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Communicable Diseases, Globalization of

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Introduction

Communicable diseases are the greatest disease threat facing humankind. Diseases previously considered eradicated are re-emerging and new viruses are emerging. Due to increased human population and accelerated global travel, local outbreaks become instant global threats. Despite technological advances in medicine, devastating communicable diseases such as Ebola, severe acute respiratory syndrome (SARS) or avian influenza continue to surface and ravage humankind. The 1918 influenza outbreak killed at least 20 million people in about 24 weeks, but HIV/AIDS has killed more than 25 million since 1981 and continues its march around the globe. Researchers are concerned that an avian influenza outbreak could kill many more people when it emerges because of the absence of immunity and human travel interaction patterns.

Diseases are not distributed uniformly in space. Throughout the world, certain locations have diseases that are not present in others. Even when a disease occurs in different locations, the rate of occurrence frequently varies between places. Some areas have high rates of a particular disease than others or may not have that disease at all. Generally, tropical regions with warm, humid climates tend to facilitate the proliferation of disease causing organisms, or insects and animals that carry such disease. Similarly, physical environmental characteristics, such as soil type and the mineral content of soils and rock, which vary from one location to another, may also inhibit or encourage disease. Swampy vegetation in low-lying areas of the tropics is ideal for the proliferation of mosquitoes and thus, endemic malaria. Finally, cultural practices, including diet, behavior, and occupation, also contribute to geographic variations in health and disease.

Communicable diseases, diseases that are easily transmitted from one person to another, also vary spatially. Geographic differences such as levels of crowding, sanitation, and health practices such as defecation, or even sexual behavior contribute to these differences. Medical geographers study the spatial differences in disease occurrence, how diseases spread across geographic space, and also the spatial distribution of health care resources. They seek to answer the question of who is getting what diseases/health care where and why? This article examines the geographic distribution of leading communicable or infectious causes of disease and death. We begin with one basic conceptual framework commonly used to account for spatial variations in disease.

Disease Ecology Model

The disease ecology model attributes spatial variations in disease to three major variables – environment, genetics and behavior. Environment is a broad context and includes not just the physical environment of livelihood, environmental pollution e.g. (including indoor pollution such as radon) and water quality, but also the socio-economic environment, including relative deprivation, healthcare quality and access, land mines, and the political economic context. For example, unlike Canada, where universal access to care based on need is provided for all citizens, in the United States, access to care depends on ability to pay. Thus, immunization is more easily available in Canada than in the US and this influences the infant mortality rate and life expectancy in the two countries. Genetic predisposition is important particularly for degenerative diseases. People with light skin pigmentation are more prone to skin cancer than others with a darker pigmentation. Similarly, recent research suggests that Ashkenazi Jewish women have a higher risk of breast cancer compared to other women. The human genome project is not only identifying genes responsible for several serious diseases such as Parkinson but also developing exciting new and effective therapies for them. Human behavior is the final component in the disease ecology model. Put simply, behavior facilitates or inhibits disease. Unhealthy behavior traits such as excessive alcohol consumption, overeating and failure to exercise, unsafe sexual practices and smoking are associated with various diseases. In contrast, regular exercise and other positive health behaviors, including proper diet, enhance health and prevent disease. Thus, spatial variations in Africa's environment, including widespread poverty that promotes extra-marital and transactional sex, poor healthcare environment with limited access to anti-retrovirals, cultural practices such as circumcision, widow inheritance, and preference for unsafe sexual practices, combine with other factors to make HIV/AIDS rates the highest in the world. Similarly, variations exist between and within countries. Besides vertical transmission (from mother to child), genetics is not as important in HIV transmission – all humans are genetically susceptible.

The disease ecology framework has been criticized for its positivist philosophy, dearth of social theory, neglect of social divisions such as race, gender, disability, and sexuality, and the trivialization of the role of place and locality. For example, Kearns called on medical geographers to incorporate social theory, but Mayer and

Meade and Paul chastised the supposed call for discarding disease ecology in favor of narrow health geography. Current work includes much broader frameworks such as vulnerability theory and political ecology.

