SOCIAL SCIENCE, HUMAN ECOLOGY, AND EMERGING DISEASES

Jonathan D. Mayer

Professor,

Departments of Geography, Medicine (Infectious Diseases),

Family Medicine, and Health Services

University of Washington

Seattle, WA 98195

INTRODUCTION

One of the crucial tenets of disease ecology is that population, society, and both the physical and biological environments are in dynamic equilibrium. Significant enough stress on this equilibrium can produce cascading effects on any of the aforementioned components. The human-environment relationship, if disturbed enough by major changes in land use, migration, population pressure, or other stressors can show significant maladaptation, as manifested by the appearance or diffusion of new diseases. Much historical work has demonstrated the effects on both Europe and the Americas of the early widespread contact of the European explorers (Crosby 1972; Crosby 1986).

Other more contemporary manifestations of disequilibrium include the tremendous increase in the incidence of schistosomiasis following the construction of the Aswan Dam, and the increase in schistosomiasis, malaria, and other vectored diseases following the Volta River project in Africa. Examples from other continents include increases in malaria following land clearance for rubber plantations in Malaysia, increases in vectored diseases with the construction of transportation routes in Brazil, and the appearance of Lyme Disease in the United States following the reforestation in suburban areas in the Northeast as previously deforested agricultural land was reforested as a result of the abandonment of these areas by agricultural land uses since the land could be used more profitably, ultimately, for residential and non-agricultural purposes.

Despite the human toll taken by the AIDS pandemic, the major lesson to be learned from the pandemic is that the assumption that infectious diseases are a phenomenon of the past, that they are largely restricted as major health threats to developing countries, and that “international health” consists of the study of problem of developing countries, are all erroneous and misplaced. HIV/AIDS serves as a prototype of emerging and resurgent infectious diseases, which the medical and public health communities now acknowledge to be a hitherto unappreciated reality and a severe threat to worldwide public health.

To understand the emergence and importance of emerging and resurgent diseases, it is crucial to understand the widespread social, economic, and geographical changes which are occurring in the world. These changes are not uniform, yet they do share some commonalities. The world may be seen as consisting of a continuum of scales, ranging from the subatomic to the macro-scale of the planet. An appreciation of all of these scales is necessary to understand disease emergence and resurgence. The larger scale, ranging from individual behavior to societal change is generally considered to be within the scope of the social sciences and human ecology. A focus on the macro-scale is not to deny the importance of micro-scale changes, such as genetic mutation. Moreover, this focus on the macro-scale is somewhat arbitrary, for the best understanding of changes in disease dynamics comes from integrating all of these scales. This is no small task, for it involves everything from molecular biology to historical and macro-geographical perspectives on world change. Intellectually, this is a sound approach, yet it is virtually impossible for any one individual to be able to be equally adept at doing pioneering research at all of the scales.

HUMAN ECOLOGY AND EMERGING INFECTIOUS DISEASES

The basic argument in this paper is that one of the most fruitful approaches in understanding disease emergence and resurgence is that of the macro-scales, ranging from the behavior of the individual, to global social and ecological change. The social sciences may be understood as those approaches which range from the individual to the global. Human ecology is the study of how individuals and groups interact with one another. This is best appreciated within the context of the natural environment as well, for disease ecology, so basic to medical geography, epidemiology, and the social sciences in general, is also a powerful approach in understanding disease emergence and resurgence (May 1958; Meade; Mayer, 1996) Moreover, many changes are a consequence of political and economic power at a variety of scales, ranging from the transnational down to the household and individual levels. Some, or even much of this power is influenced by who controls the political and the economic power in decisions over land use, which in turn, influences the relationships of people and the environment.

Thus, disease emergence is just as much a matter of social, ecological, and geographical change as it is of smaller scale molecular events. Indeed, the meaning of disease causation changes when it is considered in social and ecological contexts. The germ theory of disease and the doctrine of specific etiology concentrated much attention on the smaller scale, microscopic and submicroscopic scales of disease. Yet, causation can also be expanded to larger scales, and though not refuting the germ theory, it thus adds to our understanding of disease causation.

