Annual Review of Public Health

Climatic and Environmental Change, Migration, and Health

Celia McMichael

School of Geography, Earth and Atmospheric Sciences, The University of Melbourne, Carlton, Victoria, Australia; email: celia.mcmichael@unimelb.edu.au

Annu. Rev. Public Health 2023. 44:171–91

First published as a Review in Advance on December 21, 2022

The *Annual Review of Public Health* is online at publhealth.annualreviews.org

https://doi.org/10.1146/annurev-publhealth-071421-045148

Keywords

climate change, migration, displacement, relocation, mobility, health

Abstract

The impacts of climate change, such as sea-level rise and extreme weather events, are expected to increase and alter human migration and mobility. Climate-related mobility is not inherently a crisis; it can provide a pathway for adaptation to climate change. However, a growing body of research identifies health risks and some opportunities associated with climate-related mobility. This review examines recent research (published since 2018) on the climate change–mobility–health nexus; this research focuses largely on in-country mobility in Asia, Africa, and Pacific Island countries. It considers the links between human mobility and anthropogenic climate change and documents the findings of empirical research that addresses the health consequences of displacement, planned relocation, migration, and migration into sites of climate risk. The findings highlight the need for climate-sensitive and migrant-inclusive health care in a heating world.

1. INTRODUCTION

1.1. Climate-Related Mobility

Climate change impacts—including sea-level rise and altered frequency, intensity, duration, and location of drought, flooding, and extreme weather events—are expected to amplify the scale of human migration and mobility. Climate change is identified as a driver of mobility in global frameworks including the 2010 Cancún Adaptation Framework, the Nansen Initiative 2015 Agenda for the Protection of Cross-Border Displaced Persons in the Context of Disasters and Climate Change, the 2015 Paris Agreement, the Sendai Framework for Disaster Risk Reduction, the 2016 United Nations Summit for Refugees and Migrants, the Platform on Disaster Displacement, and the 2018 Global Compact for Migration (40). National and regional frameworks, such as the 2019 Kainaki II Declaration for Urgent Climate Change Action Now by the Leaders of the Pacific Islands Forum, also recognize climate change as a driver of human mobility (50). Popular media widely refers to migration as the human face of climate change (30). This review article examines recent research that addresses the connections between climate change, human migration and mobility, and health.

A large body of research examines climate change and human mobility, variously characterizing it as a crisis response to failed in situ adaptation or an effective form of adaptation to climate risks (88). With varying degrees of rigor, studies have sought to identify pathways by which climate change will contribute to human mobility and to identify hotspots of climate-related mobility. Three main types of climate mobility are broadly identified as follows:

- Displacement, forced movement of people from their places of residence due to climate-related disaster;
- Relocation (also referred to as resettlement, retreat, realignment), permanent movement of infrastructure and people away from hazards and settlement into a new location; and
- Migration, voluntary movement and settlement of people within or across national borders, albeit with other pressures that drive migration decisions; note that people migrate both from and into sites of climate risk (64).

In addition, immobile populations live in sites of climate risk who are unable to move (i.e., poorer households that lack necessary financial, human, and social capital) or prefer to stay in sites of belonging (2, 40, 52, 81).

However, climate change impacts intersect with other factors to shape mobility. It has proved difficult to unambiguously disentangle climate change impacts from these other socioeconomic, political, demographic, and environmental factors that enable and constrain human mobility. Indeed, climate is seldom identified by migrants as the main factor informing decisions to migrate, even in regions of high climate vulnerability (22). Furthermore, climatic events do not cause mobility, but rather it is prompted by associated effects such as loss in land productivity, disrupted livelihoods, food and water insecurity, and reduced habitability of place (4). Scholars have made numerous attempts to estimate how many people will move as a result of climate change impacts. For example, Rigaud et al. (72) predict that by 2050 climate change will lead to the forced internal migration of more than 143 million people in three regions (i.e., sub-Saharan Africa, South Asia, and Latin America). Few quantitative estimates, however, separate climate change impacts from other migration drivers or sufficiently consider the capacity for human adaptation to climate risks (e.g., selling assets, diversifying livelihoods, in situ protection and resilience, accessing public assistance programs) (40).

Climate-related mobility is not inherently a crisis; it can provide a way by which people adapt to climate change (51). As with mobility drivers, the outcomes of climate-related mobility occur

through the intersection of physical hazards (e.g., sea-level rise, flood events), the scale and nature of exposure to the hazard, vulnerability of people and populations, perceptions of risk, and capacities to prepare for, adapt to, and recover from climate events. Livelihoods and economic resources are widely used as a primary measure of climate-related mobility outcomes (51). Yet there are other indicators of climate vulnerability and adaptation, including health, among mobile populations.

1.2. The Nexus of Climatic and Environmental Change, Mobility, and Human Health

A rapidly growing body of research examines the health risks associated with climate change impacts: for example, temperature-related illness and mortality, changes in the range and distribution of vector-borne diseases, intensification of extreme events, waterborne diseases, and food insecurity (27, 73). More recently, researchers have begun to examine the linkages between climate change, human mobility, and population health (53, 81–84). Drawing on analogous case studies of human mobility and emerging empirical studies of climate-related mobility, a number of recent review articles, reports, comments, and editorials address the climate change–mobility–health nexus (1, 11, 14, 24, 33, 36, 43, 49, 52, 56, 75, 79, 84, 93, 95). They variously consider the potential for climate-related risks to health to act as a migration push factor (1, 11, 52, 79); the health risks to climate migrants during transit and in sites of settlement (11, 14, 24, 36, 49, 52, 75, 84, 93, 95); and recognition that migrants can move into places with climate-related health risks, such as heat extremes (1, 52).

These review articles highlight and hypothesize potential intersections and pathways in the three-way climate–migration–health nexus. And yet, limited empirical research explicitly addresses this nexus. A recent comprehensive review of research by Schwerdtle et al. (82) identified only 50 empirical studies published over 3 decades—between 1990 and 2018—that address the nexus of climate change–mobility–health. In the past few years, however, there has been a proliferation of empirical research that addresses climate change–mobility–health.

1.3. Aims and Methods

Accordingly, the aim of this review is to assess recent (published 2018–2022) empirical research ($n = 36$) on the climate change–mobility–health nexus. The timeframe captures recent evidence, subsequent to the publication of the review on climate change–mobility–health by Schwerdtle et al. (82). The following inclusion criteria were applied: a peer-reviewed empirical study (including qualitative, quantitative, mixed methods); a focus on the relationship between climate change, human mobility, and health; and published in English. The literature search was conducted in March 2022. Google Scholar, PubMed, Scopus, and Global Health (CAB) were searched according to search terms such as those in **Table 1**.

Table 1 Examples of search terms, tailored to database requirements

Search term area 1	Search term area 2	Search term area 3
climate change	migration	health
sea level	displacement	mental health
global warming	relocation	well-being
climate variability	retreat	disease
greenhouse effect	mobility	nutrition
weather	immobility	health care
	trapped population	

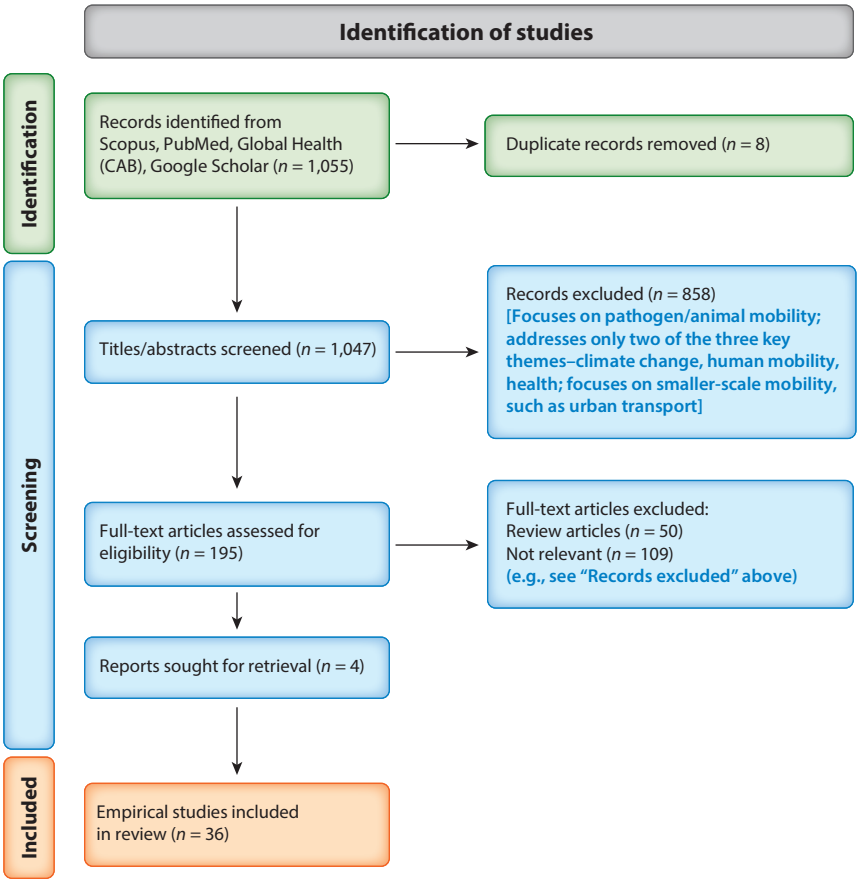

Figure 1

Search and inclusion/exclusion process for identifying relevant literature.

