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Despite technological advances in medicine, communicable diseases are the greatest disease threat facing humankind. Diseases previously considered eradicated are reemerging, as new viruses and devastating communicable diseases such as Ebola, Zika, and dengue continue to surface and ravage humankind. Increased human population and accelerated global travel make local outbreaks instant global threats. 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. Even more troubling antibiotic drug resistance is becoming more widespread.

Diseases are not distributed uniformly across the world; certain locations have diseases that are not present in others. Even when a disease occurs in multiple locations, its severity usually varies between places. Generally, tropical regions with warm, humid climates are ideal for the proliferation of disease-causing organisms, or vectors. For instance, swampy vegetation in low-lying areas of the tropics is ideal for the proliferation of mosquitoes and thus, endemic malaria. Similarly, sociocultural practices, including living arrangements, diet, behavior, and occupation, also contribute to geographic variations in health and disease. Medical geographers study the spatial differences in disease occurrence and also the spatial distribution of healthcare resources. They seek to answer the question of who is getting what diseases/healthcare where and why? This article examines the geographic distribution of leading communicable causes of sickness and death. We begin with a description of the disease ecology model—a 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 includes not just the physical environment of livelihood, environmental pollution (e.g., indoor pollution such as radon), and water quality, but also the socioeconomic environment, including relative deprivation, healthcare quality and access, land mines, and the political-economic context. For example, low vaccination rates anywhere produce higher rates of vaccine-preventable diseases in those locations. Genetic predisposition is important particularly for noncommunicable diseases. People with light skin pigmentation are more prone to skin cancer than are 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 serious diseases such as Parkinson but also developing effective therapies for them. Human behavior is the final component in the disease ecology model. Put simply, behavior facilitates or inhibits disease. Unhealthy behaviors 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 and cultural practices, including widespread poverty, poor healthcare resources with limited access to antiretrovirals, and unsafe burial practices, combine with other factors to produce the highest risk for human immunodeficiency virus (HIV)/AIDS and Ebola in the world. Similarly, variations exist between and within countries.

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 trivializing 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 such as race, gender, disability, and sexuality; and trivializing 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 such as race, gender, disability, and sexuality; and trivializing 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 such as race, gender, disability, and sexuality; and trivializing 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 such as race, gender, disability, and sexuality; and trivializing 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 such as race, gender, disability, and sexuality; and trivializing 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 such as race, gender, disability, and sexuality; and trivializing 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 such as race, gender, disability, and sexuality; and trivializing 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 such as race, gender, disability, and sexuality; and trivializing 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 such as race, gender, disability, and sexuality; and trivializing 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 such as race, gender, disability, and sexuality; and trivializing 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 such as race, gender, disability, and sexuality; and trivializing 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 such as race, gender, disability, and sexuality; and trivializing 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 such as race, gender, disability, and sexuality; and trivializing 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 such as race, gender, disability, and sexuality; and trivializing 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 such as race, gender, disability, and sexuality; and trivializing 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 such as race, gender, disability, and sexuality; and trivializing 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 such as race, gender, disability, and sexuality; and trivializing the role of place and locality.

**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. Recent developments in technology and travel have so accelerated the role of travel-related communicable disease spread that national boundaries no longer offer isolation or protection. The brief review that follows highlights recent cases of globalization of communicable disease. It shows that uncontrolled communicable disease anywhere on earth is a threat everywhere.

**HIV/AIDS**

Easily the world’s worst communicable disease, HIV/AIDS has affected every world region 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 2016, about 36.7 million people were living with HIV globally, with 25.6 million cases 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 more than 15% in South Africa and Zambia. But the world’s most affected region remains southern and eastern Africa where an estimated 19.4 million people were living with HIV in 2016, 59% of them being female. The region also had 43% of the global total of new HIV infections, but only 60% of the people living with HIV in the region were accessing antiretroviral therapy in 2016.

