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How Place Shapes Assortativity:

Sexual Partnerships and Race in Atlanta

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Abstract

How Place Shapes Assortativity:

Sexual Partnerships and Race in Atlanta

By Christiana E. Toomey

Background: Men who have sex with men (MSM) remain the group most affected by the United States' HIV/AIDS epidemic. Racial sexual assortativity, or the degree to which a man chooses partners from his same race, may play a role in transmission risk, especially in light of recent findings regarding concurrency and partner-to-partner risk among MSM. While existing methods have been used to measure risk conferred by concurrency, and this risk has been compared by race (on individual-, individual-to-partner, and partner-to-partner levels), the relationship between men in space, and their dyadic racial sexual assortativity, has not.

Objective: To evaluate the application of a geostatistical analysis method as a means for quantifying clustering of similar behavior, as demonstrated by spatial clustering of similar dyadic racial sexual assortativity, in an online study of MSM.

Methods: Data collected from participants in the June 2010-December 2012 prospective observational study of Atlanta MSM were collapsed to census tract. A new method was used to calculate racial assortativity prevalence per tract, in which participants were classified as either fully-assortive (only choosing male sexual partners within their stated race) or non-assortive (choosing some or all male sexual partners outside their race). Geospatial statistics were generated on the full group of participant census tracts, as well as strata for tracts in which black and white participants resided. The summary statistic Moran's I was calculated for each group (overall, race strata) to determine significance in clustering (at $p<0.001$), and the Getis-Ord Gi* statistic was calculated at each census tract centroid.

Results: In the analysis of 349 census tracts, the z-score for spatial autocorrelation (Moran's I) was 3.5 ($p=0.0004$) for the fully-assortive prevalence. In the analysis of 238 census tracts containing black participants, the z-score was -13.4 ($p<0.0001$) for fully-assortive prevalence. In the analysis of 177 census tracts containing white participants, the z-score was 2.9 ($p=0.004$) for fully-assortive prevalence. Spatial clustering maps revealed one statistically significant hotspot of fully-assortive tracts southeast for the overall sample and central and southwest Atlanta for black MSM.

Conclusions: Geographic differences in assortativity highlight an area of further exploration of root causes in racial differences in HIV risk in MSM.

Keywords: racial assortativity, MSM, sexual-network measurement, online questionnaire, geospatial analysis

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Abstract

Background

Men who have sex with men (MSM) remain the group most affected by the United States' HIV/AIDS epidemic. Racial sexual assortativity, or the degree to which a man chooses partners from his same race, may play a role in transmission risk, especially in light of recent findings regarding concurrency and partner-to-partner risk among MSM. While existing methods have been used to measure risk conferred by concurrency, and this risk has been compared by race (on individual-, individual-to-partner, and partner-to-partner levels), the relationship between men in space, and their dyadic racial sexual assortativity, has not.

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To evaluate the application of a geostatistical analysis method as a means for quantifying clustering of similar behavior, as demonstrated by spatial clustering of similar dyadic racial sexual assortativity, in an online study of MSM.

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Data collected from participants in the June 2010-December 2012 prospective observational study of Atlanta MSM were collapsed to census tract. A new method was used to calculate racial assortativity prevalence per tract, in which participants were classified as either fully-assortive (only choosing male sexual partners within their stated race) or non-assortive (choosing some or all male sexual partners outside their race). Geospatial statistics were generated on the full group of participant census tracts, as well as strata for tracts in which black and white participants resided. The summary statistic Moran's I was calculated for each group (overall, race strata) to determine significance in clustering (at $p<0.001$), and the Getis-Ord Gi* statistic was calculated at each census tract centroid.

Results

In the analysis of 349 census tracts, the z-score for spatial autocorrelation (Moran's I) was 3.5 ($p=0.0004$) for the fully-assortive prevalence. In the analysis of 238 census tracts containing black participants, the z-score for spatial autocorrelation (Moran's I) was -13.4 ($p<0.0001$) for fully-assortive prevalence. In the analysis of 177 census tracts containing white participants, the z-score for spatial autocorrelation (Moran's I) was 2.9 ($p=0.004$) for fully-assortive prevalence. Spatial clustering maps revealed one statistically significant hotspot of fully-assortive tracts southeast for the overall sample and central and southwest Atlanta for black MSM.

Conclusions

Geographic differences in assortativity highlight an area of further exploration of root causes in racial differences in HIV risk in MSM.

Keywords: racial assortativity, MSM, sexual-network measurement, online questionnaire, geospatial analysis

Background/Introduction

As many patterns have emerged in the differential rates of HIV acquisition between men who have sex with men (MSM) from different demographic groups, much is still unknown as to the causes of these differences. In previous analyses of partner-level behavior, techniques to glean the complex interplay of individual- and network-level factors have been employed, yet there is still a missing link in extrapolating these data to larger groups, or to the distribution of individuals across space. In turn, the ecological view of these factors is extremely limited.

In a prospectively enrolled cohort of Atlanta MSM, diverse across a range of demographic factors, including age, socioeconomic status (SES), and other factors, race data and geolocation data by census tract were collected. In addition, the original cohort collected a wide range of partner data, including partner race(s) in the study period prior to enrollment. In this study, the relationship between home location of black and white MSM, reporting from across Atlanta, and partner race(s) of these men men, was analyzed. This enabled us to report whether in areas across the landscape, partnerships differ significantly, in terms of racial mixing.

Literature Review

Incidence of human immunodeficiency virus (HIV) and sexually-transmitted infections (STIs) has been high among MSM since the early 1990s(1). Evidence suggests race and racial disparities may play a role in acquisition of HIV, whether through risk behavior or other means (2-5). However the causal factors driving the differential in risk of HIV infection between blacks and whites in the US remain unknown.

