Virulence 6:6, 544–549; August/September 2015; © 2015 Taylor & Francis Group, LLC

Climate change-related migration and infectious disease

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Keywords: climate change, displacement, health, infection, infectious disease, migration, mobility, population health, resettlement

Abbreviations: GMS, Greater Mekong Subregion; HEV, Hepatitis E Virus; HIV, Human Immunodeficiency Virus; IPCC, Intergovernmental Panel on Climate Change; STIs, Sexually transmissible infections; TB, Tuberculosis; WHA, World Health Assembly.

Anthropogenic climate change will have significant impacts on both human migration and population health, including infectious disease. It will amplify and alter migration pathways, and will contribute to the changing ecology and transmission dynamics of infectious disease. However there has been limited consideration of the intersections between migration and health in the context of a changing climate. This article argues that climate-change related migration - in conjunction with other drivers of migration – will contribute to changing profiles of infectious disease. It considers infectious disease risks for different climate-related migration pathways, including: forced displacement, slow-onset migration particularly to urban-poor areas, planned resettlement, and labor migration associated with climate change adaptation initiatives. Migration can reduce vulnerability to climate change, but it is critical to better understand and respond to health impacts – including infectious diseases - for migrant populations and host communities.

Introduction

Much of the population mobility throughout human history has been an adaptive response to changing environmental and climatic conditions.[1] Contemporary migration, however, is shaped by complex and diverse factors including globalisation and trade, innovations in travel and communication, transnational migrant networks, profound socio-economic disparities, skill shortages, demographic change, economic and political crises and conflicts, shifting capital, and the search for opportunities in work and education. Climate change will amplify many of these migration drivers, and will create additional pressures that contribute to the displacement and migration of individuals, families and communities. With now very strong consensus among climate scientists that anthropogenic climate change is occurring, increasing research, policy and humanitarian attention is focused on understanding the connections between climate change and migration, including the human, social and political consequences.

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Submitted: 08/14/2014; Revised: 02/11/2015; Accepted: 02/15/2015
http://dx.doi.org/10.1080/21505594.2015.1021539

Climate change is anticipated to contribute to substantial increases in human population movement in coming decades.[2-6] Migration is likely to occur in response to environmental changes, including both slow-onset change (e.g. sea-level rise, drought, food insecurity) and fast-onset changes (e.g., extremes of flooding, cyclones).[7] Environmental and social impacts of climate change result in diverse risks to human health. With the prospect of increasing human migration and mobility in response to environmental changes, it is important to understand the many different health risks and the public health needs of those who are forcibly displaced or who migrate.

This review discusses the intersections – current and forecast - between climate change, human migration and infectious disease. First, it provides a brief overview of the (much debated) associations between climate change and population movement. Evidence for the links between climate change-related human migration and infectious disease is then discussed in relation to 4 different migratory responses: forced displacement, slow-onset migration particularly to urban-poor areas, planned resettlement, and labor migration associated with climate change adaptation initiatives. This section draws on examples from Bangladesh, China, the Horn of Africa, and the Greater Mekong Subregion (GMS). Some of these are examples-by-analogy since the migration experiences and associated infectious disease outcomes are not the result of climate change. However, given the limited current level of migration that is clearly attributable to climate change, these examples serve as a proxy for understanding potential future health outcomes of climate change-related migration. The final discussion considers implications for climate change adaptation planning and policy response.

Climate change and population movement

The impact of anthropogenic climate change on migration is now of critical concern and extensively debated.[4,8-13] Most frameworks, descriptive or analytic, start with climate change as a driver of population mobility, and consider the potential numbers of affected people and pathways for their migration.[14] Climate change is anticipated to increase population movement

through: (1) an increase in the intensity and frequency of extreme weather events and climate-related disasters; (2) loss of arable and habitable land, such as people who lose island habitats or coastal or riverine terrestrial land due to sea-level rise; and (3) adverse impacts on ecosystems that are important sources of amenity and livelihood, including land degradation, declining abundance of fish, erosion of river banks and beaches, declining freshwater availability, and coral degradation.[8,15,16] These climatic changes will have diverse impacts, ranging across a spectrum of 'forced' to voluntary' migration, short- to long-distance, and permanent, circular, seasonal and short-term movement.

