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Introduction

It is obvious with many diseases – and with health status in a wider sense – that their geographical distribution tends to change, that is, the spatial occurrence or extension of diseases varies through time. So does the intensity of a certain disease, calculated as incidence, prevalence, mortality, or case fatality. As diseases – and health status in general – are largely functions of individual properties, behavior, and environmental circumstances, their spatial distribution will tend to change over time as individuals come and go and as the physical and social environment changes. Infections will spread with people, animals, and things moving from place to place. The distributions of noninfectious diseases will change too, and ostensibly these redistributions will appear as
spatial diffusion and waning, but the character of the process will depend on the type of the disease and a multitude of geographically different physical and social circumstances.

With increasing mobility and environmental change, disease diffusion is an urgent public health issue on local, regional, national, and global levels. Recently several infectious diseases, which have been more or less under control or even eradicated from large parts of the earth, have reemerged, while 'new' diseases have appeared and noninfectious ones have expanded in numbers and spatial distribution.

Along with epidemiology, concepts and methods from geography and cartography can be useful for understanding, describing, and analyzing the processes leading to new spatial patterns of ill health, but current epidemiological trends call for methodological and theoretical development.

**Disease Occurrence – Disease Distribution**

Basically, disease distribution or occurrence can be perceived in two different ways. On the one hand, it can be thought of as the places where cases (i.e., affected individuals) are found. On the other hand, it could be perceived as the locations where the necessary circumstances for causing illness are prevalent, for example, the microbes or living conditions that constitute health hazards.

In the first view, disease is seen as an outcome which can be observed, like any state of health, in an individual. In other words, information about disease occurrence is linked to the individuals. This view is a basis for epidemiology, which measures incidence and prevalence in search of correlations with circumstances that might clarify the etiologies of diseases. The occurrence of disease could thus be considered equivalent with the individuals themselves and from this perspective geographical distribution can be understood as a number of more or less mobile points with varying lifetimes, sometimes appearing in clusters or within more or less clearly distinct regions or zones. This notion has led to important discoveries and progress in epidemiology and medical geography, most notably John Snow’s mapping of cholera in Soho (Figure 1). The alternative view focuses on the causes, which means that disease occurrence is associated with an area where some potential health hazard prevails. Pathogenic factors may be around, but cases actually occur only when susceptible individuals are exposed to them. This perspective is the basis for identifying risk areas often visualized on maps in vaccination clinics.

Consequently, there are also two main ways to understand disease diffusion – either as the diffusion of cases or as the diffusion of the causes and hazards.

Since every spatial observation is valid at a certain point or period in time the notion of disease diffusion is a spatial–temporal concern.

In a formal sense disease occurs when a case is discovered, diagnosed, and registered, making it available for research and statistics. In a more real and personal sense disease occurs once an individual feels ill, which often but not necessarily happens before the diagnosis is made. It is also possible that a disease (e.g., cancer in its early stage) is discovered at a routine screening before the patient has noticed any symptoms. In a wider perspective, a pathogenic process may begin with exposure to circumstances that may eventually lead to a disease. Between exposure or the start of a pathogenic process and the onset of symptoms lies a period of incubation or latency. With influenza, the incubation time is a matter of days, whereas AIDS, which is caused by a lentivirus, has an incubation period of months or years and hepatitis C might cause only mild or no symptoms and therefore remain undetected for decades. With noninfectious diseases, such as cancer and neurological disorders, the latency period may be not only years, but even decades. In the meantime, the affected individuals may have moved, which means that the exposure or pathogenic onset may have happened in a different place and a different environment than the place where the case is eventually recorded. This time–space lag complicates the notions of disease occurrence and diffusion.

Mapping disease diffusion must account for the spatial changes in the time dimension. Thus, cartographical methods have included vectors, isopleths (isochrones), map sequences, and time-geographical visualization.

**Diffusion Process**

While medicine focuses on causes, exposure, transmission of pathogens, and the ensuing pathological outcome, geographical issues concern the locations and numbers of cases plus the directions and pathways that diseases apparently follow to reach new victims as well as the means and geographical circumstances that favor or inhibit the spatial spread of ill health.

Spatial diffusion theory makes a main distinction between the dispersal and the structural dimension of a diffusion process. Whereas the dispersal aspect of the diffusion concerns the routes of the movements, the structural dimension refers to the reciprocal relationships between the locations along the route.