Researchers at the CDC put together the first systematic reviews indicating that established risk factors did not play the role once thought in creating racial differences in HIV risk among MSM (2, 3). In a review of studies spanning from 1980 to 2006, Millett et al. found that black MSM were less likely than white MSM to report some types of risk behavior – for example, the black MSM in these studies reported fewer partners. At the same time, these facts made it all the more perplexing that black MSM demonstrated disproportionate risk in HIV acquisition. One factor that was highlighted was higher likelihood of STI among black MSM; another, among HIV-positive individuals, black MSM were less likely to be on antiretroviral therapy. However the risk factors found in the meta-analysis could not fully explain the difference in risk of HIV between black and white MSM. This meta-analysis highlighted the need to explore additional avenues of study through which to better understand the observed racial differences.

In a more recent meta-analysis(4), behavioral risk factors failed to explain the disproportionate incidence of HIV among black men compared to men from other racial groups. Seroselection, or selection of HIV-positive or HIV-negative partners based on an individual's known or presumed HIV status, with inclination toward seroconcordance, or selecting partners with the same HIV status, was comparable in black and non-black groups. Furthermore, protective behaviors were more prevalent among black MSM than white MSM.

Data from the more recent HPTN-061 trial suggest that HIV incidence rates among black MSM may be more than five times that among white MSM (6). This alarming disparity in incidence and the lack of basic behavioral factors that explain this disparity underscore the need to determine upstream factors that may play a role in HIV acquisition among black MSM. One of these potential factors was sexual partnership concurrency.

Partnership concurrency is the overlap of two or more sexual partnerships across time. The issue of partnership concurrency has been examined as a risk factor in HIV acquisition – though before 2009, empirical studies of sexual concurrency's impact on HIV acquisition was limited to heterosexual populations (7-10). Early studies of concurrency focused on its role in 'bridging' sexual networks – that is, connecting two or more groups that may not otherwise come in contact, such as across age groups, or racial groups – thus spreading HIV outside a demographic group (9). In the late 2000s, Adimora et al. conducted several studies using a national sample frame. In their 2007 examination of the 2002 data from the National Survey of Family Growth (NSFG), this UNC-based group compared concurrency in relation to demographic risk characteristics (10). While the study explored behavioral data on men in primary heterosexual relationships, it also served to establish structural factors that impact men in a community of color; furthermore, a small but significant proportion of men among the 4928 respondents reported concurrent partnership with men, indicating that bridging between heterosexual and homosexual networks occurred. Concurrency of any type was three times more likely to occur among non-Hispanic Black men as compared with non-Hispanic White men (OR=3.06); this pattern persisted when controlling for other factors, such as socioeconomic status.

Expanding on the work of Gorbach et al. and their investigation of bridging across several demographic factors and impact on STI acquisition in a young adult heterosexual population (8). Doherty et al. had developed a microsimulation demonstrating *a priori* the risks associated with concurrency of bridging across disassortive pairings (9). In this study, risk increased the most for the lowest-risk group, while this risk decreased sharply in these groups with racial assortativity, despite concurrency. However, concurrency remained a driving factor for dispersion of theoretical viral STI through the model population. While both these studies served to establish methodologies for examining concurrency, significant differences in both the sexual partnership patterns of heterosexual as compared with MSM populations across time exist, as well as significant differences in the biologic risk of transmission between partners.

Neaigus et al. continued the empirical examination of concurrency in their study amongst MSM in New York; this study was important in methodologic progression of concurrency studies as it established individual-level concurrency measures within an MSM population (11).

In 2014 Hong-Van and the M2M research team published the results of a nearly 1500 participant study conducted between 2010 and 2013, focusing on the role of concurrency and serodiscordant partnerships within a sample of MSM in New York City (12). As with other studies, serodiscordant unprotected intercourse was associated with alcohol/drug use at time of sex, and having more partners. Rates of concurrency (self, partners) within this sample were high (with 64% of participants reporting concurrent partners), but the prevalence of concurrency did not vary significantly among the sociodemographic factors captured in the study, including race and annual household income. Similarly there were no differences observed by race or ethnicity in reported concurrent unprotected anal intercourse (UAI). There were significant limitations including low number of subjects out of the recruited sample who were able to complete the survey, and extensive use of audio computer-assisted self-interview technology (ACASI) for self-reported measures. Furthermore true rates of HIV incidence were difficult to assess as a total of 381 participants refused testing, though some data were available via self-report.

Additional settings nationally have explored the issue of concurrency among MSM. Concurrency among MSM has also been examined in other settings around the world (13-24). However the most important examination of concurrency to date was conducted by Rosenberg in 2012, as his examination of triadic relationships created a framework within which to discuss partner-to-partner risk within a sexual network(25). One direct extension of the results of the concurrency modeling investigation conducted by Rosenberg et al. that is reiterated several times is that partner-to-partner risk, not individual (participant-) level risk, enables rapid transmission throughout the nodes of a network.

In addition to concurrency, another factor to consider in assessing sexual networks is assortativity. Assortativity is the degree to which nodes in a network associate with those similar to themselves, and can be used to document sociologic trends (26). In sexual networks, assortive behaviors describe men's selection of sex partners of the same race as themselves. Racially assortive behaviors may play a role in men's choice of sex partner, based on both the individual's, and his intended partner's, race, and may be common or dissimilar on a neighborhood level, or within a racial group.

Several recent studies highlight assortativity as one of many factors that may play a role in differential risk. It is important to note that assortive behaviors of any kind play a different role in network HIV transmission than either partner concurrency or partner number. Assortive behaviors are not typically protective – rather, they may amplify effects within an at-risk group. This is due to increased likelihood of interaction between a smaller number of nodes in the network. The impact of racial assortativity is highlighted in the progression of findings from the studies described below.

