Spatial analysis of influenza and cholera activities in temperate zones or/and the tropics by using a geographical information system

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ABSTRACT

Many kinds of infectious diseases are endemic and novel viruses emerged in tropics. However, those full epidemiological studies and disease burden still remain. I described here application of GIS technology to influenza and cholera outbreak. Its application enabled us to monitor the occurrence and spread of those infections, and also to identify risk areas and attribute factors. Thus, we would like to emphasize that GIS is a useful tool for epidemiological study to define areas of highest incidence and people at the highest risks not only in developed and also developing countries.

1. INTRODUCTION

Prof. Sugihara proposed a new paradigm for humanity, biosphere and geosphea. He called for a fundamental shift in the value and norms underlying our understanding of the environment and sustainability. On the Introductory Chapter of the book, one of three types of paradigm shifts in terms of the range of enquiry was from ”temperate zones” to the “tropics” as the geospheric and biospheric center of the earth.

Table 1. Factors in Emergence*

Categories	Specific Examples
Societal events	Economic impoverishment; war or civil conflict; population growth and migration; urban decay
Health care	New medical devices; organ or tissue transplantation; drugs causing immunosuppression; widespread use of antibiotics
Food production	Globalization of food supplies; changes in food processing and packaging
Human behavior	Sexual behavior; drug use; travel; diet; outdoor recreation; use of child care facilities
Environmental changes	Deforestation/reforestation; changes in water ecosystems; flood/drought; famine; global warming
Public health infrastructure	Curtailment or reduction in prevention programs; inadequate communicable disease surveillance; lack of trained personnel (epidemiologists, laboratory scientists, vector and rodent control specialists)
Microbial adaptation and change	Changes in virulence and toxin production; development of drug resistance; microbes as cofactors in chronic diseases

*Adapted from reference 1.

In the West, there has been a renewed interest in tropical medicine over recent years. Over 30 new infectious agents have been detected in the last three decades, 75% of which have originated in animals (zoonosis). Those infections were called as emerging infections diseases which are diseases of infectious origin whose incidence in humans has increased within the past two decades or threatens to increase in the near future. New pathogens, particularly viruses, remain unpredictable and continue to emerge and spread across countries. More than half of the world's population lives in the tropics. There is also greater public concern over the health problems of the developing world.

The geographic information system (GIS) can be used to map a wide array of variable including location, disease occurrence, and environment, and can provide a valuable analysis tool for epidemiology and public health personnel. The principal advantage of GIS is its spatial analysis capabilities. We present here the special analysis of influenza and cholera in temperate zones or/and the tropics by using GIS, and discuss about the intimate connections between humans and infectious agents as well as environmental factors.

2. INFLUENZA

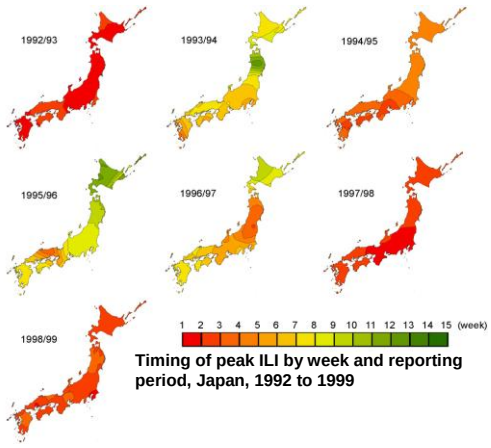
Influenza is a highly contagious acute respiratory disease of global importance that has caused epidemics and pandemics for centuries. Influenza viruses have segmented genomes and show great antigenic diversity. Of the three types of influenza viruses –A, B, and C – only types A and B cause widespread outbreaks. Influenza A viruses are classified into subtypes based on antigenic differences between their two surface glycoproteins, haemagglutinin (H) and neuraminidase (N). Sixteen haemagglutinin subtypes (H1-H16) and nine neuraminidase subtypes (N1-N9) have been identified for influenza A viruses. Viruses of all H and N subtypes have been recovered from aquatic birds, but only three H subtypes (H1, H2, and H3) and two N subtypes (N1 and N2) have established stable lineages in the human population. Various subtypes have also been isolated from pigs, horses, seals, and whales. The substantial reservoir of all known influenza A subtypes is aquatic birds and these avian viruses can jump to human as zoonosis. Influenza A viruses are perpetuated in the wild birds of the world, and influenza-bird association is ancient. Thus, influenza is not considered an eradicable disease.

