Globalization of Infectious Diseases: The Impact of Migration

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With up to 2% of the world's population living outside of their country of birth, the potential impact of population mobility on health and on use of health services of migrant host nations is increasing in its importance. The drivers of mobility, the process of the international movement, and the back-and-forth transitioning between differential risk environments has significance for the management of infectious diseases in migrant receiving areas. The management issues are broad, high-level, and cross-cutting, including policy decisions on managing the migration process for skilled-labor requirements, population demographic and biometric characteristics, and family reunification; to program issues encompassing health care professional education, training, and maintenance of competence; communication of global events of public health significance; development of management guidelines, particularly for nonendemic diseases; access to diagnostic and therapeutic interventions for exotic or rare clinical presentations; and monitoring of health service use and health outcomes in both the migrant and local populations.

Current estimates are that ~2% of the world's population resides in a nation different than the one in which they were born. Although small in terms of percentages, the total number of the foreign-born individuals living abroad is significant. Worldwide, the number is >200 million people, which is equivalent to the size of many large nations. These mobile, migrant populations are composed of several groups, including immigrants, migrant and seasonal workers, refugees, asylum seekers, international students, and others. Table 1 lists the numerical impacts of immigration on the major immigrant-receiving developed nations.

Historical patterns of immigration, seasonal work, and population flows coupled with the presence of national policies that encourage or support immigration as a source of population growth combine to ensure that the global distribution of these migrant populations is not uniform. Foreign-born residents make up significantly different percentages of national populations. Long-standing immigration policies in nations such as Australia, Canada, Israel, and the United States produce diverse national populations that reflect both recent and longer-term population flows, which in turn have an impact on health outcomes [6]. Other nations, particularly those in Europe, have foreign-born populations that are reflective of refugee movements, asylum seeking, or temporary worker flows.

In each of these cases, the health characteristics of the foreign-born or migrant cohorts of the populations are influenced by the health environments and situations at their place of original residence, the environments through which they made the transition, and their new destination [7]. For many migrants, the transition period is inconsequential in terms of health because of the short duration of transportation. For other migrants, such as those transitioning through refugee camps [8] or those experiencing trafficking or smuggling [9] as a means of arrival, the transition period can greatly affect health. If the health and disease parameters that influence the prevalence of infections at a migrant's point of origin and transition periods are different from those at the destination, the process of migration and travel can bridge the difference in disease prevalence and function as a method of transfer between regions.

The population-based downstream health impact and consequences of the epidemiological bridging produced by migration is directly related to 2 basic factors. The first is the degree of difference between origin and the destination [10], and the
second is the size of the mobile population that moves between
the different disease prevalence patterns. In 2002, >700 million
international arrivals were recorded [11]. Specific individual
health status and outcomes are influenced by several other fac-
tors, such as the amount of time spent in the location, complex
social and economic factors, access and availability to afford-
able health care, educational attainments, and cultural health
practices.

In terms of infectious disease epidemiology, the association
between the introduction of disease and migration has long
been recognized. Border health and quarantine medicine prac-
tices were developed out of attempts to control the importation
of epidemic infections. Over the past 40 years, both the process
and scope of migration have undergone several major shifts,
and many of those changes have altered the nature of migra-
tion-associated infectious disease.

Since the 1960s, the immigration patterns in many immi-
gration-receiving patterns have changed. Regions supplying im-
migrants to Australia, Canada, and the United States, which
were historically western and central European population
movements, have predominantly shifted to Latin American,
African, and Asian sources. Source regions are now more likely
to encompass less developed regions of the world, many in
tropical and subtropical environments. During the same period,
the conditions determining the overall health of the popula-
tion—including institutional health services and public health
capacities in many immigrant source areas—have experi-
cenced significant detrimental challenges. Developed regions
of the world have continued to make great strides in the control
of infectious diseases of significance to public health. Many
infections in the more developed regions are at historical levels
of low prevalence or elimination of endemic transmission.

In most immigrant source regions, infectious diseases con-
tinue to represent major causes of death and morbidity due to
respiratory infections, gastrointestinal and diarrheal diseases
[12], tuberculosis [13], and HIV infection/AIDS [14]. The risks
of infectious disease acquisition in those source nations are
manifest in certain immigrant and migrant populations after
they move to their new destination. As migration continues in
an increasingly globalized world, health care providers at the
primary care and specialist level can expect to be faced with
the challenges of recognition, diagnosis, and management of
diseases that are themselves the consequences of international
factors.

THE INCREASING IMPORTANCE
OF MIGRATION IN NATIONAL INFECTIOUS
DISEASE EPIDEMIOLOGY

During the past 50 years, many national and some interna-
tional disease control, immunization, and communicable disease
prevention strategies have been successful. Incidence and preva-
ience rates of many previously serious infections have decreased
dramatically. In several developed nations, local transmission
of vaccine-preventable diseases has practically ceased. However,
these successes have not been uniform, and infectious diseases
continue to be major causes of mortality and morbidity in some
regions of the world.