The dispersal dimension is designated either contagious (contact) or hierarchical while the structural dimension is characterized as either expansion (expansive) or relocation. The word contagious is used as a metaphor in diffusion theory. When it is used in connection with disease diffusion it does not necessarily refer to infections
that are literally transmitted from individual to individual. Thus, drug abuse and its health consequences might spread from a metropolitan area to neighboring suburbs because of their proximity before spreading to regional centers and towns further down the urban hierarchy. In this context, contagious means that something tends to spread by proximity – to nearby places, whereas hierarchical diffusion takes place in a stepwise

Figure 1  During a cholera epidemic in London 1853–54, Dr. John Snow mapped every death on a map and found that they clustered around one of the public pumps. This observation supported the hypothesis that cholera was spread by water.
manner – from one, usually more central, location to the other, not necessarily nearby, locations from which the diffusion may proceed.

Considering the different ways of defining disease occurrence, this typology is not unconditionally applicable to disease diffusion. Medical geography has largely concentrated on the diffusion of infections, but the occurrence of noninfectious disorders displays similar trends. Epidemics/epizootics and pandemics spread as microorganisms and vectors move over distances and through time – just like goods, travelers, innovations, information, or habits. As to noninfectious diseases, the actual diffusion process may be more complex and constitutes a methodological challenge.

Increasing numbers of cases, as such, reflect a diffusion process, but the spatial process may take very different shapes. First, diffusion might imply that more individuals are taken ill within unchanged outer spatial limits, that is, a condensation but no spatial expansion of cases takes place. Second, diffusion could imply that more individuals are affected within a wider area (i.e., the outer limits of a core area are widened and the process is expansive), for example, as drug abuse spreads from the inner city to the suburbs. Third, diffusion could mean that individuals in other places fall ill. In the latter case, different types of diffusion may be more or less distinguishable. If an epidemic affects one country or continent after another, the extension of the disease is enlarged as more individuals in new places fall ill. Eventually the disease might subside in the locations where it struck first, which would appear as a relocation of the disease, but the individual cases are not relocated. Relocation of cases would imply that affected individuals have moved to other places. This, however, is conceivable with genetically conditioned disorders.

A crucial issue in epidemiological geography is to what extent the observed cases of disease in a certain place are caused there as a result of selective migration, that is, individuals with a certain predisposition have moved to that place. For example, it has been suggested that persons with poor mental health or risky behavior (e.g., abuse) would tend to move to cities (drift), which would imply a relocation of health problems. Alternatively, physical and psychosocial stimuli in the urban environment would cause (breed) ill health. Sometimes, this issue is referred to as the breeder and drift hypotheses.

The diffusion process involves numerous events on all spatial levels from intercontinental transport and climatic variations down to households, workplaces, and hospitals. Geographically speaking, besides what is being spread, a diffusion process involves a place of origin (a source), one or more receiving places, the pathways of spread, and a force driving the diffusion.

1. The potential for spatial diffusion depends on the character of the causative agents, such as their transmission modes, mobility, reach, and viability, as well as various determinants. Exposure (i.e., the contact between causes and susceptible individuals) is crucial for transmission and the start of a pathological change in a human or other living being.

Contagious diseases (e.g., influenza or STDs (sexually transmitted diseases)) may be transmitted either directly to a susceptible person through intimate contacts with infected humans and animals or indirectly by a vector (e.g., ticks – tick-borne encephalitis (TBE) and Lyme disease; mosquitoes – malaria). The pathogen may also enter a human body through the air as droplets, with blood, food, and water as well as by surface contacts with objects. The viability of pathogenic agents and their vectors is a crucial factor with infectious diseases. Unless they find a suitable host soon enough they will perish, no transmission will take place, and the diffusion will stop.

Noncontagious diseases may be caused or triggered by some physical, chemical, or even social exposure. Some diseases may be the outcome of genetic predispositions, either inevitably caused by genes or triggered by external circumstances. The reach of noninfectious pathogens (such as radioactivity or pollutants) is closely related to the medium which carries them, for example, winds and waters.