Climate change, however, rarely acts on its own; it is one of a number of factors that intersect to cause migration.[14,17] For less developed countries in particular, social, demographic, political and economic stressors – e.g. high population density, limited economic opportunity and employment, inequitable distribution of resources and services, and armed conflict – will coexist with climate risks and influence decisions about migration.[6,8,11,12]

Nuanced views of environmentally-related migration further recognize human capacity to adapt to environmental changes, the significant barriers to migration for many affected people, and the sensitivities of existing migration flows to the added influence of climatic change.[2,13] Ability to migrate is facilitated by economic resources, social and human capital, and the availability of places and livelihoods to move to; poorer and vulnerable populations may be less able to migrate in response to environmental disaster and deterioration.[2,3] Climate change will also contribute to migration flows via indirect pathways such as, for example, labor migration and displacement associated with climate change adaptation infrastructure initiatives.

Climate change-related migration and infectious disease

The evidence and public discussion relating to the impacts of climate change has, to date, focused largely on effects on the natural and built environments. Yet there are critical outcomes at a human scale, including adverse impacts on both population health and migration.[18] Epidemiological studies have identified health risks associated with, for example, differences and extremes in temperature, climate-related natural disasters, altered food yield and water supply, and changing infectious disease patterns.[19,20] These outcomes signify that the basic environmental support systems for sustained biological health and for human security are being weakened or depleted. Yet the health impacts of climate change emerging from indirect causal pathways (i.e. those mediated through social, political and economic factors), such as health impacts of climate-related migration and displacement, have received limited consideration.[18,21-23]

Well-managed migration could provide an adaptive response that reduces the adverse health impacts of climate change.[24] When compared to their places of origin, some migrants may have better access to health care services in sites of settlement, better diets, cleaner environments, health-promoting economic benefits, and increased opportunities for social mobility.[25] Further, in many settings migrants can be healthier than host populations (i.e., 'the healthy migrant effect') because those who migrate generally have the resources and capacity to move.[25]

But the challenges associated with migration processes (predeparture, during transit/travel, following migration, during return visits), the vulnerabilities of certain migrant groups (e.g., irregular migrants, those originating from areas of poverty, forcibly displaced populations), and social-cultural structural constraints in host countries contribute to adverse health outcomes for many migrants.[26,27] For example, in 2 low-lying atoll nations in the Pacific region, The Republic of Kiribati and Tuvalu, urban migration associated with climate change and socioeconomic factors has been linked to a decline in human development indicators and increased stress on local health facilities.[28] And populations forcibly displaced by events linked (cautiously) to climate change – e.g. Hurricane Katrina and the Darfur conflict – have experienced adverse health consequences.[19,29]

Infectious disease risk is affected by migration. International and internal migration alters the distribution and incidence of infectious disease as migrating people are exposed to infection in new locations, serve as carriers of infection during transit and to their new sites of residence, or reintroduce infectious agents during return migration.[18,22] A population's prior level of immunity to particular infectious diseases is an important modulator of risks for both migrating and host populations.[27] Climate-related migration will potentially expose migrants to endemic diseases for which they have limited resistance or socio-cultural experience.[30,31] For example, people migrating through or into areas of high malaria endemicity are at particular risk of infection.[32] Conversely, migrants may bring with them infections such as tuberculosis (TB), hepatitis B and sexually transmissible infections (STIs) that can then spread within the host population.[18,22] Infectious disease risks also have social determinants associated with working and living conditions and health behaviors in sites of settlement, including migrants' access to health services (see **Fig. 1**).

The following sub-sections consider infectious disease risks associated with 4 broad migration processes that are anticipated to increase with climatic change. These sub-sections do not provide an exhaustive review of all infectious disease risks, but rather – by drawing on analogous examples from the wider migration-health research - point to the potential relationship between climate-related migration and infectious disease. Though not discussed in depth here, climate change can also present infectious disease risks for immobile populations who do not have the resources to move: for example, those left behind following environmental disaster may experience risks due to the impact of the disaster on disease vectors, water and sanitation systems, shelter, and public health infrastructure and services.[3,33]

