Visualizing the Accessibility and Spatial Equity of HIV-Related Services:
A Geographic Analysis of Chicago Neighborhoods

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Abstract

Our paper will use Exploratory Spatial Data Analysis to examine accessibility to HIV service providers and identify the neighborhood-level factors (i.e., demographic and socio-economic) that overlap with accessibility across Chicago neighborhoods. Three access measures will be used in our analyses. The container index estimates the number of service providers within a given neighborhood (as proxied by the census tract), the equity index estimates the minimum distance to the nearest service provider, and the travel cost index estimates the average distance to all service providers. Our preliminary findings (using the container index) point to significant clustering of both highly accessible and highly inaccessible neighborhoods across Chicago. There is also substantial overlap in the clustering of the container access measure and the clustering of neighborhood-level demographic and socio-economic variables. Some clusters of inaccessible neighborhoods in the south and central areas of Chicago (Near South Side, East Garfield Park, Fuller Park, Grand Boulevard and Washington Park) overlap with clusters of neighborhoods with higher rates of AIDS infection and HIV infection mortality, and percentage of African Americans. Clusters of accessible neighborhoods are located in the northeast (Edgewater and Uptown) and downtown area of Chicago (Loop) and overlap with clusters of neighborhoods that have been hard hit by the AIDS epidemic. This suggests an inequity in the distribution of HIV-related services that may disproportionately affect African Americans. Our initial findings point to the need for policy makers to clearly identify those neighborhoods and subsequently the populations in those neighborhoods that are less accessible to HIV-related services that also have a higher level of need than other neighborhoods.

KEY WORDS:

Healthcare Accessibility; Social Service Provision; Community Access; Geographic Analysis

Introduction

Efforts have been made by policy makers, researchers and healthcare providers to identify, reduce and ultimately eliminate health disparities (U.S. Department of Health and Human Services, 2000), yet inequities in access to preventive medicine and healthcare continue to be an important concern. Given changes in the faces of AIDS over the last decade, it is crucial that these disparities in health and access to healthcare are addressed. While rates of HIV infection for Whites have declined over the last decade, minority populations represent the greatest increase in new cases of HIV infection (Health Resources and Services Administration, 1999; Chicago Department of Public Health, 2000). For example, while racial and ethnic minorities represent 27 percent of the nation's population, they account for 66 percent of new AIDS cases (Health Resources and Services Administration, 1999). Chicago and other large cities have been particularly hard hit by the AIDS epidemic. Where African Americans make up 26 percent of Cook County (U.S. Bureau of the Census, 2000), African American men comprise 53 percent of the men with AIDS, while African American women make up 72 percent of the women with AIDS.

African American and Hispanic/Latino populations have not only been disproportionately affected by the AIDS epidemic, they enter medical treatment later in disease stage, are less likely to have access to a regular source of healthcare and are less likely to participate in clinical trials or receive antiretroviral therapy (Health Resources and Services Administration, 1999; Siegel and Raveis, 1997). While a number of demographic, social, economic, and psychosocial factors determine healthcare utilization (Takahashi, Wiebe and Rodriguez, 2001; Seigel and Raveis, 1997), the accessibility of healthcare in terms of the location and distribution of health services are important factors in healthcare utilization (Mays, Cochran and Sullivan, 2000; Health Resources and Services Administration, 1999).

The major goal of this paper will be to map, visualize and analyze the location and accessibility of HIV-related services for the City of Chicago. The paper contributes to knowledge on: (1) the location and spatial variation in the distribution of HIV-related services; (2) the neighborhood factors (i.e., social, economic and demographic etc.) that determine access and barriers to HIV service providers; and (3) the spatial equity of HIV-related services using a GIS and spatial data analysis. GIS allows users to more efficiently manage, analyze and display spatial, demographic and socio-economic data that is geographically referenced, while also providing tools for spatial queries, dynamic mapping, geo-coding, and simulating alternative scenarios for resource allocation (Lee and Wong, 2001).

The accessibility of HIV-related services may be defined in a number of ways. This includes the total number of services available to a given population within their own neighborhood (Queralt and Witte, 1998), the distance to the nearest HIV service provider (Hyndman and Holman, 2001), the average distance to all service providers (Talen and Anselin, 1998), the estimated travel time along a transportation network to the nearest service provider (Walsh, Page and Gesler, 1997), and travel cost (Weber and Kwan, 2002). The identification of the spatial equity of HIV service provision (Waters, 2000) and the determination of the causal factors in the inequitable distribution of healthcare resources requires the integration of access, specifically the geographic equality of access or territorial variation in access to HIV-related services, with an investigation of need for services or social justice (Talen and Anselin, 1998).