Gray literature and non-peer-reviewed documents were not included (e.g., briefings, reports from organizations, and National Adaptation Programmes of Action). Comments, editorials, and review articles were not included but were collated as relevant literature ($n = 50$) to inform the review. **Figure 1** summarizes the screening process and key reasons for exclusion of literature.

All included empirical publications concurrently address climatic and/or weather-related hazard (e.g., flooding, sea-level rise, coastal erosion), mobility (e.g., migration, displacement, relocation, trapped populations), and health (e.g., mental health, nutrition, heat stress) (see **Figure 2**). Eligible publications (**Table 2**) were analyzed by extracting key information pertaining to the review topic: study setting/population, research question(s), study design, environmental and/or weather-related hazard, mobility type, health outcome, main findings, and limitations.

The remainder of the review is organized as follows. It unpacks the ways in which the identified empirical studies link human mobility to anthropogenic climate change (Section 2.1). Then, it reviews these studies, specifically the documented health consequences of disaster-related displacement, planned relocation, climate-related migration, and migration into sites of climate risk (Section 2.2). Next, it considers health system and health-related policy and practice responses to human mobility in a warming world, questioning generic calls for climate-sensitive and migrant-inclusive health care and calling for more nuanced climate adaptation actions (Section 3). Finally,

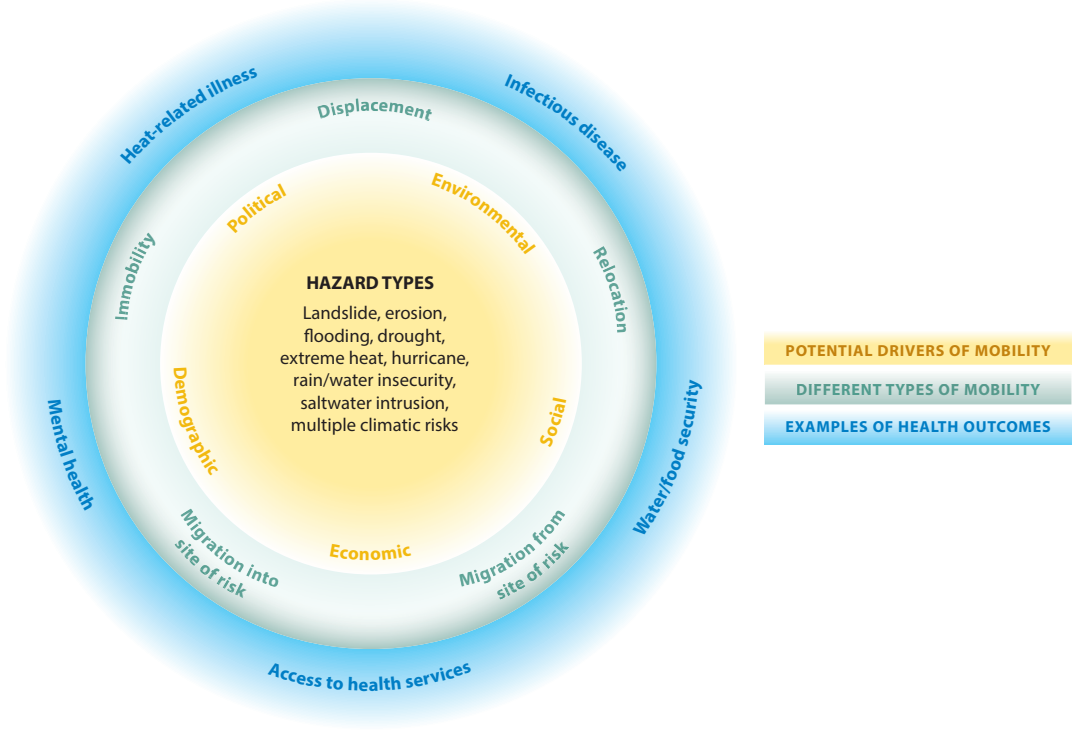

Figure 2

Climate–mobility–health nexus.

it underscores the need to promote the health of mobile populations and increase mobility choices in a warming world (Section 4).

2. CLIMATE CHANGE, HUMAN MOBILITY, AND POPULATION HEALTH

2.1. Establishing Connections Between Human Mobility and Climate Change

This review is restricted to studies that refer to climate change as a contributing driver of displacement, relocation, or migration and/or as a health risk amplifier in sites of migrant destination. The included empirical studies report on mobility in contexts of landslide ($n = 1$), coastal and riverbank erosion ($n = 3$), flooding ($n = 2$), drought ($n = 3$), extreme heat ($n = 4$), hurricanes ($n = 2$), irregular rainfall and limited water resources ($n = 2$), and saltwater intrusion ($n = 2$); almost half of the studies report on mobility in contexts of environmental and climatic hazards, rather than a specific event or risk ($n = 17$). Many consider other drivers of mobility that intersect with environmental and climatic variables. All studies address health outcomes for mobile populations (see **Figure 2**).

But are these studies definitively about anthropogenic climate change–related mobility? The majority of studies refer to the wider scholarly research around climate change and human mobility, referring, for example, to the phenomena of "climate-induced mobility" (9), "climate change-related mobility" (13), "climate migrants" (17), and "climate change-induced displaced people" (19). These studies cite literature that establishes a connection between climate change

Table 2 A summary of key information in the 36 empirical publications, organized by hazard type: e.g., study country or region, study design, climate/environment/weather-related hazard, mobility type, and health outcome

Primary environmental factor	Author(s)	Study country or region	Study design	Climate, weather, environmental factor	Mobility (internal/international)	Health outcome
Landslide	Burrows et al. 2021 (13)	Indonesia	Quantitative survey	Landslide	Displacement (internal)	Mental health
Coastal and riverbank erosion	Albert et al. 2018 (5)	Solomon Islands; Alaska, USA	Qualitative methods, media analysis	Coastal erosion	Relocation (internal)	Self-reported health risks and opportunities
	Kabir & Kamruzzaman 2022 (39)	Bangladesh	Qualitative interviews, group discussions	Acute riverbank erosion (plus heat waves, flooding, storms)	Short-term migration and displacement (internal)	Health care access, sanitation
	McMichael & Powell 2021 (54)	Fiji	Qualitative interviews and group discussion (multiyear)	Coastal erosion	Planned relocation (internal)	WaSH, diet, health care access, housing, place attachment
Flooding	Ambikapathi et al. 2021 (6)	Peru	Longitudinal quantitative methods	Flooding, ENSO	Temporary displacement (internal)	Diet
	Woodhall-Melnik & Grogan 2019 (98)	Canada	Groups discussion, qualitative interviews	Flooding	Displacement (internal)	Mental health
Drought	Lindvall et al. 2020 (45)	Somalia, Kenya, and Ethiopia	Qualitative interviews, validation workshop	Prolonged droughts	Displacement (internal)	Nutrition, vaccination, mental health, gender-based violence, health care
	Orievulu et al. 2022 (59)	South Africa	Qualitative interviews	Drought (plus reduced agricultural production, food/water insecurity)	Forced mobility/displacement (internal)	HIV treatment adherence
	Pardhi et al. 2020 (60)	India	Qualitative interviews	Severe drought	Displacement (internal)	Reproductive and child health
Extreme heat	Campbell-Staton et al. 2021 (16)	Mexico–USA border	Modeling of physiological stress	Extreme heat	Undocumented migration (international)	Physiological stress due to evaporative water loss
	Lundgren-Kownacki et al. 2018 (47)	India	Climate forecast data analysis, occupational heat stress measures	Extreme heat	Labor migration (internal)	Heat exposure–related illness
	Messeri et al. 2019 (55)	Europe	Questionnaire survey	Heat waves	Labor migration (international)	Heat-related health risk and health literacy
	Pradhan et al. 2019 (66)	Qatar	Quantitative analysis of mortality data and daily temperatures, qualitative interviews	Heat exposure	Labor mobility (international)	Cardiovascular disease

(*Continued*)

Table 2 (*Continued*)