2. Like other geographical objects, sources of disease diffusion may assume point, line, area, or diffuse shapes. Point sources may be infected wells or polluting anthropogenic plants, such as incinerators. Line-shaped potential sources could be polluted rivers, heavily trafficked roads, or high-voltage cables. Area sources of disease diffusion may be endemic regions and natural reservoirs or places with high radon content in bedrock or buildings. Finally, diffuse sources could be certain behaviors, habits, and practices.

3. Next, no infectious diffusion can become apparent (in terms of cases) unless the pathogenic influence reaches a place with a population including susceptible or vulnerable individuals.

4. The courses of diffusion are guided and shaped by available routes and nodes as well as barriers. Throughout history, contagious diseases have followed people and animals along rivers, roads, railroads, and caravan trails. Eventually railways, steamships, trucks, buses and, not least, airlines have altered the modes, velocity, and routes of disease diffusion. Winds and water also play a role for the transportation of organisms and vectors. Thus, foot-and-mouth disease has probably been spread by winds from farm to farm without any direct contact between
Infected and susceptible animals. Cholera diffusion may have been influenced by wind directions.

Diffusion of contagious diseases may also follow social routes without obvious physical manifestations. Such diffusion has been mapped, for example, HIV in personal networks.

Noninfectious pathogens, such as radiation, chemical emissions, and toxic compounds from volcanic eruptions may be carried by winds and waters.

Nodes of diffusion are places where people frequently meet. Typical nodes for the transmission of contagious diseases are urban centers, ports, refugee camps, marketplaces, trading towns, and border towns. Due to poor sanitary and crowded conditions refugee camps are high-risk areas for infections. Thus, in African refugee camps diseases like AIDS and other STDs, cholera, dysentery, plague, diphtheria, Ebola and Lassa fever have been reported. Other nodes are large workplaces, shelters for homeless, schools, and prisons. Likewise, not only permanent localities, but certain occasions such as local festivities and similar social events may increase transmission risks. For example, haymaking in the summer has probably been an occasion for spreading measles in Iceland, contributing to characteristic seasonal waves.

On the contrary, disease diffusion may be stopped or deflected by permanent or temporary barriers. Physical barriers, such as vast spaces of water, mountain chains, or large ice sheets, can be effective against 'contact' diffusion (to nearby places). Diffusion may be stopped or slowed down by biological barriers such as widespread immunity and habitats unsuitable for agents or vectors. Further, social barriers involve cultural practices, habits, and knowledge. Thus, disease diffusion may be precluded by public health interventions and precautions, such as quarantine procedures, disinfection, dissection, and vaccination campaigns, or by widespread knowledge about personal protection.

5. Finally, diffusion depends on micro-scale events that bring individuals in contact with health hazards. Humans, animals, transport networks, vehicles, and various objects may be involved in the process. Occupational conditions, daily personal routines and attitudes may be decisive for exposure. Sexual and other cultural practices play an important role for either spreading or barring the spread of STDs — for example, promiscuity versus fidelity, polygamy, circumcision and other rites.

Key groups for infectious transmission are highly mobile people like migrants (such as migrant laborers), refugee populations, truck drivers, and commercial sex workers and their clients. In situations of armed conflicts, troops often appear as another key group.

In reality, it is not unusual to see different epidemic waves of a certain disease behaving differently or to find both 'contagious' and hierarchical phases simultaneously or sequentially as parts of a larger diffusion process. Also, new geographical conditions affect the diffusion routes. For example, cholera epidemics swept across the United States and Russia several times in the nineteenth century and it has been ascertained that in the later part of the century both diffusion routes and velocity were affected by the growing railway networks. Instead of advancing slowly to the most nearby places the disease would leap from place to place along the lines (Figure 2).

Political circumstances sometimes affect, indirectly, disease diffusion in different ways. Thus, the South African apartheid regime seems to have impacted the spread of HIV in the region in two ways. As the regime imposed restrictions on nonwhites' movement within the country, the diffusion was inadvertently constrained. Then large numbers of opponents went into exile in neighboring countries where HIV was more prevalent, thus becoming exposed and later bringing the disease to South Africa when they returned after the change of regimes.

In all, the conditions for disease diffusion are rooted in complex ecological circumstances and chains of causes and determinants. Proximal determinants (sometimes called downstream factors) are involved with the actual transmission, such as commuting and sexual behavior, whereas distal determinants (or upstream factors) cover micro- and macro-scale, socioeconomic, and cultural conditions, like migration, poverty, urbanization or religion.