Globalization and Communicable Diseases

Globalization, particularly the increased economic and cultural interdependence, and associated shrinking of time and space due to technological advancements, is transforming disease transmission patterns. Traditionally, immigrants have always provided a vital link in disease transmission between their home regions and their destination. By establishing close contact between distant places, immigrant travels promote disease spread. For example, European travelers carried diseases that killed many people in the Americas. However, recent developments in technology and travel have escalated the role of travel-related disease spread. In fact, the volume, speed, and reach of travel today have so accelerated the spread of communicable diseases that national boundaries no longer offer isolation or protection. The brief review that follows demonstrates that permanent migrants are not the only means of disease spread. Short-term visitors, including tourists, are also very important in the spatial diffusion of microbes and pathogens.

HIV/AIDS

Easily the world's worst communicable disease, HIV/AIDS has affected every country but sub-Saharan Africa has experienced the worst devastation. The Caribbean and parts of Eastern Europe and Asia also have high rates. Even in the United States where rates are much lower, increasing numbers of people are living with HIV/AIDS, and prevalence is particularly high among subpopulations such as Blacks, men who have sex with men, and intravenous drug users.

At the end of 2006, an estimated two-thirds of the world's 40 million cases were in sub-Saharan Africa, a region with 11% of the world's population, and 91% of the world's children living with the disease. HIV prevalence rates vary widely between African countries, ranging from a low of less than 1% of the adult population in Senegal and Somalia to 15–20% in South Africa and Zambia. A few countries have even higher prevalence rates – Swaziland with 33.4% is the highest, Botswana has 24.1%, while Lesotho and Zimbabwe have 23.2% and 20.1%, respectively, at the end of 2006. Generally, West Africa has much lower rates than Southern Africa. Besides Cote d'Ivoire which has an adult rate of 7.1%, most West African countries have lower than 5%. In East Africa, prevalence exceeds 6% in Uganda, Kenya, and Tanzania.

Due to cost, antiretroviral medications reach only a small fraction of Africans who need them. Rwanda and Namibia serve about 70%, Kenya, Malawi, and Zambia range between 25 and 45%, but Ghana, Nigeria, and Mozambique serve fewer than 20%. As a result, life expectancy has fallen across the region and averaged 47 years in 2005.

Women are more vulnerable and thus more severely affected than men, and at much younger ages. The major driving forces of HIV/AIDS include poverty and economic inequality which necessitate transactional sex, cultural practices such as widow inheritance, misguided national policies, and neglect such as in South Africa where the government, disputing the link between HIV and AIDS, refused to provide antiretrovirals to prevent vertical transmission of the disease. Global efforts to control the disease through improved testing and supply of inexpensive medications and other programs will help those who need care most in African countries.

Tuberculosis

Tuberculosis (TB) is an airborne respiratory disease caused by *Mycobacterium tuberculosis*. TB bacilli are propelled into the air when people who are sick with pulmonary TB cough, sneeze, talk, or during normal breathing. Inhaling even a small number of these airborne bacilli is enough to cause infection. Most exposed persons never become ill but develop latent tuberculosis. An important minority (5–10%) progress from latent to active tuberculosis due, for example, to immunosuppression from co-infection with the human immunodeficiency virus (HIV).

Despite treatment advances, tuberculosis remains an uncontrolled communicable disease worldwide. Worldwide about nine million persons are diagnosed and two million die yearly from tuberculosis particularly in developing countries. Currently, more than 90% of the global tuberculosis burden occurs within developing countries due to, among other things, widespread HIV/AIDS infection, malnutrition, crowding, medication shortages, and poor healthcare programs. In developed countries, newly diagnosed TB occurs most frequently among foreign-born immigrants, and native-born homeless who typically live in extremely crowded and unsanitary conditions. For example, in Germany and France immigrants are 3 times and 6 times, respectively, more likely to be diagnosed with TB than are native-born persons.

In Canada, while comprising only 18% of the Canadian population, the foreign born accounted for 65% of all reported TB cases in 2000. In the US, 54.3% of TB cases were found in foreign-born persons. Immigrants entering the US and Canada from countries with high tuberculosis incidence have a higher risk of latent or

active tuberculosis when they arrive. Thus, states or provinces with high immigrant populations have high rates. For example, British Columbia, Ontario, and Quebec, Canada's leading immigrant destinations, accounted for 87% of foreign-born tuberculosis cases. Moreover, a disproportionate number of the cases were reported from large cities with significant ethnic and minority concentrations such as Toronto, Montreal, and Vancouver. In the US, five states – California, New York, Florida, Texas, and Illinois – account for 66% of the total foreign-born tuberculosis cases reported. Similar to the Canadian pattern, major US cities, including New York City, Los Angeles, San Francisco, San Diego, Miami, Atlanta, and Houston, all report disproportionately high numbers of cases from immigrant neighborhoods.

