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Behind the Cascade: Analyzing Spatial Patterns along the HIV Care Continuum

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Abstract

Background—Successful HIV treatment as prevention requires individuals to be tested, aware of their status, linked to and retained in care, and virally suppressed. Spatial analysis may be useful for monitoring HIV care by identifying geographic areas with poor outcomes.

Methods—Retrospective cohort of 1,704 people newly diagnosed with HIV identified from Philadelphia's Enhanced HIV/AIDS Reporting System in 2008–2009, with follow-up to 2011.

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Outcomes of interest were not linked to care, not linked to care within 90 days, not retained in care, and not virally suppressed. Spatial patterns were analyzed using K-functions to identify 'hot spots' for targeted intervention. Geographic components were included in regression analyses along with demographic factors to determine their impact on each outcome.

Results—Overall, 1,404 persons (82%) linked to care; 75% (1,059/1,404) linked within 90 days; 37% (526/1,059) were retained in care; and 72% (379/526) achieved viral suppression. 59 census tracts were in 'hot spots', with no overlap between outcomes. Persons residing in geographic areas identified by the local K-function analyses were more likely to not link to care (AOR 1.76 [95% CI 1.30–2.40]), not link to care within 90 days (1.49, 1.12–1.99), not be retained in care (1.84, 1.39–2.43), and not be virally suppressed (3.23, 1.87–5.59) than persons not residing in the identified areas.

Conclusion—This study is the first to identify spatial patterns as a strong independent predictor of linkage to care, retention in care, and viral suppression. Spatial analyses are a valuable tool for characterizing the HIV epidemic and treatment cascade.

INTRODUCTION

Early initiation of antiretroviral therapy (ART) for people living with HIV (PLWH) is beneficial to both the individual's health and for reducing the likelihood of HIV transmission to others.[1,2] Successful HIV treatment as prevention requires individuals to be tested, receive their test results, be linked and retained in care, initiate HIV therapy, and achieve viral load suppression. [3–5] Understanding the dynamics of this treatment cascade is essential to control HIV transmission on a community level. [3–5]

Local and federal agencies have used surveillance data to evaluate the treatment cascade by age, sex, race/ethnicity, and HIV transmission risk.[6–9] However, limited data exists on how geographic factors impact access to and retention in ARV treatment and suppression of viral load. Geographic information systems (GIS) technology allows for mapping and analyses able to identify geographic foci or hot spots, of disease, and have been effectively used to map the burden of tuberculosis, syphilis, and HIV infection in communities.[10–12] In addition, GIS technologies have been used to analyze measures of proximity and access to resources.[13–15] This methodology may also be useful for monitoring the HIV treatment cascade by identifying geographic areas with poor engagement in care and inadequate viral suppression.

As part of a Centers for AIDS Research (CFAR) supplement to support the Enhanced Comprehensive HIV Prevention and Planning (ECHPP) initiative, investigators from the Philadelphia Department of Public Health (PDPH) and the University of Pennsylvania (Penn) used GIS technologies to examine the current HIV treatment cascade (linkage to care, retention in care, and viral suppression) status for people originally diagnosed with HIV infection between 2008–2009 in Philadelphia, PA. To assist in public health planning of HIV care and case management services, we sought to identify geographic areas associated with *not* linking to care, *not* linking to care in 90 days, *not* retaining in care, and *not* achieving viral suppression after HIV diagnosis by comparing spatial patterns of a cohort of recently diagnosed cases.

METHODS

Data Source & Study Population

Data for analyses reported here were extracted from the City of Philadelphia's Enhanced HIV/AIDS Reporting System (eHARS), a database containing information on all HIV cases reported to the PDPH AIDS Activities Coordinating Office (AACO) Surveillance Unit. Philadelphia has mandatory name-based case reporting of all new HIV infections in the City. Additionally, local mandates require reporting of all CD4 cell counts < 350/ml (or CD4 percent < 25%) and all HIV-1 RNA levels to the PDPH.[16] Thus, eHARS contains records and laboratory results of all PLWH who were diagnosed with HIV in Philadelphia, were a resident of Philadelphia at any time after their HIV diagnosis, and all PLWH who received care in Philadelphia after their HIV diagnosis.

The eHARS database contains information collected through medical record abstraction including identifiers such as name, address, date of birth and address at diagnosis; as well as laboratory, pharmacy, and health service utilization information. Death data from the Pennsylvania Bureau of Vital Statistics, Social Security Death Master Index, and the National Death Index are routinely matched to eHARS data to identify deceased persons and document cause of death when available. The eHARS data are routinely monitored to identify duplicate cases and undergo quality control and verification to ensure that abstracted data are correctly assigned to unique case records.

As this study required assigning a spatial location to each person, individuals were included if they had a: (1) new HIV diagnosis date in 2008 or 2009, and (2) Philadelphia address at time of diagnosis. Those with invalid or insufficient address data and with prison addresses at time of diagnosis were excluded from analyses (N=157).