While there are a number of factors that influence a person's decision to seek HIV testing or related services (Takahashi, Wiebe and Rodriguez, 2001; Seigel and Raveis, 1997), the location and distance to interventions and the transportation needs of residents are also important determinants of urban and social service utilization (Mays, Cochran and Sullivan, 2000). The geographic gaps in social services and other medical interventions may leave many disadvantaged minority populations with fewer choices than others for obtaining needed care (Cornelius, 2000). Logan (1996) suggests that accessibility, both in the sense of physical and cultural location, is a primary determinant of social service utilization. Recent research also suggests that the number of health and social service non-profits in a given area is influenced by a number of neighborhood characteristics including income and racial and/or ethnic composition (Bielefeld, Murdoch and Waddell, 1997). GIS and spatial analytic applications permit an examination of the geographic and spatial distribution of HIV services across

neighborhoods, offering an opportunity to explore the link between service accessibility, utilization and the economic inequality and racial composition of neighborhoods. In this paper we extend the existing literature on social service utilization by integrating it into an examination of the implications of neighborhood characteristics, such as economic disadvantage and ethnic/racial composition, on the distribution of HIV-related services across Chicago neighborhoods.

Health Care Services and GIS

The accessibility of health services has important implications for healthcare utilization and a number of health outcomes (Higgs and Gould, 2001; Nemet and Bailey, 2000). Increased attention to the impact of geographic barriers to healthcare includes a number of GIS applications. GIS has been applied to the examination of healthcare delivery, the accessibility of urban services and have increased attention to the impact of geographic barriers to healthcare. More specifically, geographic research on healthcare accessibility has explored neighborhood and city-level variation in service provision (Hendryx et al., 2002; Hyndman and Holam, 2001; Auchincloss et al., 2001), urban/rural differences (Heckman et al., 1998) and the implications of geographic disparity in medicare expenditures (Hirth et al., 2001). GIS allows researchers and policy makers to examine the concept of accessibility using simulation models to suggest sites for new medical and social service agencies and the impact of closing existing sites. Spatial analytic techniques have also been used to identify neighborhoods and communities (and consequently the populations living within these areas) that are underserved by social service and healthcare interventions (Hyndman and Holman, 2001).

Underclass Hypothesis

In our paper we adapt Meier, Stewart and England's (1991) hypothesis regarding the distribution of urban services to examine the distribution of HIV-related services across Chicago neighborhoods. Our research examines Meier, Stewart and England's (1991) Underclass Hypothesis that suggests that the political and economic system that determines the distribution of urban services is biased and that racial/ethnic minority groups and economically disadvantaged communities receive a less than equal share of a city's services. In testing the underclass hypothesis, our research uses data from the 2000 Census of the population to examine the impact of neighborhood level economic measures and racial and ethnic composition.

Our examination of the spatial distribution of HIV services across Chicago neighborhoods also incorporates an important element identified by Bolotin and Cingranelli (1983), specifically neighborhood need for service. "The incorporation of systematic controls increases the internal validity of analyses of municipal service distribution" (Bolotin and Cingranelli, 1983: 219). For our analyses we integrate and map epidemiological data collected by the Chicago Department of Public Health, Division of STD/HIV/AIDS Public Policy and Programs on the incidence and prevalence of HIV and STD infection and HIV mortality rates across Chicago neighborhoods, thereby including appropriate measures (and statistical controls) for the neighborhood-level need for HIV-related services.