In 2007 Sifakis et al. (27) presented their findings related to two cohorts totaling 843 young men (ages 15-29) recruited from venues in Baltimore between 1996 and 2000. In this study, reported UAI was higher than for other cities (52.4%), and the white participants were more likely than participants of other races to have engaged in UAI. Although other risk behaviors such as intravenous drug use were not examined by race in this study, drug use at time of sex was linked to UAI. HIV incidence was linked to being high during sex within the last six months, and >4 male partners in the six months prior to the study, but no single "risk" for HIV incidence was greater than non-Hispanic black race. The disproportionate HIV incidence among this group could not be explained by the factors assessed within this four-year study.

In what is perhaps one of the most illustrative studies to-date, researchers at University of California, San Francisco examined network factors among 1142 men, focusing specifically on partnerships, perceptions, and presumed risk by race (28). In this 2008 cross-sectional study, Black men, who comprised 9% of the final study population available for analysis, were three times as likely to partner with other Black men. At the same time, all races/ethnicities within the study perceived Black men as the riskiest partners with respect to HIV, including Black men themselves. Irrespective of actual partnerships, men were asked about their preferences by race; all groups, including Black men, ranked Black partners lowest among all choices (Black men ranked Latino men as preferred to other Black men). Black men also reported feeling less welcome at gay bars and clubs in San Francisco. Amongst men reporting more than one partner, 93% of MSM of color were disassortive; only men of color reporting same/mostly-same race friends and preferring men of the same race as partners were associated with assortative partnering.

In a separate analysis of the same study population in 2009, researchers reiterated the threefold likelihood as compared with chance that Black MSM would partner with Black men, while this group was associated with lower number of partners, which would typically connote decreased risk (29). However, in a partner-by-partner analysis, Black MSM were more likely to have partnerships occur closer together or else overlap completely in time.

In a third analysis of the 2008 data, researchers applied Newman's assortativity coefficient (30) to characterize mixing by race among the participants (31). This coefficient scale ranges from 1 (completely assortive) to 0 (completely random mix) to -1 (completely disassortive – every network tie connects partners of different types). The primary findings were that assortative partner coefficient was relatively high for Black participants as compared with other races, suggesting assortative behavior within Black but not Asian, White, or Latino groups. Seroassortment was also evaluated and it was determined that while selecting a partner with the same HIV status was important among the Black participants in the study, it was not the only factor.

By the 2011 NHBS sampling within San Francisco, however, it seems that the HIV risk paradigm had shifted (32). In the HIV-tested sample, HIV prevalence differences between race/ethnicity groups was not statistically significant ($X^2 = 4.78$, $p = 0.19$). The authors go on to explain that this may be due in part to shifting population, such as Blacks leaving the study area, though these shifts are not likely to fully explain the trend.

The role of the Involvement trial was to further clarify causes of differences in risk of HIV acquisition between black and white MSM, by asking more detailed questions regarding concurrency and partnership timing (25). Involvement, a prospective cohort of black and white HIV-negative MSM recruited at venues across Atlanta, enrolled several thousand participants between June 2010 and December 2012. Among demographic data collected at baseline were participant race, geographic location, and a partner inventory for up to five recent sex partners. The questions to collect these data were structured such that questions regarding sexual partner concurrency and racial assortativity of sexual partnerships could be ascertained from study data.

In 2012, Kelley et al. described population-based measures as an alternative metric of exposure risk among MSM (33). This study used data from the Involvement trial while enrollment to the cohort was still in progress. The Transmission Risk Prevalence (TRP) was published in this study, incorporating participant race among other factors as a factor in acquiring HIV, due to the trifold risk of HIV acquisition within this group. Despite evaluation of population and community risk, causes of this differential risk remained unexamined.

After Involvement's enrollment end, investigators went on to examine causes of HIV disparity between black and white men through a multilevel approach (34). This study examined, among potential causes of disparity, psychosocial factors, such as age, educational attainment, and employment; behaviors which directly affect HIV risk such as unprotected anal intercourse (UAI) and coinfection with other sexually transmitted infection. The study noted significant differences across nearly every behavioral measure between the black and white participant groups, as well as significantly different distribution across Atlanta's geography. This study concluded that individual-level factors were likely insufficient to explain the disparities between HIV risk between black and white MSM. However, this study, as well as a subsequent study (35), did find, as suggested by Rosenberg's modeling in 2012, that having black partners at least partially explained risk to other, concurrent partners. Furthermore, triadic relationships exposed both casual (as opposed to main) sex partners, as well as black sex partners, disproportionately to potential HIV risk as compared with partners of other types (16).

Most recently, Involvement study investigators examined the geospatial relationship between gay stigma, poverty, and HIV infection among black and white MSM in Atlanta, again utilizing data from Involvement (36). This study utilized kriging to estimate stigma across the entire population and also the two race strata in the study, black and white. Areas of high and low stigma were identified across the Atlanta landscape for the entire cohort, and compared to those identified for blacks and whites. For this study, US Census data was utilized to identify areas of poverty. The study illuminates significant differences between the black and white men who were diagnosed with HIV by study conclusion. (Black men in the cohort living with HIV resided in areas with high gay stigma and high poverty, whereas white men in the cohort with HIV resided in areas with relatively low gay stigma and lower poverty.)

As was noted in the Involvement research group's 2015 examination of the data for black and white risk factors for HIV acquisition, members of the study cohort were highly racially assortative in relation to their partners (35). One unexamined factor in the Involvement cohort is racially assortive behavior relative to the cohort's distribution across Atlanta's geography, and how these behaviors may differ between black and white MSM. Clarifying the relationship between geography and assortativity in sexual partnerships may add to a future analysis of causal factors relating place and HIV risk. A number of geospatial analytic techniques have been employed in public health, especially in infectious disease epidemiology, most notably in the mapping of dengue fever (37). Additionally, different techniques have been employed to examine geospatial relationships in urban areas in a variety of contexts (38) (39).