Predictor and Outcome Variables

For each person, we defined age, sex at birth, race/ethnicity, HIV transmission risk, and insurance status at the time of diagnosis. Age was divided into three groups: 13–24, 25–44, and ≥ 45 years old. Race/ethnicity was categorized as White, Non-Hispanic Black, Hispanic, or other. Transmission risk was grouped into heterosexual, men who had sex with men (MSM), injection drug use (IDU), and other/unknown. Patients who had IDU in combination with another risk factor (e.g. MSM, heterosexual transmission) were classified as IDU.

In addition, we collected information on imprisonment (dichotomously defined as one or more prison stay during the observation period); visits to multiple care sites (dichotomously defined as accessing two or more clinics during the observation period); and proximity to medical care (dichotomously defined as distance to the nearest care site less than the population average distance to the nearest care site). In Philadelphia, laboratory results are assigned a unique identifier indicating the facility associated with the requesting medical provider. This unique identifier was used to classify imprisoned patients and those accessing two or more clinics during the observation period.

Outcomes of interest were based on four steps of the HIV treatment cascade and included: 1) not linked to care; 2) not linked to care within 90 days; 3) not retained in care; and 4) not achieving viral suppression. Linkage to care was defined as documentation of one or more CD4 or viral load test results after the date of diagnosis. Linkage to care within 90 days described patients with one or more CD4 or viral load test results in the 90 day period after diagnosis (calculated as the difference between date of diagnosis and date of first laboratory test). Retention in care was defined using the National Quality Forum Medical Visit Frequency Measure.[17] This measure defines retention in care as completing at least one medical visit with a provider with prescribing privileges in each 6-month interval of the 24-month measurement period, with a minimum of 60 days between medical visits. Date of first linkage to care defined the start of the 24-month measurement period. We used laboratory reports of CD4 and/or viral load testing as a proxy for HIV medical care visits. Prior studies have shown high correlation between laboratory test and medical visit data and retention in care.[18] Viral suppression was classified as evidence of HIV-1 RNA < 200 copies/ml closest to the end of the 24-month measurement period ± 120 days.

Mapping and Spatial Analyses

Residential address data for persons meeting inclusion and exclusion criteria were imported to ArcGIS 9.3 for geocoding using ArcMap and address locator data provided by the PDPH Department of Technology (DOT). Persons were assigned spatial coordinates for subsequent analyses based on geographic location of residence at the time of diagnosis.

In its most straightforward application, the K-function provides an estimate of spatial dependence; and is based on all the distances between events in a given study area.[19] This function compares the actual spatial location of points to a simulated random distribution of points using one or more distance bands. The value of the K-function determines whether a given point pattern is more clustered or dispersed than a point pattern of complete spatial randomness. Unlike other tests that examine variations in the intensity of phenomena over a given area, either by dividing an area into segments or calculating densities, the K-function is able to utilize multiple distance bands to detect clustering or dispersion at different scales. The ‘local’ K-function, which calculates a value at each point, rather than for the entire region, also identifies whether a point pattern is more clustered or dispersed; but, can additionally identify specific locations in the region (‘hot spots’ and/or ‘cool spots’) where the distribution of points differs significantly from the random distribution.[20–22] The cross K-function utilizes a marked point process, and can be used to compare subgroups (e.g. persons linked versus not linked to care) of a single population to the distribution of all points in the region. This test can be used to compare points marked as ‘not linked to care’ with all points in the region to determine if the distributions are significantly different or spatially indistinguishable. [20–22] The local version of the cross K-function can identify specific locations in the region where points marked as ‘not linked to care’ are more clustered than all points in the region.

We used the local cross K-function to determine if: (1) the spatial patterns exhibited by persons that did not meet specific steps along the HIV treatment cascade differed

significantly from the overall pattern of people diagnosed with HIV; and if so, (2) where in the City those differences were observed.

The spatial location of each case was analyzed using three radial distance bands (1000, 2500 and 5000 feet) to determine if points in marked pattern 1 (e.g. persons not linked to care) were significantly more clustered than points in marked pattern 2 (e.g. persons linked to care) for each of the four outcomes. Feet were used as the distance unit because the coordinates were calculated in feet. The primary distance radius of 5000 feet was selected based on one-half of the maximum distance between each point and its five nearest neighbors. The 5000 feet distance also encompasses the nearest neighbor distance for 99.9% of the cohort, and represents a rough approximation of one mile.

Cross K-function p-values were calculated using MATLAB and publicly available programs (designed by Tony E. Smith: http://www.seas.upenn.edu/~ese502/NOTEBOOK/Part_I/5_Comparative_Analyses.pdf) to detect local variations of a marked point process. The p-values at each spatial location were then imported to ArcMap and interpolated to a continuous raster surface file using the spline method in ArcToolbox. The interpolated surface raster was then converted to contour lines to highlight specific geographic areas where persons classified with negative outcomes along the HIV treatment cascade exhibited significant clustering compared to the full cohort of patients.

Our a priori hypothesis was that each step in the cascade is a distinct outcome with independent predictors that include both individual and community factors. As a result, the chosen denominator for each outcome was the numerator of the previous step in the cascade; all eligible diagnoses for linked to care, all persons linked to care for linked within 90 days and retention in care, and retained in care for viral suppression.