Method

Data on Chicago Area HIV Service Providers

The study includes a comprehensive list of all HIV/AIDS interventions in Metropolitan Chicago. The initial compilation of the list of 345 HIV service providers for Chicago's 77 community areas came from the 2002 HIV Services Directory and the 2002 Chicago Area Directory of HIV Professionals published by the Test Positive Awareness Network (funded through Title I of the Ryan White Comprehensive AIDS Resources Emergency Act through the Chicago Department of Public Health). This includes 219 HIV service providers and 126 HIV professionals for the Chicago area. In addition to address and contact information, the TPAN directory contains information by service category (i.e., Case Management, Dental, Housing Placement, Testing and Counseling, etc.) and for each service provider – by service category - on fees (i.e., free, sliding scale, private insurance, etc.), and population served (i.e., women, men, children and youth, etc.). The Test Positive Aware Network (TPAN) in Chicago generously provided the TPAN directory to the researchers. [See www.tpan.com]

Distribution of Services Provided by Chicago HIV Service Providers

Chicago HIV service providers offer numerous and diverse services and social support networks to those who wish to be tested for HIV and those already diagnosed with HIV and AIDS (See Table 2). Across the 219 HIV service providers in Chicago offer a variety of services including: case management (55%), voluntary AIDS counseling and testing (56%), alternative therapies (11%), day and respite care (9%), financial assistance (13%), and food and other basic needs (22%). Most AIDS service organizations (63%) and HIV professionals (73%) offer their services for free, on a sliding scale, or accept Medicaid or Medicare. Additionally, while many service providers serve all populations or those that are HIV positive, other service providers have specialized services for women, families and children.

Chicago Department of Public Health: Community Area Health Inventory

As suggested by Bolotin and Cingranelli (1983), our analyses incorporate elements of neighborhood need for service, and in particular neighborhood rates of STD and HIV infection and AIDS diagnoses. We draw on the Chicago Community Area Health Inventory that summarizes data from a number of public health sources and is a summary report of health measures for Chicago's 77 community areas and the Chicago Department of Public Health's HIV/AIDS Surveillance Reports. The Chicago Department of Public Health, Division of STD/HIV/AIDS Public Policy and Programs also collect data on STD/HIV/AIDS incidence and prevalence. See Table 1 for descriptive statistics of Chicago's health characteristics and Maps 1 and 2 for an examination of the geographic variation in the HIV epidemic in Chicago (Map 1 is the Rate of AIDS Infection and Map 2 is the Rate of HIV Infection Mortality). The average annual AIDS incidence across Chicago communities is highly concentrated in the northeastern (Edgewater and Uptown), downtown and central areas of Chicago (Loop, Near South Side, East Garfield Park, Fuller Park, Grand Boulevard and Washington Park) (Office of HIV/AIDS Surveillance, 2000). These communities also have high rates of HIV infection and gonorrhea, chlamydia and syphilis (Chicago Department of Public Health, 1999).

Chicago Neighborhood Characteristics

Our analyses will examine the demographic and socio-economic characteristics of Chicago neighborhoods associated with HIV service provision using data from the 2000 United States Census of the population. In 2000, Chicago's population was just over 5.4 million, a 5% increase over the 1990 population. Chicago is an ethnically and racially diverse city, being 20% immigrant and made up of 26% African American and 20% Hispanic/Latino. Among Chicago residents 22% live below the poverty line, 17% reside in female-headed household, 34% of children live in poverty, and the median household income is $37, 949.

Measuring Access to HIV Service Providers

There are a number of approaches that may be used in applying spatial analytic techniques to an examination of the spatial equity of HIV service provision. The container approach estimates the number of service providers within a given neighborhood. For example, we will examine the number of case management providers within each neighborhood. This approach constrains the notion of access to the presence, number and services offered by case management providers within a given neighborhood and is not concerned with the case management available in adjacent neighborhoods. In this case, spatial spillovers or spatial externalities to other neighborhoods are excluded from consideration. The container approach may increase the likelihood of finding un-patterned inequality. This is because the selection of the unit of analysis (i.e. the census tract) does not match the actual service area of the HIV service provider (Talen and Anselin, 1998).

In our full paper to be presented at the PAA meetings in Boston we also will use a distance approach to examine the distance from each neighborhood to all HIV service providers as an indicator of accessibility. Currently little is known about the geographic distribution of HIV services, including services for those seeking testing and information, in addition to the services specific to those living with HIV/AIDS. [For an examination of nationwide variation in access to HIV testing sites see Centers for Disease Control and Prevention, 2002] Our

project examines the distribution of services specific to HIV/AIDS. The access approach measures the distance between residential locations (proxied by census tract centroids) and HIV service providers. We consider the Travel Cost Index of accessibility which is the average distance to all facilities. The access measure was computed in a spatial statistics software program (SpaceStat 1.91) using the shortest path distances, as distance inputs, between the centroids of each census tract and the service providers (Talen & Anselin, 1998).