In order to assess the relationship between an individual's race, his partners' races, and the distribution of these relationships spatially, the racial assortativity in sexual partnerships was tested across the geography of Atlanta for the Involvement participants, a cross-section of the population of men who have sex with men (MSM) who reside in Atlanta. This was done by characterizing racial assortativity for participants, generalizing to census tracts (the highest granularity spatial unit for which data was available), and performing a geospatial assessment using a geostatistical analysis technique commonly employed in infectious disease epidemiology.

Methods

Overview

Differences were examined when comparing assortativity of partnerships of black and white MSM across space, collapsed to a prevalence rate (PR) of fully assortive partnership per reporting census tract. The geographic area of interest was defined as the Atlanta metro statistical area (MSA), as defined by the US Census bureau TIGER geodatabase files (40). Further geospatial analysis was conducted to test for clustering.

Study Design

The Involvement study design involved the recruitment of men from greater metropolitan Atlanta (34). Men were recruited using venue-based sampling (VBS) which is accepted as the current best method to sample within a population of MSM (41). To be eligible to participate, respondents had to be male, over 18 years of age, and reporting having had at least 1 male sex partner within the 12 months prior to participation. In addition, participants could only be included if no main sex partner was reported, they resided in Atlanta currently and did not intend to move for the next 2 years, and self-identified as either black or white race (excluded other races, Hispanic ethnicity, and multi-racial men). If eligible, participants could continue on to the HIV test and survey portions of the study. Partner data (for up to 5 partners) was collected only for participants' sex partners within the 6 months prior to survey, for all eligible participants (any HIV status). To be prospectively enrolled in the cohort and followed for the 24-month duration of the study, participants had to test negative for HIV at baseline. Baseline enrollment occurred from July 2010 to December 2012. The Involvement Study was reviewed and approved by the Institutional Review Board of Emory University.

Measures

For the geostatistical analysis performed, only the baseline data for participants was used. This group of participants included both HIV- and HIV+ men. Address data, race, STI status, and other descriptive data were collected at the baseline visit for Involvement. To protect participant privacy for Involvement, whose primary endpoint was HIV acquisition, no individual address data was preserved in the final data set – all data points were anonymized to the census tract level.

For inclusion in the geospatial analysis, participants' address data had to be able to be mapped to a census tract, and participants had to contribute to the partner survey (up to 5 male sex partners, for the 6 months prior to baseline). The dependent measure assessed in the investigation was assortive variability, stratified by race. Assortive variability was characterized as "fully assortive," or partnering only with the same race as the participant, and "non-assortive", or partnering either sometimes or exclusively with the other race in the study. Men who reported only one male sex partner were included. Due to the constraints of this type of geostatistical analysis, previously established assortativity measures, such as Newman's assortativity coefficient (31), could not be used. To derive a numeric value for participant assortativity, for the purposes of this study, 0 was used for any man reporting non-assortive pairing; for men reporting fully-assortive partnership, including only one partner during the interval, a 1 was assigned.

Assortativity was then collapsed to a percentage for each reported census tract. To perform the geostatistical analysis, data per census tract had to be collapsed; otherwise, data values would recur on single points on the map, causing data to be overly associated (overclustering). To account for this issue, assortive percentages were computed for the population overall (fully assortive behavior in individual participants in the tract, per total number of participants in the tract) and subsequently for black and white MSM separately.

The percentage of participants involved in fully-assortive partnerships was calculated for each census tract for which there were participants – percent assortive was calculated on the enrollment number for which there was available data, per tract. Thus a prevalence rate of fully racially assortive partnership, per reporting tract, is calculated. The prevalence rate of fully-assortive partnership, per reporting census tract, was computed to determine the effect of race across the Atlanta metropolitan statistical area (MSA). This data was then compared between census tracts contributing data for each of three strata.

Analyses

Shape files for Atlanta MSA and Georgia census tracts were obtained from US Census Bureau, per 2010 decennial census. The shape files were imported to ArcGIS 10.2 (ESRI, Redlands, CA); percent assortativity by census tract was also imported to

ArcGIS 10.2. The Spatial Pattern Analysis tutorial ("Exploring Dengue Fever") was utilized to guide steps in the analysis process. The projection used in the analysis was Georgia Statewide Lambert, an equal area projection that encompassed the area of the Atlanta MSA. After projecting the data, all other area, distance, and centroid calculations required for the analysis were performed.

The area of the projected Atlanta Metro Statistical Area (MSA) was calculated (square feet). A map layer containing all census tracts within Georgia was matched to all reporting census tracts (a minority of these tracts fell outside the Atlanta MSA). Centroids of these tracts were located using xy-coordinates and projected; these centroids were then used to calculate the spatial relationships between the reporting census tracts.

Constraining the study area to this geographic area, a Nearest Neighbor Analysis was performed to determine geostatistical distribution of the total population of Involvement participants' reporting census tracts (i.e. census tracts from which the required participant data was available). Significance (<0.0001) of spatial clustering of participant census tracts (home location, irrespective of endpoint data) was established.

After establishing statistical significance of clustering by the study-defined, tract-level assortativity metric in the overall population (both black and white reporting tracts together), the data was then stratified by black and white participant reporting tracts. For the overall population, and the race strata, z-scores were computed by utilizing a spatial autocorrelation analysis (Moran's I) (42); these scores were compared.

The Moran's I calculation allows generalization of whether the endpoint data overall are clustered, without highlighting areas of significance.

To conceptualize the differences across space, a Hot Spot Analysis was performed, using a Fixed Distance Band. The Fixed Distance Band was computed using Calculate Distance Band in the Neighbor tool (Spatial Statistics toolbox). The same procedure was used three times: to determine distance bands for the population overall, and stratified by black and white participants. However, different distance bands were used in the three separate analyses, due to the differences in the computed Moran's I in these three groups. The input for set distance bands for each of the three separate analyses was determined from the maximum nearest neighbor distance. Finally, a hot spot analysis (Getis-Ord Gi*) (43) was performed for the participant reporting census tracts overall, and for black and white participant tract levels. This statistic, calculated at each point, allows a determination of the likelihood that point would have its reported prevalence rate due to chance, when considering the point's geographic proximity to its neighbors. . Due to the relative paucity of data per tract, a 99% confidence level (alpha = 0.01) was selected to report clustering as 'significant.'

