

Role of Immigrants and Migrants in Emerging Infectious Diseases

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KEYWORDS

• Immigrant • Migrant • Emerging infectious diseases

Migrant populations have had a critical role in the spread of infectious diseases since ancient times. Examples range from biblical plagues, the importation of smallpox into Mexico, the 1918 influenza pandemic, and the AIDS pandemic, to severe acute respiratory syndrome (SARS), outbreaks of meningococcal meningitis associated with the Hajj, and diseases spread by population movement due to political conflict.^{1,2} In the debut issue of the journal *Emerging Infectious Diseases*, Stephen S. Morse³ defined emerging infectious diseases as “infections that have newly appeared in a population or have existed but are rapidly increasing in incidence or geographic range.” Migrant populations have played roles in introducing infections into naïve populations (smallpox and measles into Pacific island nations, the global spread of HIV), in changing the incidence of infections in a population, and in increasing the potential for local transmission (hepatitis A, tuberculosis [TB]). Migrants may also carry infections that pose little risk to the local population but increase the geographic range at which these infectious diseases might be encountered by health professionals unfamiliar with them (leishmaniasis, Chagas disease, and malaria in North America). Such infections present diagnostic dilemmas and over time also change the face of chronic disease in a population (seizures and neurocysticercosis, heart disease and Chagas infection, hepatocellular carcinoma and hepatitis B infection). Finally, population mobility may increase the potential for establishing transmission of new infections in North America (dengue and chikungunya fever in areas where vector mosquitoes exist). Immigrants have ongoing links with populations in their countries of origin that may provide a channel through which infectious diseases potentially can be introduced to new areas. This article focuses on the recent demographic changes in North America that have

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facilitated the introduction and spread of new microbial threats, the role migrant populations play in changing the demographics of specific infectious diseases, and the potential responses of clinicians and public health officials in addressing the challenges posed by these infections. The emphasis of the article is on immigrant and migrant populations entering North America; the role of travelers in emerging infectious diseases is addressed in another article in this issue.

MIGRATION PATTERNS AND EMERGING INFECTIOUS DISEASES

More than 200 million people (roughly 2% of the world's population) currently live outside their country of birth.⁴ The largest number, more than 38 million, live in the United States. Canada is the country with the sixth largest number of migrants, with just over 6 million.⁵ The proportion of the United States population who were foreign born was higher in the late nineteenth and early twentieth centuries, when it reached almost 14%, but then it declined to less than 5% in the 1970s; it has been increasing steadily for the past 3 decades and is now more than 12% and growing. Almost 20% of the population of Canada is foreign born.⁶ More than half (54%) of the migrants living in the United States are from the Americas, with an additional 26% from Asia, 16% from Europe, and 3% from Africa. In contrast, migrants living in Canada are mostly from Europe (41%) and Asia (37%), with 16% from the Americas and 5% from Africa.⁷

International travel is also increasing at a record pace. More than 30 million trips outside the United States were made in 2006, an increase of more than 10 million in the decade since 1996.⁸ Outbound travel from Canada is also increasing rapidly, with an almost 8% increase from 2004 to 2005, and a record number of more than 21 million trips made.⁹ A larger proportion of trips are made by those, usually immigrants and their families, who identify visiting friends and relatives as the primary purpose of their trip.¹⁰ The profile of travel destinations is linked to the changing demographics of the North American population.

Population migration has been associated with the spread of diseases ranging from plague, smallpox, measles, and syphilis to, more recently, HIV and TB. Travel and trade are also associated with the spread of disease vectors, such as the mosquito vectors for yellow fever and dengue fever.¹¹ The rapidity of air travel has facilitated the spread even of diseases with short incubation periods such as influenza and measles.^{12,13} A 2003 Institute of Medicine report identified 13 factors affecting the appearance of new and emerging infectious diseases, many of which were related to migrating populations.¹⁴ Migrant populations can, however, have other roles in changing the pattern of diseases present in a population. Some chronic conditions are associated with remote acquisition of infections, such as American trypanosomiasis or Chagas disease (heart and esophageal disease), the parasitic infection cysticercosis (seizure disorders), and hepatitis B and C infection (hepatic cirrhosis). The incidence of some cancers (hepatocellular carcinoma, cervical cancer) in the future may also be affected by the prevalence of infections such as hepatitis B and C and human papillomavirus (HPV) in mobile populations resettling in areas where these infections are less common.