The Travel Cost Index is a measure of the average distance between each neighborhood and all HIV service providers across Chicago. A lower index value indicates better accessibility to HIV-related services. This much broader view of accessibility takes into account spatial externalities to better capture the relationship between the spatial distribution of all facilities and key explanatory variables. The Travel Cost Index or average travel distance measure captures the spatial externalities and accessibility (Talen and Anselin, 1998) of all the facilities within Chicago.

Spatial Analysis

Spatial analytic approaches permit the opportunity to explicitly model spatial interactions and identify the importance of space, location and distance in a variety of neighborhood processes. We use Exploratory Spatial Data Analysis (ESDA), to visualize the spatial distribution of the HIV service provision for Chicago. ESDA is a collection of techniques to describe and visualize spatial distributions, identify atypical locations, and discover patterns of spatial association (See Messner, Anselin, Baller, Hawkins, Deane & Tolnay, 1999 for a discussion). Prior to exploratory spatial data analysis, decisions must be made regarding the structure of the spatial weights matrix and a neighboring structure among census tracts must be assumed and clearly defined. This is the inclusion of prior structure of spatial dependence between spatial units (between census tracts). This is required due to insufficient information to specify a full matrix of interactions between all census tracts. Spatial analyses are conditional upon the choice of the spatial weights matrix. For our analyses of the spatial association of HIV service provision, we considered the queen criterion for defining neighbors. The queen criterion defines neighbors as those that share a common boundary and common corner. All statistical computations will be done using the Luc Anselin's GeoDa software package and all mapping will be done using ArcMap.

Data Visualization: The Mapping of HIV Service Providers

In our analyses we will use choropleth quartile maps to examine the spatial patterns in the data, including the clustering of similar values in space, identifying adjacent neighborhoods that are similar to each other in terms of food panty use and food stamp receipt. This allows us to examine the clustering of neighborhoods with high and/or low levels of access to HIV-related services. Anselin and Bera (1998) refer to spatial autocorrelation as the clustering of similar values is space (i.e., positive autocorrelation) or locations that are surrounded by neighbors with dissimilar values (i.e., negative autocorrelation).

The spatial patterns identified in the maps may be tested against two spatial autocorrelation statistics. The clustering of neighborhood reliance on the food safety net is examined both globally and locally. As Baller and Richardson (2002; 879) note, global clustering refers to the average amount of clustering throughout a county, whereas local clustering refers to the relationship between a given rate of food safety net use in a neighborhood and the average of neighboring rates.

Measures of Spatial Association: Global and Local Moran's I

The Moran's I statistic is a global measure of spatial autocorrelation that provides an indication of the extent to which the spatial pattern of the data is compatible with the null hypothesis of spatial randomness. The null hypothesis for spatial randomness assumes: (1) values observed in one neighborhood do not depend on values observed in an adjacent neighborhood; (2) observed spatial pattern of values is equally likely as any other spatial pattern; and (3) the location of values may be altered without affecting the information content of the data.

Global measures of spatial association sometimes do not reveal local patterns in the data in terms of smaller clusters or outliers. Anselin (1995) suggests the application of local indicators of spatial association (LISA) that

assess the null hypothesis of spatial randomness by comparing values in each specific location with values in neighboring locations. The local Moran's I statistic may be used to determine whether the autocorrelation is greater than would be expected by chance. The local Moran's I is used to identify local spatial clusters of census tracts that have more or less access to HIV related services. It may also be used to examine the clustering of demographic and socio-economic characteristics across Chicago.

Moran Scatterplot Map based on LISA statistic allows for distinguishing between the clustering of high and low rate neighborhoods. [See Baller and Richardson, 2002 for a discussion] The maps presented below are initial analyses that have been conducted. We plan on examining a number of census attributes related to the distribution of HIV-related services (i.e., average household income, percent below the poverty line, percent of children living in poverty, etc).

The shading in the maps presented below denote census tracts that have rates (i.e., distance to an HIV service provider, percent African Americans, percent Latino, etc.) that are significantly related to neighboring rates (based on the local Moran's I statistic). Additionally, the color scheme denotes the nature of the relationship between a census tract's rate and neighboring rates. For example, census tracts with high rate of access to HIV service provision, and whose neighbors also have high rates are shaded in red and are labeled high-high, while census tracts with low rates of access to HIV-related services, and whose neighbors also have low rates are shaded in pink and are labeled low-low. We are also interested in those census tracts that are significantly different from their neighbors. The census tracts shaded dark blue denote census tracts with high rates of access, and whose neighbors have low rates and are labeled high-low, while census tracts shaded light blue denote census tracts with low rates of access, and whose neighbors have high rates and are labeled low-high.