Statistical Analyses

Univariate statistics were used to describe the dataset. Multivariate logistic regression models were used to assess relationships between predictors and the outcomes. Models were adjusted for age, sex at birth, race/ethnicity, HIV transmission risk, and insurance status at the time of diagnosis; as well as imprisonment status, visits to multiple care sites, and proximity to nearest HIV medical provider. Additionally, we included geographic “hot spot” areas in the final model. To do this, contour hot spots were spatially joined to each person in order to assign a value indicating the distance between each person and the nearest contour. Persons were considered to be within the contour area if the calculated distance value was less than or equal to 5000 feet. Persons were assigned as either residing inside or outside of a particular area for each of the four outcomes. Adjusted odds ratios (AOR) with 95% confidence intervals (CI) are presented. Relationships were considered statistically significant at $p<0.05$.

RESULTS

Between 2008 and 2009, 1,861 people newly diagnosed with HIV were identified (Table 1). Of these, 157 (8%) had invalid address data or were imprisoned at time of diagnosis and were excluded from subsequent analyses. Excluded persons were less likely to be Black or

Hispanic; and more likely to be older adults, people with IDU as an HIV risk factor, and people with private insurance compared to included individuals. In addition, excluded patients were more likely to have had a prison stay during the subsequent observation period. Among the 1,704 persons included in the analyses, 70% were male, 63% were Black, and 30% were 45 years of age or older at time of diagnosis. The two most common HIV transmission risk factors were heterosexual (40%) and MSM (36%).

Overall, 1,404 persons (82% of 1,704) linked to care. Among those linked, 1,059 (75%) linked within 90 days and 526 (37%) were retained in care. Out of the 526 individuals retained in care, 379 (72%) achieved viral suppression. Correspondingly, 18%, 25%, 63%, and 28% of eligible individuals were not linked to care, not linked to care within 90 days, not retained in care, and not virally suppressed, respectively. (Table 2)

Geographic Patterns

As shown in Figure 1, Philadelphia is a city of neighborhoods bordered on the east by the Delaware River, which separates Pennsylvania and New Jersey, and to the north and west by three Pennsylvania counties: Montgomery, Delaware, and Bucks. The maps presented in Figure 2 show the geographic distribution of new HIV diagnoses (A1), HIV care sites (A2), and the areas identified as hot spots for each of the four outcomes (A3–A6). Overall, 12–19 census tracts were included in the geographic clusters for each outcome, with a total of 59 unique tracts (15.4% of all census tracts in Philadelphia).

New HIV cases tended to cluster in areas of high population including sections of North Philadelphia, Center City, South Philadelphia, and West Philadelphia. Geographic areas associated with not linking to care included North Philadelphia, as well as smaller segments of West Philadelphia and the Lower Northeast, and a long strip along the City's western border with Montgomery County in the Roxborough section. Areas associated with not linking to care within 90 days include a small area of North Philadelphia, two small areas in West Philadelphia, and a long strip along the river in the Kensington section. Areas associated with not retaining in care are both more numerous and more geographically varied, including a large area in northern part of West Philadelphia near Fairmount Park, a smaller section in the neighborhood of West Philadelphia, an area at the southern end of South Philadelphia, a strip along the river in Center City, two sections of Oak Lane along the border with Montgomery County, and an area in the central section of the Lower Northeast. Three areas of the City were associated with not achieving viral suppression, including the Kensington section of North Philadelphia, a small area of Southwest Philadelphia, and the tip of Northwest Philadelphia in the Olney/Oak Lane neighborhood.

Multivariate Analyses

Logistic regression models were fit to evaluate the relationship between geographic hot spots (individually identified for each of the four steps evaluated in the HIV treatment cascade) and the outcomes of interest. (Table 3)

Model 1 – Not linked to care—Persons residing inside of the geographic areas identified by the local K-function analysis were more likely to not link to care compared to those

residing outside of these areas (AOR 1.76 [95% CI 1.30–2.40]). Additionally, Blacks (vs. whites), persons with IDU transmission risk (vs. heterosexual), and those with Medicare or no insurance (vs. private) had higher odds of non-linkage. Males were more likely to be not linked to care than females. No significant differences in linkage to care were detected between whites and Hispanics.

Model 2 – Not linked to care within 90 days—Among persons linked to care, individuals residing inside of the geographic areas identified by the local K-function analysis were more likely to not link to care within 90 days compared to those residing outside of these areas (AOR 1.49 [95% CI 1.12–1.99]). Compared to persons with private insurance, individuals with no insurance had higher odds of non-linkage within 90 days (i.e. less likely to link within 90 days). No differences were observed by sex, age, race/ethnicity, transmission risk, prison stay during the observation period or proximity to medical care sites.

Model 3 – Not retained in care—Among persons linked to care, individuals residing inside of the geographic areas identified by the local K-function analysis were more likely to not be retained in care compared to those residing outside of these areas (AOR 1.84 [95% CI 1.39–2.43]). Blacks and Hispanics were more likely to be non-retained (i.e. less likely to be retained) than whites, while younger individuals were more likely to be non-retained compared to those older than 45 and older.