Results

Of the 803 participants in the available Involvement dataset, 6 were excluded as they did not match to a valid census tract, and 1 was excluded due to no reporting of partnerships in the period 6 months prior to baseline. Black men (N=448) comprised more of the cohort than white men (N=348)(Table 1). The black participants tended to be younger than the white participants. White participants' sexual identity tended to be reported as gay or homosexual whereas black participants were likely to self-identify across a broader spectrum. A high proportion of the black participants reported being unemployed at baseline. A similarly high proportion of black participants reported being homeless in the 12 months prior to baseline. Levels of educational attainment were higher among white participants than black participants. At baseline, 239 (30%) of 796 participants tested positive for HIV. Among 448 black participants, 193 (43%) tested positive for HIV at baseline. Among 348 white participants, 46 (13%) tested positive for HIV at baseline.

Of the 448 black participants, 153 (34%) were racially non-assortive across total male sexual partnerships, and 295 (66%) were racially fully-assortive. Among the 348 white participants, 180 (52%) were non-assortive, and 168 (48%) were fully assortive. The proportions of participants who were fully-assortive significantly differed by race (X^2=24.9, p<0.0001).

Participants included in this analysis came from a total of 350 census tracts; 316 (91%) tracts contained participants reporting an average of 2 or more male sex partners within the past 6 months. Black participants came from a total of 238 tracts; of these, 172 (72%) tracts contained only 1 participant (Table 2). In examining tracts by black participants only, the maximum per-tract count was 11 participants, and the median was 1 participant; of these, 214 (90%) tracts contained participants reporting an average of 2 or more male sex partners within the past 6 months. White participants came from a total of 177 tracts; of these, 111 (63%) tracts contained only 1 participant (Table 3). For the white participant tract group, the maximum per-tract count was 27 participants, while the median was 1 participant; of these, 162 (92%) tracts contained participants reporting an average of 2 or more male sex partners within the past 6 months.

Distinct patterns emerged in the examination of participant geospatial clustering. For the census tracts containing Involvement participants (n=349), The Nearest Neighbor z-score is -8.6 ($p<.0001$). This z-score indicates a statistically significant level (non-random dispersion) of geographic clustering of participants overall (irrespective of assortativity measures) across the study area.

The maximum distance band indicated by the Moran's I Spatial Autocorrelation procedure was approximately 280,914 feet; thus, a distance band of 280,914 was used for subsequent analyses. The z-score for spatial autocorrelation (Moran's I) accounting for the outcome variable (prevalence rate, fully-assortive male sexual partnerships per tract) is 3.5 ($p=0.0004$). A visualization of the Hot Spot Analysis (Getis Ord Gi* Z-Scores) (Figure 1) maps the tract-level Z-scores calculated by the Getis Ord Gi* procedure (Appendix 1). In the visualization of hot and cold spots for the participants overall, a hot spot occurs to the south and slightly east of the I-285 perimeter near the 1-75/1-675 junction, closer to Morrow, Riverdale, and Stockbridge; a weaker hot spot appears directly west of the center of the city, along and outside I-285, extending out past the eastern borders of Candler-McAfee/Decatur, scattering toward Redan/Lithonia.

For tracts containing black participants (n=238), the Nearest Neighbor z-score was –13.4 (p<.0001). This z-score indicates a statistically significant level of geographic clustering of black participants across the study area.

The maximum distance band (Nearest Neighbor analysis) was approximately 85,628 feet; a distance band of 85,628 feet was used for subsequent analyses. The z-score for spatial autocorrelation (Moran's I) accounting for the outcome variable (prevalence rate, fully-assortive male sexual partnerships per tract) is 7.7 (p-value <0.0001). A visualization of the Hot Spot Analysis (Getis Ord Gi* Z-Scores) (Figure 2) maps the tract-level Z-scores calculated by the Getis Ord Gi* procedure (Appendix 2) for the reporting census tracts of black participants.

In the visualization of hot and cold spots (Figure 2), we can see prominent hot spots of assortive tracts in the neighborhoods south and east within I-285, such as South Atlanta, Lakewood Heights, Constitution, Gresham Park, Candler-McAfee; whereas relatively non-assortive clusters appear to the north and west of the perimeter. This indicates a strong relationship between fully assortive partnership and clustering for some areas of the city. The GI*p-values for many tracts within the black participant group reflect this relationship (Appendix 2, at the p<.01 level).

For tracts containing white participants (n=177), the Nearest Neighbor z-was -6.6 (p<.0001). This z-score indicates a statistically significant level of geographic clustering of white participants across the study area. To conceptualize the differences across space a Hot Spot Analysis was performed, using a Fixed Distance Band. The maximum distance band was approximately 280,914 feet; a distance band of 280,914 feet was used for subsequent analyses.

The z-score for spatial autocorrelation (Moran's I) accounting for the outcome variable (prevalence rate, fully-assortive partnership per tract) is 2.9 (p-value=0.004). A visualization of the Hot Spot Analysis (Getis Ord Gi* Z-Scores) (Figure 3) maps the tract-level Z-scores calculated by the Getis Ord Gi* procedure (Appendix 3) for the reporting census tracts of white participants. In the visual representation (Figure 3), there are no significant individual hot or cool spots. This is reflected in the tract-by-tract Gi*p-value, which does not fall below 0.09 for any tract (Appendix 3). We do see very weak cold spots (90% confidence level) north and west of the city.