Preliminary Results:

Below we present some preliminary findings, our paper presented at the PAA meetings will build on these initial analyses. Map 3 is the LISA Map of the Container Index. In Maps 4 and 5 we map the census tracts with significant local Moran statistics (LISA) for the percentage of the African American population, and the Latino population. By linking the accessibility of HIV related services to vulnerable and target populations directly, our examination of the spatial distribution of HIV service providers offers an exploration of differential access to HIV-related services. In the following discussion we highlight the findings in Maps 4 and 5 and the statistics as indicated in Map 1 through 3 (these are the LISA maps for the HIV epidemic and the LISA maps for the Container Index).

As indicated in Map 3 (the LISA Map for the container index). The areas that are most highly served are shaded in red, these are census tracts with a high rate of access to HIV service provision, and whose neighbors also have high rates of access to HIV-related services. The Chicago communities that are clearly accessible to HIV-related services are highly concentrated in the northeast (Edgewater and Uptown), downtown area of Chicago (Loop). Note that these areas partially overlap with the areas that have been hardest hit by the AIDS epidemic (Refer back to the distribution of AIDS infection and HIV infection mortality in Maps 1 and 2). Also note that an area indicated in Maps 1 and 2 that has also been hard hit by the epidemic, specifically the south and central areas of Chicago (Near South Side, East Garfield Park, Fuller Park, Grand Boulevard and Washington Park) lack access to HIV-related services. These are predominantly African American communities.

Map 4 is a LISA Map for the Percent African American. The south and central areas of Chicago have a large cluster of African American neighborhoods as indicated in Map 4. Map 5 is a LISA Map for the Percent Latino. Note a large cluster of Latino neighborhoods in the west/central and north/central portions of Chicago. These areas also overlap with the areas of Chicago that are less accessible to HIV related services (Refer to Map 3), yet these areas have lower rates of AIDS infection and HIV infection mortality. In our paper to be presented at PAA we will further explore the issue of inequity in the distribution of HIV-related services as it relates to the geographic distribution of Chicago's economic, race and ethnic groups.

Research Implications:

Our findings may have implications for public policy and the allocation of healthcare resources. The application of GIS to an examination of healthcare accessibility allows for the targeting of healthcare resources that may better inform policy and planning. The application of spatial databases and analyses to an examination of HIV service provision may help to identify criteria to be used to evaluate the impact of changes in the allocation of healthcare resources and the optimal locations for new services. These criteria may include neighborhood racial and ethnic composition, neighborhood level socio-economic indicators, and current level of healthcare provision. We hope that our findings and future research using GIS may be used by public health and other policy makers to develop what if scenarios of suitable locations for new services and for targeting vulnerable populations based on communities with high rates of HIV infection and inadequate service provision.