Model 4 – Not virally suppressed—Among all persons retained in care, those residing inside of the geographic areas identified by the local K-function analysis were more likely to not be virally suppressed compared to those residing inside of these areas (AOR 3.23 [95% CI 1.87–5.59). Persons whose nearest care site was more than the average distance to the nearest care site were more likely to not achieve viral suppression (i.e. less likely to be virally suppressed) compared to their counterparts who resided closer to their care sites. No differences were observed by sex, age, race/ethnicity, transmission risk, insurance, or prison stay during the observation period.

DISCUSSION

In this cohort, we identified 1,704 newly diagnosed persons with HIV who met inclusion criteria. Among these, 82% were linked to care; of whom 75% linked to care within 3 months of diagnosis. Only 37% of patients linked to care were retained in care over 24 months, and 72% of those who were retained in care achieved viral suppression. Overall, 22% of persons recently diagnosed were linked to care, retained in care, and virally suppressed at the end of the follow-up period. This estimate is consistent with other published estimates of the treatment cascade and viral suppression in the United States.[4] Although predictors of failing to be linked to care, retained in care, and virally suppressed have been previously evaluated[3,9,18,23–26], this study is unique in that it used community factors including geography and proximity to care as predictors.

Geographic clustering was independently associated with poor outcomes at each step along the HIV treatment cascade. We identified between 12 and 19 census tracts included in the

geographic clusters for each outcome, with a total of 59 unique tracts (15.4% of all census tracts in Philadelphia) across all outcomes. Interestingly, the geographic clusters identified for each step of the cascade were unique, with no geographic overlap between cascade steps. This suggests that the community-level factors responsible for worse outcomes may differ depending on the step of the HIV treatment cascade being evaluated.

Community factors related to poverty such as crime, housing stability, and poor access to transportation and social services may impact HIV treatment outcomes for individuals residing in geographic "hot spot" areas.[27–29] We identified several characteristics differentiating these hot spots from the rest of the City of Philadelphia. First, hot spots for three of the four outcomes evaluated had narcotic arrest rates at least two times greater than the City average[27]. High narcotic arrest rates may indicate high drug use and crime in these communities. In addition, hot spots associated with not remaining in care had higher rates of aggravated assault compared to other parts of the City. Surprisingly, other markers of low socioeconomic status (poverty and education level) did not differ between hot spots and the remainder of the City. This finding may be limited by the high rate of poverty in Philadelphia overall, with nearly 45% of the general population living below 200% of the federal poverty level[28]. Of the ten largest cities in the US, Philadelphia has the highest rate of deep poverty, defined as people with incomes below half of the federal poverty level[29]. Evaluation of whether there are differences in the prevalence of deep poverty in these "hot spots" warrants further investigation.

Previous studies have shown that low neighborhood/community socioeconomic status is associated with a lower likelihood of having a usual source of health care, obtaining preventive services, and an increased likelihood of having unmet medical need, even after controlling for patient characteristics and supply of health care providers. [30] The impact of neighborhood environment and residents' reaction to and perception of that environment has been linked to both risk of chronic disease and rates of self-management behaviors necessary for managing chronic disease. [31–34] Our study did not examine access to public transportation in these areas, access to social services or pharmacies, measures of social disorder such as crime and community response to crime, and community networks and norms (especially related to health and healthcare). We hypothesize that community norms and social disorder may have a greater effect on linkage to care; access to public transportation and social services may have a greater effect on retention in care; and access to pharmacies may have a greater effect on viral suppression. Differences in community factors that influence each step of the cascade may explain the lack of overlap in hot spots.

While, the 59 unique census tracts associated with the geographic "hotspot" areas represent 14.5% of the population of Philadelphia, they represent 22.2% of all PLWH in the City. A higher burden of HIV disease in these communities with poor outcomes could indicate a need for additional services in these areas. However, proximity to HIV medical care site was not associated with linkage to care, linkage to care within 90 days, and retention in care, suggesting that inaccessibility to care is not the primary driver for the geographic clustering observed. Furthermore, our previous work on geography and access to HIV care in Philadelphia has shown that individuals do not tend to utilize HIV care at the facility nearest to their home residence[35].

Similar to prior studies, linkage to care, retention in care, and viral suppression rates differed for different socio-demographic groups[18,25,26,31,32]. After adjusting for geographic "hot spot" areas, IDU, heterosexuals, males, those with Medicare, and those without insurance were less likely to be linked to care. However, only those with no insurance coverage were less likely to link to care within 90 days. Our analysis of linkage to care differentiates between individuals who were ever linked to care from those who never linked to care (the denominator includes all people diagnosed with HIV). Whereas, our analysis of linkage to care within 90 days is in essence an evaluation of early versus late linkage to care; all persons in the denominator were those linked to care. Several prior studies examining predictors of delayed linkage to care did not identify any associations with demographic factors and mode of transmission, after persons who never linked to care were excluded. [38–40] One study; however, did find that persons of non-white race and IDU as mode of transmission were independently associated with delayed linkage, but the authors excluded persons with AIDS. [41] The exclusion of persons with AIDS may explain the associations with non-white race and IDU since these groups are more likely to present with AIDS than other demographic groups. Several studies have shown that the strongest predictor of delayed linkage to care is the type of setting in which an individual is tested and found to be HIV positive with non-medical sites, inpatient medical sites or while incarcerated being associated with delayed entry. [36, 40, 41] Our study did not look at the type of facility where the HIV diagnosis was made but this will certainly be a focus of future work.

