing the health impacts of complex humanitarian emergencies.

## Mitigating the Impact of Climate Change with Vaccines

At this point, the impact of climate change is inevitable, but there are steps we can take to mitigate its effects on human health. We must strengthen efforts to increase access to vaccines for diseases that will become more prevalent as extreme weather events continue, prioritizing disadvantaged communities that will be hardest hit by climate-related disasters. Beyond vaccine introduction, we must work to make sure that adequate supplies are made available to those who need them most. For example, millions of doses of life-saving malaria vaccines are being rolled out in Africa over the next two years (30), but there is still significant work to be done to meet the global demand for these vaccines and to ensure that LMICs can afford them (31). Similarly, the global supply of oral cholera vaccine (OCV) is currently unable to meet the needs of more and more frequent cholera outbreaks and must be allocated equitably (32).

Over the last decade, enormous victories have been won in protecting children from preventable illnesses. As climate change has been recognized as a serious threat to public health, policymakers must take decisive action now to safeguard vulnerable populations from potentially catastrophic infectious diseases and counteract immunization backsliding.

### ADDITIONAL READING

1. [Will the Earth's changing climate make TB spread faster?](#) [Bhekisisa Centre for Health Journalism]
2. [Children displaced in a changing climate: Preparing for a future that's already underway](#) [UNICEF]
3. [Vaccines for a sustainable planet](#) [Science Translational Medicine]

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