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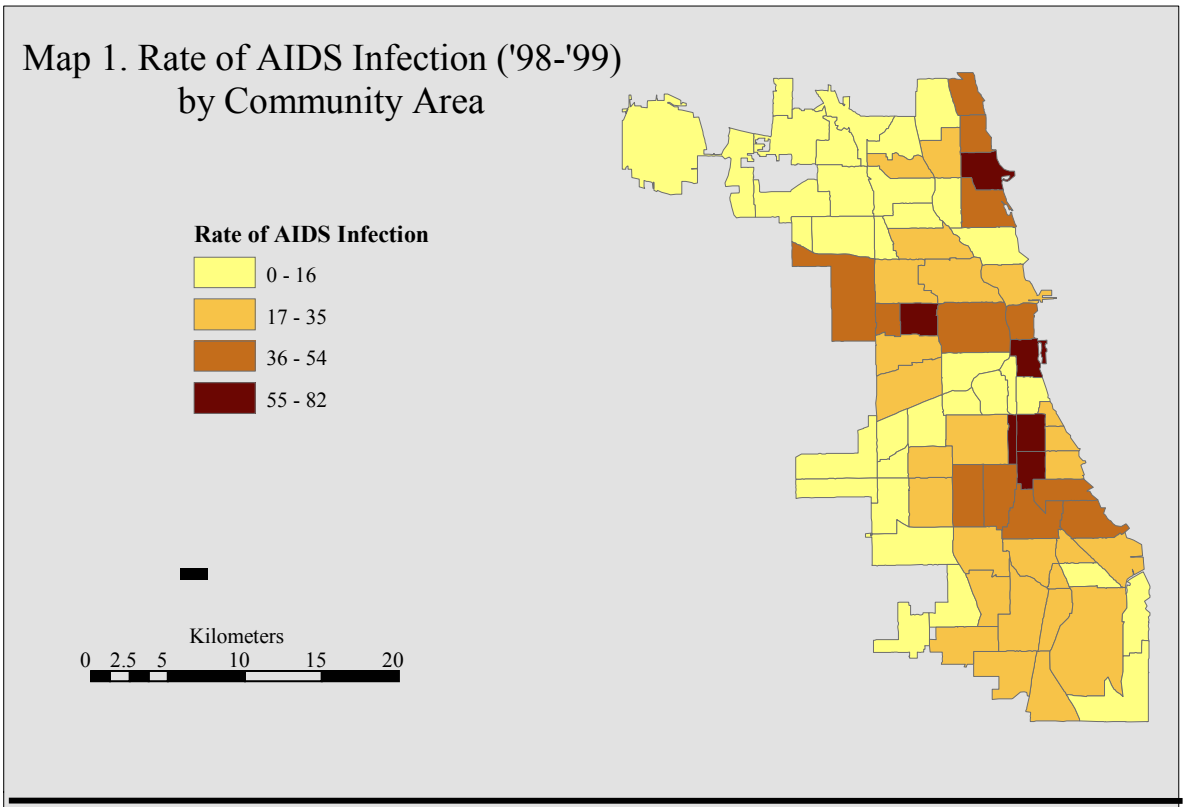
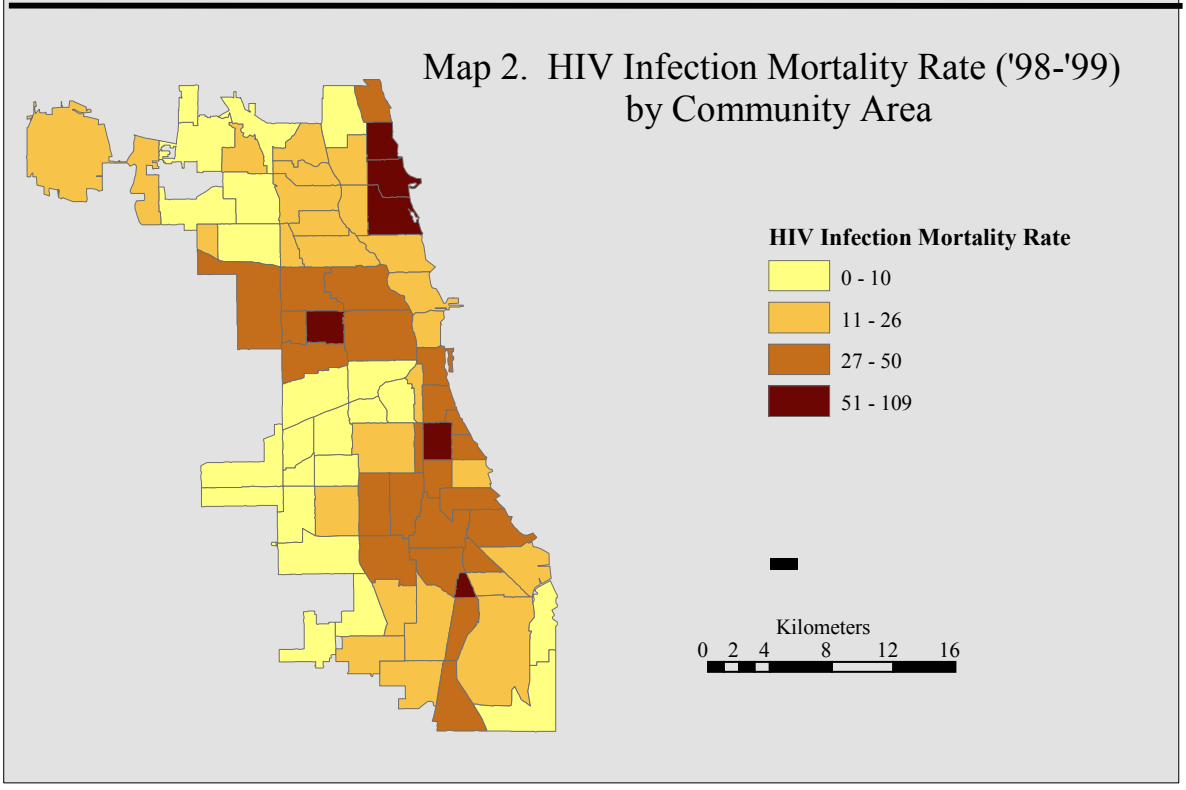
Table 1 Health Characteristics of Chicago's 77 Neighborhood Areas.
Chicago Department of Public Health Epidemiology Program.