Women are more vulnerable and thus more severely affected than are men, and at much younger ages. The major driving forces of HIV/AIDS include poverty and economic inequality which necessitate transactional sex, and gender inequality enshrined in cultural practices such as widow inheritance. Global efforts to control the disease through improved testing and supply of inexpensive medications and other programs are beginning to yield positive results including plummeting death rates, and UNAIDS has set a goal of ending AIDS by 2030.

### 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 TB. An important minority (5%–10%) progress from latent to active TB due, for example, to immunosuppression from coinfection with the HIV.

Despite treatment advances, TB remains an uncontrolled communicable disease worldwide and about 9 million persons are diagnosed and 2 million die yearly. Currently, more than 90% of the global TB burden occurs within developing countries due to widespread HIV/AIDS infection, 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 three times and six times, respectively, more likely to be diagnosed with TB than are native-born persons. In 2016, 10 countries in eastern and southern Africa (Angola, Ethiopia, Kenya, Lesotho, Mozambique, Namibia, South Africa, Tanzania, Zambia, and Zimbabwe) were listed among the countries with the highest TB burden.

The two epidemics—HIV/AIDS and TB—are intertwined in such a catastrophic way that they have been termed syndemic. HIV is now associated with epidemic outbreaks of TB, multidrug-resistant TB (MDRTB), and extensively drug-resistant TB (XDR-TB). Similarly, TB is now the leading cause of death in HIV-positive adults, and in 2017, people living with HIV were 20 times more likely to have TB worldwide.

### Poliomyelitis

Polio is a viral disease that is usually spread through fecal contaminated water and food. 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. 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%) result in paralysis, and at least 50% of cases occur in children 3–5 years old. Because most infected people have no symptoms at all while spreading the highly contagious virus for weeks, once introduced, polio usually infects many people before an outbreak is detected.

Polio provides an illustrative example of the challenges in global disease control. Once considered almost eradicated worldwide, polio resurfaced not only in the six countries with endemic polio (Nigeria, India, Pakistan, Niger, Afghanistan, and Egypt) but transmission was reestablished in an additional six countries (Burkina Faso, Central African Republic, Chad, Cote 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 it 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. For example, gonorrhea, which causes an estimated 78 million cases worldwide each year—about 820,000 in the United States—is becoming more and more resistant to antibiotics. Early in 2018, a superresistant strain was reported in the United Kingdom, diagnosed in
a man, who developed symptoms after sexual contact with a woman in Southeast Asia. The bacterial infection was resistant to the two major antibiotics for treating the disease—azithromycin and ceftriaxone. This case confirms one major concern for sexually active humanity: drug-resistant gonorrhea is spreading around the globe.

ZIKA Virus Disease

Long known to be endemic in Africa, Southeast Asia, and the Pacific Islands, Zika virus (ZIKAV) was first identified in Brazil in 2015 (where it threatened cancellation of the Rio Olympics) and subsequently spread throughout the Region of the Americas. ZIKAV is spread primarily by the mosquito vector, Aedes aegypti, and also by sexual contact, blood transfusion, and congenitally—from a pregnant woman to her unborn baby during pregnancy or around birth. Symptoms include mild rash, fever, red eyes, body pains, and headache. Infection during pregnancy can cause miscarriage; congenital microcephaly—babies with abnormally small heads; or other serious brain anomalies.

In 2016, a total of 3,168 noncongenital ZIKAV disease cases were reported in the United States, mostly in travelers returning from ZIKAV–affected areas, but local mosquito-borne transmission increased. No local mosquito-borne transmission has been reported in the continental United States in 2018. Despite the presence of Aedes aegypti in multiple states, other environmental conditions (e.g., use of air conditioning and window screens and temperate climate) likely limit the transmission risk in US states.

As of March 2017, a total of 84 countries globally had reported local mosquito-borne ZIKAV transmission. Determining accurately the complete global burden of ZIKAV disease is extremely difficult due to significant underreporting. Because disease is often clinically mild, patients might not seek medical care. Among those who do, the disease may be easily mistaken for another illness with similar presentation (e.g., dengue or chikungunya virus disease), testing may not be available or requested, and diagnosed cases may not be reported.