Forced displacement

Climate-related migration will include 'forced' displacement in response to sudden-onset environmental disasters such as floods and cyclones.[2] Some analyses also suggest that the effects of climate change and climate-related migration may increase the risk of civil conflict, leading to further forced displacement.[34] This 'forced' displacement will be influenced by social-cultural

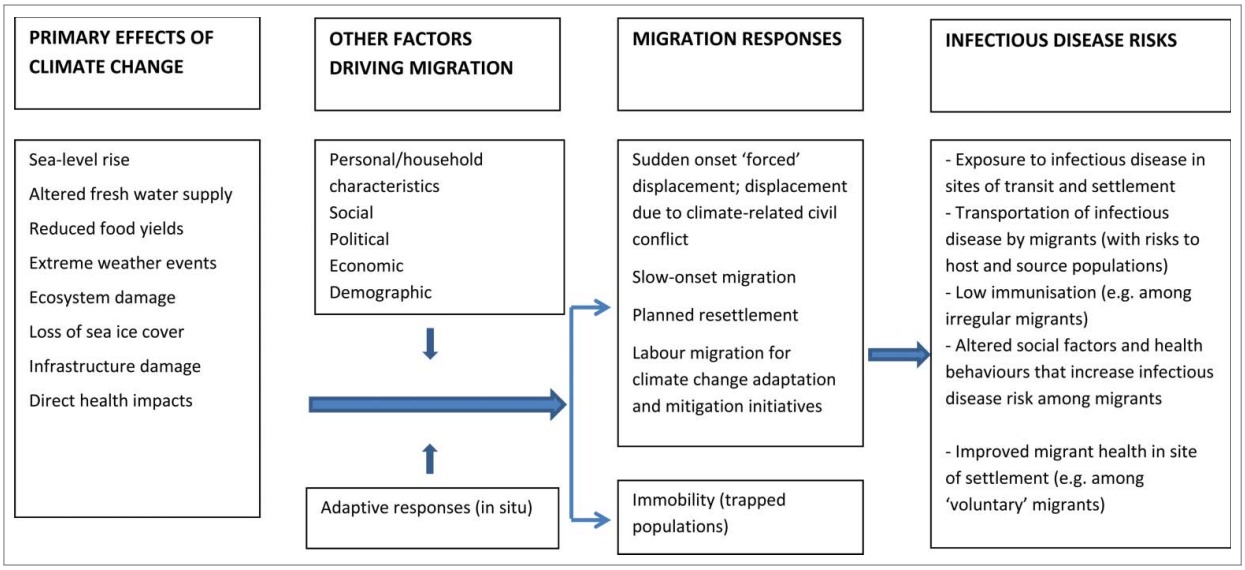

Figure 1. Climate change effects, migration responses and infectious disease risks.

and structural factors – economic, political, social, demographic – that shape vulnerability.[3,4,14]

Few studies have examined the health impacts of forced displacement and relocation following environmental disaster; the health impacts of forced displacement following conflict are better understood.[35,36] Forced displacement (particularly in developing regions) typically increases the risks of adverse health outcomes – including morbidity and mortality associated with infectious disease - due to crowding, poor ventilation, inadequate shelter, a lack of basic necessities such as food and water, inadequate public health resources, reduced access to health services and immunization, and loss of social networks and assets.[36,37] The more common infectious diseases in post-disaster contexts include diarrheal disease, measles, meningitis, acute respiratory infections, tuberculosis, and malaria.[38,39] Social instability associated with large-scale displacement also presents high-risk situations for the spread of STIs including HIV infection.[36] And pandemics, such as the influenza A (H1N1) virus, are of concern in crowded camp settings with often under-nourished populations.[40] Where climate-driven disasters contribute to forced displacement, infectious disease prevention and management is likely to require a significant public health response.

