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Invited Perspective: Uncovering the Hidden Burden of Tropical Cyclones on Public Health Locally and Worldwide

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As climate change and health researchers of Filipino heritage, we both are all too directly familiar with the cycles of devastation that typhoons (such as Typhoon Haiyan[1] in 2013 and Typhoon Noru[2] in 2022) and other tropical cyclones can leave in their path. For our families, the destruction wrought by tropical cyclones has manifested as downed trees, damaged or destroyed homes, and uprooted lives. Sadly, such traumatic experiences are commonplace when tropical cyclones make landfall, be it in the Philippines, China, Mexico, the United States, or elsewhere.

Tropical cyclones, intense rotating storms that form over warm tropical waters, are characterized by a panoply of mortal hazards, including high wind speeds (≥39 mph), storm surges, rip currents, and heavy precipitation.[3] The strongest tropical cyclones, with wind speeds of ≥74 mph, are known by different names throughout the world (hurricanes, typhoons, cyclones) but are universally devastating to societies.[4] The health impacts can be wide-ranging; physical trauma can result directly from the force of tropical cyclones, whereas outbreaks of diarrheal and mosquito-borne diseases can result from unsafe or unhealthy conditions in their aftermath.[5] Recent tropical cyclone seasons—which have yielded stronger,[6] more active,[7] and longer-lasting[8] storms than previously recorded—demonstrate that these events will remain a critical public health concern; Hurricane Ian's rapid intensification in North America during 2022 is a reminder of how climate change is modifying tropical cyclones.[9]

In a scoping review in this issue of *Environmental Health Perspectives*, Ghosh et al. assess the literature published through the end of 2021 evaluating the association of tropical cyclones with cardiovascular health.[10] They found emerging evidence of short-term increases in adverse cardiovascular health outcomes following tropical cyclones, particularly in people with existing health conditions. Specifically, observed increases in cardiovascular-related illness[11] and death[12] have been linked to heart attacks and cardiac arrests from physical overexertion,[13] increases in stress,[14] and disrupted treatment of chronic cardiovascular conditions.[15]

Ghosh et al. also noted that the majority of the research they reviewed focused on the United States—a focus that should be expanded. Low- and middle-income countries (LMICs), such as the Philippines, a country of more than 100 million people with a year-round tropical cyclone season, are some of the most affected by climate change.[16] Yet LMICs remain some of the least studied with respect to climate-related exposures and public health.[17] More high-quality public health research on tropical cyclones focused on LMICs is essential[10]; from our experience, doing so requires greater cooperation between researchers from high-income countries and LMICs. Addressing worldwide knowledge gaps on the health impacts of tropical cyclones and other climate-related hazards also requires a multidisciplinary approach, involving diverse contributions from climate science, public health, and the social sciences to capture the lived experiences of people affected by tropical cyclones.

The public health impact of tropical cyclones certainly reaches beyond injuries and cardiovascular diseases. Associations of tropical cyclones with neuropsychiatric conditions, respiratory diseases, and infectious and parasitic diseases are all evident in recent research.[11,12] The long-term mental health consequences of repeated tropical cyclones need to be more completely understood,[18] as well as the influence on childhood neurodevelopment, educational attainment, and DNA methylation. Even counting the number of dead after a tropical cyclone is a challenge; mortality estimates of the same hurricane can vary greatly, such as Hurricane Maria in 2017, for which official death counts were up to 70 times lower than the total number of estimated excess deaths.[19,20] Research identifying those "hidden burdens" of tropical cyclones on life expectancy, illness, and mortality is critical to mitigating their overall impact worldwide.

Although tropical cyclones will inevitably arrive each year, the worst consequences on public health and society are often avoidable with an equitable, long-term approach[5]; resilience to tropical cyclones is built over a long time via robust societal infrastructure, including adequate social services, housing stock, and power distribution. In the United States, the same tropical cyclone can affect communities differently, with differences likely driven by demographic, economic, and social factors[21]; in nonaffluent communities, impacts are often exacerbated by systemic inequity due to institutional neglect.[22] The recovery after a tropical cyclone is also often inequitable, with federal aid and private insurance particularly difficult to obtain by Black and low-income individuals.[23] Evacuation is a useful way to provide short-term relief from a tropical cyclone. However, this luxury is not available to all, due to a lack of early warning systems, financial resources, or adequate transport.[24] Others are constrained by health conditions that they or a family member experience.[25] Some simply have nowhere to go. In short, many cannot leave.

It is almost too painful to read the news stories every time a powerful tropical cyclone makes landfall; we are all regularly reminded that typhoons and hurricanes are some of the most deadly and frequent climate-related hazards there are. For those of us not directly affected by extreme weather, it is much too easy to move on with our lives once the headlines fade. However, the long shadow of a tropical cyclone can destroy lives and result in hospitalization and death. Recovery and rehabilitation can seem to move in slow motion over the subsequent months and

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years. Giving appropriate attention and funding to understanding the full impacts of tropical cyclones on health locally and worldwide is critical to the fight for social, environmental, and climate justice.

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