MIGRANT POPULATIONS AND ACUTE AND CLINICALLY APPARENT INFECTIOUS DISEASES

Immigrants may have a direct role in transmitting acute infectious diseases from one geographic location to another. This concern is especially great when large groups, such as refugees, are resettled to locations around the world. Since 2004, the resettlement of refugee populations has been disrupted in Kenya, Tanzania, Thailand,

Ethiopia, and Ivory Coast by outbreaks of vaccine-preventable diseases including measles, mumps, rubella, polio, pertussis, hepatitis A, and typhoid fever. The planned movement of 8000 Liberian refugees scheduled to begin in June 2003 and conclude in April 2004 was interrupted several times by outbreaks of varicella, measles, o'nyong-nyong fever, and rubella.¹⁵ During this period, 16 cases of varicella were imported into four states and an infant who had congenital rubella infection was born to a mother who had asymptomatic infection.¹⁶ Experts in refugee resettlement have proposed immunization of large mobile populations before resettlement to reduce the spread of infectious diseases and to realize a cost-savings compared with administering all vaccines in the destination country.¹⁷

The United States and Canada, through successful routine immunization programs, have reduced the rates of vaccine-preventable diseases to extremely low levels in the general population.¹⁸ Disease due to *Haemophilus influenzae* type b has decreased by more than 99%, and most cases of measles and rubella in the United States are now imported or associated with imported cases.^{19–21} Health care professionals have become less familiar with the typical clinical manifestations of some of these infections, leading to potential delays in diagnosis, as illustrated by several recent outbreaks of measles associated with children adopted internationally.²² Other diseases, including varicella, pneumococcal disease, and pertussis, have been reduced significantly by routine childhood immunization, although clinicians continue with some regularity to see patients who have these diseases.^{23–25} The major role of clinicians when evaluating newly arrived immigrants is to maintain a high index of suspicion for diseases that have become rare in the United States. Immigrants may not have received in their country of origin vaccines given routinely in North America, or may have had exposures that would be rare in North America.

Hepatitis A poses an additional challenge, in that individuals, usually children, who have anicteric or asymptomatic infection may still shed virus and transmit disease to others. Hepatitis A disease and disease mortality has decreased in the United States since implementation of immunization at age 2 in high-incidence communities, and is expected to decline further with routine immunization of all children at age 1.^{26,27} Cases have been linked, however, to internationally adopted children and to immigrants and their families who live along the United States–Mexico border and travel back and forth frequently.^{28–31} Clinicians must have a high index of suspicion for situations that would place individuals at increased risk for hepatitis A, and provide these individuals with hepatitis A vaccine.

Children adopted internationally are a special group who deserve additional mention. Because they are not required to receive immunizations before leaving their birth country, they may be susceptible to, or already infected with, vaccine-preventable diseases at the time of arrival in North America. Transmission of measles, hepatitis A, hepatitis B, TB, and other infectious diseases has been documented from internationally adopted children. Pertussis, rubella, and varicella have been diagnosed in adoptees soon after arrival.^{32,33} Children adopted internationally, because they join families that have not shared similar exposures, may pose a unique potential for transmitting infectious diseases in their adoptive country. Recent reports of measles and hepatitis A outbreaks in association with internationally adopted children illustrate this phenomenon.^{22,28} The potential risk for transmission of diseases from the migrant population of internationally adopted children has led to recommendations for enhanced protection of families traveling to adopt children and of family members and others who will have close contact with these children on arrival in North America.^{32,34–36}

MIGRANT POPULATIONS AND LATENT AND CHRONIC INFECTIOUS DISEASES LESS FAMILIAR TO NORTH AMERICAN HEALTH PROFESSIONALS

The health characteristics of migrant populations depend on the conditions to which migrants are exposed in their countries of origin, during migration, and in their resettlement environment.⁴ Understanding a person's journey from his/her country of origin to his/her country of current residence is especially important when assessing risk for diseases of long latency, such as TB, HIV, leprosy, and Chagas disease, and diseases that occur when an individual's immune status changes, such as strongyloides and latent TB. Few of these diseases, with the notable exception of TB, pose significant risk to the local population.