That there was complacency over the supposed conquest of infectious diseases is, in part, understandable. Improvements in sanitation and nutrition in developed countries in the nineteenth century, the development of antimicrobials and antibiotics by the mid-twentieth century, and the proliferation of vaccines by the mid to late twentieth century led to a spirit of optimism, and diverted funding and training to chronic, apparently non-infectious diseases in most developed countries. The World Health Organization embraced the idea that there could be “Health for All by the Year 2000,” a notion that presupposed that most nations would already have undergone the “health transition” whereby infectious diseases are displaced by non-infectious diseases as the major causes of mortality and morbidity (Garrett, 1996). The statement in 1969 that it is “time to close the book on infectious diseases, declare the war on pestilence won, and shift national resources to such chronic problems and heart disease” came from none other than the Surgeon General of the United. Yet, as Morse (1993, 23) argues, “The lesson of AIDS demonstrates that infectious diseases are not a vestige of our premodern past; instead, like disease in general, they are the price we pay for living in the organic world.” The general significance of HIV/AIDS was not realized when it first appeared in the Western World. It is interesting in retrospect to note that one of the earliest reports of AIDS (Science 1982) termed it a new disease, but did not set it within any context of a host of “new infectious diseases.” AIDS was seen in isolation, rather than as a harbinger or an early of a more general phenomenon of the reappearance of then controlled infectious diseases, or the initial appearance of new infectious diseases. This, however, was understandable, since AIDS represents the prototype of emerging diseases: it was really the first emerging disease of major threat to public health, and the initial emergence was not enough to establish any concern over or identification of a pattern.

With the destruction of complacency comes uncertainty, and it is this uncertainty which we now face as our assumption of the conquest of major infectious diseases has been negated. Originally termed “emerging infectious diseases,” the new concentration on “emerging and resurgent infectious diseases” and their effects on society have been receiving increased attention worldwide. Though a clinical focus is important for treatment, and surveillance and containment are equally as important as public health measures, the disease ecological approach is essential for understanding the emergence of new diseases, the re-emergence of older ones, and their mutual potential for rapid diffusion.

As a response to the recent recognition of emerging diseases, the Institute of Medicine of the U.S. National Academy of Sciences convened a meeting in 1992 to come to an understanding of the nature of emerging diseases, including the causes of their emergence, surveillance for their detection, and strategies for their containment (Lederberg and Oaks, 1992). In 1994, the Centers for Disease Control and Prevention published a report which was a prevention strategy for infectious diseases for the United States (Centers for Disease Control, 1994), and this document gave official recognition to the necessity of acknowledging that infectious diseases are a major threat to public health, and that prevention must be of vital concern to public health agencies. An interagency conference on emerging and re-emerging infectious diseases was concerned to a greater degree with international surveillance and prevention (Report of the NSTC Committee, 1994).

The definitions of “emerging and resurgent diseases” may, by now, be intuitively meaningful, yet many of the formal definitions are flawed. For example, according to the Institute of Medicine’s report (1992, p. 34) “Emerging infectious diseases are clinically distinct conditions whose incidence in humans has increased.” This is singularly unhelpful, for it fits the criteria of any epidemic, where the incidence of a disease, and particularly of an infectious disease, is much greater than expected under usual conditions. Much more helpful is Morse's (1993) specification of emerging viruses, which can be expanded to other pathogens: "We may use the term 'emerging viruses' to refer to viruses that either have newly appeared in the population or are rapidly expanding their range, with a corresponding increase in cases of disease (p. 10)" This echoes many other definitions, and leads to the generalization that major social and geographical trends in the world, such as greater national and international connectivity, mobility, and other factors make it likely that hitherto unknown diseases will be discovered, and that older ones, once thought to be extinct, or not major public health problems, will reappear (Wilson 1994).

Another aspect in the definition of emergence is also troublesome. What may be an emerging disease in one society may have been present, at low or high levels, in other societies, for varying lengths in time. For example, the northward movement of dengue fever toward the United States, such that at least one indigenously acquired case has now been reported, may be regarded as a newly emerging disease in the United States, it is hardly newly emerging in the tropical countries of Latin America and the Caribbean, where it has been endemic for decades. Conversely, the appearance of chronic diseases such as ischemic heart disease and cancers in developing countries may reflect emergence to the populations of those countries, but these diseases have been highly endemic in developed countries for centuries. Thus, a distinction must be made between those diseases which are introduced into new areas through diffusion and other phenomena, and those which arise de novo. This is discussed further subsequently.

MICROBIAL TRAFFIC

There are several ways in which new pathogens can appear in a human population in a new region. Many of these are encompassed in the concept of "viral traffic," as conceived by Morse (1993). The concept is not applicable only to newly emerging diseases in the contemporary era, but may be applied retrospectively to phenomena as diverse as the appearance of syphilis in new areas during the period of the conquistadors and the trans-species transfer of viral and other pathogens, such as in trypanosomiasis, Yellow Fever, and, as is very likely, AIDS.

Though originally developed in the context of viruses (Morse is a virologist), the term "traffic" has much broader implications and is more appropriately labeled "microbial traffic," of which viruses are only one element. The concept of "traffic" inherently has geographical implications, for it implies movement and interaction, and certainly should not be limited to viruses, though these pathogens pose the most daunting threats to human health.