A highly pathogenic H5N1 influenza A virus appears to have become endemic in avian hosts in Asia. To date, H5N1 viruses cannot transmit readily from human to

human. A novel swine-origin H1N1 influenza virus emerged in Mexico in April 2009 and rapidly spread worldwide, causing the first influenza pandemic of the 21st century, but now the world is no longer in phase 6 of influenza pandemic alert. The phasing and geographical spread of influenza pandemic has important implications for pandemic planning. However, influenza spread in space even within one cycle of an epidemic is also an important question.

To better understand the spread of influenza epidemics, we used geographical information system (GIS) with several kinds of surveillance data, focusing on the kriging method applied to illustrate and clarify the spatio-temporal dynamics of influenza and better understand the influenza epidemic spread. GIS map showed clearly the spreading mode of peak influenza activity throughout Japan in each epidemic that the starting Prefectures or areas of peak influenza activity were mostly in the western-central part of Japan and that the peak influenza activity covered all of Japan within 3 to 5 weeks in larger epidemics with new antigenic variants of A/H3N2.

Timing of peak ILI epidemic activity by week in Japan



Timing of peak ILI by week and reporting period, Japan, 1992 to 1999

(T Sakai, Emerg Infect Dis, 2006)

Although influenza A or B viruses circulate virtually every winter in temperate zones of the northern and southern hemispheres, quantification of the burden of influenza has been difficult because influenza lacks pathognomonic features, it co-circulates with other respiratory pathogens, and it causes a range of nonspecific complications. On the other hand, in the tropics and subtropics, influenza occurs either throughout the year with no distinct seasonality or visible excess mortality, or twice a year, with the more intense activity during the rainy season. Consequently, the morbidity and mortality from influenza are probably greatly underestimated in these regions. However, rapid influenza tests and molecular techniques can show whether

virus is circulating in specific populations or localities, and they may become a useful adjunct to surveillance programs.

Recent studies indicated from antigenic and genetic analysis of HA that influenza A(H3N2) virus epidemics worldwide were seeded each year by viruses that originated in East-Southeast (E-SE) Asia. They showed also that temporally overlapping epidemics in E-SE Asia create a circulation network in which its viruses continually circulate within the region by passing from epidemic to epidemic. E-SE Asia's strong travel and trade connections with Oceania, North America, and Europe, couples with weak connections to South America, could explain the seeding hierarchy observed in this period where new virus variants first seed epidemics in Oceania, North America, and Europe and later in South America.

2. CHOLERA OUTBREAK IN ZAMBIA

Cholera is a disease that continues to ravage developing countries and reemerges sporadically elsewhere throughout the world, and the epidemics must continue to demand an active public-health response. However, the annual figures of WHO actually represent the tip of the iceberg, because the morbidity and mortality caused by Vibrio cholerae is grossly underreported owing the surveillance difficulties and also for fear of economic and social consequences.

The spread of the disease is probably associated with maritime transportation, because no case was notified in intermediate villages and travel by land between these towns is very difficult. The quick propagation of the outbreak may be explained by many favorable conditions such as poor hygiene and sanitary conditions (absence of latrines), poverty, lack of information, and bad weather conditions (heavy rains at the end of the wet season). In tropical regions, diarrhea diseases typically peak during the rainy season. Better understand of the relation to climate would allow better planning for epidemics by public-health official. The long-term prevention of cholera will require improved infrastructure, such as water and sanitation facilities, but these improvements are not happening rapidly in most regions where cholera is prevalent.