In many developed countries, TB occurs disproportionately in the foreign-born population. In the United States, more than 50% of TB cases have occurred in non-United States-born individuals since 2002, and most of these become apparent within 5 years of entering the United States.³⁷ Although the total number of cases of TB reported in the United States declined in 2007, 58.5% were in foreign-born individuals, and the TB rates in the foreign-born were 9.7 times higher than in individuals born in the United States. Multidrug-resistant TB also occurs more commonly in foreign-born individuals; 84.5% of cases occurred in such individuals in the United States in 2006.³⁸ Since the early 1990s, more than half the cases of TB in Canada have been reported in foreign-born individuals.³⁹ Patterns of TB seen in North America today and those predicted for the future are therefore driven by the trends in immigration now and in the recent past. Currently, more than half of all TB cases in the United States occur in individuals from four countries: Mexico, the Philippines, India, and Vietnam.³⁸ In Canada, most cases are seen in individuals from the Western Pacific region, although increased numbers of cases from Southeast Asia and Africa are being reported.³⁹ TB control programs must take into account the needs of the foreign-born population and make TB diagnosis and prevention programs accessible and acceptable to foreign-born populations.⁴⁰

The global burden of HIV falls disproportionately on individuals from certain parts of the world, especially Africa. In North America, an increasing proportion of individuals living with HIV are foreign born. In Massachusetts, as of November 2007, 19% of those living with AIDS were foreign born, compared with a foreign-born population of about 12%.⁴¹ Less than 1% of Minnesota's population was born in Africa, yet in 2004, 19% of new HIV diagnoses were among those born in Africa.⁴² MacPherson and colleagues⁴³ contrast the prevalence of HIV in Canadian immigration applicant children (14/100,000) with the rate of domestically reported pediatric HIV cases (0.02/100,000). They conclude that population migration and immigration could more than double the number of children who have HIV/AIDS in Canada, requiring a refocusing of efforts to provide culturally and linguistically appropriate programs of HIV care and prevention for immigrant families. Health care professionals and HIV program directors face significant challenges in accommodating the needs of diverse immigrant populations. Overcoming language and cultural barriers to care, addressing differing beliefs about HIV/AIDS, providing care in the context of competing priorities such as housing, jobs, and family stress, and addressing the psychiatric needs of immigrants living with HIV are all critical to the success of programs caring for immigrant populations, yet are stretching the resources of these programs in unprecedented ways.⁴⁴

Immigrants may present with conditions unfamiliar to American-trained health care professionals, resulting in delays in diagnosis. Dermatologic conditions are especially challenging. Chronic conditions such as leprosy, leishmaniasis, and filarial disease

can provide diagnostic dilemmas and may not be recognized easily. Keystone⁴⁵ provides an excellent overview of skin conditions of immigrants, and contrasts these with those likely to be seen in travelers. Arriving at the correct diagnosis often requires detailed information from the patient about migration history, access to specialized laboratories that can assist in making a diagnosis, and, for some diseases, access to specialized medications with limited availability. Once a diagnosis is made, additional challenges include addressing the stigma associated with diseases such as Hansen's disease (leprosy), the long period of treatment required (sometimes with specialized medications), and, with conditions such as visceral leishmaniasis, addressing the possibility of HIV coinfection.

Parasitic diseases contracted outside North America may present after migration, possibly because of long latency periods or because relapse or recrudescence is characteristic of the infection. Relapses of malaria may present long after migration and the diagnosis may seem elusive unless the migration history is known. Lymphatic filariasis may present as intermittent leg swelling, and patients may undergo multiple evaluations for cellulitis or deep venous thrombosis or other conditions unless residence in an area where lymphatic filariasis exists is ascertained. Neurocysticercosis is one of the most common causes of seizures in some immigrant populations; seizures may occur years after leaving the country of exposure. Granulomas formed by *Schistosoma* may result in long-term complications such as hepatic fibrosis, hydro-nephrosis, and infertility in women many years after initial exposure. Heart block, cardiomyopathy, or esophageal dilatation may be late manifestations of Chagas' disease. The clinician's challenge for all these diseases is to link these clinical manifestations with a remote exposure occurring outside North America. With the multiple pressures on clinicians today, including decreased time to spend with each patient, increased requirements to complete specific tasks during a visit, and the challenges of caring for patients with limited English/French proficiency and limited health literacy, it is easy to understand how taking a migration history would be missed. Even when migration histories are requested, additional barriers may exist, such as fear of deportation, which may hinder obtaining an accurate history of exposure. This situation was illustrated poignantly by Matteelli and colleagues,⁴⁶ who described a group of illegal Chinese immigrants to Italy diagnosed with malaria. The circuitous route by which they traveled was obtained only with extreme difficulty partly because of the clandestine status of these immigrants.