Moreover, the origin of foreign-born tuberculosis cases reported from each of these states was largely homogenous, revealing established migration. In 2003, New York reported approximately 64% of the US total of tuberculosis cases born in the Dominican Republic; Florida reported 60% of cases born in Cuba; Texas and California reported 60% of cases born in Mexico; and Minnesota reported 55% of Somali born cases.

Poliomyelitis

Polio is a viral disease that is usually spread through fecal contaminated water and food or oral human to human contact. Early symptoms of infection include fatigue, fever, vomiting, headache and pain in the neck, and extremities. The virus invades the nervous system and can cause paralysis in hours. The incubation takes between 3 and 30 days, but a person begins to shed the virus in their stool 7–10 days before, and 3–6 weeks after the onset of symptoms. A small minority of cases (0.5–1%) of cases result in paralysis, and while polio can affect people at any age, at least 50% of cases occur in children 3–5 years old. Most people infected with the polio virus have no symptoms at all but continue to spread the highly contagious virus for weeks. Thus once introduced, polio spreads very quickly and usually infects many people before an outbreak is detected.

Once considered almost eradicated worldwide, polio has resurged not only in the six countries with endemic polio (Nigeria, India, Pakistan, Niger, Afghanistan, and Egypt) but transmission has been reestablished in an additional six countries (Burkina Faso, Central African Republic, Chad, Côte d'Ivoire, Mali, and Sudan). Despite massive efforts, total eradication continues to be an elusive goal. The global campaign to eradicate polio by 2005 suffered a severe setback when parts of northern Nigeria rejected the polio vaccine because Muslim clerics claimed that the vaccine causes infertility and spreads HIV/AIDS and cancer. From those few states, polio spread through large parts of the country, neighboring

countries, and eventually to Saudi Arabia through Nigerian Muslims on pilgrimage to Mecca. Indonesian Muslims, who were exposed during their pilgrimage in Mecca, carried the disease with them to Indonesia where it became reestablished. Polio reminds us that global cooperation is critical for controlling communicable diseases.

Sexually Transmitted Infections

Sexual behavior of travelers is contributing to spatial mixing of different strains of sexually transmitted pathogens worldwide. Consequently, sexually active travelers risk being infected with new strains of known sexually transmitted infections. An often cited example is the current endemicity of quinolone-resistant *Neisseria gonorrhoeae* (QRNG) in California and Hawaii. This pathogen was originally common only in Asia. According to the CDC, persons who engaged in sexual activity abroad first introduced these strains of QRNG in the US, but now incidence is no longer related to travel. Whereas less than 1% QRNG isolates were identified between 1999 and 2001, 9.4% were reported in 2005, and in people with no history of travel. In short, travel, whether in the form of short-term recreational travel or permanent migration, facilitates the spatial spread of disease. Consequently, the spatial distribution of immigrant neighborhoods and ethnic islands may provide an important key to understanding the geography of disease diffusion.

Severe Acute Respiratory Syndrome

Severe acute respiratory syndrome (SARS) illustrates how migration facilitates the spatial spread of disease. From its source, Guangdong Province in South China, SARS spread initially to Hong Kong from where it diffused worldwide. When it was over, a total of 8439 probable cases and 812 deaths had been identified from 30 countries. The devastation of SARS was not uniformly distributed, however, but followed a path of spatially linked places and peoples facilitated by international travel.

Canadians returning from Asia imported SARS into Canada. The first cases involved a Canadian family of Hong Kong descent who live in Toronto. A 78-year-old woman and her husband traveled to Hong Kong and stayed at a hotel where a cluster of 13 persons with suspected or probable SARS are known to have stayed. Two days after returning home, the woman developed what is now known as SARS and died. Several family members who had close contact with the index case then developed SARS symptoms, and one was later admitted to a hospital that subsequently became the epicenter for the Toronto outbreak. SARS killed 44 Canadians, caused illness in hundreds more, paralyzed a major segment of

Ontario's healthcare system for weeks, and put more than 25 000 residents of the Greater Toronto Area in quarantine.