Discussion

The Involvement MSM cohort overall, as well as black MSM, exhibited significant geographic clustering of racially assortive male sexual partnerships. Where the clustering occurred within Atlanta differed in the overall and black MSM samples. Clustering was absent from the white participant census tract stratum. This could be a reflection of true differences in partner choice across the Atlanta landscape. In the overall population, we see clustering outside the urban core, farther from the geographic center of the city, and lying near or outside the geographic boundary created by the interstates running around the city. In the black population, we see clustering closer to the core, inside the perimeter, and within more heavily populated areas. Given the more geographically dispersed white participant census tracts, and number of single-participant tracts, within this stratum, a real effect may not be observable if it does exist. It is difficult to determine from the data whether the overall population clusters represent a pattern that is truly unique relative to the black or white strata distributions separately, or whether it simply represents a mixing of clustering effect between the black and white participants.

In considering the differences in the patterns exhibited by these strata, it is important to remember that there were was a significant difference ($p<0.0001$) when the black participants were compared to the white participants across the fully assortive indicator variable. This is likely to be a true difference in ths study population, previously investigated through test of racially/ethnically concordant partnerships, which differed significantly when black and white participants' total partnerships were compared ($p<0.0001$) (34). Given the significant difference between the two groups, caution must be taken not to over-interpret the overall population with respect to fully-assortive partnership.

Other interpretations of the data are possible. For example, while a less stringent cutoff would yield significance for the overall Moran's I in the white participant group, given the number of participants reporting per tract, the clustering if present, is less significant than for black MSM or MSM overall. In drawing conclusions from this study it is important to remember that the purpose is not to condemn an already stigmatized group. Rather, looking at the context, it is more appropriate to consider this study as a means of quantifying an in-group effect in a marginalized population. The results of the geostatistical analysis of partnership assortativity provide some evidence of an ecological effect on individual-/partnership-level behavior.

Perhaps this could best be considered as evidence of an exosystem-macrosystem interaction within Bronfenbrenner's Social Ecological Model (44). Many social factors may be at play, though it may be difficult to generalize based on the data presented here. It is likely that there are underlying causes driving the geographic clustering observed in this study of fully racially assortive partnerships by census tract. These underlying factors may be poverty, stigma (36), or other neighborhood level factors we have yet to explore. Future analysis should address the following data to be included as potential confounders, as they may contribute to racial assortativity across geography (including, but not limited to): participant age; job/employment status, income level, and housing security (homelessness); educational attainment; and measures of stigma. The conclusions that can be drawn are limited by the low number of contributors per census tract in the analysis. To further assess the impact of neighborhood boundaries, the analysis could be re-run on aggregated data within a community boundary. The determination of community boundaries and assessment within more complex social frameworks is beyond the scope of this work.

The fundamental context of these results is multifactorial. The clustering observed could hold meaning not in the individual-participant assortativity modeled here, but perhaps partner-to-partner assortativity. Due to the low number of participants within each tract presented in the analysis here, fewer conclusions can be drawn, but a more generalized analysis could yield results related to triadic data.

The factors that may contribute to place-dependent assortative behavior among MSM are worthy of further investigation, as they may play a role in the complex story of differential HIV rates between black and white MSM. Two simultaneous next steps could be pursued to further answer the question of the impact of geospatial difference in assortive behavior in black and white MSM. The first would be to extend this analysis into acquired HIV during the study, to examine if the assortive clustering identified bore correlates related to clustering of existing versus new HIV positivity during Involvement. Another direction would be to delve more deeply into the demographic questions posed by the study, looking more specifically at neighborhood factors, and mapping participant perception of place as compared with partner selection by race as well as other partnership behavior factors, to control for these factors. However to look more extensively at the impact of place, a larger sample may be required. Another approach may be to collapse on spatial boundaries, using data presented here or other *a priori* factors, as it would not be possible to maintain sufficient power across these variables using individual census tracts.

Yet another avenue that could be explored is utilization of real distance data between individual participants' home addresses. For preservation of participants' privacy regarding their HIV status, the individual address data were redacted and not available for this study. However the analytic methods presented here may be better suited for an individual-level analysis.

Limitations

One analytical limitation to the data was a lack of gradation in non-assortive partnership (the negative portion of the Neumann's coefficient scale). Using the new method restricts comparison to previously published data. However, while using the full coefficient calculation would capture the segment of the Neumann's coefficient scale that was not captured by the analysis presented as-is, it would also likely further dilute any observed effects presented. There were also analytic restrictions on using this computed measure in the geographic modeling, where either a prevalence rate or count data alone would be preferable.

Another analytical limitation was the aggregation over census tracts rather than individual measurements. This had to be done to correct for overestimating association when using centroids. In an ideal situation actual geographic proximity would be used on true count data between men with identical racially assortive sex partner selection behaviors, so that the geographic relationships could be established. In an individually geolocated approach, we would be more likely to detect true clusters than with the current approach. Due to the distance bands calculated, the distances are small enough that individual's addresses would be a more appropriate measure. In the study data as collected it would be impossible to store these data. However, in a carefully designed study where location was appropriately anonymized in all maps and reported data, and no data were intended to be shared, this may be feasible.

A third significant limitation relates to the generalizability of results among MSM. Per the enrollment criteria, participants enrolling to Involvement reported no main partner at the time of enrollment (though may have reported main partnerships in the 6 months prior to enrollment). Where racial assortativity of main partnerships differ from other types of sexual partnerships, this may represent a source of bias in our study.