The appearance of new pathogens in populations can therefore be due to the following factors:

1) Cross-species transfer;

2) Spatial diffusion;

3) Pathogenic evolution, or change in the structure and immunogenicity of earlier pathogens.

4) The new description of a pathogen which had been present in humans for years, but which is "newly recognized."

Cross Species Transfer

Of these mechanisms, cross-species transfer and spatial diffusion appear to be of greatest importance. It is widely acknowledged that the pathogens responsible for a multitude of infectious diseases can be transferred to and from humans and other mammals. These include influenza, which can be highly prevalent in swine and avian populations; Yellow Fever, which is present in South American and African monkeys, and, quite likely, HIV.

The appearance of new pathogens in humans which have been present in other species leaves humans vulnerable to the pathogens, since they lack the necessary acquired immune response. Genetic variations, some major and some minor ("genetic drift" and "genetic shift") is responsible for the regular and almost predictable emergence of new strains of influenza, which almost always originate in China and involves avian and swine hosts. Each year, avian influenza seems to be communicated to domestic swine in parts of China. Genetic changes occur within the swine population which are then communicated both to the avian and human populations, resulting in new outbreaks of influenza among susceptible, non-immune humans. Since immunity is very specific for a particular configuration of the surface antigens on the influenza virus, anybody who has not been vaccinated against a particular strain, or who has not gained immunity through actual exposure to the specific viral strain, is highly susceptible to each new variant of influenza.

This mechanism of transfer may either be due to viral evolution, or to new interactions between human activities and disease pathogens. The former is exceedingly important, particularly in the case of viruses. In summary, as Morse (1993, p. 27) writes, "the seemingly insoluble problem of viral origins thus reduced to a more manageable...question of viral traffic, and attacking the problem includes better understanding and appreciating the viruses that already exist in nature, including some viruses not yet discovered."

How does a recently mutated virus or other pathogen become established in human populations? This question is of great geographical concern, since it involves May's (1958) concept that for an infectious disease to occur, there must be coincidence in time and space of agent and host. Thus, humans must come into contact with infectious agents which have either newly evolved, or have been introduced to new areas. Either one of these is considered to be an element of viral traffic.

Recent concern over some of the tropical hemorrhagic fevers serve to illustrate this point. For example, the recent outbreak of Ebola Hemorrhagic Fever in May, 1995 in Kikwit, Zaire posed a serious question and remained a mystery: why did the disease, which had been recognized and described two decades earlier, make a sudden reappearance: a reappearance as deadly as its original appearance in the same area of the world? The mode of transmission seemed to be clear, since the highest risk groups for transmission were either health care workers who had had documented contact with the secretions of patients, family members who had contact with infectives either prior to the onset of symptoms, prior to hospitalization, or family caretakers. There were and are many mysteries which surround this disease. Why did it make its appearance in Kikwit when it did? What social and human-environment interactions provided the conditions which were appropriate for its development and spread? Much related to this is the fact that there is no known natural reservoir for the Ebola Virus. In the 1996 outbreak of Ebola-Zaire in Gabon, almost all of the affected people shared the same dead chimpanzee for food. Chimpanzees in this region are predators of soota-mangabeys. This was the single epidemiological factor which united these cases. Research is still ongoing and there is no definitive or singular animal reservoir which has been identified for Ebola. Teams of zoologists and entomologists were dispatched by numerous agencies from several countries shortly after the outbreak in Zaire waned to try and identify definitive hosts, yet virtually nothing has been learned from this. The interesting footnote to this epidemic was described earlier, where the common risk factor in the 1996 outbreak of Ebola in Gabon was the consumption of meat from apparently infected monkeys.

Spatial Diffusion

Spatial diffusion has, of course, been of tremendous interest to geographers and epidemiologists for centuries. Recent changes in travel patterns have altered the human ecology of infectious disease. Two examples suffice to illustrate this point.

A well known characteristic of contemporary society is the increasing speed with which individuals and transportation vehicles traverse the earth. This is illustrated by the diffusion of new influenza strains, originating in China and then diffusing rapidly to other parts of the world, as discussed previously.

The rates and patterns of diffusion depend on the mode of transmission. With respiratory viruses, such as influenza, where viral replication takes place on the outer cells (epithelial cells) of the respiratory tract, and then the virus is transmitted via the airborne route, the rate of diffusion is rapid. The particular diffusion patterns are determined largely by understanding the origins and destinations of human travelers. Where spatial interaction is more intense, the likelihood of spatial diffusion is greater.

This is particularly significant for rapidly diffusing diseases with high attack rates such as influenza. Influenza moves so rapidly because it replicates on the epithelial cells of the human respiratory tract with great speed, and the incubation period is accordingly low.