**Epidemiological Landscapes**

The geographical context of health and disease can be thought of as an epidemiological landscape or a landscape of exposure. The pathogenic complex with a similar concept distinguishes natural bio- or eco-pathogenic complexes from two types of man-made complexes. Whereas socio-pathogenic complexes refer to potentially harmful social circumstances, such as standard of living, occupational environment, food habits, and other cultural phenomena, techno-pathogenic complexes are associated with technical products, by-products, or waste.

Conversely, the term therapeutic landscape has been suggested for places that exert a healthy influence.

Several concepts are used to designate areas with certain disease ecological characteristics. Natural focus refers to a landscape associated with biotic and abiotic factors which are vital for the pathogens and other factors involved in the ecology of a particular disease. Natural *nidus* (plural, *nidi*) is defined as a micro-scale region constituted of a living community where a disease agent...
continually circulates among the individual members and the habitat conditions are necessary to maintain the disease system. Nosochoros and urban risk cells are other concepts with similar meanings.

Landscapes are dynamic, that is, their contents and extensions will change over time with consequences for health and disease. This change is closely connected with the process known as epidemiological transition.

**Epidemiological Transition and Future Prospects**

Throughout history, epidemics and pandemics of infections have repeatedly swept across the earth from their endemic areas to vulnerable populations and places. The era of European discoveries brought people and infectious diseases from the Old World and other continents in contact with each other.

However, disease ecology has gone through an epidemiological transition which implies that diseases caused by infections, parasites, and poor nutrition eventually have been mastered, more or less, but superseded by others, usually called chronic, degenerative, or man-made diseases. This transition, which started in the nineteenth century with a protracted process in England and some other European countries, has eventually reached other parts of the world, where the process has tended to be faster. This transition might appear as a spatial diffusion of diseases, but is rather the outcome of changing biological as well as geographical preconditions for disease diffusion, including diffusion of determinants.

First, social and structural changes have altered the ecological landscapes. Large-scale urbanization and new lifestyles provide new opportunities for transmission and exposure. Further, as demographic structures are changing, susceptibility and vulnerability assume new spatial patterns.

Second, the conditions for diffusion have been radically altered by increasing spatial connectivity – modern transportation systems as well as increasing and diversified mobility. Migration and other types of mobility appear in many shapes with complex effects on the diffusion and distribution of health and disease. The notion of a ‘healthy migrant effect’ is based on the assumption that persons in good health are more likely than others to migrate. However, ‘forced migration’ is a common effect of natural disasters, enduring violence, and adverse living conditions, which might induce people in poor health to move. Also, elderly or persons already suffering from poor health may move to healthier places or closer to healthcare. Thus, migration entails large-scale relocation of health-related factors. Commuting entails regular exposure to different environments, while
tourism and other long-distance traveling bring people in occasional contact with unfamiliar risks.

Third, global and local environmental changes alter the health prospects. In the future, the living conditions for agents and vectors involved in disease ecology might change in the wake of climatic change, just like prevalent winds and weather conditions might favor or disfavor the diffusion of a particular epidemic.

In all, the present global panorama of health and disease includes new, emerging, and reemerging diseases as well as increased frequencies of chronic disorders. Infectious epidemics continue to change the distribution of health in short- and long-time perspectives, but non-infectious health issues are also sometimes said to assume epidemic proportions, for example, smoking, overweight, and obesity as well as drug abuse and its health

Figure 3  The spread of a measles epidemic across Iceland month by month (1946–47). From Cliff, A. D., Haggett, P., Ord, J. K. and Versey, G. R. (1981). Spatial Diffusion. An Historical Analysis of Epidemics in an Island Community. Cambridge: Cambridge University Press.
consequences. However, smoking, obesity, etc. are actually not diseases per se but rather health hazards.

Several infectious diseases had been perceived as new when they had been discovered in human population but had probably been circulating in animal populations (reservoirs). Thus, AIDS, now a major public health concern, was perceived as a new disease in the 1980s. Later examples include the ‘severe acute respiratory syndrome’ (SARS), the West Nile virus, and Ebola.

While infectious and parasitic diseases are often successfully combated, degenerative – often ‘man-made’ – disorders are gaining ground as a consequence of altered physical environments, pollution, and occupational hazards as well as new lifestyles and disruption of social networks. It has been suggested that the epidemiological transition leads to a situation where patterns of mortality by causes differ significantly between countries that have reached the same stage in terms of general morality. Such geographical differences might reflect underlying national and cultural influences but remain to be explored.