Primary environmental factor	Author(s)	Study country or region	Study design	Climate, weather, environmental factor	Mobility (internal/international)	Health outcome
Hurricane	Koslov et al. 2021 (42)	USA	Survey	Hurricane	Relocation and immobility (internal)	Mental health/stress
	Loebach & Korinek 2019 (46)	Nicaragua	Longitudinal quantitative analysis	Hurricane	Displacement (internal)	Diarrheal disease and respiratory disease
Irregular rainfall, limited water	Tshimanga et al. 2021 (90)	Congo Basin	Hydroclimatic, land use, migration data; group discussion, qualitative interviews, household survey	Water insecurity (plus climate change vulnerability)	Migration, displacement (internal, regional)	Social determinants of health, food security, health, access to services, WaSH
	Vinke et al. 2022 (96)	Burkina Faso	Qualitative interviews	Irregular rainfall patterns	Seasonal migration (international)	Self-reported health
Saltwater intrusion	Chen & Mueller 2018 (18)	Bangladesh	Quantitative analysis of SES, migration, and environmental data	Inundation and saline contamination of soils	Migration (internal and international)	Consequences of salinity on crop production
	Rakib et al. 2019 (68)	Bangladesh	Household survey, group discussion, qualitative interview, field observation	Drinking water scarcity and salinity	Migration (internal)	Health threats caused by drinking water scarcity and salinity hazards
Multicausal	Adger et al. 2021 (3)	Bangladesh	Survey, qualitative interviews, photo elicitation	Environmental hazards	Urban migration (internal)	Poor health, poor social determinants of health
	Andronov et al. 2021 (7)	North-Western Siberia	Survey, medical exam, analysis of food storage	Climate change	Seasonal mobility (internal)	Diet
	Ayeb-Karlsson 2020 (8)	Bangladesh	Storytelling methodology	Cyclone, riverbank erosion, climatic and environmental risk	Urban migration, trapped populations (internal)	Self-reported physical and mental health
	Ayeb-Karlsson et al. 2020 (9)	Bangladesh	Q-methodology and discourse analysis	Cyclones and riverbank erosion	Urban (im)mobility (internal)	Mental health
	Baada et al. 2021 (10)	Ghana	Qualitative interviews	Climate variability	Rural migration (internal)	Family planning, access to health care
	Castellano et al. 2021 (17)	Bangladesh	Survey	Climate change	Rural-urban migration (internal)	Funding for health care
	Chowdhury et al. 2020 (19)	Bangladesh	Quantitative survey, group discussions, qualitative interviews	Riverbank erosion, cyclones, altered temperature, and rainfall	Displacement (internal)	WaSH, health care services, infectious diseases, heat-related illness, injury

(*Continued*)

Table 2 (*Continued*)

Primary environmental factor	Author(s)	Study country or region	Study design	Climate, weather, environmental factor	Mobility (internal/international)	Health outcome
Multicausal	DiGiorgi et al. 2020 (25)	Italy	Qualitative interview, clinical psychological interview and test	Country-level vulnerability to climate change	Displacement/ asylum seeking (internal)	Emotional disorders
	Emont et al. 2021 (28)	New Zealand (Tuvaluan migrant)	Qualitative interviews, participant observation	(Future) threat of climate change	Migration (international)	Health care, diet, physical activity
	Furusawa et al. 2021 (29)	Solomon Islands	Health checkups, qualitative interviews	Climate impacts	Planned relocation (internal)	Physical and mental health
	Haque et al. 2020 (31)	Bangladesh	Quantitative survey	Extreme climate events	Displacement (internal)	Childbirth/ delivery and postnatal case service use
	Haque et al. 2020 (32)	Bangladesh	Household survey	Climate vulnerability	Displacement (internal)	Social determinants of health, health care access
	Patel & Giri 2019 (62)	India	Focus group discussions	Repeated floods and extreme climatic event	Urban migration (internal)	Safety and security of young girls
	Rahaman et al. 2018 (67)	Bangladesh	Household survey, qualitative interview, group discussion	Climate-vulnerable districts	Migration (internal)	WaSH, health care, living conditions, waterborne disease, nutrition
	Scheerens & Madzimbamuto 2021 (77)	Sub-Saharan Africa	Group discussion	Climate change	Migration (internal, regional)	Health care
	Schwerdtle et al. 2021 (80)	Bangladesh	Qualitative interviews	Climate change	Migration (internal)	Food security, shelter, WaSH, mental health, health care access
	van der Geest et al. 2020 (94)	Republic of the Marshall Islands, USA	Survey, group discussions, interviews, geospatial analysis	Sea-level rise, flooding, soil and water salinity, drought, heat stress	Migration (international)	Climate-sensitive health risks and health care

Abbreviations: ENSO, El Niño Southern Oscillation; SES, socioeconomic status; WaSH, water, sanitation, and hygiene.

impacts and human mobility; Di Giorgi et al. (25), for example, cite research by Reuveny (69) to establish that "the negative effects of climate change affect. . .migration to urban areas and other states, with a gradual abandonment of the most exposed environments."

Studies also draw on wider climate science to connect local weather events and/or environmental anomalies with anthropogenic climate change. For example, in their analyses of displacement following hurricanes, Loebach & Korinek (46) and Koslov et al. (42) cite research to indicate that anthropogenic climate change will result in increasing frequency and severity of hurricanes. In their study of "climate migrants" in urban Bangladesh, Rahaman et al. (67) cite research that indicates Bangladesh is experiencing climate-induced problems, including erratic rainfall, increased heat, and climate extremes. And in their analysis of relocation from low-lying coastal areas, Albert et al. (5) cite studies that document rates of sea-level rise in the Solomon Islands of 7–10 mm per year (three times the global average) over the past 2 decades.

More frequent and/or severe weather and environmental anomalies are certainly occurring as a result of long-term climate change trends, with these trends projected to accelerate under certain greenhouse gas emissions scenarios (27, 38). Yet while the science of quantifying the influence of anthropogenic climate change on individual weather events (e.g., heat waves, extreme precipitation) is rapidly evolving, there is potential to misattribute individual weather events and their impacts as being caused by anthropogenic climate change on the basis of analysis focused on classes of weather events (63). Notably, none of the studies in this review draw on data and methods to establish an anthropogenic signal behind specific weather-related and environmental events. And the likelihood that people and populations identify climate change as a driver of mobility depends on local perceptions of climate risk, interactions with other migration drivers (e.g., socioeconomic status), and aspects of place (e.g., protective infrastructure) (36). Therefore, what is observed and reported are weather- and environment-related anomalies that are plausibly linked, by study participants and/or researchers, to anthropogenic climate change.

In sum, these studies of climate-related mobility variously cite wider global and/or regional research that connects climate change impacts with human mobility, cite wider climate science to plausibly establish anthropogenic climate change as a potential driver of observed local environmental changes and weather events, and/or report people's local experiences of climate impacts that link to migration and mobility decisions. However, applying detection and attribution methods to determine how anthropogenic climate change affects local sudden- and slow-onset events and risks is not without challenges (57). These challenges raise important questions about where the locus of responsibility lies for identifying a climate change signal in contexts of human mobility.

2.2. Climate Change–Mobility–Health: Empirical Studies

Studies were conducted in the South Asian and Southeast Asian regions ($n = 16$), the African region ($n = 6$), the Pan American region ($n = 7$), Oceania including New Zealand and the Pacific Islands ($n = 5$), Europe ($n = 3$), and the Middle East ($n = 1$) (note, two studies included case studies from two countries). Notably, one-third of the studies focus on Bangladesh ($n = 12$). The majority of studies were conducted in low- and middle-income countries. While noting the elevated vulnerability of populations in low- and middle-income countries to climate impacts and associated risks, Piguet et al. (65) argue that research on environmental migration is disproportionately conducted in the Global South and may reflect the framing of environmental refugees as a problem for poorer countries and a security risk for the North.

Of the 36 empirical papers considered in this review, 27 focus on climate change as a driver of human mobility, including displacement, relocation, and out migration. They identify specific weather- and environment-related events that are plausibly connected to climate change (e.g., flooding, coastal erosion, riverbank erosion, landslide, hurricane, severe drought, irregular rainfall)

and/or refer more generally to climate vulnerability, climate risk, or climate change impacts. The other nine papers focus on migration into sites of climate risk, including the health of migrant workers and people who move to urban poor areas.

The subsections below group and discuss studies according to these four mobility types: displacement, relocation, migration from sites of climate risk, and migration into sites of climate risk.

2.2.1. Disaster and displacement. Several empirical studies examined health outcomes of displacement following disaster, including severe El Niño Southern Oscillation (ENSO) conditions, hurricanes/cyclones, flooding, riverbank erosion, and landslides. Disaster-related displacement is associated with elevated risks to health (92). It is notable, then, that three studies reported some improved outcomes in health or in the determinants of health among displaced populations. One study found that populations displaced by landslides in Indonesia were more likely than those left behind to report improved mental well-being (13); a study in coastal Bangladesh found that internally displaced people experience some improvements in the standard of water and sanitation facilities, access to cyclone shelter, and health care services in the new site of residence (19); and a study of flooding and displacement in New Brunswick, Canada, found that communal and collaborative postdisaster responses were protective of mental health risk (98).

However, most studies highlight risks to health among displaced populations. A study of flood-related displacement in Canada reported negative mental health impacts, particularly among those who experienced residential damage (98). In Nicaragua, in the aftermath of Hurricane Mitch, individuals from households headed by women or with low expenditure were more likely to be displaced to shelters and to experience increased risk of respiratory disease and communicable disease (46). Ambikapathi et al. (6) examined children's diets in the Peruvian Amazon following the 2011–2012 La Niña that led to widespread flooding and displacement and identified reduced dietary quantity (i.e., decreased amounts of grains, rice, dairy, sugar), quality, and diversity, particularly among girls. Five studies focus on the health of internally displaced people in Bangladesh living in urban poor settlements and slums, who have been displaced by climate-related factors, including cyclones, flooding, and riverbank erosion. They variously document health challenges, including skin diseases, diarrhea, waterborne diseases, malnutrition, respiratory disease, and injuries (8, 19); limited access to maternity and postnatal services among displaced women (29); poor social determinants of health, such as crowded living conditions and inadequate land, electricity, sanitation, and health care services (30); and loss of belonging, poor quality of life, social exclusion, and experiences of depression and anxiety, particularly among people who are unable to return home or move elsewhere due to a lack of resources (8, 9). These studies highlight health risks among displaced women, children, and poor people and households in postdisaster settings. They underscore that preexisting socioeconomic vulnerabilities can amplify risks to health among displaced populations (27).