Newly Recognized Diseases

Newly recognized pathogens do not present a major conceptual problem. They are unrecognized either because they have not been encountered by a population which has either the technological capacity to identify the pathogen, or the conceptual framework to correctly attribute a syndrome to a disease of either a specific etiology, or the correct specific etiology. One example of this is Legionnaire's Disease (legionellosis) which was thought to have constituted a new form of pneumonia when it struck the American Legion convention in Philadelphia in 1976. It was subsequently realized, however, based on serologic tests of previous blood samples from other outbreaks of mysterious pneumonias that Legionnaire's Disease was not a new disease at all, but was merely a newly recognized disease.

One of the reasons for the new recognition of a disease stems from the difference between a syndrome and a disease. A syndrome consists of a cluster of symptoms (and even the word "symptom" implies something subjective) without having any notion of the underlying causal relationships. A disease is a more systematic concept of cause and effect: a set of symptoms which are subjective, signs that are objective, and an assumption of a unifactorial or multifactorial cause or set of causes. Since syndromes and even diseases can resemble one another to the point of appearing, on the surface, as being identical, an apparently emergent disease may simply be newly recognized. The difference between new recognition and actual emergence may even have no implications for treatment or therapy.

Changes in the Human-Environment Relationship

A question of more profound significance in disease ecology, however, is not so much how mutated viruses and other pathogens become established in human populations, but how changing ecological patterns and social activities can result in fundamental changes in the interaction between people, the biological environment, and the broader social and economic context. From the perspective of social science, it is here that the most interesting questions concerning emerging diseases arise. A question of more profound significance in disease ecology, however, is not so much how mutated viruses and other pathogens become established in human populations, but how changing ecological patterns and social activities can result in fundamental changes in the interaction between people, the biological environment, and the broader social and economic context. From the perspective of social science, it is here that the most interesting questions concerning emerging diseases arise.

FACTORS IN EMERGENCE

One of the most elegant schemata for understanding the whole ecology of disease emergence is contained in the report by Lederberg and Oaks (1992). Economic and social emergence factors—changes in land use, human occupation and activity, urbanization—are integrated with biological factors in emergence such as mutation, genetic factors, changes in the zoonotic pool, and other elements. These in turn affect both human and animal hosts, as well as vectors, if the disease is a vectored infectious disease. Patterns of human movement and transportation are seen as being of crucial importance, and all of these are integrated into the particular forms of social organization in given society. The patterns are exceedingly complex, and the ecology of the intersecting elements are difficult to understand or represent in any simple scheme.

This is the case with Lyme Disease, caused by *Borrelia burgdorferi*. The story of this bacterial arthritis is familiar and has been described elsewhere on numerous occasions. When clusters of the disease were first discovered near Lyme, Connecticut, and when the agent was identified, some authorities suggested that it was a new disease. However, it had been present for many years in Europe and Scandinavia, and was labeled as erythema chronicum migrans, among other names. Nonetheless, analyzing the web of causation in the Northeastern United States is instructive.

Advances in transportation technology made the development of suburban communities possible at relatively great distances from Central Business Districts, as described by Sam Bass Warner and others. These communities were principally commuter communities for central cities. However, more recently, these communities have also seen great population growth. Much of this growth has been on the outskirts of the already developed suburbs, and has required deforestation and land development for tract housing. Much of the growth surrounding the newer suburban communities is secondary growth. This condition has made it possible for white tailed deer to populate the areas into which people are moving. This is significant since the vector of East Coast Lyme Disease (ticks called *Ixodes dammini* according to some and *I. scapularis* according to others—itself a fascinating debate) is transported by these deer. Thus, the ecological conditions are perfect for the transmission of Lyme Disease: new settlement on the fringes of suburban and peri-urban areas; reforestation; and the presence of the vector. To understand the chain of causation of Lyme Disease in the Eastern United States, one must understood the population, settlement, and transportation geographies of these areas, both at present and historically; the political economy of land development; the natural ecology of the areas, and their regional entomologies, and zoogeographies. Lyme Disease will be discussed more fully in the next section.

Understanding the human ecology of any other diseases, emerging or not, is equally complex. Despite the major innovations and advances in molecular biology and immunology, it is reductionistic to restrict the analysis of disease emergence to this scale. However, this is rarely done any more, though scientists trained in molecular biology may feel a personal lack of ability and knowledge in social science. It is vitally important to continue to integrate social scientists into the analysis of emergence, as is happening to an increasing degree.

POLITICAL ECOLOGY OF DISEASE

The political ecology of disease is a promising if as yet underdeveloped approach to understanding disease dynamics. It combines the elements of traditional disease ecology with the concepts of political economy which have been very productive in explaining a whole variety of human projects (Mayer 1996). Political ecology emphasizes the unintended human and natural consequences of individual and bureaucratic projects, and demonstrates aptly that disease has its “human-made” components as well as its natural components. At its deepest, it changes the concepts of the causality of disease from a purely biomedical concept to one which also incorporates the unintended yet frequently tolerated aspects of human action.