**Changing Conditions for Old Diseases**

The distribution and diffusion of infectious diseases is affected not only by (micro) biological changes, but also by social and structural changes in societies.

Since some organisms remain unchanged, infection and survival will yield future immunity, whereas mutations will prevent immunity. For example, influenza virus regularly appears in new strains, preventing lifelong immunity, while measles virus remains stable. Current health threats are mutations giving rise to new varieties and drug-resistant forms of causal organisms, for example, methicillin resistant staphylococcus aureus (MRSA) and tuberculosis (TB).

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**Figure 4**  Salmonella diffusion in a local context. The diffusion of salmonella is a complex chain (network) of farming, food processing, and transportation, retail, and central kitchens. In October 1995 an outbreak of nosocomial salmonella was discovered at a university hospital, affecting nine buildings, including several clinics, a kindergarten and the central kitchen. Data about the infected staff, patients, and children, the internal logistics, and a retrospective analysis of meal preparation on the day of the outbreak were georeferenced and analyzed in a high-resolution GIS. The source of the salmonella diffusion was found in the kitchen, where vanilla pudding was prepared in the spatial vicinity of defrosting poultry and the pudding was probably contaminated by thawing water. From Kistemann, T. et al. (2000). GIS-supported investigation of a nosocomial salmonella outbreak. *International Journal for Hygiene and Environmental Health* 203, 117–126.
Figure 5  Transmission – exposure – diffusion: time geographic outlines. Transmission and diffusion happens on any scale from the individual (micro) to the global and often in complex chains. The figures are based on time-geographical visualization principles. The vertical lines in the figures represent life-paths (trajectories) of individuals. (a) In the most obvious kind of disease diffusion, pathogens are transmitted from one individual to another susceptible individual. One contact may be enough. (b) Sometimes, only one infected person is sufficient to introduce a communicable disease to another area with a virgin population and to start an epidemic. In fact, highly mobile individuals carrying a communicable disease may be in a position to spread the pathogen widely to one person after another and even one place after another. Healthy individuals are represented by full-drawn lines while persons carrying diseases are represented by dashed lines. (c) Short-term relocation and occasional exposure, say during a holiday, when susceptible individuals expose themselves to risks, like excessive sunlight, unfamiliar food, unfamiliar microorganisms, temporary sexual contacts, etc. (d) Diffusion by relocation of vector or artifact. Another type of transmission and diffusion occurs when pathogens are relocated from place to place, between spatially separate populations, without any direct human involvement but with a vector, for example, malaria transmitted by a mosquito. In a similar way, hepatitis and HIV can be transmitted if a syringe is first used by a carrier and then by a noninfected person. (e) The
population in a certain place may be exposed to a sudden and temporary insult, such as radioactive fallout after a nuclear accident (thick black horizontal line). The cohorts living in the place at the time will probably carry the effects of the incident during the following years (dashed area). Children born in the place might be affected by lingering effects or genetic damages (shaded area). Out-migrants will bring – relocate – their health effects, while in-migrants from other places will be unaffected. Similarly, external factors may exert an insult on a whole population for any length of time or just a certain group, for example, schoolchildren or infants. Likewise the population or certain groups can be affected by health-promotion intervention. (f) Diffusion by relocation of predisposed individuals. Further, people may carry conditional ‘predispositions’ for diseases when they move. Predispositions are not communicable but congenital – genetically inherited or individually inborn. This situation in turn opens two alternatives. The predisposed individual will develop the disease either in any case or only under a certain environmental influence. In diffusion terms, a relocation of the disease takes place (cf. Figure 5d). The diffusion may proceed further as a genetically inherited disorder eventually becomes predominant in an isolated population. Generally, large groups of migrants are needed for major changes of the gene frequency in a population but one migrant can be sufficient to spread a dominant, potentially pathogenic gene to another area and another population. (g) Pathogenic diffusion by innovation spread. Finally, just like innovations of any kind are diffused, lifestyle stimuli may reach a place and a population from outside. Subsequent health effects may produce the impression of disease diffusion – or the reverse, that is, the disappearance of ailments. In fact, the epidemiological transition has largely been due to such changes.
Measles epidemics in Iceland illustrate the effects of changing conditions for diffusion. Measles is not endemic in Iceland, since the country is topographically isolated and its population is too small for the virus to remain in circulation. Thus, each epidemic is introduced from abroad, usually from Scandinavia or Britain. Mapping all epidemics of measles in Iceland from the 1870s has revealed several changes of diffusion, probably reflecting structural modernization. Since 1945 measles epidemics have become more frequent and always started in the capital region, close to the international airport, whereas some previous epidemics started in harbor villages along the coast. The spread within the country became faster during the century, probably as a result of increasing urbanization, improved transportation, and a shift from an ambulatory school system in rural areas to fixed schools (Figure 3).

