Spatial Variations of Tuberculosis In The State Of Kansas

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Tuberculosis (often referred to by the acronym "TB") is one of the major public health problems existing today, both in the United States and the world. Long thought to be one of the diseases that were "defeated" by the post-World War II antibiotic revolution, recent years have seen a dramatic and wholly unexpected resurgence, after nearly thirty years of decline. The impacts of this resurgence have of course not been distributed uniformly; the developing world has been affected more than the developed world, the poor more than the wealthy, the HIV sufferer more than those who are HIV negative. But despite these disparities of impact, it seems safe to say that virtually every part of the world has in some way been affected by the resurgence of what was once called the "White Plague." Unfortunately, the state of Kansas is no exception.

Tuberculosis exists in the state of Kansas, and to a greater degree than might be supposed. In 2001 Kansas had 80 cases, up three from the previous year, placing the number of cases per 100,000 at a six-year high. In 2000, Kansas had an over infection rate of 2.9 per 100,000 population – lower than the national average of 6.4 per 100,000, but over 50% above the rate of twenty years ago. There were over 715 new cases of tuberculosis in the state of Kansas over the period 1990 – 2000. This alone would be cause for concern. But even more significant is the fact that these cases are not distributed in a random manner. Spatial analysis reveals that the distribution of tuberculosis in Kansas displays a distinct spatial pattern. In particular, the southwestern portion of the state and certain urban areas seem to show signs of disparate impact, since these area displays a higher incidence of tuberculosis than its population would warrant. – indeed some Kansas population subgroups have recorded case rates as high as 83 per 100,000. The purposes of this study are to analyze this situation, and: 1) attempt to understand the spatial distribution of tuberculosis in Kansas; 2) suggest possible underlying mechanisms and substructures which might account for this uneven distribution; 3) point out the ways in which these patterns and structures might impact current and future mitigation efforts, and 4) to investigate the possible uses of GIS in identifying areas and groups at risk for tuberculosis. In this way, it is hoped that this study will be of some utility in the ongoing
The Need for a Spatial Perspective

The need for a spatial perspective on the tuberculosis epidemic is evident when examined in light of both the manner in which the disease is spread, and of potential mitigation strategies. The uneven spatial distribution of the disease is a natural corollary of the nature of the disease itself. Tuberculosis is generally spread by close and prolonged contact with an infected individual, and the conditions, which lead to this sort of contact, are not randomly distributed (Kline et al 1995; Fischl et al 1992.) Understanding the spatial patterns of incidence is helpful in understanding where such conditions exist, and hence where future outbreaks might be expected. An understanding of the spatial distribution patterns of tuberculosis is also useful in targeting mitigation efforts. Resources for the combating of tuberculosis, while growing, are not infinite; understanding where occurrences of tuberculosis are greatest, or where outbreaks are most likely, allow the focusing of health-related resources on the areas where need is greatest, thus providing efficient treatment and mitigation with a minimum of public expenditure. An understanding of the spatial patterns coupled with a knowledge of the demographic, racial, gender, and ethnic characteristics of those suffering from the disease make for an even more efficient targeting of these valuable health resources. It is one of the major purposes of this study to facilitate such targeting through the media of GIS.

Methodology of the Study

The methodology of the study was to an extent determined by the disease itself. A bacillus, Mycobacterium tuberculosis, which is propagated through the air, causes tuberculosis. Prolonged contact is generally necessary for transmission to occur, making crowded living conditions and poor ventilation a risk factor for the spread of the disease. The incubation period is relatively long, lasting from 2 to 12 weeks, and very often this means that there is both temporal and spatial distance between the point of initial infection and the point at which recognizable symptoms appear. In addition, TB often will remain virtually asymptomatic for long periods of time, which serves to increase the temporal and spatial lapse between infection and diagnosis. Extended travel can and often is undertaken during both the incubation and asymptomatic periods, which means that a
TB infection can be diagnosed far removed in space and time from its actual point of origin. These factors produce some pronounced spatial patterns.

In addition to the factors outlined above, the hierarchical diffusionary spread of tuberculosis makes the identification of “risk groups” and important part of combating the disease in an efficient manner. Some groups of people are far more likely to contract TB than are others, and targeting health and educational resources at these vulnerable groups is essential. Since TB requires prolonged contact in order to spread, the disease tends to occur in spatial “clusters.” Due to these same factors, people living in crowded or poorly ventilated conditions are most vulnerable, often making TB in the United States a disease most common among poor or marginalized groups. Immigrants from South and Central America, Africa, and Asia are also more likely to be diagnosed with TB, since they often come from countries where the TB exposure rate is far higher than in the U.S. Those with compromised immune systems, the very young, and the elderly are also uniquely vulnerable to the “white plague”. The methodology of the study was conditioned by these factors.