Blacks and Hispanics were less likely to be retained in care, as were persons <25 years of age at the time of their HIV diagnosis. Persons who attended multiple clinics were more likely to meet the criteria for retention. Prior studies have demonstrated that patients utilizing multiple sites of care attend more outpatient visits compared to those receiving care at only one care site[42]. Proximity to care and geographic area were the only variables associated with viral suppression. Unlike prior studies that have identified disparities in rates of viral suppression for racial/ethnic minorities, we did not identify any demographic differences[26,37,43]. While further research is warranted, the lack of observed racial/ethnic disparities in viral suppression in our study may in part be explained by greater demographic similarity among those retained in care combined with a smaller sample size. Among those retained in care, environmental factors may be more salient predictors of treatment success.

Our study has several limitations that should be acknowledged. First, there were statistical differences in the demographic characteristics of age, mode of transmission, and insurance status between those in the cohort and those who were excluded. We believe the impact of these differences on our results is minimal because a high proportion of the potential cases (92%) were included in the analysis. Second, we excluded patients diagnosed while in the jail system. The incarcerated population represents a vulnerable population that should be studied independently. Their exclusion here was due to their diagnosis during incarceration which did not reflect the geographic predictors we intended to explore. Third, our findings come from routine HIV surveillance data; as such we could not assess ART coverage, may have incompletely accounted for migration out of Philadelphia among the patients in the cohort, and may have had underreporting of CD4 counts. Although, only CD4 results > 350 cells/μL or > 25% of the total T-lymphocyte count were not reportable to the PDPH during

the cohort follow up period. All HIV viral loads were reportable as mandated by law, including those that were undetectable. Therefore, linkage to and retention in care would have been accurately ascertained by receipt of a viral load. Fourth, not all persons diagnosed with HIV during 2008 and 2009 would have been eligible for ART based on DHHS treatment guidelines during the follow up period, which may in part explain the lower than expected viral suppression rate. Fifth, we did not assess the impact of the density of general medical facilities, hospitals, and pharmacies, access to public transportation or other social services, and housing stability as a mechanism for the geographic clustering that we observed. Future studies should examine the impact of these community services on the HIV treatment cascade.

Lastly, our study cohort included individuals in a single large urban area who tested positive for HIV in one continuous 24 month period. Although the results may not be generalizable to other areas, the methods utilized for the spatial analyses could easily be replicated in other jurisdictions.

Our findings have very clear prevention implications. Previous studies have identified neighborhoods with high community viral loads as areas where uninfected individuals are at greater risk of acquiring HIV, compared to neighborhoods with lower community viral load.[44–45] Measuring and utilizing community viral load is a goal of the National HIV/AIDS Strategy (NHAS) for the United States.[46] NHAS also calls for innovative solutions for reducing community viral load that may help reduce the number of new HIV infections in specific communities. Our study is innovative in this regard, providing practical information on both when and where the breakdown in the care cascade occurs (which likely results in higher community viral load). Furthermore, the Centers for Disease Control and Prevention's High Impact Prevention program calls for using combinations of scientifically proven, cost-effective and scalable interventions targeted to the right populations in the right geographic areas to increase the impact of HIV prevention efforts and meet the NHAS goals. [47] The methods used in our study can help identify the right populations (those not linked to care, not retained in care, and not virally suppressed) in the right geographic areas to scale-up scientifically proven, cost-effective interventions. We believe that a jurisdiction could specifically target separate linkage, retention and adherence interventions in the areas identified with the greatest need.

This study is the first to identify spatial patterns as a strong independent predictor of linkage to care, retention in care, and viral suppression. Moving forward, it will be important to assess other, ecological, community level and neighborhood infrastructure factors that may influence access to HIV medical care and treatment outcomes within the geographic clusters identified. Thus, spatial analyses are a valuable tool for characterizing the HIV epidemic and treatment cascade. Geographic-based tailoring of interventions to improve each aspect of the cascade will be critical to controlling the HIV epidemic in the United States.