2.2.2. Planned and autonomous relocation. Relocation, whether planned with the support of external agencies or undertaken autonomously by community members, is a way to move from a site of climate risk (48). To date, there have been few planned relocation processes in response to climate impacts, yet the need for this form of adaptation will likely increase as climate impacts escalate (23). Relocation can affect health risks and opportunities, including mental health, social capital, food security, water and sanitation, infectious disease, housing quality, disrupted place attachment, and health care access (23, 44, 85).

This review identified three studies that consider the health consequences—both benefits and risks—of relocation (5, 42, 54). A study of community relocation in the Solomon Islands in response to sea-level rise, coastal erosion, and destruction of homes identified diverse health outcomes; households moved to different places and, depending on context and location, variously

reported risks and opportunities for water and sanitation, health care access, subsistence food security, and access to fertile land (5). A study of people living in Hurricane Sandy–affected areas of New York and New Jersey found that those eligible for home buyout and who relocated were significantly less likely to report worsened stress (39%) compared with those who rebuilt in place (59%) (42). Research with residents of a village in Fiji who relocated from a site exposed to coastal erosion, flooding, and saltwater intrusion identified both reported health benefits (e.g., improved water and sanitation, food security, access to health services) and health threats (e.g., increased consumption of packaged goods and alcohol, disrupted social structures, loss of place attachment) (54). Given that prior research indicates that relocation can have adverse health outcomes (23), it is notable that these studies report both health risks and benefits of relocation. Equitable approaches to relocation require attentiveness to processes and outcomes in ways that reduce climate risks and support health, livelihoods, and security (48).

However, without longitudinal analysis or a baseline reference, health impacts of relocation can be difficult to establish and monitor. Furusawa et al. (29) call for baseline health assessments from which to monitor health consequences of relocation and other adaptation strategies; they conducted a health assessment (e.g., rates of obesity, hypertension, depressive symptoms) of communities in the Solomon Islands that are under threat from sea-level rise. Similarly, Albert et al. (5) documented emerging health threats in Shishmaref, Alaska—including waterborne disease and altered subsistence food sources—where flooding and shoreline erosion undermine habitability; while many residents hope to relocate, they are unable to move due to the lack of government resources to facilitate the relocation of services, infrastructure, and housing. It is notable that a number of review articles highlight mental health risks among people who are unable to move from places of climate risk, such as Indigenous peoples across the Arctic and subarctic regions (43, 56). Baseline assessments of health and other development indicators such as these can provide a foundation for tracking impacts of relocation over time.

2.2.3. Migration in a warming world. People who move in response to climate impacts can experience health risks (and potentially opportunities), such as limited access to health care, increased incidence of water- and foodborne diseases, mental health risks, threats to sexual and reproductive health, disrupted social networks, loss of place attachment, skin diseases, and food insecurity, during transit and in sites of settlement (11, 14, 24, 36, 49, 52, 75, 84, 93, 95). Several recent empirical studies examine the health risks and opportunities among people who migrate, either permanently or as seasonal labor migrants, during or following climatic and weather-related threats, including drought, flooding, riverbank erosion, and cyclones (10, 25, 28, 59, 60, 62, 67, 90, 96).

A few studies focus specifically on drought, migration, and health. Orievulu et al. (59) suggest that for people living with HIV in KwaZulu-Natal, South Africa, drought-related pressures—e.g., loss of livestock and income—can drive labor migration and mobility, which potentially disrupts HIV treatment adherence and care. In their study of urban migration following the 2015 drought in Maharashtra, India, Pardhi et al. (60) found that pregnant women reported homelessness, inadequate water and sanitation, poor nutrition, and limited access to antenatal care. And Vinke et al. (96) examined seasonal labor migration of men from Burkina Faso to neighboring countries following a period of low rainfall, poor harvests, and food insecurity; migrants work primarily in gold mines or sugar cane plantations and report adverse health outcomes including malaria, injury, physical exhaustion, and stress.

Other studies address the health consequences of migration from places experiencing a range of climatic vulnerabilities rather than a specific class of event (e.g., drought). Rahaman et al. (67) report that "climate migrants" in the overcrowded urban slums of Khulna City, Bangladesh,

experience poor living conditions and limited access to health facilities; residents report diarrhea, malaria, undernutrition and micronutrient deficiencies, skin diseases, asthma, and hypertension. Focusing on host community attitudes, another study in Bangladesh found that local slum dwellers were 16% less likely to donate funding to health care services that support climate migrants than to services for generic migrants (17). Patel & Giri (62) examined the experiences of poor women from coastal districts of Odisha who move to urban areas due to work on construction sites following repeated floods, cyclones, and depleted livelihood opportunities. While some women describe improved living conditions, financial status, access to health facilities, and educational opportunities for children, they also report social marginalization and inadequate safety and security for young girls. A study of political asylum seekers in Italy found that those who report climate change vulnerabilities in their country of origin (in Africa or the Middle East) are more likely to report emotional disorders (25). And a study of climate variability and migration in Ghana found that smallholder farmers, and increasingly women farmers, migrate to other rural areas in search of better livelihoods, where many face reproductive health and family planning challenges (10). These studies document threats to (and some opportunities for) health and determinants of health among those who move from sites of environmental and weather-related risk.

Others consider whether climate-related risks to health act as a specific driver of migration decisions and reach different conclusions. Two studies in coastal Bangladesh suggest that drinking water scarcity, soil salinity, and associated health threats (e.g., high blood pressure, kidney disease) as well as saltwater intrusion and reduced crop production will contribute to future migration pressures (18, 68). Conversely, a study with Marshall Islanders living in the United States finds that despite people's knowledge of climate-related risks to health, such as reduced food and freshwater availability, these and other climate impacts are not considered current drivers of migration (94). Similar uncertainty is noted in review articles that consider whether climate-related risks to health—e.g., food shortages following drought, water insecurity—act as push factors for migration (1, 11, 52, 75, 79). For example, Stoler et al. (87) theorize that climate-related household water insecurity—and associated disruptions to physical and mental health, livelihoods, and social relationships—can precipitate an invisible "slow drip" of migration. But while some suggest that climate-related risks to health will lead to mobility, including cross-border migration "when home countries become inhospitable" (21, p. 14), there is limited evidence to date for such claims.

2.2.4. Migration into sites of climate-related risks to health. In a mobile world, migrants might move into places with climate-related risks to health such as heat extremes (1, 52). Inward migrants might be particularly vulnerable to risks in destination sites due, for example, to limited social capital and poor disaster awareness (1). So, beyond the focus on climate-related mobility—i.e., people who are displaced, relocate, or migrate away from contexts of climate risks—several recent empirical studies consider the health of migrants who move for wider social, political, and economic reasons (e.g., labor migrants) and who move into or through sites of climatic and environmental risks. These studies document climate-related threats to migrant health in sites of transit and destination.

A study with migrants in low-income urban neighborhoods in Chattogram, Bangladesh, finds increases in perceived insecurity due to environmental and climate-related hazards such as flooding (3). Similarly, Schwerdtle et al. (80) find that immigrants in an urban slum in Dhaka, Bangladesh, experience climate-related health risks at their cities of origin, en route to, and at their destination, including risks associated with food environments, shelter, and water, sanitation, and hygiene. An analysis of undocumented migration across the southern US border warns of the potential for increased illness and death in a warming world, with increasing heat and associated physiological stress leading to severe dehydration (16). And a study with nomadic Indigenous

residents of the Western Siberia Arctic finds that rising temperatures, changing river cycles, later freezing, and early melting are disrupting herding routes, fishing seasons, and cryogenic food storage, leading to altered food availability and rising hypertension (7).

Research also documents heat-related health risks among migrant workers, including (*a*) migrant brick kiln workers in India, with workers reporting symptoms of heat stress (e.g., muscle cramps, headaches, nausea, fainting, prickly heat, dizziness) during the hot seasons (47); (*b*) Nepali migrant workers in Qatar, with strong correlation between excessive heat and cardiovascular disease mortality, likely due to severe heat stress (66); and (*c*) outdoor immigrant workers in the agricultural and construction sectors in Italy, who report limited training on heat-related health risks as compared to Italian workers (55). These studies point to the potential for heightened exposure to climate risks among migrant workers and to more limited capacity to adapt to weather extremes.