Immigrants and refugees originating from areas where in-
fec tions persist can pose a significant challenge for national
disease control and or elimination strategies. The factors that
support and sustain the prevalence of diseases in the less de-
veloped world are beyond the control of national and state/
provincial/municipal public health programs at the migrant’s
ultimate destination. As a consequence, the continued dispar-
ities in prevalence levels of infectious diseases in a world of
increasing travel and migration makes national disease control
or elimination almost impossible. These same factors also in-
crease the epidemiological likelihood that many infections that
are now very well controlled in the developed world will be
increasingly observed in migrant or foreign-born populations
resident in host destinations.

Tuberculosis is an example of the situation described above.
Beginning in the early part of the 20th century, extensive tub-
erculosis-control programs, coupled with the development of
effective pharmacotherapy, resulted in the marked reduction of
the prevalence of the disease in North America, Australia, and
many parts of Europe. Over the past 50 years, tuberculosis in

<table>
<thead>
<tr>
<th>Nation</th>
<th>Total population</th>
<th>Visible minority/ethnic population</th>
<th>Proportion of foreign born, Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>284,796,887</td>
<td>7,091,442 (24.9%)</td>
<td>11.1 US Census Bureau [1]</td>
</tr>
<tr>
<td>Australia</td>
<td>19,996,058</td>
<td>...</td>
<td>25 Australia Bureau of Statistics [2]</td>
</tr>
<tr>
<td>Canada</td>
<td>29,639,035</td>
<td>3,983,845 (13.4%)</td>
<td>18.4 Statistics Canada [3]</td>
</tr>
<tr>
<td>Israel</td>
<td>6,500,000</td>
<td>1,500,000 (Arabs, 23%)</td>
<td>42.2 Government of Israel—Ministry of Immigrant Absorption [5]</td>
</tr>
</tbody>
</table>

*a Calculation based on the arrival of 1 immigrant every 3 minutes and 51 s gives an estimate of 136,519 foreign-born persons arriving per year.

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Table 2. Selected imported infectious diseases illustrating high to low prevalence impacts.

<table>
<thead>
<tr>
<th>Disease or syndrome</th>
<th>High-prevalence regions</th>
<th>Impacts in low-prevalence zones</th>
<th>Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuberculosis</td>
<td>Africa, Asia</td>
<td>Acute infections in migrants; secondary, local transmission; multiple-drug resistance patterns</td>
<td>Delay in regional control or elimination program goals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Realignment of public health prevention and diagnosis resources; diminished resources for other programs</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Potential for introduction in susceptible wild animal reservoirs; establish zoonotic-human cycles</td>
<td></td>
</tr>
<tr>
<td>Severe acute respiratory syndrome</td>
<td>East and Southeast Asia</td>
<td>Outbreaks of atypical pneumonia and unexplained death</td>
<td></td>
</tr>
<tr>
<td>Monkeypox</td>
<td>Sub-Saharan Africa</td>
<td>Outbreaks of animal to human transmission with vesicular, febrile illness; potential for death</td>
<td></td>
</tr>
<tr>
<td>Leishmaniasis—viscerotropic and visceral</td>
<td>Middle East Asia, South Asia, Africa</td>
<td>Acute infections in migrants</td>
<td></td>
</tr>
<tr>
<td>Malaria—Plasmodium falciparum</td>
<td>Sub-Saharan Africa</td>
<td>Acute morbidity and mortality in migrants; potential for secondary transmission by mosquitoes or blood products</td>
<td></td>
</tr>
<tr>
<td>Strongyloidiasis</td>
<td>Global tropical zones: Africa, Southeast Asia</td>
<td>Acute dissemination syndromes; chronic eosinophilia syndromes with or without pulmonary involvement; chronic urticaria</td>
<td></td>
</tr>
<tr>
<td>West Nile virus–associated syndromes</td>
<td>Middle East Asia, North Africa</td>
<td>Acute meningoencephalitis in immune naive population; established zoonotic cycles</td>
<td>Shifting in zoonotic host populations and densities; secondary environmental impacts; naive population herd immune response</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Late-onset dissemination syndromes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Predeparture assessment and treatment of high-risk migrants. Antimalarial drug and clinical management protocols</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Predeparture or postarrival treatment (with or without screening) of high-risk migrants. National management of “exotic diseases” drug therapy stockpiles</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Integration and harmonization of plant, animal and human health standards and surveillance related to mobility</td>
<td></td>
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</tbody>
</table>
these countries became centralized in specific populations with specific environmental [15], poverty-associated [16], or other behavioral risk factors [17].