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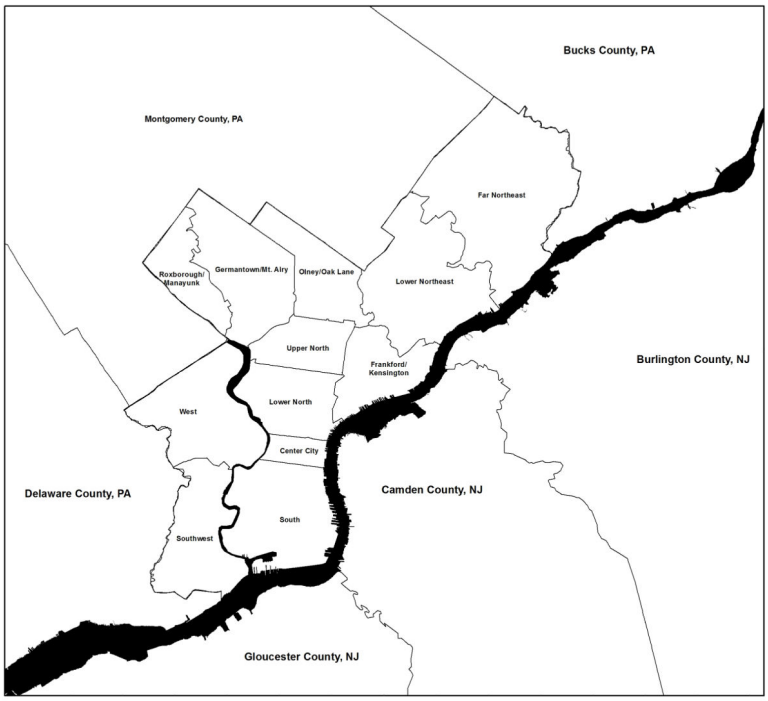

Figure 1.
Philadelphia Neighborhoods.

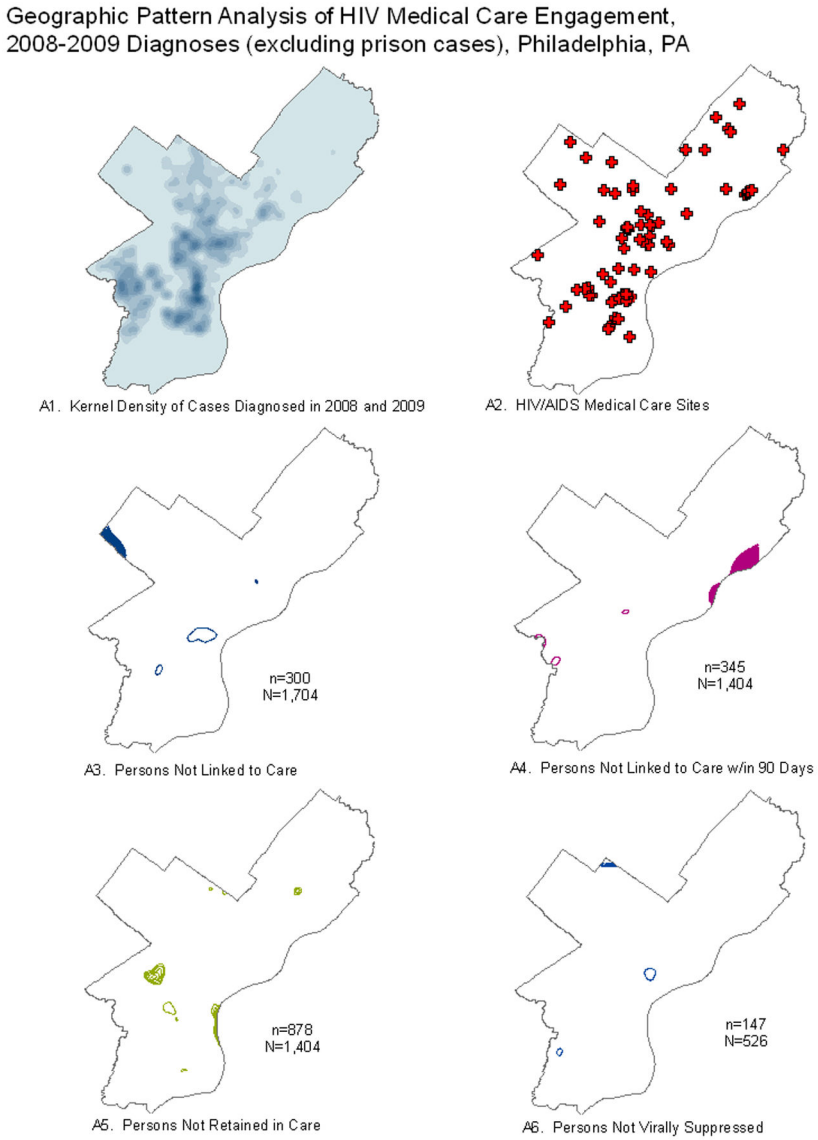

Figure 2.
Case Density, Care Location and Pattern Analyses.

Table 1

Sample Characteristics of Persons Diagnosed with HIV in 2008 and 2009

Characteristics	Included n=1,704 (%)	Excluded n=157 (%)	Chi Square	Probability
Age at Diagnosis (years)				
< 25	398 (23.4)	24 (15.3)	7.06	0.03
25–44	797 (46.8)	71 (45.2)		
45+	509 (29.9)	59 (37.6)		
Unknown		3 (1.9)		
Sex at Birth				
Female	509 (29.9)	39 (24.8)	1.40	0.24
Male	1,195 (70.1)	115 (73.2)		
Unknown	--	3 (1.9)		
Race/Ethnicity				
White	258 (15.1)	31 (19.7)	6.95	0.07
Black	1,078 (63.3)	81 (51.6)		
Hispanic	293 (17.2)	11 (7.0)		
Other/Unknown	75 (4.4)	34 (21.7)		
HIV Risk Factor				
Heterosexual	683 (40.1)	45 (28.7)	24.32	<0.0001
MSM	619 (36.3)	51 (32.5)		
IDU	175 (10.3)	35 (22.3)		
Other/NIR	227 (13.3)	26 (16.6)		
Insurance			26.77	<0.0001
Private	338 (19.8)	19 (12.1)		
Medicaid	487 (28.6)	26 (16.6)		
Medicare	169 (9.9)	20 (12.7)		
Uninsured	285 (16.7)	26 (16.6)		
Other/Unknown	425 (24.9)	66 (42.0)		
Prison Stay			0.39	0.53
No	1,606 (94.2)	19 (12.1)		
Yes	98 (5.8)	150 (95.5)		
Proximity to Care[1]				
No	742 (43.5)	NA	--	--
Yes	962 (56.5)			