In 2011, the Horn of Africa experienced the worst drought in recent history following a decade of disrupted rainfall patterns, which led to severe food insecurity in East Africa.[41] In conjunction with other pre-existing vulnerabilities in the region – e.g., poverty, conflict and political violence, contracting labor opportunities, socio-economic inequalities, governance failure, inadequate access to humanitarian assistance – the drought contributed to highly increased levels of displacement, particularly to Kenya and Ethiopia. Within one month of the drought beginning, the world's largest refugee camp - Dadaab refugee camp in Eastern Kenya – had expanded to 353,921 people, 4 times its capacity.[42] Overcrowding and poor sanitation led to outbreaks of enteric diseases, including cholera and shigellosis (i.e. bacillary dysentery). In September 2012, in Dadaab refugee camp, an outbreak of cholera occurred simultaneously with an outbreak of acute Hepatitis E virus (HEV). Control measures included construction of new latrines and hygiene messaging, however the response to the outbreak was constrained by significant security risks and the difficulties in implementing effective prevention measures under camp conditions.[43] Migration during the 2011 drought cannot be ascribed solely to environmental conditions, as droughts and associated food insecurity interact with broader social, political and historical processes. As this example illustrates, however, climate-related environmental disaster is typically a risk multiplier that contributes to forced displacement and can increase risk of infectious disease, particularly in camp settings.

Slow-onset migration

Longer-term environmental changes – e.g. declines in agricultural yields, increasing physical risks from sea-level rise - can drive population migration and mobility as people seek to move to areas where livelihoods, land, and food sources are available.[44-46] This amplifies the existing trend globally of rural-urban migration, particularly within and between developing countries.[14,16] For example, increased flooding in the Mekong Delta has contributed to internal displacement and seasonal migration to urban centers, particularly Phnom Penh and Ho Chi Minh City.[47] In industrialised nations, urbanisation has contributed to an overall improvement of health and to a major shift in disease patterns toward a rise in non-communicable diseases.[48] However, in low-income countries, people who migrate to crowded urban-poor environments face exposure to pathogens and a range of infectious disease risks.[49]

The heterogeneity in health status of urban residents, crowding and increased rates of contact, and mobility, results in a high risk of disease transmission in urban populations.[48] Some national and municipal governments do not have the resources

to cope with the influx of migrants or the demographic growth of urban centers, and there is inadequate infrastructure (e.g., water and sanitation), health and education facilities all of which further increase infectious disease risks.[48] New infectious diseases (e.g. intestinal parasites, multi-drug resistant malaria) may be introduced by migrants to host populations.[50] Further, many urban poor communities are in locations at high risk of adverse climate change impacts, including water shortages, sea-level rise, flooding, and elevated rates of infectious disease.[51,52] People who migrate into such settings face an increased risk of infectious disease.

In Bangladesh, for example, over recent decades there has been continuing migration of poor rural families (including those affected by tidal surge floods and riverbank erosion) into large and crowded slum settlements of Dhaka. Relocating Bangladeshis face infectious disease risks including diarrheal diseases, skin infections, and mosquito-borne infections including dengue. Bangladesh (and the South Asia region) is vulnerable to an increase in dengue as temperatures rise and rainfall episodes become more intensive, particularly in large urban slums in tropical cities. A recent modeling study projected Dhaka's future dengue transmission risk extending to 2100 based on: i) Dhaka's average temperature data and reported dengue rates for the 2000-2010 period; ii) projected annual population growth rate; and iii) a medium IPCC climate change scenario which entails an estimated increase of 3.3°C in South Asia between 1980-1999 and 2080-2099. The annual rates of dengue fever in Dhaka were projected to increase 2-fold by 2100 for a 1°C temperature rise, 7-fold for a 2°C rise, and approximately 40-fold for a 3.3°C rise.[53] As this example indicates, climate-related migration to urban poor areas may expose populations to infectious disease risks, risks that may be further elevated by climate change.

Planned resettlement

Planned resettlement can serve as an adaptation measure that reduces vulnerability to climate change impacts, particularly for populations in low-lying islands and coastal deltas.[54,55] Climate-related resettlement planning is occurring in various sites, including coastal and low-lying settlements in the Pacific Islands, communities in the Mekong River delta of Vietnam, the Inner Mongolia Autonomous Region of China, and indigenous communities in Alaska that have in recent decades experienced erosion, flooding and loss of sea ice cover (i.e., Alaska).[4,56] Further, large-scale climate change mitigation and adaptation schemes will result in significant population displacement and planned resettlement (e.g., dams for hydropower and water storage, biofuel plantations).[56]