3. CLIMATE-RESILIENT AND MIGRANT-INCLUSIVE HEALTH SYSTEMS

3.1. Climate-Resilient Health Systems

Given the grossly insufficient efforts to reduce greenhouse gas emissions, global average temperature increases of at least 1.5°C above preindustrial levels will occur in the near term (up to 2040), and far greater warming is likely by 2100 (12, 38). Adaptation to climate change impacts is necessary to reduce vulnerabilities and protect people's health. To adapt to (and prevent) population health threats in a changing climate, climate-resilient health systems are required that incorporate surveillance of emerging climate-sensitive health threats, effective disaster response around the health risks of extreme events, financing and support for low-resource communities and countries, long-term planning and health system strengthening, information about current and projected climate risks to inform adaptation planning, and cross-sectoral action on the wider social determinants of health (27, 61, 73).

A key action for climate-resilient health systems is to identify climate-related health risks for vulnerable populations, including children, older adults, workers, people living in poverty, Indigenous people, and migrant and displaced populations. Globally, a growing number of climate policy initiatives and frameworks address both human mobility and health: As of 2020, 45 national policies (across 37 countries) connect climate change and migration, many of which mention climate-sensitive health risks (although not necessarily the health consequences of migration in a warming world) (73). Policy examples include the Bangladesh National Strategy on the Management of Disaster and Climate Induced Internal Displacement, Fiji's Displacement Guidelines in the Context of Climate Change and Disasters, and the Vanuatu National Policy on Climate Change and Disaster-Induced Displacement (73).

Several recent review articles, comments, and empirical studies point to the need for health system preparedness for climate-related migration (58, 71, 74, 82). They suggest that health services need to be prepared for the burden of climate migration, warning that climate-related migration will increase pressure on local health services (20, 58). For example, Negev et al. (58) point out that health systems in sub-Saharan Africa are ill-equipped for additional pressures from climate migrants, given that they are fragmented, experience acute material and human resource shortages, are weakened by decades of underinvestment, and are coping with high rates of infectious diseases and rising rates of noncommunicable diseases. Reuveny (70) develops a hypothetical model of climate-related migration and health and suggests that immigration could lead to situations where local demand for health care exceeds capacity. And Sabasteanski et al. (74) argue that there is inadequate policy focus on the health consequences of climate migration, specifically for internal migrants, and health system preparedness.

There are explicit calls by researchers for migrant-inclusive health systems to ensure that so-called climate migrants, particularly irregular/undocumented cross-border migrants, have access to health care resources and culturally appropriate services in destination sites (58, 74, 78, 82). Drawing on research with physicians in sub-Saharan Africa, Scheerans et al. (76) emphasize the need for both climate-resilient and migrant-inclusive health systems (see also 77, 78). Similarly, Lindvall et al. call for improved stakeholder knowledge (i.e., United Nations agencies, government ministries, nongovernmental organizations, regional leaders) of the health and health care needs of climate-displaced populations in the Horn of Africa (45). A number of review articles highlight the mental health risks associated with climate-related displacement, relocation, and migration, including in Bangladesh (33), in small island developing states (41), in the Pacific Islands (99), and where displacement intersects with other drivers of mental health risk, such as armed conflict (84). These works call for interventions to reduce the adverse mental health consequences of climate-related displacement (41, 84).

3.2. Can Health Systems Really Prepare for Climate Migrants?

Problematically, calls for health systems that are prepared for and inclusive of climate migrants presuppose an identifiable, often cross-border, climate migrant population. Indeed, some researchers have suggested that establishment of a legally recognized status for "climate refugee" would improve access to health care (95). Yet, as this review has illustrated, climate-related mobility is diverse—ranging from forced displacement to voluntary migration to relocation—and can occur across different spatial scales and time frames, albeit typically within national borders. While some contexts have clear links between climate risk and human mobility, such as retreat and relocation of low-lying communities exposed to sea-level rise and associated coastal erosion, there is no archetypal climate migrant that can be readily identified (35). Furthermore, there is a distinct lack of evidence, in this review and more broadly, for international migration linked to climate change (22). There remains a need to decouple climate mobilities from narratives that emphasize cross-border migration and so-called climate refugees (22). Indeed, overly simplified representations of climate migrants may prevent visibility of health risks among diverse mobile populations in a warming world.

Since in most cases it will be difficult to distinguish climate migrants from those moving primarily or solely for other reasons, the practical response to the anticipated increase in climate change–related mobility is to address and support the rights and health of all mobile populations (15). Rather than targeting health services for climate migrants, health care services must be accessible, affordable, and effective for anyone on the move in a warming world, whether a labor migrant, a person displaced following environmental disaster, an internal migrant in an urban-poor settlement, or a relocated community. To illustrate, in 2020, 30 million people were newly internally displaced by weather-related disasters; climate change is altering extreme weather events and plausibly contributing to increased displacement, and models predict increasing climate-related displacement (e.g., at current population levels, flood-related displacement is predicted to increase by >50% with each degree of warming) (37). However, the health needs of all displaced people, regardless of the climate signal behind environmental disaster and/or displacement, should be addressed. This proposal is in accordance with the ambitions of universal health coverage and calls for climate-resilient health systems that can bring sustained improvements in population health, even with the escalating impacts of anthropogenic climate change (27).

3.3. The Health of Migrants in a Warming World

Efforts to address the health of migrants in a warming world must also look beyond health care systems to address climate adaptation and the broader social determinants of health, e.g.,

environmental conditions, food security, safe water and sanitation, adequate housing, safe work conditions, and livelihood opportunities, in places into which people move (12, 49, 61). There is a need for intersectoral collaboration on initiatives to ensure healthy and climate-resilient migration (1, 26). For example, urban renewal efforts to improve the conditions of informal settlements—building resilience to environmental hazards such as flooding and landslides, planning and infrastructure development, adequate building codes, development of green spaces, safe water and sanitation, improved occupational health, access to services—would reduce residents' climate vulnerability and improve the conditions for good health, including for rural-urban migrants (86). Indeed, migration and mobility can confer health benefits and present opportunities to enable climate adaptation, particularly when there are healthy socioeconomic and material conditions for everyday life (97). Social protection options are required to address the wider determinants of health and vulnerability among populations on the move, support long-term adaptation and resilience to climate risk, and create conditions for transformative change (89).

Furthermore, community-led climate adaptation builds local resilience, respects local knowledge and values, is cost-effective, and builds capacity for future adaptation, particularly when supported by institutions that connect the state and communities. For example, in their review of coastal risk, climate adaptation, and well-being, Solecki & Friedman (85) state that community involvement in managed retreat processes can help create policies and plans that address local values and improve quality of life. But community-led adaptation is not a panacea for reducing climate vulnerability and can devolve responsibility from greenhouse gas–emitting populations to at-risk populations (12). So, while migrant and mobile populations have a right to be involved in planning, decision-making, and action, and should be supported to adapt to climate change risks, they should not be charged with the burden of responsibility for reducing their climate vulnerability.

It is the role of the state to support and protect people who move in a warming world, as well as those left behind (86). Vulnerable or marginalized populations, such as young children (91) and some Indigenous populations (56), may face health risks of particular concern. Some states may have the capacity and resources to address the needs of mobile populations in the context of climate change. But climate change generates geographically asymmetrical harms; national greenhouse gas contributions (and associated economic gains) are unequal as well. As many researchers point out, those most at risk of climate-related mobility and/or health risks come from regions that are least responsible for greenhouse gas emissions (14, 91). The global community acknowledges the need for adaptation and adaptation financing, and there is ongoing debate around how to measure, address, and compensate for loss and damage (i.e., the negative effects of climate change to which people are unable to adapt). However, both the climate adaptation and loss and damage agendas remain fragmented avenues through which to address human mobility and human health in a warming world. For example, the Taskforce on Displacement of the Warsaw International Mechanism has made only general calls to minimize loss and damage arising from unplanned migration. And funding for health adaptation is negligible (<1% of international climate adaptation finance) because climate change is not yet adequately understood as an urgent population health issue (27). Collaboration, along with global climate finance for adaptation and loss and damage, is necessary across public and private sectors and global institutions to address climate-related risks to population health.

3.4. Limitations of this Review

The review has limitations. First, as discussed above, these findings are based on studies that consider environmental and weather-related events that are plausibly linked to climate change;

however, the climate signal behind specific mobility pathways and/or health risks is not unequivocally established in these studies. Nonetheless, it is clear that environmental and climatic risk acts as an indirect driver of mobility and a threat multiplier, particularly in contexts of preexisting social vulnerabilities (22). Second, while there has been a rapid increase in empirical studies investigating the climate–mobility–health nexus over the past five years, the literature is sparse. Third, few studies investigate the role of policies and institutions in shaping mobility pathways and human health outcomes, such that there is limited evidence on policy effectiveness and outcomes.