Conclusion

Despite the limitations discussed above, the study speaks to the fact that geostatistical techniques can be employed to enhance previous, primarily descriptive/qualitative techniques employed in behavioral analysis across space. In this study, we observed that significant clustering occurred on racial assortativity of sexual partnerships. This clustering differed by race and was stronger among the black participants than the white participants. Additionally, where the clustering occurred in Atlanta also differed by participant race. The data present a case for further exploration of geography as an upstream factor affecting racially assortive partnerships in MSM populations, especially within Atlanta, to establish why/how differences in HIV risk relate to the place/race relationship, and hopefully move further away from the stigmatizing assignment of race as the only factor in understanding HIV infection disparities in this community. Now that the significance of differences in prevalence of racially assortative partnership across space has been established, it also would be useful to analyze the spatial relationship between triads or partner-to-partner relationships to see if concurrency patterns differ across geography, as the role of concurrency has a complex relationship with racial assortativity in this population of MSM.

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Tables

Table 1. Involvement Participant Characteristics at Baseline

Participant Characteristic	Overall (*N=796*) n (%)	Black (*n=448*) n (%)	White (*n=348*) n (%)
Age			
18-19	43 (5.4%)	27 (6.0%)	16 (4.6%)
20-24	245 (30.8%)	155 (34.6%)	90 (25.9%)
25-29	238 (30.0%)	133 (29.7%)	105 (30.2%)
30-39	245 (30.8%)	124 (27.7%)	121 (34.8%)
40-49	16 (2.0%)	7 (1.6%)	9 (2.6%)
50+	9 (1.1%)	2 (0.4%)	7 (2.0%)
Sexual Identity			
Heterosexual or Straight	3 (0.4%)	1 (0.2%)	2 (0.6)%
Homosexual, Gay	670 (84.6%)	346 (77.9%)	324 (93.1%)
Bisexual	101 (12.7%)	83 (18.7%)	18 (5.2%)
Other	18 (5.2%)	14 (3.2%)	4 (1.2%)
Currently Employed			
Yes	594 (75.1%)	314 (71.04%)	280 (80.5%)
No	198 (24.9%)	128 (28.96%)	68 (19.5%)
Homeless within the last 12 months			
Yes	88 (11.1%)	64 (14.3%)	24 (6.9%)
No	703 (88.6%)	381 (85.2%)	322 (92.8%)
Arrested within the last 12 months			
Yes	86 (10.7%)	55 (12.3%)	30 (8.6%)
No	710 (89.3%)	392 (87.7%)	318 (91.4%)
Education Level			
Some high school	18 (2.3%)	16 (3.6%)	2 (0.6%)
High school or GED	131 (16.5%)	97 (21.8%)	34 (9.8%)
Some college, Associate's degree, and/or technical school	322 (40.7%)	199 (44.7%)	123 (35.5%)
College, post graduate, or professional school	321 (40.5%)	133 (29.9%)	188 (54.2%)
Health Insurance			
Yes	466 (58.8%)	213 (48.1%)	252 (72.5%)
No	315 (39.8%)	221 (49.9%)	94 (26.9%)
Baseline HIV Status			
Positive	239 (30.0%)	193 (43.1%)	46 (13.2%)
Negative	557 (70.0%)	255 (56.9%)	302 (86.8%)

Table 2. Distribution of Fully Assortive Partnership Prevalence Per Reporting Census Tract, Black Participants

Prevalence of Fully Assortive Partnership, Black Participants	Census Tract Count
0.12	2
0.17	1
0.21	1
0.25	4
0.33	6
0.35	1
0.36	1
0.40	2
0.43	2
0.48	1
0.50	27
0.60	2
0.67	6
0.75	6
0.80	3
0.83	1
1.00	172

Table 3. Distribution of Fully Assortive Partnership Prevalence Per Reporting Census Tract, White Participants

Prevalence of Fully Assortive Partnership, White Participants	Census Tract Count
0.17	1
0.20	3
0.25	6
0.33	6
0.40	2
0.50	27
0.52	1
0.57	2
0.60	2
0.64	1
0.65	1
0.67	6
0.75	4
0.79	1
0.83	1
0.88	2
1.00	112