Evidence related to development forced displacement and resettlement indicates, however, that planned resettlement is often associated with adverse health outcomes, including increased infectious disease.[57,58,59,60] For example, the Three Gorges Dam in China is the largest of more than 60 hydrological modifications on the Yangtze River. Estimates of resettlement caused by the Three Gorges Dam vary widely, but over 1 million people have been displaced. Resettlement of communities has affected infectious disease dynamics. Due to resettlement in marginal agrarian environments, people have been exposed to infectious diseases during subsistence and livestock activities (e.g. schistosomiasis).[61] Relocation to crowded areas has increased risks of hepatitis, pneumonia, diarrheal diseases, and Hantavirus, and an outbreak of malaria has occurred at the dam site.[62] Planned resettlement schemes entail multiple threats to health and wellbeing, and their success and legitimacy depend on effective and participatory planning and implementation processes, including provision of preventive health services and addressing the social determinants of health.[4,56]

Labor migration for climate change adaptation initiatives

The intersections between climate change, migration and infectious disease will also operate via less direct pathways, such as through the influx of migrant workers (and their families) to meet the workforce demands of climate change adaptation infrastructure initiatives. For example, the Asian Development Bank provides support for climate resilience measures and disaster risk management, such as the GMS Southern Economic Corridor Towns Development Project which aims to protect urban infrastructure (e.g., water supply and sanitation facilities) from the impact of floods, and to transform transport corridors in the GMS. Yet development projects such as this attract labor migrants (including through unregulated pathways) who often have poor health outcomes including elevated rates of infectious diseases (e.g. malaria, TB, HIV) due to diverse social, behavioral and environmental determinants and lower immunisation rates.[63,64] Further, the influx of foreign workers can bring infectious agents to new sites of residence.

With assessment of the potential elevated health risks of infectious disease associated with labor migration, effective health services and programs can be developed as well as strategies to address social determinants of health (e.g., adequate housing, water and sanitation). In Laos, the arrival of workers for construction of the Nam Theun 2 hydroelectric scheme (one of the largest infrastructure development projects in Southeast Asia) was expected to lead to an increased incidence of infectious disease (e.g. malaria, HIV, TB, acute respiratory infection) for both workers and local populations.[65] Health sector infrastructure, human resource development, health education, service delivery, and surveillance and monitoring were established that reportedly led to improved nutritional status of children, reduced infant mortality, improved utilization of health services, and reduced parasitic infestation. These examples highlight the complex linkages between climate change, development and adaptation processes, labor migration and infectious disease.

Conclusion

Climate change will significantly shape the scale and nature of migration in coming decades.[4] Rather than being viewed as a crisis to be contained, migration is increasingly understood as an adaptive response to the effects of climate change.[5,8,66,67] The UK Government's Foresight report on migration and global

environmental change contends that migration related to environmental change will offer opportunities as well as challenges.[3] The 2010 Cancun Adaptation Framework calls for 'measures to enhance understanding, coordination and cooperation with regard to climate change-induced displacement, migration and planned relocation, where appropriate, at national, regional and international levels'.[68] Migration may be an effective way for people to increase resilience and diversify incomes in the face of environmental change and associated vulnerability. Yet the health of migrants and host communities can be adversely affected during migration processes and in sites of relocation or settlement. Indeed, the 2008 World Health Assembly (WHA) and the 2010 Global Consultation on Migrant Health have directed focus toward migrants' vulnerability to health problems.[69]

Climate change-related migration processes and contexts will varyingly shape health outcomes, and specifically infectious disease, among migrants and host communities. In order to support migration as an adaptive response to climate change, it is critical to better understand and respond to health impacts for migrant populations and host communities. Migration will be most effective as an adaptive response to climate change when it occurs in supportive social and political contexts, which requires health systems, resources, policies and programs that address the health vulnerabilities and needs of migrant populations.[18,24]

Population health responses – research, policy advice and practice – need to take a multi-disciplinary and multi-sectoral perspective that can address the complexity (social, political, economic and environmental) of climate change-migration-health relationships. Climate-sensitive development policies should build local resilience by reducing the need to migrate away from adversely affected areas, protecting the rights and well-being of those who experience barriers to mobility, and supporting the adaptive potential of migration. Climate change presents a global challenge to international policy making, modes of production and consumption, eco-systems, economies, human and environmental research, and ethics. It is critical that the world community understands and responds in more coordinated ways to climate change-related migration and associated infectious disease risk and other health impacts.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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