4. CONCLUDING COMMENTS

Climate change impacts, and their consequences for human health and mobility, are distributed and experienced unevenly across different places and populations. This review builds on a previous review of climate change–human mobility–health (82) and analyzes recent empirical literature. The three main points are summarized as follows. First, few studies draw on data and methods to establish an anthropogenic climate change signal behind local weather/environmental events and associated human mobility; they report on local experiences of weather and environmental anomalies that are plausibly linked to anthropogenic climate change (e.g., coastal and riverbank erosion, flooding, extreme heat, hurricanes, and, more broadly, climate vulnerability). However, attribution science is rapidly developing, with the potential to link local weather-related and environmental changes to anthropogenic climate change (34). Second, the relationships between climate change (or, more accurately, environment- and weather-related events), mobility, and health are highly heterogeneous and intersect with other determinants of mobility and health. Diverse forms of climate-related mobility, including displacement, relocation, migration, and, as a few studies highlight, other forms of mobility (e.g., labor migrants, political asylum seekers, nomadic Indigenous groups), occur in a warming world. Accordingly, it makes more sense to promote migrant-inclusive health care in a warming world rather than attempt to identify and address the health of climate migrants. Third, while some studies highlight health benefits in contexts of climate-related mobility, most document threats to health and to the determinants of health: for example, infectious disease risks, extreme heat exposure, poor mental health, food insecurity, inadequate water and sanitation, poor living conditions, limited access to health care services, loss of belonging, and social exclusion. These threats require migrant-inclusive and climate-resilient health care as well as intersectoral action on the social determinants of health. Climate change already threatens global health gains. There is impetus to protect and promote the health of mobile populations and to enable mobility choices in the context of accelerating climate change.

FUTURE ISSUES

1. Researchers should draw on baseline assessments and longitudinal analyses to examine the changing dynamics over time of health and development in contexts of climate-related mobility.
2. In case studies of human mobility, identifying opportunities to draw on attribution science to link local weather and environmental changes to anthropogenic climate change (while also acknowledging and accounting for multiple drivers of mobility) should be prioritized.
3. Studies should examine how realized and/or anticipated climate-related mobility affects the mental health and well-being of people and populations.

4. Researchers need to identify health risks for people, such as outdoor labor migrants, who move into sites of climate-related risk.
5. Studies should examine how the connections between source communities and destination sites shape the health, development, and resilience of those who remain and those who leave.

DISCLOSURE STATEMENT

The author is not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

LITERATURE CITED

1. Abubakar I, Aldridge RW, Devakumar D, Orcutt M, Burns R, et al. 2018. The UCL–Lancet Commission on Migration and Health: the health of a world on the move. *Lancet* 392:2606–54
2. Adams H. 2016. Why populations persist: mobility, place attachment, and climate change. *Popul. Environ.* 37:429–48
3. Adger WN, de Campos RS, Siddiqui T, Gavonel MF, Szaboova L, et al. 2021. Human security of urban migrant populations affected by length of residence and environmental hazards. *J. Peace Res.* 58:50–66
4. Ajibade I, Sullivan M, Haeffner M. 2020. Why climate migration is not managed retreat: six justifications. *Glob. Environ. Chang.* 65:102187
5. Albert S, Bronen R, Tooler N, Leon J, Yee D, et al. 2018. Heading for the hills: climate-driven community relocations in the Solomon Islands and Alaska provide insight for a 1.5°C future. *Reg. Environ. Change* 18:2261–72
6. Ambikapathi R, Kosek MN, Lee GO, Olortegui MP, Zaitchik B, et al. 2021. La Niña weather impacts dietary patterns and dietary diversity among children in the Peruvian Amazon. *Public Health Nutr.* 24:3477–87
7. Andronov S, Lobanov A, Popov A, Luo Y, Shaduyko O, et al. 2021. Changing diets and traditional lifestyle of Siberian Arctic Indigenous Peoples and effects on health and well-being. *Ambio* 50:2060–71
8. Ayeb-Karlsson S. 2021. 'When we were children we had dreams, then we came to Dhaka to survive': urban stories connecting loss of wellbeing, displacement and (im)mobility. *Climate Dev.* 13(4):348–359
9. Ayeb-Karlsson S, Kniveton D, Cannon T. 2020. Trapped in the prison of the mind: notions of climate-induced (im)mobility decision-making and wellbeing from an urban informal settlement in Bangladesh. *Palgrave Commun.* 6:62
10. Baada JN, Baruah B, Sano Y, Luginaah I. 2021. Mothers in a 'strange land': migrant women farmers' reproductive health in the Brong-Ahafo region of Ghana. *J. Health Care Poor Underserved* 32:910–30
11. Baillat A. 2020. [Health and mobility facing climate change, what are the synergies?] *Rev. Infirm.* 69:29–32 (in French)
12. Barnett J. 2022. Global environmental change III: political economies of adaptation to climate change. *Prog. Hum. Geogr.* 46(4):1106–16
13. Burrows K, Pelupessy DC, Khoshnood K, Bell ML. 2021. Environmental displacement and mental well-being in Banjarnegara, Indonesia. *Environ. Health Perspect.* 129(11):117002
14. Butler CD, Hanigan IC. 2019. Anthropogenic climate change and health in the Global South. *Int. J. Tuberc. Lung Dis.* 23:1243–52
15. Byravan S, Rajan SC. 2022. Cross-border migration on a warming planet: a policy framework. *WIRES Clim. Change* 13:e763
16. Campbell-Staton SC, Walker RH, Rogers SA, De León J, Landecker H, et al. 2021. Physiological costs of undocumented human migration across the southern United States border. *Science* 374:1496–500
17. Castellano R, Dolšak N, Prakash A. 2021. Willingness to help climate migrants: a survey experiment in the Korail slum of Dhaka, Bangladesh. *PLOS ONE* 16(4):e0249315

18. Chen J, Mueller V. 2018. Coastal climate change, soil salinity and human migration in Bangladesh. *Nat. Clim. Change* 8:981–87
19. Chowdhury MA, Hasan MK, Hasan MR, Younos TB. 2020. Climate change impacts and adaptations on health of internally displaced people (IDP): an exploratory study on coastal areas of Bangladesh. *Heliyon* 6(9):e05018
20. Cloos P, Ridde V. 2018. Research on climate change, health inequities, and migration in the Caribbean. *Lancet Planet. Health* 2:e4–5
21. Coates SJ, Norton SA. 2021. The effects of climate change on infectious diseases with cutaneous manifestations. *Int. J. Women's Dermatol.* 7:8–16
22. Cundill G, Singh C, Adger WN, Safra de Campos R, Vincent K, et al. 2021. Toward a climate mobilities research agenda: intersectionality, immobility, and policy responses. *Glob. Environ. Chang.* 69:102315
23. Dannenberg AL, Frumkin H, Hess JJ, Ebi KL. 2019. Managed retreat as a strategy for climate change adaptation in small communities: public health implications. *Clim. Change* 153:1–14
24. Dayrit JF, Sugiharto A, Coates SJ, Lucero-Prisno DE 3rd, Davis MDD, Andersen LK. 2022. Climate change, human migration, and skin disease: Is there a link? *Int. J. Dermatol.* 61:127–38
25. DiGiorgi E, Michielin P, Michielin D. 2020. Perception of climate change, loss of social capital and mental health in two groups of migrants from African countries. *Ann. Ist. Super. Sanita* 56:150–56
26. Ebi KL, McLeman R. 2022. Climate-related migration and displacement. *BMJ* 379:o2389
27. Ebi KL, Vanos J, Baldwin JW, Bell JE, Hondula DM, et al. 2021. Extreme weather and climate change: population health and health system implications. *Annu. Rev. Public Health* 42:293–315
28. Emont JP, O'Brien S, Nosa V, Toll ET, Goldman R. 2021. Characterizing the health experience of Tuvaluan migrants in Auckland, New Zealand. *Int. J. Migr. Health Soc. Care* 17:508–24
29. Furusawa T, Pitakaka F, Gabriel S, Sai A, Tsukahara T, Ishida T. 2021. Health and well-being in small island communities: a cross-sectional study in the Solomon Islands. *BMJ Open* 11:e055106
30. Gemenne F. 2011. How they became the human face of climate change. Research and policy interactions in the birth of the "environmental migration" concept. In *Migration and Climate Change*, ed. E Piguet, A Pécoud, P de Guchteneire, pp. 225–59. Cambridge, UK: Cambridge Univ. Press
31. Haque MR, Parr N, Muhidin S. 2020. The effects of household's climate-related displacement on delivery and postnatal care service utilization in rural Bangladesh. *Soc. Sci. Med.* 247:e112819
32. Haque R, Parr N, Muhidin S. 2020. Climate-related displacement, impoverishment and healthcare accessibility in mainland Bangladesh. *Asian Popul. Stud.* 16:220–39
33. Hayward G, Ayeb-Karlsson S. 2021. 'Seeing with empty eyes': a systems approach to understand climate change and mental health in Bangladesh. *Clim. Change* 165:29. **https://doi.org/10.1007/s10584-021-03053-9**
34. Herring SC, Christidis N, Hoell A, Hoerling MP, Stott PA. 2020. Explaining extreme events of 2018 from a climate perspective. *Bull. Am. Meteorol. Soc.* 101:S1–128
35. Huang C, Vaneckova P, Wang X, Fitzgerald G, Guo Y, Tong S. 2011. Constraints and barriers to public health adaptation to climate change: a review of the literature. *Am. J. Prev. Med.* 40:183–90
36. Hunter LM, Koning S, Fussell E, King B, Rishworth A, et al. 2021. Scales and sensitivities in climate vulnerability, displacement, and health. *Popul. Environ.* 43:61–81
37. IDMC (Intern. Displac. Monit. Cent.). 2021. *Global report on internal displacement 2021*. Rep., IDMC, Geneva. **https://www.internal-displacement.org/global-report/grid2021/**
38. IPCC (Intergov. Panel Clim. Change). 2022. *Climate change 2022: impacts, adaptation, and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Rep., IPCC, Cambridge Univ. Press, Cambridge, UK. **https://www.ipcc.ch/report/ar6/wg2/**
39. Kabir ME, Kamruzzaman P. 2022. Exploring the drivers of vulnerability among disadvantaged internal migrants in riverbank erosion prone areas in north-west Bangladesh. *J. South Asian Dev.* 17(1):57–83
40. Kaczan DJ, Orgill-Meyer J. 2020. The impact of climate change on migration: a synthesis of recent empirical insights. *Clim. Change* 158:281–300
41. Kelman I, Ayeb-Karlsson S, Rose-Clarke K, Prost A, Ronneberg E, et al. 2021. A review of mental health and wellbeing under climate change in small island developing states (SIDS). *Environ. Res. Lett.* 16:033007
42. Koslov L, Merdjanoff A, Sulakshana E, Klinenberg E. 2021. When rebuilding no longer means recovery: the stress of staying put after Hurricane Sandy. *Clim. Change* 165:59