Variable	Rate per 100,000
Health Characteristics of Chicago Neighborhoods	
All Cancer Mortality	144
HIV Infection Mortality	26
Pneumonia and Influenza Mortality	18
Annual AIDS Cases	45
Syphilis Cases	19
Gonorrhea Cases	469
Chlamydia Cases	484
Tuberculosis Cases	23
Infant Mortality	11

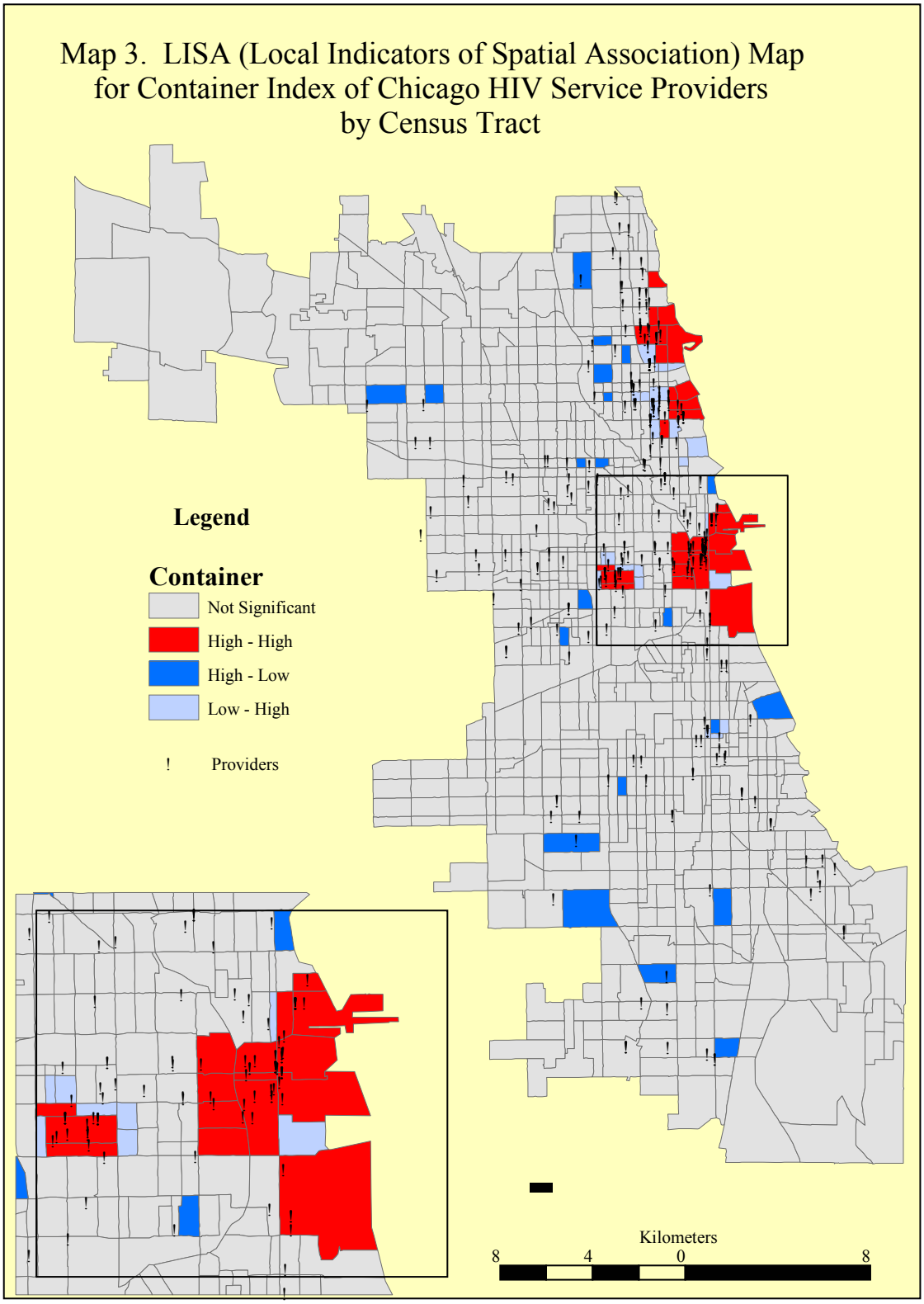
Table 2 Characteristics of HIV Service Providers and Professionals in Chicago

