Geographical Distribution and Surveillance of Tuberculosis (TB) Using Spatial Statistics

Ila Agnihotri, RRSC-W/NRSC/ISRO, Department of Space, Government of India, CAZRI Campus, Jodhpur, RJ, India
PK Joshi, Department of Natural Resources, TERI University, New Delhi, DL, India
Neeraj Tiwari, Department of Statistics, Kumaun University, Nainital, UR, India

ABSTRACT
Socio-demographic and health indices vary across the administrative units in a country. Thus, reported morbidity and mortality figures vary and inter/intra state comparison becomes a challenge. To handle such issues and administer a centralized health management system, identifying disease clusters and providing services to high risk population become important. Exploring a small part of the immense potential of geographic information systems (GIS) in centralized health management, this study presents a method of generating effective information for proper health management at local level. Such information is important for infectious diseases like tuberculosis (TB). The present paper discusses quarterly GIS mapping and assessment of TB in 1,965 villages of Almora district, Uttarakhand, India from 2003 to 2008. The values for Morbidity Rate (MBR) are depicted in risk maps for each quarter. Moran’s I indices were used to estimate the global spatial autocorrelation between the morbidity rates. Local Moran’s I (LISA) was used to detect spatial clusters and outliers, and for the prediction of hotspots of the disease. The result of this study has the potential to reflect a realistic assessment of the disease situation at the local level. Future work on this study can be utilized for planning and policy framework related to TB and other diseases.

Keywords: Almora, Empirical Bayes, Geographic Information System (GIS), Health Management, Human Immunodeficiency Virus (HIV), Local Indicators of Spatial Association (LISA), Moran’s I, Risk Maps, Tuberculosis (TB)

INTRODUCTION
In India, national-level disease surveillance mechanisms require an integrative and efficient tool for effective screening and management of diseases as well as for emergency response measures. Currently, the Indian healthcare system structure is organized at national, state, district, community, primary health center and sub-center levels based on the population receiving government benefit. The health management is currently based on health data collected in the form of hard copy reports from government primary health centers. Gross statistics are...
generated and presented, which also represent only those from government sector (World Health Organization, 2011). Precise data is not available at central level for the proper planning and management of diseases and generation of centralized spatial database is the need of the hour (World Health Statistics, 2009). In order to improve the overall public health in India, the appropriate planning, surveillance, and management of disease at the local level is vital.

The first thing to consider when discussing disease surveillance is the knowledge of disease epidemiology. It focuses on the three major elements of disease causation – environment, agent and host also commonly known as the epidemiological triad. For many years, this epidemiological triad helped epidemiologists to focus on different classes of factors responsible for a disease. TB causes the disease of the lungs (pulmonary TB) but can affect other sites as well (extrapulmonary TB). It has its own epidemiological triad with Mycobacterium tuberculosis as the causative agent. The host includes man in all age groups. The environment required for the transmission of TB is air. Air is contaminated with the agent when people are infected with pulmonary TB and expel the bacteria through coughing and sneezing. A single patient can infect ten or more people in a year. In humans, natural immunity against this disease does not exist but nutrition plays a role in the development of disease after being infected by the agent. Not all infected cases turn into TB. In general, a relatively small proportion of people infected with Mycobacterium tuberculosis will develop TB; however, the probability of developing TB is much higher among people infected with the human immunodeficiency virus (HIV) (World Health Organization, 2011). For TB Control, the Directly Observed Treatment, Short Course (DOTS) chemotherapy strategy along with the other components of the Stop TB strategy are implemented under the Revised National Tuberculosis Control Programme (RNTCP). India has adapted and tested the DOTS strategy in various parts of the country since 1993, with excellent results; consequently, nation-wide DOTS coverage was achieved in March 2006. DOTS has also been proven to prevent the emergence of MDRTB (multidrug-resistant tuberculosis), and also to reverse the incidence of MDRTB where it has emerged. (Ministry of Health and Family Welfare website).

These epidemiological factors provide many clues about individualistic approaches for the disease evaluation. However, there are few individual approaches which address large and variable populations. The reason was omission of an important factor between the population under consideration and disease epidemiology – the location. When location is not considered, a study usually involved very small populations; if location is considered, a study is able to examine the impact of a particular location of the epidemiological triad and have the potential of addressing larger populations – from the regional to national levels.

The use of geographic information systems (GIS) as a tool in health is demonstrated in this study using TB as the disease and villages as the geographical unit to be analyzed. This is the first study to use health data at village level, along with the spatial epidemiological approaches and GIS in Almora district, Uttarakhand. In this study, we describe the use of new GIS-based approaches in spatial epidemiological studies for visualizing and analyzing the disease surveillance mechanisms in Almora district, from 2003 to 2008 (on a quarterly basis).

**METHODOLOGY**

A wide array of techniques has been suggested in literature to deal with the instability of rates in disease maps and one has to choose from the wide array, depending on the form of available data and information and the objective to be solved. No method can satisfy all requirements that are expected from a risk estimate (Anselin, Syabri, & Kho, 2006). The calculations were performed in this study using the spatial statistical software GeoDa (Anselin, 1994; GeoDa, 2010).
Procedural Modeling in 3D GIS Environment
www.igi-global.com/article/procedural-modeling-in-3d-gis-environment/122865?camid=4v1a