43. Lebel L, Paquin V, Kenny T-A, Fletcher C, Nadeau L, et al. 2022. Climate change and Indigenous mental health in the Circumpolar North: a systematic review to inform clinical practice. *Transcult. Psychiatry* 59(3):312–36
44. Li J, Spidalieri K. 2021. Home is where the safer ground is: the need to promote affordable housing laws and policies in receiving communities. *J. Environ. Stud. Sci.* 11:682–95
45. Lindvall K, Kinsman J, Abraha A, Dalmar A, Abdullahi MF, et al. 2020. Health status and health care needs of drought-related migrants in the horn of Africa—a qualitative investigation. *Int. J. Environ. Res. Public Health* 17:5917
46. Loebach P, Korinek K. 2019. Disaster vulnerability, displacement, and infectious disease: Nicaragua and Hurricane Mitch. *Popul. Environ.* 40:434–55
47. Lundgren-Kownacki K, Kjellberg SM, Gooch P, Dabaieh M, Anandh L, Venugopal V. 2018. Climate change-induced heat risks for migrant populations working at brick kilns in India: a transdisciplinary approach. *Int. J. Biometeorol.* 62:347–58
48. Mach KJ, Siders AR. 2021. Reframing strategic, managed retreat for transformative climate adaptation. *Science* 372:1294–99
49. Mazhin SA, Khankeh H, Farrokhi M, Aminizadeh M, Poursadeqiyan M. 2020. Migration health crisis associated with climate change: a systematic review. *J. Educ. Health Promot.* 9:97
50. McDonnell S. 2021. The importance of attention to customary tenure solutions: slow onset risks and the limits of Vanuatu's climate change and resettlement policy. *Curr. Opin. Environ. Sustain.* 50:281–88
51. McLeman RA, Hunter LM. 2010. Migration in the context of vulnerability and adaptation to climate change: insights from analogues. *Wiley Interdisc. Rev. Clim. Change* 1:450–61
52. McMichael C. 2020. Human mobility, climate change, and health: unpacking the connections. *Lancet Planet. Health* 4:e217–18
53. McMichael C, Barnett J, McMichael AJ. 2012. An ill wind? Climate change, migration, and health. *Environ. Health Perspect.* 120:646–54
54. McMichael C, Powell T. 2021. Planned relocation and health: a case study from Fiji. *Int. J. Environ. Res. Public Health* 18(8):4355
55. Messeri A, Morabito M, Bonafede M, Bugani M, Levi M, et al. 2019. Heat stress perception among native and migrant workers in Italian industries—case studies from the construction and agricultural sectors. *Int. J. Environ. Res. Public Health* 16(7):1090
56. Middleton J, Cunsolo A, Jones-Bitton A, Wright CJ, Harper SL. 2020. Indigenous mental health in a changing climate: a systematic scoping review of the global literature. *Environ. Res. Lett.* 15:053001
57. Nand MM, Bardsley DK. 2020. Climate change loss and damage policy implications for Pacific Island countries. *Local Environ.* 25:725–40
58. Negev M, Teschner N, Rosenthal A, Levine H, Lew-Levy C, Davidovitch N. 2019. Adaptation of health systems to climate-related migration in Sub-Saharan Africa: closing the gap. *Int. J. Hyg. Environ. Health* 222:311–14
59. Orievulu K, Ayeb-Karlsson S, Ngwenya N, Ngema S, McGregor H, et al. 2022. Economic, social and demographic impacts of drought on treatment adherence among people living with HIV in rural South Africa: a qualitative analysis. *Climate Risk Manag.* 36:100423
60. Pardhi A, Jungari S, Kale P, Bomble P. 2020. Migrant motherhood: maternal and child health care utilization of forced migrants in Mumbai, Maharashtra, India. *Child. Youth. Serv. Rev.* 110:104823
61. Parry L, Radel C, Adamo SB, Clark N, Counterman M, et al. 2019. The (in)visible health risks of climate change. *Soc. Sci. Med.* 241:112448
62. Patel A, Giri J. 2019. Climate change, migration and women: analysing construction workers in Odisha. *Soc. Change* 49:97–113
63. Perkins-Kirkpatrick SE, Stone DA, Mitchell DM, Rosier S, King AD, et al. 2022. On the attribution of the impacts of extreme weather events to anthropogenic climate change. *Environ. Res. Lett.* 17:024009
64. Piggott-McKellar AE, McMichael C. 2021. The immobility-relocation continuum: diverse responses to coastal change in a small island state. *Environ. Sci. Policy* 125:105–15
65. Piguet E, Kaenzig R, Guélat J. 2018. The uneven geography of research on "environmental migration." *Popul. Environ.* 39:357–83

66. Pradhan B, Kjellstrom T, Atar D, Sharma P, Kayastha B, et al. 2019. Heat stress impacts on cardiac mortality in Nepali migrant workers in Qatar. *Cardiology* 143:37–48
67. Rahaman MA, Rahman MM, Bahauddin KM, Khan S, Hassan S. 2018. Health disorder of climate migrants in Khulna City: an urban slum perspective. *Int. Migr.* 56:42–55
68. Rakib MA, Sasaki J, Matsuda H, Fukunaga M. 2019. Severe salinity contamination in drinking water and associated human health hazards increase migration risk in the southwestern coastal part of Bangladesh. *J. Environ. Manag.* 240:238–48
69. Reuveny R. 2007. Climate change-induced migration and violent conflict. *Polit. Geogr.* 26:656–73
70. Reuveny R. 2021. Climate-related migration and population health: social science-oriented dynamic simulation model. *BMC Public Health* 21:598
71. Ridde V, Benmarhnia T, Bonnet E, Bottger C, Cloos P, et al. 2019. Climate change, migration and health systems resilience: need for interdisciplinary research. *F1000Research* 8:22
72. Rigaud KK, De Sherbinin A, Jones B, Bergmann J, Clement V, et al. 2018. *Groundswell: preparing for internal climate migration*. Rep., World Bank, Washington, DC. **https://openknowledge.worldbank.org/handle/10986/29461**
73. Romanello M, McGushin A, Di Napoli C, Drummond P, Hughes N, Jamart L. 2021. The 2021 report of the *Lancet* Countdown on health and climate change: code red for a healthy future. *Lancet* 398:1619–62
74. Sabasteanski ND. 2021. Climate migration and health system preparedness in the United States. *Clim. Policy* 21:368–82
75. Savage A, McIver L, Schubert L. 2020. Review: the nexus of climate change, food and nutrition security and diet-related non-communicable diseases in Pacific Island countries and territories. *Clim. Dev.* 12:120–33
76. Scheerens C, Bekaert E, Ray S, Essuman A, Mash B, et al. 2021. Family physician perceptions of climate change, migration, health, and healthcare in Sub-Saharan Africa: an exploratory study. *Int. J. Environ. Res. Public Health* 18(12):6323
77. Scheerens C, Madzimbamuto FD. 2021. Climate change, migration, and health(care) in primary care training. *Afr. J. Prim. Health Care Fam. Med.* 13(1):3227
78. Scheerens C, Ruyssen I, Ray S, De Sutter A, Vanhove W, et al. 2020. Tackling adverse health effects of climate change and migration through intersectoral capacity building in Sub-Saharan Africa. *BJGP Open* 4(2). **https://doi.org/10.3399/bjgpopen20X101065**
79. Schütte S, Gemenne F, Zaman M, Flahault A, Depoux A. 2018. Connecting planetary health, climate change, and migration. *Lancet Planet. Health* 2:e58–59
80. Schwerdtle PN, Baernighausen K, Karim S, Raihan TS, Selim S, et al. 2021. A risk exchange: health and mobility in the context of climate and environmental change in Bangladesh—a qualitative study. *Int. J. Environ. Res. Public Health* 18:2629
81. Schwerdtle PN, Bowen K, McMichael C, Sauerborn R. 2019. Human mobility and health in a warming world. *J. Travel Med.* 26(1):tay160
82. Schwerdtle PN, McMichael C, Mank I, Sauerborn R, Danquah I, Bowen KJ. 2020. Health and migration in the context of a changing climate: a systematic literature assessment. *Environ. Res. Lett.* 15:103006
83. Semenza JC, Ebi KL. 2019. Climate change impact on migration, travel, travel destinations and the tourism industry. *J. Travel Med.* 26(5):taz026
84. Shultz JM, Rechkemmer A, Rai A, McManus KT. 2019. Public health and mental health implications of environmentally induced forced migration. *Disaster Med. Public Health Prep.* 13:116–22
85. Solecki W, Friedman E. 2021. At the water's edge: coastal settlement, transformative adaptation, and well-being in an era of dynamic climate risk. *Annu. Rev. Public Health* 42:211–32
86. Stapleton SO, Nadin R, Watson C, Kellett J. 2017. *Climate change, migration and displacement: the need for a risk-informed and coherent approach*. Rep., Overseas Dev. Inst., London. **https://cdn.odi.org/media/documents/11874.pdf**
87. Stoler J, Brewis A, Kangmennang J, Keough SB, Pearson AL, et al. 2021. Connecting the dots between climate change, household water insecurity, and migration. *Curr. Opin. Environ. Sustain.* 51:36–41
88. Tacoli C. 2009. Crisis or adaptation? Migration and climate change in a context of high mobility. *Environ. Urban.* 21:513–25