[1] Proximity to care indicates < average distance to nearest care site.

Table 2

Proportion of Sample Engaged and Not Engaged in Each of Four Steps on HIV Treatment Cascade

Predictors and Values	Linkage to Care n=1,704		Linkage within 90 days among those linked n=1,404		Retention in Care among those linked n=1,404		Viral Suppression among those retained n=526	
	Yes n (%)	No n (%)	Yes n (%)	No n (%)	Yes n (%)	No n (%)	Yes n (%)	No n (%)
Total	1,404	300	1,059	345	526	878	379	147
Age at Diagnosis (years)								
< 25	341 (85.7)	57 (14.3)	247 (72.4)	94 (27.6)	99 (29.0)	242 (71.0)	71 (71.7)	28 (28.3)
25–44	663 (83.2)	134 (16.8)	503 (75.9)	160 (24.1)	262 (39.5)	401 (60.5)	184 (70.2)	78 (29.8)
45+	400 (78.6)	109 (21.4)	309 (77.3)	91 (22.8)	165 (41.3)	235 (58.8)	124 (75.2)	41 (24.8)
Sex at Birth								
Female	427 (83.9)	82 (16.1)	323 (75.6)	104 (24.4)	172 (40.3)	255 (59.7)	123 (71.5)	49 (28.5)
Male	977 (81.8)	218 (18.2)	736 (75.3)	241 (24.7)	354 (36.2)	623 (63.8)	256 (72.3)	98 (27.7)
Race/Ethnicity								
White	227 (88.0)	31 (12.0)	178 (78.4)	49 (21.6)	105 (46.3)	122 (53.7)	75 (71.4)	30 (28.6)
Black	857 (79.5)	221 (20.5)	642 (74.9)	215 (25.1)	308 (35.9)	549 (64.1)	226 (73.4)	82 (26.6)
Hispanic	260 (88.7)	33 (11.3)	197 (75.8)	63 (24.2)	93 (35.8)	167 (64.2)	27 (29.0)	66 (71.0)
Asian	12 (66.7)	6 (33.3)	6 (50.0)	6 (50.0)	2 (16.7)	10 (83.3)	2 (100)	0 (0.0)
Multi-race	38 (97.4)	1 (2.6)	30 (78.9)	8 (21.1)	15 (39.5)	23 (60.5)	9 (60.0)	6 (40.0)
Other/Unknown	10 (55.6)	8 (44.4)	6 (60.0)	4 (40.0)	3 (30.0)	7 (70.0)	1(33.3)	2 (66.7)
HIV Risk Factor								
Heterosexual	569 (83.3)	114 (16.7)	425 (74.7)	144 (25.3)	207 (36.4)	362 (63.6)	147 (71.0)	60 (29.0)
MSM	538 (86.9)	81 (13.1)	407 (75.7)	131 (24.3)	191 (35.5)	347 (64.5)	139 (72.8)	52 (27.2)
IDU	127 (72.6)	48 (27.4)	96 (75.6)	31 (24.4)	45 (35.4)	82 (64.6)	29 (64.4)	16 (35.6)
Other/NIR	170 (74.9)	57 (25.1)	131 (77.1)	39 (22.9)	83 (48.8)	87 (51.2)	64 (77.1)	19 (22.9)
Insurance								
Private	302 (89.3)	36 (10.7)	249 (82.5)	53 (17.5)	117 (38.7)	185 (61.3)	80 (68.4)	37 (31.6)
Medicaid	420 (86.2)	67 (13.8)	318 (75.7)	102 (24.3)	156 (37.1)	264 (62.9)	119 (76.3)	37 (23.7)