Zambia experienced widespread cholera epidemics in 1991, 1992, and 1999. In response to the large outbreak in 1999, the Government of Zambia urged use of in-home chlorination, point-of-use water disinfection and a safe-water storage. However, another cholera epidemic emerged in Zambia in November 2003.

We described application of GIS technology to the outbreak, and did analysis of factors of cholera outbreak in Lusaka, Zambia by using GIS.

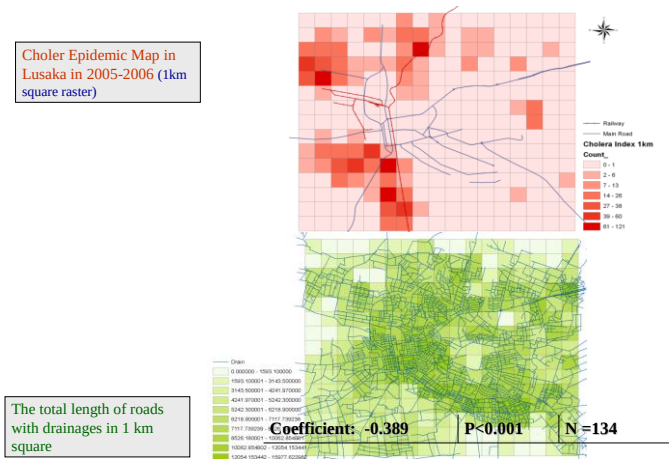
A cholera patient map showed that more than 80% of cholera cases resided in the western part of the city, which was clearly demonstrated by the railway lines. We found that those geographic distributions strongly correlated with a town-planning policy for Lusaka instituted during the colonial period. Residential areas of the native population were segregated from the city's central areas, where the colonialists resided, to protect the latter from health-related contamination. The native population's areas were separated by railway lines as a cordon sanitary. This town-planning policy was aimed to minimize movement and contact between the people of the western and the eastern parts of the city, and consequently to control the transmission of disease. Our observations lead us to conclude that the city succeeded in controlling the transmission of cholera to the colonialist areas through its heritage of segregation.

Lusaka Cholera Map

Several widespread cholera epidemics had occurred during the rainy season. Usually heavy rains, which cause flooding, are blamed for the high incidence of disease in cholera outbreaks. Our study supported the strong correlation between the amount of rainfall and the number of cases of the disease. In addition, as the amount of rainfall climbed to its peaks, the number of the cases also increased. We concluded that the rainfall triggered the spread of outbreaks of the disease once *Vibrio cholerae* was imported in Lusaka.

Cholopleth map of cholera cases demonstrated that higher incident rate of cholera in administrative boundary was statistically associated with lower coverage of latrines and effective drainage systems. In relation to GIS analysis, regression analysis of attributable risk factors by zones indicated that a significant association between lack of latrine and drainage system surrounding houses and high incidence of cholera in the study area. The matched case-control study to identify risk factors for cholera demonstrated a protective role for hand washing with soap and the importance of

hygiene and clean water for cholera prevention.



We would like to emphasize again use of in-home chlorination, point-of-use water disinfection and safe-water storage, and also to support construction of deep-well facilities for safe water supply to an unplanned settlement in Lusaka. This study also demonstrated a protective role for hand washing with soap and the importance of hygiene, clean water, and sanitary food handling for cholera prevention.

3. CONCLUSION

In the present study, we described application of GIS technology to influenza and cholera outbreak. In the tropics and subtropics, influenza occurs either throughout the year with no distinct seasonality, and yearly waves in the temperate regions originate in the tropics. This study also demonstrated a protective role for improvement of infrastructure, and hygiene and health education both with households and mass focused approach.

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