The emergence of many diseases is the direct result of human action. For example, if Ebola Hemorrhagic Fever may be taken as one prototype of an emerging disease, there are only two things that are clear about the disease. One is that it is poorly understood, and the other is that it has a very high case fatality rate. While the viral basis of the disease has been identified, its human and political ecology are enigmatic and remain mysteries despite intense attempts at identifying how the virus moves from an enzootic into one which affects. As human activities expand the range of human action to include new portions of tropical rainforest, the potential for diseases hitherto unknown or very rare in the human population to appear in the population is high. As discussed elsewhere, species jumps are common, and are not particularly exotic. Influenza is present in avian populations; psitttacosis is primarily a disease of psittacine birds which have become fond pets in the western world, and Hantavirus Pulmonary Syndrome has its reservoir in rodent populations.

In the case of Lyme Disease, the chain of events which have led to the emergence and recognition of this disease in New England is complex. Initially, virgin forest was cleared for agricultural land use in the 18th and 19th centuries. With the invention of the steam locomotive, it became possible for commuters to New York City and other metropolitan areas to live further away from major employment centers. Agriculture moved to upstate New York and even further west, and second growth forest replaced agricultural land uses. This allowed the white tailed deer to be introduced into these areas where they could thrive, and the ticks which are the vectors for Lyme Disease thrived and continue to thrive on the deer. With further population growth, towns such as Lyme have exhibited radial growth, mostly for housing. The real estate industry and land developers have been inextricably involved in the complex nature of land use change. Consistent with the major lesson of disease ecology, wherein agent and host must come into contact at the same time, the incidence and prevalence of Lyme Disease has increased.

ANTIMICROBIAL RESISTANCE

The development of antimicrobial-resistant agents is as serious a threat, and perhaps more of a threat, to the population in developed countries than are some of the more exotic agents mentioned above. Tuberculosis is the infectious disease which is responsible for the greatest number of deaths worldwide, yet most of these deaths are in developing countries which lack the resources for adequate drug treatment. In the United States and elsewehere, the development of multidrug-resistant TB (MDRTB) threatens efforts to decrease the impact of this disease. Though the prevalence of TB has been declining in the United States in recent years, certain pockets of population are particularly susceptible to some very serious forms of the disease. There are five antimicrobials available in the treatment of TB, yet the intersection of itinerant populations, homelessness, poverty, and migration provide a challenge for TB control. Drug protocols in patents whose susceptibility to active TB requires the use of a minimum of two medications and up to four medications on a daily basis for at least six months provide a formidable challenge. If they do not complete their medication regimens, the environment is creative for the selective breeding of drug resistant organisms. Should the individual develop a form of TB which is then resistant to known drugs, this airborne disease may be easily communicated to others, and it is a sobering scenario that the medical establishment may then lack the appropriate antimicrobials for treatment and prophylaxis of TB. The origins of the resistant forms of TB are social and are not merely medical. In countries where poverty and homelessness do not present the severe problems that they do in the United States, drug resistant TB is not a major concern. Similarly, though this particular disease has the potential of spreading to the West Coast, and has, to some extent, it remains mostly a problem of the large Eastern and midwestern urban areas: areas where the social challenges of poverty are particularly poignant. It is quite reasonable to expect, though, that MDRTB will not remain confined to the Eastern U.S. and will become a severe problem for the inner city urban population of the country. Multiple drug resistant TB, which is most prevalent in homeless and poor populations, is thus caused just as much by underlying social conditions as it is by the bacillus itself. Social stratification, geographical concentrations of poverty within concentrated urban neighborhoods, and the underlying social and economic conditions are as important in understanding the emergence of MDRTB as is the comprehension of the smaller scale biological processes which are of great importance in the pathogenesis of drug resistant TB.

Recent developments in molecular biology allow the identification of specific strains of bacteria and other microbes very specifically, not by the morphology and structure of the pathogens, but by the very structure of the RNA and DNA. These techniques are frequently called RNA or DNA “fingerprinting” in the popular press, thereby conveying the idea that microbes can differ in minute ways. These techniques actually trace specific RNA and DNA sequences. A microbe which is resistant to one medication will show a specific structure, and it therefore becomes possible to identify the spatial patterns and diffusion of antimicrobial resistance.