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 8,439 probable cases and 812 deaths had been reported in 30 countries. The devastation of SARS followed a path of spatially linked places and people facilitated by international travel.

Canadians returning from Asia imported SARS into Canada. The first cases involved a Canadian family of Hong Kong descent who lived 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.

Dengue

Dengue is transmitted by the mosquitoes Aedes aegypti and Aedes albopictus, which are found throughout the world. In many parts of the tropics and subtropics, dengue is endemic, that is, it occurs every year, usually during a season when Aedes mosquito populations are high, often when rainfall is optimal for breeding. These areas are, however, additionally at periodic risk for epidemic dengue, when large numbers of people become infected during a short period. Dengue epidemics require a coincidence of large numbers of vector mosquitoes, large numbers of people with no immunity to one of the four virus types (DENV 1, DENV 2, DENV 3, DENV 4), and the opportunity for contact between the two. Although Aedes are common in the southern United States, dengue is endemic in northern Mexico, and the US population has no immunity, dengue transmission in the continental United States is low primarily because contact between people and the vector is too infrequent to sustain transmission.

Today about 2.5 billion people, or 40% of the world’s population, live in areas with a risk of dengue transmission. Dengue is endemic in at least 100 countries in Asia, the Pacific, the Americas, Africa, and the Caribbean. The World Health Organization (WHO) estimates that 50 to 100 million infections occur yearly, including 500,000 DHF cases and 22,000 deaths, mostly among children.

Chikungunya

Chikungunya virus is most often spread to people by Aedes aegypti and Aedes albopictus mosquitoes, the same mosquitoes that transmit dengue virus. Chikungunya was first described during an outbreak in southern Tanzania in 1952. The name “chikungunya”
derives from a word in the Kimakonde language, meaning “to become contorted,” and describes the stooped appearance of sufferers with very debilitating joint pain that usually lasts for a few days or may be prolonged to weeks. Occasional cases of eye, neurological, and heart complications have been reported, as well as gastrointestinal complaints. Outbreaks have occurred across Africa, Asia, Europe, and the Indian and Pacific Oceans. In the late 2013, chikungunya virus was found for the first time in the Americas on islands in the Caribbean. There is no vaccine to prevent or medicine to treat chikungunya virus infection. The symptoms of chikungunya are similar to those of dengue and Zika.

**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 unsustained. 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.

Research continues into new vaccines to counter a possible flu 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 flu 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 geographic information system (GIS), the role of mapping in disease tracking, surveillance, and control has burgeoned. Recent examples include West Nile virus and TB 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 TB 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 TB decreased from 28.5 cases per 1000 screenings to 2.4 cases per 1000. The rate of developing latent TB 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 TB or recent acquired latent TB infection and thus not as cost-effective. Despite their incredible potential, these approaches are rarely employed in developing countries where they are most needed.

**Anti-vaccination Movement and Reemerging Diseases**

Before the measles vaccine existed, 9 out of every 10 children got the disease before age 15 and 2 million people died from it every year. Similarly, smallpox killed 3 out of every 10 people and left survivors with unsightly scars. Sadly, as vaccinations have successfully eliminated such previously deadly or terribly debilitating diseases, people have become indifferent or even hostile to them. The number of parents refusing to vaccinate their children, and the surge in the opposition to vaccines, in general, what has been termed the anti-vaccination movement, particularly in developed countries, should be a major concern. Recent measles outbreaks in the
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United States, the United Kingdom, and France should be a shocking reminder that surging opposition to vaccines surely paves the way for the return of deadly diseases.

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 areas where outbreaks are most likely. Strengthening the health and surveillance systems of poor developing countries is critically important because communicable diseases do not respect political boundaries. Sadly, as vaccinations have successfully eliminated previously deadly or terribly debilitating diseases, people have become indifferent or even hostile to vaccinations, making it more likely the deadly diseases return. Global cooperation is vital to prevent this threat to humankind.

See Also: Diffusion; Health Geography; Medical Geography.

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See Also:

Diffusion; Health Geography; Medical Geography.
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