Globally, tuberculosis remains a major infectious disease threat. Tuberculosis was declared a global emergency by the World Health Organization in 1993. Rates of tuberculosis infection in some regions of the world are several orders of magnitude greater than those in the developed world. During this period of time where control was increasingly effective in migrant-receiving nations, immigration movements from areas of the world where tuberculosis remained a major public health challenge increased. As a consequence, in many immigration-receiving nations, the majority of cases of tuberculosis are now observed in the foreign-born population related to importation from high-prevalence source nations to low-prevalence host nations [18, 19].

Similar epidemiological patterns are now being observed in other infections in the developed world. Migration and population mobility are associated with continuing—and in some cases, increasing—levels of diseases that can be effectively controlled. These shifts in infectious disease epidemiology are the consequence of the disparity in public health and infectious disease-control measures across the globe. As these differences in disease control programs and outcomes continue or expand, the impact of migration on infectious disease epidemiology in the low-prevalence regions of the world, including most of North America, Australia, and Europe, will likewise increase. Current examples to illustrate this include malaria, which has been historically diagnosed in returning visitors and tourists from zones of endemicity to zones of nonendemicity, or linked to returning migrants or rare examples of transmission outside of zones of endemicity [20]; Hansen disease (leprosy), a condition in which migrants and foreign-born populations make up the majority of national case loads in immigration-receiving nations such as Canada [21]; and HIV infection/AIDS, associated with a profound global disparity in its prevalence and occurrence, combined with growing immigration and population mobility patterns, resulting in high rates of HIV infection in foreign-born populations. As HIV/AIDS prevention programs developed in the 1980s and 1990s and the burden of disease fell to the developed world, new cases will be increasingly prevalent in some migrant populations. Another example is American trypanosomiasis (Chagas disease), which is rarely imported from areas of endemicity, but high levels of immigration from areas of the Western Hemisphere where this parasitic disease is endemic have resulted in national policy decisions on transfusion blood product screening [22] and donation practices [23] in migration-receiving nations (for example, where blood product screening or pretreatment [24] may not be effective approaches to reducing population risk of transfusion-related trypanosomiasis, historical screening of potential donors and establishing donor ineligibility criteria may be done [25]).

Other examples include vaccine-preventable diseases. Migration and refugee movements frequently deliver individuals from areas of the world where immunization programs may less comprehensive to destinations where immunization has proved very effective at disease control or elimination. As a consequence, migrants and other mobile populations are increasingly related to individual cases or small outbreaks of imported vaccine-preventable disease with local transmission to the developed world. Specific examples include polio [26], hepatitis A [27] and hepatitis B [28], mumps [29], measles [30, 31], pertussis [32, 33], diphtheria [34], and rubella [35, 36] (table 2).

The current and future influence of migration on the epidemiology of infection diseases in the developed world is not limited to infections for which there are current or historic control strategies. The nature of modern migration is that it is a dynamic process, and immigrant source nations and regions evolve in response to a complex series of political, social, and international factors. Conflict, political upheaval, and social unrest traditionally initiate the movements of refugees and other displaced individuals. These unorganized movements are often followed by subsequent generations of migrants in organized and regular migration movements. These sustained population flows are associated with family reunification movements and nonfamilial but intracultural linkages that support secondary arrivals.

Just as the refugee movements from Southeast Asia and Africa starting in the 1960s brought new infectious disease challenges in terms of malaria, hepatitis B, and Hansen disease to the host nations, more recent movements from the Balkans and Middle East can be expected to result in future infectious disease events. Common infections, such as hantavirus infection in the Balkans [37] or leishmaniasis in the Middle East [38], can be expected to be represented in migrant communities originating from those areas. As the populations of new arrivals from these regions increases over the next decade, the incidence of infectious diseases common to those areas will correspondingly increase in destination countries related to primary, permanent movements or secondary movements associated with temporary stays [39].

CURRENT AND FUTURE IMPLICATIONS FOR THE MANAGEMENT OF INFECTIOUS DISEASES IN MIGRATION-RECEIVING NATIONS

The impact of migration-associated changes in global infectious disease epidemiology will have immediate and direct implications for those who provide clinical infectious disease and laboratory diagnostic services in ways not traditionally considered.
The first is an increased need for international public health information. Effectively managing infectious diseases in situations where many of the influences originate beyond national borders will require an evolving reference base of accurate, verifiable baseline and outbreak data linked to dynamic population health determinants, such as demography, biometrics, and mobility, which are also influenced by health services availability, access, and affordability; and socioeconomic, biological and genetic, environmental, and behavioral factors.

In combination, these factors have immediate and pressing consequences for expanding educational programs at all levels of clinical and administrative health services. As national populations become more diverse, infectious disease physicians will need knowledge and information previously associated with international public health providers. For example, information regarding the extensive transmission of hepatitis C during schistosomiasis control programs in parts of northern Africa [40] has been important to those working in public health in the region. However, that same knowledge has important implications for those practitioners involved in the care of migrants after their relocation.