Chagas' disease (American trypanosomiasis) deserves special mention for its impact on health care policy. It is estimated that more than 100,000 individuals infected with *Trypanosoma cruzi* may be living in the United States; most are asymptomatic and are unaware that they are infected. These individuals, however, are able to transmit infection to others through donated blood or organs; such cases have occurred in the United States. In addition, an infected pregnant woman can transmit the infection to her fetus.⁴⁷ During a 5-month period in 2006/2007, almost 150,000 blood donations were tested for antibodies to *T cruzi*; approximately 1 in 2365 donations was positive. In January 2007, the American Red Cross and Blood Systems, Inc., organizations that supply about 65% of the United States blood supply, adopted routine screening of all blood donations for *T cruzi*.⁴⁸

MIGRANT POPULATIONS AND CHANGING PATTERNS OF ONCOLOGIC DISEASES

Human migration patterns may have far-reaching implications for patterns of cancer that will manifest in North America over the next few decades. The period of latency between being infected with viruses such as hepatitis B or C, or HPV, and bacteria

such as *Helicobacter pylori*, and development of malignancy may be decades. Diagnoses of hepatocellular carcinoma, cervical and other HPV-related cancers, and gastric cancer made in the next 20 years are likely to be made in the populations of immigrants who arrive already infected with these organisms. Individuals from many regions outside the United States that are the origin of many immigrants are more likely to be infected with hepatitis viruses, HPV, and *H pylori* than individuals born and raised in the United States. The Centers for Disease Control and Prevention (CDC) estimates that between 1994 and 2003, approximately 40,000 immigrants who had chronic hepatitis B were admitted to the United States annually.⁴⁹ Thus, these infection-related cancers will be emerging diseases in immigrant populations in the future. Efforts toward prevention of transmission of these infections and early diagnosis and treatment of resulting diseases must be made with the populations most at risk in mind. An example of the challenges presented by such a need is the situation with respect to cervical cancer in Vietnamese women in California. Although Vietnamese-American women have the highest rates of cervical cancer of any group in the United States, and are diagnosed later than women in other groups, one report noted that only 50% of them have ever had a Pap smear, compared with almost 98% of women in the general United States population.⁵⁰ Another example is that of hepatitis B infection and hepatocellular carcinoma in the Chinese-American population. Approximately 10% of Chinese immigrants are infected with hepatitis B, compared with about 1% of the American-born population. Several reports indicate, however, that fewer than 40% of immigrants from China have been tested for hepatitis B infection. Coronado and colleagues,⁵¹ in a study of Chinese immigrants in Seattle, found that factors associated with having been tested included knowledge that Chinese immigrants are more likely than whites to get hepatitis B, being told by a doctor that they needed to be tested or requesting of a health care professional that they be tested, and not needing an interpreter for the visit. The CDC currently recommends screening for hepatitis B all immigrants from Africa, Asia, the Pacific islands, and other areas where high rates of infection with hepatitis B occur, regardless of vaccination status.⁴⁹ Finally, *H pylori*, associated with gastric cancer, is more common in individuals born in developing countries than it is in those born in industrialized countries. The implications of this colonization over the long term is unknown.⁵²

IMMIGRANTS AND RISK FOR EXPOSURE TO INFECTIOUS DISEASES

As immigrants enter the workforce in their countries of resettlement, they may be exposed to risks for infectious diseases for which they are unprepared. Jenks and Trappasso⁵³ describe a cohort of migrant workers in New York who lacked familiarity with Lyme disease, although their working conditions placed them at increased risk for exposure to this disease. Pollock and colleagues⁵⁴ report a high proportion of immigrant workers involved in an outbreak of Q fever in Scotland in 2006. An outbreak of *Plasmodium vivax* malaria involving migrant workers from Mexico was reported from San Diego County, California, in 1986. These workers were not only at greatest risk for disease (likely from sleeping outside near a marshy area where *Anopheles hermsi* mosquitoes were breeding) but they also probably played a role in sustaining local transmission through several generations.⁵⁵ These situations highlight the challenges of diagnosis and prevention of infectious diseases related to occupational exposures in workplace situations where multiple languages and cultures complicate access to health care, obtaining complete medical and migration histories, and the ability to provide information about preventing infection.

Table 1
Emerging infectious diseases and role of migrants, public health officials, and clinicians