Not all bacterial diseases are still treatable via prior methods of drug treatment, and this is partly due to the diffusion of organisms via transportation systems. Of great concern is the diffusion of antimicrobial resistant organisms. This develops both from prescribing practices and biological processes such as mutation, but the diffusion itself is from personal travel. For example, for nearly a decade, the class of antibacterials known as fluouroquinolones appeared to be almost universally effective against gonorrhea (caused by *Neisseria gonorrhea*, or more popularly, by gonococci). Resistance to the quinolones has developed in Asia, principally in the Philippines, and subsequently appeared in Hawaii, Washington State, and several other states in the United States. This could only have occurred through travel and migration. The result is that more complicated and more costly drug regimens are required to treat gonorrhea at present.

Other organisms have developed various levels or resistance to even newly developed drug protocols. Of great concern are hospital-acquired (nosocomial) infections. Methicillin resistant *Staphylococcus aureus* (MRSA) has been of great concern in institutional settings, since the presence of this organism occurs periodically in epidemic proportions within hospitals and clusters in particular communities at certain times. There are few medications available to treat this potentially lethal bacterium. It is transmitted principally via the nares of hospital workers and of patients and visitors. It tends to concentrate in larger hospitals and in intensive care units, and the most effective strategy for dealing with an epidemic of MRSA is complete isolation of carriers. In some cases, whole units of hospitals must be shut down and sanitized.

Of even greater concern is the more recent development of vancomycin-resitant enterococcus (VRE). For this bacterium (*E. faecalis and E. faecium)* vancomycin is the only available medication. When the bacterium becomes resistant, there is simply no available antimicrobial treatment for patients, and supportive care is the only alternative. It, too, occurs in clusters within hospitals and nursing homes and in clusters on a broader geographical scale. The case fatality rate is high.

Drug-resistant forms of communicable disease thus constitute major threats in developed countries, and may ultimately prove to be more serious than the newly discovered more “exotic” diseases such as Ebola, Marburg, and Lassa Fever. Rapid surveillance and quick isolation of infected individuals is crucial in the case of MDRTB, MRSA, VRE, and other drug-resistant organisms. While the development of contemporary molecular methods of microbial typing allow the description and inference of probable patterns of diffusion, their relationship to the control of the diffusion is less obvious.

Trade and transportation also constitute potential bases for the introduction of new diseases into new areas. As such, it is a factor in disease emergence. Economies and societies are highly dependent on those of other regions, and virtually all development theory considers interdependency. Interdependency can introduce diseases in several specific ways, all related to diffusion. First, humans may serve as vectors themselves. People traveling from one region to another who may be carrying a communicable can introduce that disease into a new region with relative ease. This is particularly so for airborne diseases which are readily transmitted, but also holds, though less dramatically, for vectored diseases, sexually transmitted diseases, and nonvectored bloodborne diseases.

Second, transportation vehicles can, themselves, serve as vectors for the diffusion of diseases or disease vectors. It is well known that one of the vectors of Dengue Fever, *Aedes albopictus*, was introduced into the United States from Asia via automobile tires on ships coming from Asia. The tires were damp or actually contained pools of water, which provided the vectors with ideal conditions for survival and replication. This is of great potential consequence for the United States, since the possibility exists that Dengue will be introduced into even temperate areas of the country once the vector is present.

Other examples abound wherein the transportation vehicle itself serves as a vector for transmission. The introduction of cholera into the Americas in the most recent outbreak was due to a ship from Asia dumping its bilgewater into the ocean off the coast of Peru. The cholera epidemic in the Americas has been spreading rapidly as a result of this.

The proliferation of trade and transportation is the result of economic and political factors, and affects regional development, individual firms and corporations, local economies, and the broader society. In a general sense, the “cause” of the diseases which are conveyed via transportation modes is not just biological, but is highly dependent upon entrenched interests, and the continuing drive for local and regional development. These entrenched interests include the need for raw materials, commodity shipment, and recreational and business travel.

It is a cliché to state that the world has become more interconnected as a result of economic, social, and political factors. The causes for this interconnection are complex, and are embedded in the contexts of the various societies which are increasingly intermingled. It is exactly this interconnection, the development of a world tied together through transportation and movement of goods and people, which is responsible for the sometimes apocalytptic visions of global epidemics due to emerging diseases. What these visions do underscore is that it is conceivable for new agents to move rapidly across space, and it is equally conceivable for emerging agents to have very high prevalence and case-fatality rates. After all, this is a phenomenon which is not new in history. The European "conquest" of the Americas carried with it great mortality, as documented by historians and anthropologists. The influenza pandemic of 1918-1919 killed between 20 million and 50 million individuals. The numbers are impossible to confirm because of the lack of the technology or infrastructure for surveillance at that time. It is also impossible to confirm virologically exactly what happened in that pandemic, but it was almost certainly due to antigenic shift and genetic mutation of the influenza virus. These shifts have been well-documented in the latter half of the twentieth century.