The long latency phase of some infections ensures that the majority of the chronic disease sequela and complications will only present clinically long after arrival. The long-term consequences of infections acquired before immigration occurs will become more commonly encountered by health care practitioners. Examples include strongyloidiasis [41], for which it is necessary to appreciate the risks of antecedent infections when foreign-born individuals [42, 43]—even those who have resided at their new home for many years—are treated with agents that suppress their immunity, such as cancer chemotherapy and systemic corticosteroids. Incidents of chemotherapy-induced reactivation of latent infections are not infrequent in patients of this type, and clinicians will increasingly need to be aware of the global patterns of disease to anticipate and recognize what historically have been clinically rare events [44].

Both the quantity and quality of the international public health information required by clinical and diagnostic practitioners in low-prevalence zones will be required to change. The past movements and population demographic shifts with current and the projected movements of migrants need to be linked with the evolving international epidemiology of both chronic prevalence gap conditions (e.g., tuberculosis, syphilis, HIV/AIDS, and strongyloidiasis) and new, emerging conditions of public health significance (e.g., hantavirus, West Nile virus, severe acute respiratory syndrome, monkeypox, avian influenza). These emerging conditions will continue to pose particular challenges to the existing communication and educational frameworks.

Second, there will be an increased need to understand the immigration and migration process. As the pattern of exotic imported infections becomes more commonly associated with the migration process and migrants on the move become significant risk groups for diseases of otherwise low incidence in immigration-receiving nations, clinicians will need better understanding of the variations in the migration process itself as a risk determinative factor. Traditionally, the foreign-born have been associated into one group for epidemiological purposes. Like all complex populations, there are profound differences in foreign-born migrant populations, such as immigrants, refugees, asylum seekers, and migrant workers, that affect health determination and outcomes. The unifying factor may be foreign birth and travel to a new destination, but beneath these characteristics are several components that affect the clinical management of infectious diseases. The awareness, appreciation, and clinical expertise related to the importance of those factors are currently limited to those clinicians who have substantial work experience in the area of immigration health. As the foreign-born populations expand, that knowledge will become increasingly important for all clinicians and for the services that support diagnostic and therapeutic interventions.

The management of illness and disease in foreign-born populations can be affected by the status of the individual themselves. Illegal or irregular migrants may not present for care, attend follow-up assessments, or fill prescriptions out of fear of resulting immigration enforcement actions. This can affect compliance in cases of long-term treatment and may delay initial presentation, complicating public health follow-up for communicable diseases.

Practitioners not accustomed to dealing with migrants may not be aware of the extent, intent, or outcome of routine immigration screening relevant to infectious diseases. Routine immigration screening practiced by major immigration-screening nations is limited to a small number of infections and usually only to those conditions that could pose a threat to public health through transmission or create an excessive resource burden on existing health services.

**SUMMARY**

The increasing foreign-born component in the populations of immigration-receiving regions, including the United States, Australia, Canada, and western Europe, coupled with the sustained prevalence of infectious diseases in immigration-source nations, will have a growing effect on the nature and practice of clinical infectious diseases. Global factors beyond the influence of national infectious disease control strategies will affect national disease-control programs. Migrants will become increasingly important risk groups and index cases for infections of low incidence in the immigration-receiving nations. As the demography of immigration source nations evolves, classical infectious disease concerns in migrants may become less rel-
evant [45], and new challenges can be expected as immigrants and refugees arrive from new regions of the world with different background infectious disease epidemiology.

For many infections, particularly those that have been reduced to very low prevalence or eliminated in some nations, management and control will increasingly become a process of dealing with global rather than local or national epidemiology. More and more clinical infectious disease practitioners will be confronted by situations that represent the consequences of existing infection-control practices and public health systems that operate beyond their own borders. Meeting these challenges will require the acquisition and sharing of information more commonly associated with international public health. As the process of globalization continues to reduce geographical limits to disease, wider appreciation of the importance of global and international factors will be required.

Strategies to meet those challenges include increasing the networking of clinicians; specific migration-focused surveillance, detection, and interpretation systems similar to those used for disease outbreaks among international travelers; and the rapid availability and accessibility to public health and infectious disease information relevant to migrants and mobile populations, including diagnostic, clinical evaluation, management, and control expertise.

What is becoming increasingly evident is that globalization and migration have ensured that infectious disease "hoof beats" are no longer restricted to endemic areas of the world, and the host populations within the transmission envelope of the disease may actually be the zebras that many clinicians would only consider after more common causes of the presentations were ruled out or would not consider at all. Education and training in the use of the tools of global epidemiology in infectious diseases requires a commitment from clinicians, educational institutions, health care facilities, national and international authorities in migration [46], and health to act on this emerging area of impact on international public health as a result of globalization.

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