Type of Infection	Role of Migrants	Public Health/Policy Role	Role of Clinicians
Acute infectious diseases with risk for local transmission: measles, rubella, varicella, pertussis, hepatitis A	May arrive ill or incubating infection (measles, hepatitis A) May be more susceptible than local population (varicella)	Immunization policy (provide vaccines before arrival for refugees, adoptees) Financing of and access to immunizations for immigrants	Recognition of infections uncommon in the local population Identification of need for and provision of immunizations to immigrants
Infectious diseases with latency or asymptomatic states with some risk for local transmission	May arrive ill or may reactivate disease many years later (TB) Family/community members may need immunization	Culturally appropriate TB programs Financing and provision of access to immunizations	Identification of at-risk individuals and family members and provision of appropriate preventive measures Diagnosis of infection in asymptomatic individual (LTBI, hepatitis B infection)
Infectious diseases with low potential for local transmission	Bear a disproportionate burden of disease in some communities (HIV)	Culturally appropriate treatment programs and prevention initiatives (HIV) Blood screening policies (HIV, Chagas)	Recognition of infections rare in local population (Chagas)
Infectious diseases with oncologic potential	Bear an increased burden of disease (Hepatitis B, C; HPV; H pylori) Have less access to, or less acceptance of, screening procedures (HPV)	Educational initiatives about diseases Provision and financing of screening and immunizations	Screening for infectious diseases Regular monitoring of those infected for development of sequelae Education about transmission, reduction of risk for disease and sequelae Routine cancer screening (Pap smears, colonoscopy, and so forth)
Vector-borne diseases	May arrive infected; may be more likely to visit tropical/subtropical areas with these infections when visiting relatives Intermediate hosts	Monitoring/reduction of vector populations Surveillance	Recognition of diseases rare in the local population

Immigrant groups may also have food-borne exposures that differ from the indigenous population, resulting in infectious diseases that are unfamiliar to local health care professionals. A recent report describes the differing rates of brucellosis in the local German population and the Turkish immigrant population; this association has also been reported in the Hispanic population in the United States.^{56,57} Childhood brucellosis in the United States is seen almost exclusively in immigrants with a history of travel to Mexico or ingestion of unpasteurized milk products from Mexico.⁵⁸ *Mycobacterium bovis*, spread through consumption of raw dairy products or contact with infected cattle, rather than from person to person, accounted for 8% of all TB cases and 45% of cases in children from 1994 through 2005 in San Diego County, California.⁵⁹ Thirty-five cases of TB due to *M bovis* were identified in New York City between 2001 and 2004 and were linked in preliminary investigations to fresh cheese brought from Mexico; no cases of human-to-human transmission were found.⁶⁰ Reducing the risk for *M bovis* infection will require multiple approaches, including education of affected communities about unpasteurized dairy products, collaboration with Mexico, where *M bovis* continues to be prevalent in cattle, and high index of suspicion of this unusual form of TB by clinicians, because treatment may involve different drug regimens or longer courses of treatment than disease caused by *Mycobacterium tuberculosis*.

MIGRANTS AND VECTOR-BORNE DISEASES

West Nile virus has spread rapidly across North America since its introduction in 1999. The virus is transmitted to humans, horses, and other mammals by mosquitoes, and domestic and wild birds play a critical role in the spread of this disease. The rapid emergence of West Nile virus in the United States and Canada is a wake-up call for the public health community, highlighting that emergence of other mosquito-borne illnesses is a real possibility. The presence in the United States of mosquito populations that are competent to transmit several arboviruses means that viremic individuals entering the United States could potentially spark local transmission.⁶¹ It is worth remembering that outbreaks of yellow fever once occurred as far north as Boston, and that malaria occurred throughout much of the United States. Changes in relationships among vectors and intermediate hosts of parasitic diseases and humans as reservoirs of infection are occurring and will continue to occur. On the west coast of the United States, two intermediate hosts of the human lung fluke have appeared since 1990: the Chinese mitten crab in 1990 and the estuarine snail in 2007. These arrivals set the stage for completion of the lung fluke life cycle should sanitary conditions allow the lung fluke, carried by infected Asian immigrants, to enter bodies of water containing both intermediate hosts. At this time, the habitats of the two intermediate hosts do not overlap, but it is likely that they will in the future (James T. Carlton, personal communication, 2008). Human activity is constantly changing the balance among vectors, hosts, and reservoirs of infection; migration of human populations contributes to, and is affected by, changes in this balance.

SUMMARY

Population migration plays a critical role in the spread of disease by initiating outbreaks of acute diseases, changing the prevalence of infectious diseases at a given location, and changing the face of chronic disease resulting from previous infection. Roles of migrants, public health officials, and clinicians are summarized in **Table 1**.

Human populations also interact with the environment and disease vectors in ways that may contribute to the emergence of infectious diseases. Public health officials are

challenged by the extent of activities required to monitor the spread of such diseases and implement measures to limit or prevent them. Clinicians are challenged by the need to be familiar with new and emerging infections and by the need to consider migration history for a growing number of individuals. Addressing the emergence and reemergence of infectious diseases related to migration will require increased surveillance of infectious disease patterns worldwide, increased knowledge by health care professionals of a wider variety of infectious diseases and attention to migration patterns of their patients, and a high index of suspicion on the part of clinicians when faced with unfamiliar illnesses.

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