Predictors and Values	Linkage to Care n=1,704		Linkage within 90 days among those linked n=1,404		Retention in Care among those linked n=1,404		Viral Suppression among those retained n=526	
	Yes n (%)	No n (%)	Yes n (%)	No n (%)	Yes n (%)	No n (%)	Yes n (%)	No n (%)
Medicare	131 (77.5)	38 (22.5)	108 (82.4)	23 (17.6)	45 (34.4)	86 (65.6)	36 (80.0)	9 (20.0)
Uninsured	230 (80.7)	55 (19.3)	165 (71.7)	65 (28.3)	87 (37.8)	143 (62.2)	69 (79.3)	18 (20.7)
Other/Unknown	321 (75.5)	104 (24.5)	219 (68.2)	102 (31.8)	121 (37.7)	200 (62.3)	75 (62.0)	46 (38.0)
Geographic Area								
No	1144 (84.2)	214 (15.8)	839 (77.3)	246 (22.7)	97 (28.3)	246 (71.7)	37 (51.4)	35 (48.6)
Yes	260 (75.1)	86 (24.9)	220 (69.0)	99 (31.0)	429 (40.4)	632 (59.6)	342 (75.3)	112 (24.7)
Prison Stay								
No	1306 (81.3)	300 (18.7)	985 (75.4)	321 (24.6)	484 (37.1)	822 (62.9)	354 (73.1)	130 (26.9)
Yes	98 (100)	0 (0.0)	74 (75.5)	24 (24.5)	42 (42.9)	56 (57.1)	25 (59.5)	17 (40.5)
Proximity to Care[1]								
No	615 (82.9)	127 (17.1)	460 (74.8)	155 (25.2)	237 (38.5)	378 (61.5)	160 (67.5)	77 (32.5)
Yes	789 (82.0)	173 (18.0)	599 (75.9)	190 (24.1)	289 (36.6)	500 (63.4)	219 (75.8)	70 (24.2)
Multiple Care Sites[2]								
No	--	--	--	--	214 (29.4)	514 (70.6)	158 (73.8)	56 (26.2)
Yes	--	--	--	--	312 (46.2)	364 (53.8)	221 (70.8)	91 (29.2)

[1] Proximity to care indicates < average distance to nearest care site.

[2] Multiple care sites indicates >= 2 different providers reporting labs during two years after diagnosis.

Table 3

Odds Ratios for Levels of Involvement in HIV Medical Care

	Outcomes			
Characteristic	**Not Linked to Care n=1,704**	**Not Linked < 90 Days n=1,404**	**Not Retained in Care n=1,404**	**Not Virally Suppressed n=526**
Age at Diagnosis (years)				
45+	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
25–44	0.91 (0.67–1.24)	1.07 (0.79–1.45)	1.11 (0.85–1.45)	1.36 (0.84–2.21)
< 25	0.78 (0.53–1.16)	1.28 (0.89–1.83)	1.81 (1.29–2.53)*	1.45 (0.78–2.71)
Sex at Birth				
Female	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Male	1.46 (1.05–2.02)*	1.04 (0.75–1.44)	1.19 (0.89–1.59)	1.06 (0.62–1.81)
Race/Ethnicity				
White	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Black	2.12 (1.37–3.27)*	1.08 (0.74–1.58)	1.76 (1.26–2.44)*	0.96 (0.55–1.67)
Hispanic	0.93 (0.54–1.61)	1.03 (0.66–1.60)	1.92 (1.30–2.85)*	0.97 (0.49–1.94)
Other/Unknown	2.00 (0.97–4.12)	1.43 (0.74–2.75)	1.87 (1.00–3.49)	1.88 (0.66–5.32)
HIV Risk Factor				
Heterosexual	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
MSM	0.58 (0.40–0.84)*	0.85 (0.59–1.21)	0.83 (0.60–1.15)	0.79 (0.43–1.45)
IDU	2.20 (1.42–3.41)*	0.95 (0.59–1.52)	1.21 (0.78–1.87)	1.28 (0.59–2.77)
Other/NIR	1.44 (0.98–2.13)	0.74 (0.49–1.12)	0.53 (0.37–0.77)*	0.62 (0.33–1.19)
Insurance				
Private	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Medicaid	1.08 (0.68–1.69)	1.45 (0.98–2.13)	1.16 (0.83–1.62)	0.65 (0.36–1.17)
Medicare	2.15 (1.26–3.66)*	0.94 (0.54–1.64)	1.18 (0.75–1.87)	0.42 (0.17–1.03)
Uninsured	1.88 (1.18–3.01)*	1.79 (1.18–2.73)*	0.94 (0.65–1.36)	0.64 (0.32–1.26)
Other/Unknown	2.47 (1.61–3.79)*	2.17 (1.47–3.19)*	1.12 (0.80–1.58)	1.40 (0.79–2.49)

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	Outcomes			
Characteristic	**Not Linked to Care n=1,704**	**Not Linked < 90 Days n=1,404**	**Not Retained in Care n=1,404**	**Not Virally Suppressed n=526**
Geographic Area				
No	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Yes	1.76 (1.30–2.40)*	1.49 (1.12–1.99)*	1.84 (1.39–2.43)*	3.23 (1.87–5.59)*
Prison Stay				
No	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Yes	0.00 (0.00–I)*	1.02 (0.62–1.70)	1.00 (0.63–1.58)	2.09 (0.99–4.42)
Proximity to Care[1]				
No	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Yes	1.12 (0.85–1.47)	1.03 (0.80–1.32)	1.18 (0.94–1.49)	0.63 (0.42–0.95)*
Multiple Care Sites[2]				
No	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Yes	--	--	0.47 (0.37–0.60)*	0.99 (0.64–1.52)

[1] Proximity to care indicates < average distance to nearest care site.

[2] Multiple care sites indicates >= 2 different providers reporting labs during two years after diagnosis.

* $P < 0.05$, compared to reference group