89. Tenzing JD. 2020. Integrating social protection and climate change adaptation: a review. *Wiley Interdisc. Rev. Climate Change* 11:e626
90. Tshimanga RM, Lutonadio G-SK, Kabujenda NK, Sondi CM, Mihaha E-TN, et al. 2021. An integrated information system of climate-water-migrations-conflicts nexus in the Congo basin. *Sustainability* 13(16):9323
91. Uddin R, Philipsborn R, Smith D, Mutic A, Thompson LM. 2021. A global child health perspective on climate change, migration and human rights. *Curr. Probl. Pediatr. Adolesc. Health Care* 51:101029
92. Uscher-Pines L. 2009. Health effects of relocation following disaster: a systematic review of the literature. *Disasters* 33:1–22
93. van Daalen KR, Dada S, Issa R, Chowdhury M, Jung L, et al. 2021. A scoping review to assess sexual and reproductive health outcomes, challenges and recommendations in the context of climate migration. *Front. Glob. Womens Health* 2:757153
94. van der Geest K, Burkett M, Fitzpatrick J, Stege M, Wheeler B. 2020. Climate change, ecosystem services and migration in the Marshall Islands: Are they related? *Clim. Change* 161:109–27
95. Vann M, Bodenmann P, Senn N, Morisod K. 2021. [Climate migration and inequities: a major global health issue.] *Rev. Med. Suisse* 17:263–67 (in French)
96. Vinke K, Rottmann S, Gornott C, Zabre P, Nayna Schwerdtle P, Sauerborn R. 2022. Is migration an effective adaptation to climate-related agricultural distress in sub-Saharan Africa? *Popul. Environ.* 43:319–45
97. Voyatzis-Bouillard D, Kelman I. 2021. Do climate change interventions impact the determinants of health for Pacific Island peoples? A literature review. *Contemp. Pac.* 33:466–96
98. Woodhall-Melnik J, Grogan C. 2019. Perceptions of mental health and wellbeing following residential displacement and damage from the 2018 St. John River flood. *Int. J. Environ. Res. Public Health* 16(21):4174
99. Yates OET, Manuela S, Neef A, Groot S. 2021. Reshaping ties to land: a systematic review of the psychosocial and cultural impacts of Pacific climate-related mobility. *Clim. Dev.* 14(3):250–67

Annual Review of Public Health
Volume 44, 2023

Contents

Epidemiology and Biostatistics

Social Environment and Behavior

Environmental and Occupational Health

Public Health Practice and Policy

Health Services

Indexes

Errata

An online log of corrections to *Annual Review of Public Health* articles may be found at http://www.annualreviews.org/errata/publhealth

Related Articles

From the ***Annual Review of Animal Biosciences***, Volume 11 (2023)

Animal Models, Zoonotic Reservoirs, and Cross-Species Transmission of Emerging Human-Infecting Coronaviruses
Yakhouba Kane, Gary Wong, and George F. Gao

Domestic Animals as Potential Reservoirs of Zoonotic Viral Diseases
Oyewale Tomori and Daniel O. Oluwayelu

From the ***Annual Review of Biomedical Data Science***, Volume 5 (2022)

Genome Privacy and Trust
Gamze Gürsoy

Developing and Implementing Predictive Models in a Learning Healthcare System: Traditional and Artificial Intelligence Approaches in the Veterans Health Administration
David Atkins, Christos A. Makridis, Gil Alterovitz, Rachel Ramoni, and Carolyn Clancy

From the ***Annual Review of Cancer Biology***, Volume 6 (2022)

Tracing and Targeting the Origins of Childhood Cancer
Tim H.H. Coorens and Sam Behjati

From the ***Annual Review of Clinical Psychology***, Volume 18 (2022)

Cognitive Aging and the Promise of Physical Activity
Kirk I. Erickson, Shannon D. Donofry, Kelsey R. Sewell, Belinda M. Brown, and Chelsea M. Stillman

Police Violence and Public Health
Jordan E. DeVylder, Deidre M. Anglin, Lisa Bowleg, Lisa Fedina, and Bruce G. Link

The Psychology of Pandemics
Steven Taylor

From the ***Annual Review of Criminology***, Volume 6 (2023)

The Opioid Crisis: The War on Drugs Is Over. Long Live the War on Drugs
Marie Gottschalk

From the ***Annual Review of Developmental Psychology***, Volume 4 (2022)

Practice and Policy Regarding Child Neglect: Lessons from Studies of Institutional Deprivation
Charles H. Zeanah and Lucy S. King

From the ***Annual Review of Economics***, Volume 14 (2022)

The Impact of Health Information and Communication Technology on Clinical Quality, Productivity, and Workers
Ari Bronsoler, Joseph Doyle, and John Van Reenen

The Economics of the COVID-19 Pandemic in Poor Countries
Edward Miguel and Ahmed Mushfiq Mobarak

The Affordable Care Act After a Decade: Industrial Organization of the Insurance Exchanges
Benjamin Handel and Jonathan Kolstad

From the ***Annual Review of Environment and Resources***, Volume 47 (2022)

COVID-19 and the Environment: Short-Run and Potential Long-Run Impacts
Noah S. Diffenbaugh

Sustainability in Health Care
Howard Hu, Gary Cohen, Bhavna Sharma, Hao Yin, and Rob McConnell

Agrochemicals, Environment, and Human Health
P. Indira Devi, M. Manjula, and R.V. Bhavani

The Concept of Adaptation
Ben Orlove

From the ***Annual Review of Law and Social Science***, Volume 18 (2022)

Good Law to Fight Bad Bugs: Legal Responses to Epidemics
Carol A. Heimer and Clay Davis

Environmental Legal Mobilization
Lisa Vanhala

From the ***Annual Review of Medicine***, Volume 74 (2023)

COVID-19: Challenges of Viral Variants
Jana L. Jacobs, Ghady Haidar, and John W. Mellors

Post-COVID-19 Condition
Ani Nalbandian, Amar D. Desai, and Elaine Y. Wan

Maternal Mortality in the United States: Trends and Opportunities for Prevention
Siwen Wang, Kathryn M. Rexrode, Andrea A. Florio, Janet W. Rich-Edwards, and Jorge E. Chavarro

Diverse Approaches to Gene Therapy of Sickle Cell Disease
Shanna L. White, Kevyn Hart, and Donald B. Kohn

From the ***Annual Review of Nutrition***, Volume 42 (2022)

The Importance of Food Processing and Eating Behavior in Promoting Healthy and Sustainable Diets
Ciarán G. Forde and Eric A. Decker

Folic Acid and the Prevention of Birth Defects: 30 Years of Opportunity and Controversies
Krista S. Crider, Yan Ping Qi, Lorraine F. Yeung, Cara T. Mai, Lauren Head Zauche, Arick Wang, Kelicia Daniels, and Jennifer L. Williams

Advancing Health Equity Efforts to Reduce Obesity: Changing the Course
Shiriki K. Kumanyika

From the ***Annual Review of Political Science***, Volume 25 (2022)

Three Faces of Climate Justice
Nives Dolšak and Aseem Prakash

Media and Policy Making in the Digital Age
Emiliano Grossman

From the ***Annual Review of Psychology***, Volume 74 (2023)

Psychology of Climate Change
Linda Steg

From the ***Annual Review of Statistics and Its Application***, Volume 9 (2022)

Is There a Cap on Longevity? A Statistical Review
Léo R. Belzile, Anthony C. Davison, Jutta Gampe, Holger Rootzén, and Dmitrii Zholud

Framing Causal Questions in Life Course Epidemiology
Bianca L. De Stavola, Moritz Herle, and Andrew Pickles

From the ***Annual Review of Virology***, Volume 9 (2022)

Lessons from Acquired Natural Immunity and Clinical Trials to Inform Next-Generation Human Cytomegalovirus Vaccine Development
Xintao Hu, Hsuan-Yuan Wang, Claire E. Otero, Jennifer A. Jenks, and Sallie R. Permar