In the wake of increasing intercontinental mobility, infectious and vector-borne diseases are returning to Europe, North America, and other parts of the world where they have been absent or confined for decades. TB and malaria provide examples of ‘reemerging’ diseases with different geographical characteristics. Globally, TB has never been overcome. According to World Health Organization (WHO), the current prevalence is some 14 million worldwide and some 1.6 million deaths per year can be ascribed to TB. Incidence and mortality are highest in the African region, while prevalence is highest in Southeast Asia. The ‘return’ of TB in Europe and the American continents is a consequence of migration, microbiological changes, and social conditions. TB now appears in drug-resistant forms such as multi-resistant (MDR-TB) and extensively resistant (XDR-TB) forms.

As for malaria, not only do tourists visiting malaria-endemic areas return infected, but persons who have never been there have been diagnosed with so-called ‘airport malaria’ after being bitten by odd mosquitoes that have been relocated by international flights and survived for some time at the destination on higher latitudes. Certain intercontinental flight routes have been identified as particularly risky and the majority of cases have been found in France, Belgium, and United Kingdom. This development can be put down to international mobility, but even nosocomial cases have been found, when patients have received transfusions of infected blood. Although the phenomenon is rare – since the first confirmed case was diagnosed in 1977, on average two cases annually have been recorded – it is a potential future risk. If global warming induces ecological changes, new habitats for malaria might emerge. An even more imminent hazard associated with intercontinental air transportation is the risk that malaria is re-introduced in regions which are currently free but provide favorable conditions for the disease.

**Tools for Understanding Disease Diffusion**

Understanding the geographical diffusion of diseases is highly important for long-term prediction and containment of diseases. Adequate surveillance is necessary for public health intervention in emergencies. Many conventional maps of disease distribution are crude and inaccurate, but tools have been developed for monitoring, surveillance, simulation and prediction, based on better understanding of the spatial and temporal behavior of diseases. Geographic information systems (GIS) can be very useful for surveillance, simulation, and analysis, provided that cases and risk factors can be registered with high spatial and temporal accuracy. GIS has also proved efficient for tracing the sources of infection in a micro-scale context, such as salmonella diffusion in a hospital area (Figure 4). Remote sensing can be used for surveillance of ecological conditions and habitats for disease agents and vectors. GIS-supported simulation has been used to forecast the diffusion of HIV/AIDS and TB as well as the spread and health outcome of air pollution and radioactivity. With sufficiently accurate data, simulation can be applied on any level down to blocks and workplaces.

Early warning is important for national security in case of serious infectious epidemics, whether natural or deliberate, terrorist-induced attacks. RODS (Real-time outbreak surveillance) is a type of software which can be used for early detection of epidemics. If cases are reported immediately to the system it can discover signs of epidemics which individual physicians are unable to see from their limited perspective.

Growing understanding that exposure in early life may have health effects in adult or advanced age has inspired the insight that similar exposures in different places and environments might lead to similar health outcome, in different locations. Therefore, a life course approach to epidemiology has been suggested to take into account such early exposures. Time geography, which offers a similar approach with a more explicit spatial dimension, has also been suggested as a method for detecting similar life-paths and exposures of individuals who do not belong to spatially contiguous populations. The time geography approach can also be used to visualize and clarify various epidemiological processes (Figures 5(a)-5(g)).

In spite of accumulated knowledge about disease diffusion, current epidemiological trends still call for methodological and theoretical development.

**See also:** Diffusion; Mental Health; Migration; Psychotherapy/Psychotherapeutic Geographies; Radical Geography; Simulation; Time and Historical Geography; Time Geographic Analysis.
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