H5N1 Avian Influenza

Some communicable diseases originate in animals and occasionally mutate to infect humans. An excellent example is avian influenza. It occurs naturally among wild birds; they shed it in their saliva, nasal secretions, and feces, but usually do not get sick from it. Domesticated birds, including chickens, ducks, and turkeys, become infected through contact with contaminated surfaces, birds, or their secretions. Human contact with infected birds or contaminated surfaces produces infection, but human to human spread of avian influenza viruses is rare, typically limited, and unsustainable. Symptoms of avian influenza in humans include fever, cough, sore throat, muscle aches, eye infections, severe respiratory diseases, and other life-threatening complications. Human influenza virus refers to those subtypes (currently H1N1, H1N2, and H3N2) that spread widely among humans. In the United States, human flu kills 36 000 people and hospitalizes more than 200 000 people every year.

The current communicable disease of global concern is caused by influenza A (H5N1) virus. Endemic in birds, H5N1 virus is contagious and often deadly. While it usually does not infect people, human infections have occurred, usually in people with direct close contact with infected poultry or contaminated surfaces. About 60% of the human cases have died, mostly as healthy children and young adults. Because humans have little pre-existing natural immunity to H5N1 infection, it is feared that a pandemic will result if these H5N1 viruses gain the ability for efficient and sustained transmission among humans. While there has been some human-to-human spread of H5N1, it remains limited. The H5N1 virus responsible for recent human illness and death in Asia is resistant to two common antiviral flu medications and currently no commercially available vaccine to protect humans exists.

Research continues into new vaccines to counter a possible H5N1 pandemic but unfortunately, current vaccine production methods require an outbreak before an effective vaccine can be developed and even then it takes between 5 and 7 months. To avoid a global pandemic of H5N1 or other virus, new vaccine technologies are required, to respond quickly and effectively to new challenges of communicable disease outbreaks.

Mapping Communicable Diseases

Ever since the seminal work of Dr. John Snow, mapping has been a key tool in fighting communicable diseases.

Thanks to recent technological advances, particularly in GIS, the role of mapping in disease tracking, surveillance, and control has burgeoned. Recent examples include West Nile Virus, and tuberculosis control. Cromley and McLafferty provide an excellent overview of GIS applications in public health generally.

One particularly fascinating recent development is mapping genotypes of communicable disease. Each disease causing organism has a specific phenotype, and the species members have a more unique genotype. Tools exist for separating and categorizing disease organisms with these more unique genotypes into groups based on their genetic structure (isolates). Two people with identical or matching isolates indicate recent transmission from a common source; unique isolates indicate remote transmission from a different source. Analyzing and mapping these genotypes allows researchers to distinguish between not just disease species (phenotype) but also locate areas with high incidence and different strains of the disease, including recent versus remote transmission of disease. Areas with high rates of clustered genotypes indicate ongoing transmission (i.e., an outbreak), whereas multiple unique isolates indicate infections that were acquired elsewhere (are imported).

Moonan *et al.* based a recently successful TB intervention on geographically targeted screening of clustered tuberculosis isolates. Because it assumed that persons with clustered strains of disease from geographically related areas represent ongoing community transmission that can be identified and interrupted through treatment, the study focused resources on zip codes with high incidence and clustered isolates. During the 28-month intervention, the number of cases of tuberculosis decreased from 28.5 cases per 1000 screenings to 2.4 cases per 1000. The rate of developing latent tuberculosis infection fell from 14.3 to 2.2 per 100 person-years of exposure. The intervention was successful because it distinguished between high incidence areas with high and low levels of clustered strains, and deployed resources not just on the basis of incidence but on the basis of genotype. Since unique isolates represent remote transmission, location-based screening in areas with high rates of unique isolates would be less likely to identify either persons with active tuberculosis or recent acquired latent tuberculosis infection and thus not as cost-effective.

Conclusion

Communicable diseases remain a major threat to humankind. Effective surveillance and response remain our best protection against these deadly threats. Unfortunately, surveillance remains poor and rudimentary in the most vulnerable countries where outbreaks are most

likely. Strengthening the health and surveillance systems of poor developing countries is critically needed in a globalized world because communicable diseases do not respect political boundaries.

See also: Diffusion; Disease Diffusion; Disease Mapping; Health Geography; Medical Geography.

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