Taking these factors into account, the following methodology was used: demographic and residency data was obtained from the United States Census 2000 TIGER files, which supply a wide array of data. Additional data on residency and country of origin was obtained from the 1990 census, since this information had not yet been made available from the 2000 Census. Tuberculosis county level case data for the period 1990 – 2000 was obtained from the Kansas Department of Health and Environment (Image One) and coded using GeoMedia v.5.0 software into a Kansas counties GIS layer. A more detailed scale of TB data was not available due to privacy considerations. The raw score TB data was normalized by county population counts in order to account for population inequalities between counties. Those that had an unusually high occurrence of tuberculosis respective of population size were identified, and bivariate regression analysis was used to identify what particular social, economic or residency parameters placed county residents at the highest risk. The social variables analyzed were those available, using standard TIGER data files, along with 1990 census data, showing the percentage of people in each Kansas County that were born outside the United States.
Results of the Study

There is a distinct spatial clustering in cases of tuberculosis in Kansas. Counties with the largest number of cases are Sedgwick county (within whose confines the city of Wichita is located), Johnson county, Wyandotte county, and Finney county. The first three are perhaps not surprising in view of their large concentrations of population, but Finney county would seem to be an anomaly, and a site for possible investigation. The Kansas county with the highest percentage of cases is Sedgwick county, once again fitting in with the belief that TB is primarily a disease of urban areas. But when population is normalized, a somewhat different picture emerges. Greeley, Hamilton, Grant, Finney, Rice, and Wyandotte counties all have more TB cases than would be expected for their population base, and while several of these counties can be dismissed as having numbers skewed by their overall low populations, Finney and Wyandotte, at any rate, cannot. These counties have both significant populations and a significant
number of cases of tuberculosis, and should be targeted in any future prevention and treatment efforts.

An examination of social, demographic and economic factors on TB susceptibility also proved to be instructive. Using regression analysis, certain demographic categories were found to have significantly higher risk factors than the general population average. The overall r-squared correlation at the county level between total population and cases of tuberculosis was .71. At slightly higher risk were men, Native Americans, Persons of Asian ancestry born outside of the United States, Children under the age of 17, and those over the age of 65 (r-squared values of between .72 and .76 for all groups). At significantly higher risk were single men (r-squared value between .77 and .81). At high risk (.81 r-squared or over) were persons of Hispanic ancestry born outside the United States, and single parents. However, it should be noted that simply being born outside the United States was not a risk factor.

In terms of economic factors, there were some unusual county-level regression findings. There was a high degree of correlation between those counties that had a high amount of vacant property and those with a high level of TB cases - .88 r-squared, one of the strongest correlations in the study. Counties with a high percentage of renters also seemed to have an elevated risk of increased TB, with an r-squared correlation coefficient of .77. That these data were not serving as a surrogate for other economic factors can be inferred from the fact that there was almost no correlation between such variables as average county income, population change, or national origin of population, and TB caseload. These statistics might indicate some relationship between transience of population and incidence of TB, but this connection remains unproven.

Using GIS to predict TB Caseload

If the forgoing analysis is accurate, then counties in Kansas, which have high levels of at-risk populations and a high level of socioeconomic risk factors, should have higher levels of tuberculosis than those counties that are low in such variables. If this supposition is correct, than an analysis of such factors could be used to identify areas that are at an elevated risk for tuberculosis, and educational and health resources could be targeted accordingly. In order to test this possibility, a GIS raster grid was produced, and a series 12 overlays were carried out multiplicatively. Counties with a high score were
high in risk factors, and have exhibited a high TB caseload. This predictive raster was then fitted to the actual number of cases in the State of Kansas (Image Two). As can be seen, there was a high degree of correlation between actual cases of TB in Kansas between 1990 and 2000, and the risk factors identified.

![Kansas Tuberculosis Prediction Results, 2000](image)

**Image Two**

**Conclusions**

This study demonstrates the potential contributions of GIS in the spatial analysis of tuberculosis. Some of these include: identifying clusters of tuberculosis cases, as well as high-risk areas that have more cases of tuberculosis over time than their populations would seem to warrant. Coupled with regression analysis, GIS analysis can be used to identify populations at risk for TB, in order to more efficiently target scarce health care resources. Overlay analysis coupled with demographic and economic data can be used to identify those areas where TB outbreaks are most likely to occur. More work is obviously needed in the application of GIS in the prevention of disease, but the results of this study suggest that GIS can play an important role in the containment and treatment of tuberculosis.
Bibliography


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