Ultimately, then, what does political ecology add to our understanding of the dynamics of emerging disease? First, that emerging diseases are due both to human activities and to ecological realities. This is nothing new in itself, for human-environment interaction is the basis of ecology; this, in the context of disease agents and hosts is the very basis of traditional disease ecology. However, the alteration of patterns of human activities can serve some while detracting from the power and autonomy of others, and merging these sorts of considerations with disease ecology yields the "political ecology of disease" (Mayer 1996) It is incorrect to view emerging diseases as being divorced from the populations which may be affected by the diseases, and it is equally incorrect to conceive of the causes of emergence as being solely biological, as discussed in the section of this paper on "factors of emergence."

LOCALITY AND DISEASE EMERGENCE

One of the fundamental tenets of recently articulated concepts of :"locality" is that particular regions are located in a multiplicity of contexts, ranging from the local to the worldwide. The very definition of locality and of the "sense of place" that is associated with this demands appreciating this. Individuals and groups define their home and work environments in these terms, and one of the advances in human geography in the past 15 years has been the development of a sophisticated body of theory which embraces this concept.

Such is the case with the Pacific Northwest, to cite just one example. Once an isolated part of a sparsely populated continent, it is now a thriving hub of tertiary and quaternary economic activities, with the attendant transportation links to the rest of the world. Not only is this region one of the major regions of the Pacific Rim, with ties to Asia, Latin America, and the Pacific Islands, but it is also integrally tied to other centers of activity in the world, most obviously the midwestern and eastern United States, but also to Europe, Africa, and elsewhere. The presence of major corporations such as the Boeing Corporation, headquartered in Seattle, and Microsoft, headquartered in a suburb just outside of Seattle, testify to the existing and growing ties of the Northwest to the rest of the world. Boeing is the single largest exporter in the United States, and Microsoft is not far behind. There are nonstop flights between Seattle and numerous regions in Asia and Europe, and easy connections are available to Latin America, the Middle East, and Africa. In terms of connectivity, the Northwest is in no way isolated, and the risks of any rapidly diffusing emerging disease reaching and affecting the Northwest are high (Kimball and Mayer 1996; Mayer and Kimball 1996)

Yet, to generalize, many Northwesterners feel a sense of positive isolation from the rest of the world, and cite this as one reason for their continuing attraction to the region. Indeed, some rural potions of the Northwest are quite isolated, with desert-like areas separating major communities by hundreds of miles. If one includes Alaska, and perhaps British Columbia in this region, then this is particularly pronounced. The Northwest is therefore somewhat of a dualism between metropolitan communities integrated fully into the world economy, and isolated rural areas which are frequently uninhabited.

Of what relevance is this to understanding the emergence of disease? First, it is difficult to generalize about which diseases will reach a given area first, in any scenario. However, it is apparent that the urban areas of the Northwest, positioned as they are in the world society, are more vulnerable to the importation of emerging diseases than are rural areas. Yet, underlying this is a misconception. It is assumed that emerging diseases will probably come from the tropics, and there is some basis for this, for it is the tropics which have the greatest ecological diversity. Thus, it has been surprising to local populations when closer inspection suggests that emergence may be initiated in their home communities. There was recently a death in Seattle from Hantavirus Pulmonary Syndrome which was acquired indigenously in a suburb just north of Seattle. This rodent-transmitted disease, though, until now, has been restricted to rural areas such as the “Four

Corners" areas of the Southwestern United States, where there the syndrome was first described after a major cluster of cases which resulted in several deaths. This of course resulted in detailed and painstaking epidemiologic investigation which eventually linked the cluster to a virus virtually identical to one which causes a different syndrome in Korea: the Hantaan Virus.

Rodents are obviously not restricted to rural areas, and this has never changed in its implications for human health since the Black Plague. There is no inherent reason why HPS cannot establish itself in urban areas, where the contact with human populations would be much more intense and frequent than in rural areas. Thus, the death of a woman from north of Seattle from a virus similar to one described for years in Korea and identical to the virus of the Four Corners region suggests two things. First, that even peri-urban areas of the Northwest are not isolated, and second, that the Northwest itself, like any region, may serve as a point from which an "emerging disease" originates.

MIGRATION, MOBILITY, AND DISEASE EMERGENCE

Many statements have been made to the fact that society is becoming more mobile, yet this is not entirely valid. True, when considering affluent, developed nations, and the subpopulations in those societies who travel for business and pleasure, there is a great deal of domestic and international movement. However, among the poor, and in less affluent societies, mobility on the scale typified by the generalization that "society" is becoming more mobile, a major question is "which societies and which populations?" Moreover, the underlying reasons for mobility must be considered to understand the effects of mobility on disease emergence and diffusion.