Variable	Percentage
Characteristics of HIV Service Providers	
Free Services Provided	63.0
Private Insurance Accepted for Services	20.9
All Populations Served	57.3
Services for AIDS Diagnosis Patients Only	15.6
Service for HIV Diagnosis Patients Only	20.4
Characteristics of HIV Professionals	
Private Insurance Accepted for Services	87.1
Sliding Fee Schedule for Services	44.4
Medicare/Medicaid Accepted for Services	72.6

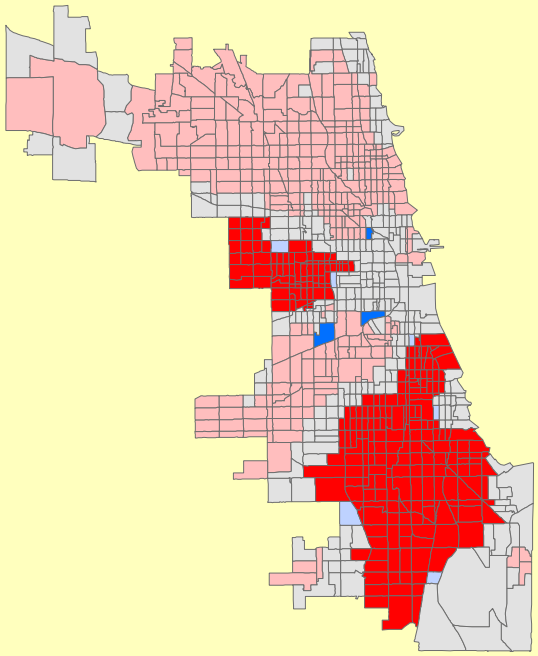

Map 1. Rate of AIDS Infection ('98-'99)
by Community Area
Rate of AIDS Infection
0 - 16
17 - 35
36 - 54
55 - 82
Kilometers
0 2.5 5 10 15 20

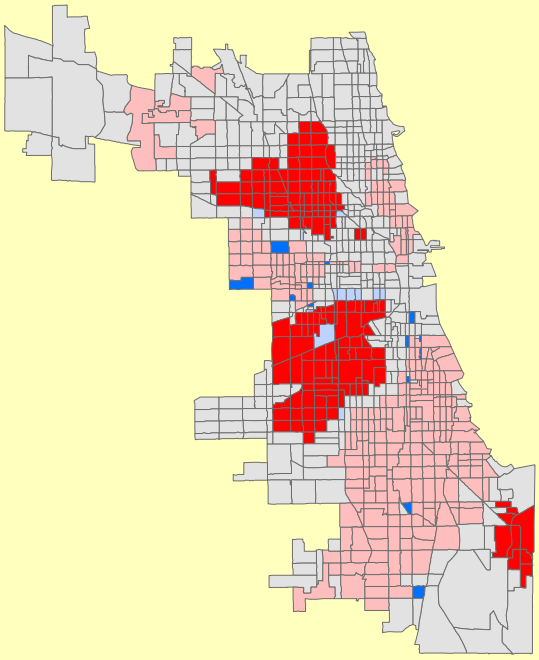

Map 2. HIV Infection Mortality Rate ('98-'99)
by Community Area
HIV Infection Mortality Rate
0 - 10
11 - 26
27 - 50
51 - 109
Kilometers
0 2 4 8 12 16

Map 3. LISA (Local Indicators of Spatial Association) Map for Container Index of Chicago HIV Service Providers by Census Tract



Map 4. LISA Map for Percent African American by Census Tract





Map 5. LISA Map for Percent Hispanic/Latino by Census Tract