The world should be considered as a continuum of mobility. In traditional society, mobility is limited to very local trips, and in hunting and gathering groups, which are admittedly disappearing quickly because of the pressures of international capital, environmental and land use modification, government regulation, and the attractions of regular wages, mobility is dictated by the seasons, by natural hazards such as drought, and by the periodic movement of the targets of hunters, such as the movements of animals in sub Saharan Africa. If , then there is a hierarchy of mobility ranging from some populations which are not mobile at all, to members of other affluent societies where intercontinental business and pleasure trips are the norm rather than the exceptions, of course facilitated by jet aircraft, then it is clear that lack of mobility—a kind of permanence in space—tends to favor stability in the spatial distribution of infectious diseases, while highly mobile individuals and the availability of speedy overseas transportation favors the possibility of very rapid international diffusion of new diseases. Similarly, immobile societies may even be protected from disease diffusion due to lack or minimization of contact with other geographically remote social groups. The point, then, is that it is an overgeneralization to argue that the word is monolithically facing increasing mobility, which predisposes most populations to the rapid influx of new disease agents.

It is also crucial to consider the reasons for mobility, and the political, social, and settlement characteristics at the origin and destination of migrants. Migration implies a more permanent movement than does travel, though population geographers and demographers classify migration into a typology which includes forced vs. voluntary migration, periodic vs. permanent or semi-permanent migration, and other typologies of migration. Migration which is forced in poor countries due to political or religious persecution, natural hazards such as drought, or war, where refugees end up in densely settled and unhygienic refugee settlements clearly favor the diffusion of a whole range of infectious diseases, including diarrheal diseases, airborne diseases, and others. Migration from one affluent society to another entails little change in disease risk and disease diffusion. Thus, it is very important to be specific about the type of mobility which is considered.

Of less significance in terms of pure numbers of affected individuals, but of great conceptual importance has been the phenomenon of "airport malaria," where individuals who live within several kilometers of international airports have contracted malaria, despite the fact that they have not been in any areas where malaria is endemic, and may have even not left their home countries for any travel. Such occurrences have happened in the past few years around the Geneva airport in Switzerland, Newark Airport, Heathrow, and Detroit Metropolitan Airport. Experimental data indicate that anophelines may survive a flight from a tropical country in the wheel wells of aircraft, and then fly into the areas surrounding the airports. This is the only way that those affected by "airport malaria" could possibly have contracted the disease. Should this occur in areas where anopheline replication is easy due to climatic and ecological factors, the potential exists to introduce malaria into previously non-endemic areas.

This phenomenon does serve the function of indicating that vector transportation is potentially a threat, particularly to tropical countries where climatic conditions are conducive to vector survival and multiplication. One fascinating example is that Yellow Fever is confined to tropical Africa and Latin America, yet it has apparently never been present in Asia, which has the correct habitats for vector survival, and potentially a highly susceptible population, lacking any immunity due to no previous exposure. Why has Yellow Fever not diffused to Asia? This remains an unanswered question.

Two examples, however, do indicate the possibility of vector transportation with major public health consequences. Dengue was introduced to the Caribbean from Asia, probably due to shipping, though there is no precise method of identifying just how dengue was introduced to the Americas. It has since become a major problem and is epidemic in Latin America and the Caribbean. It is almost certain that the movement took place because of worldwide shipping patterns.

Another example also draws upon the example of dengue. One of the Asian vectors the *Aedes albopictus*, was not present in the Americas though it has been highly prevalent in Asia. The shipment of automobile tires represented an ideal set of conditions for the introduction of this vector, which is notorious for replicating and living in the hollow portions of tires, particularly if they are damp or contain water. This may, in fact, have been the mechanism by which dengue was introduced to the Americas. It certainly provides justification for surveillance and vigilance.

CONCLUSION

The world is undergoing rapid change as human-environment relations evolve, global interdependency increases, and previously stable equilibria are disrupted. One of the consequences of these global changes is that infectious diseases, once thought to be on the wane, are still very much a factor both within developed and developing countries. The complacency with which much of the medical community viewed infectious diseases until the 1980's is understandable, for smallpox had been eliminated, tuberculosis was well on the way to being a minor problem in the United States, and many infectious diseases in the tropics appeared to be on the wane. However, because of many factors, infectious diseases are very much a cause for concern in some places, and for alarm in other places. HIV has devastated much of sub-Saharan Africa; drug-resistant tuberculosis continues to increase in the United States, particularly among the urban poor and homeless, and hospital acquired infections are increasing. Several of these have extremely high case-fatality rates, since they are responsive to no known antibiotics. Over the long term, disruption of the ecosystem and its fragile equilibrium with humans, continues to take its toll.

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