Figure 1. Participants Overall – Hot spot map of fully-assortive partnership

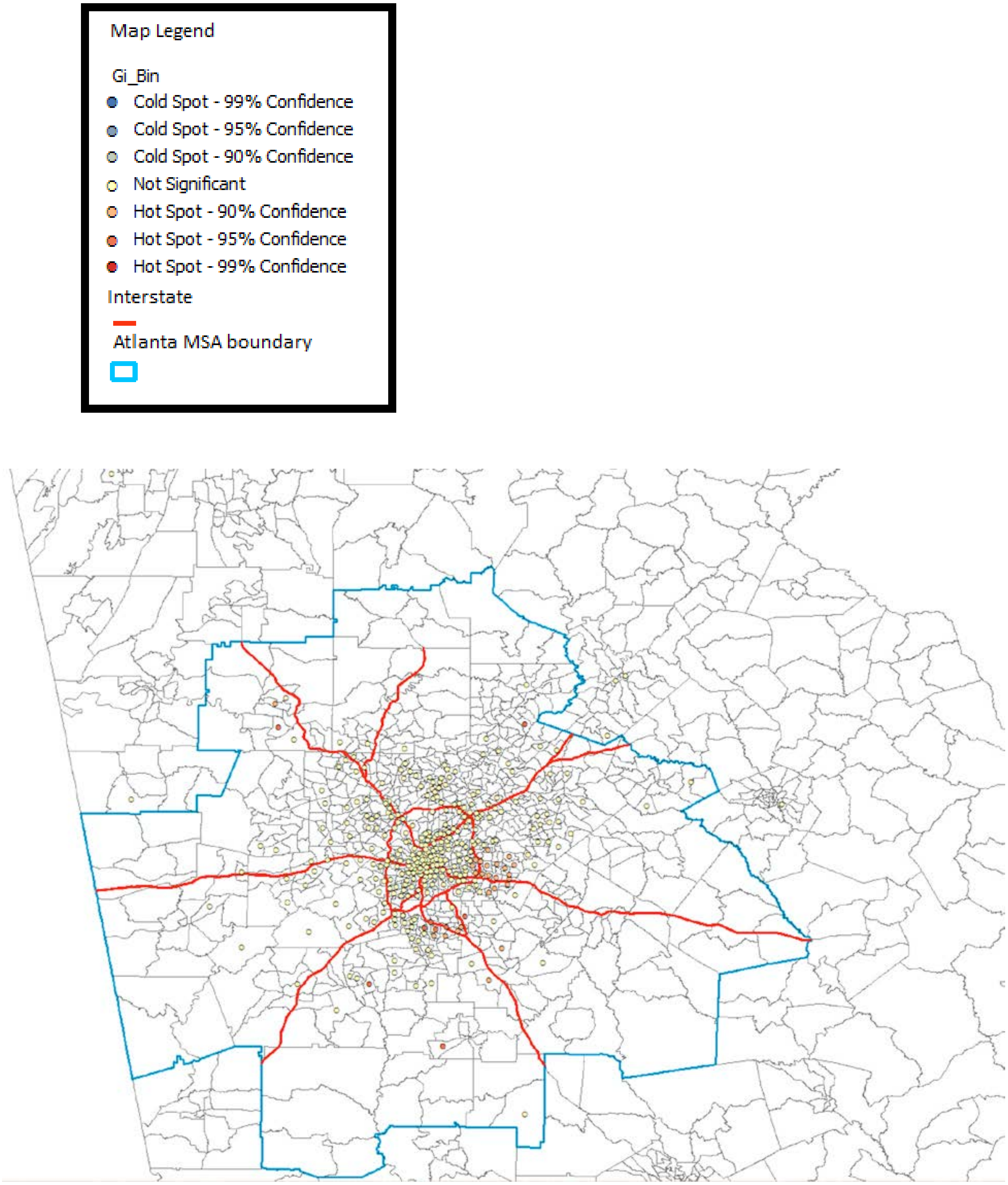


Figure 2. Black Participants– Hot spot map of fully-assortive partnership

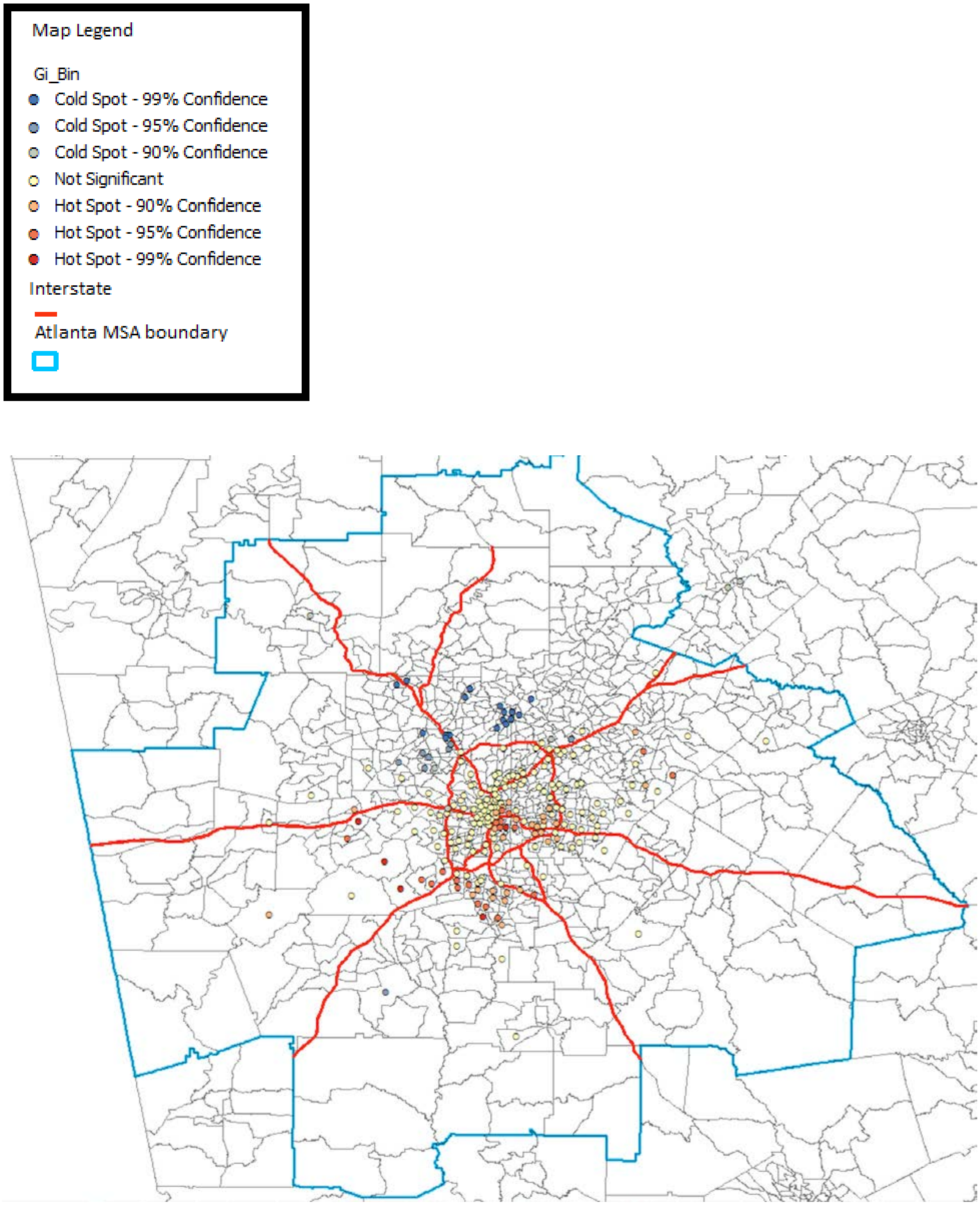
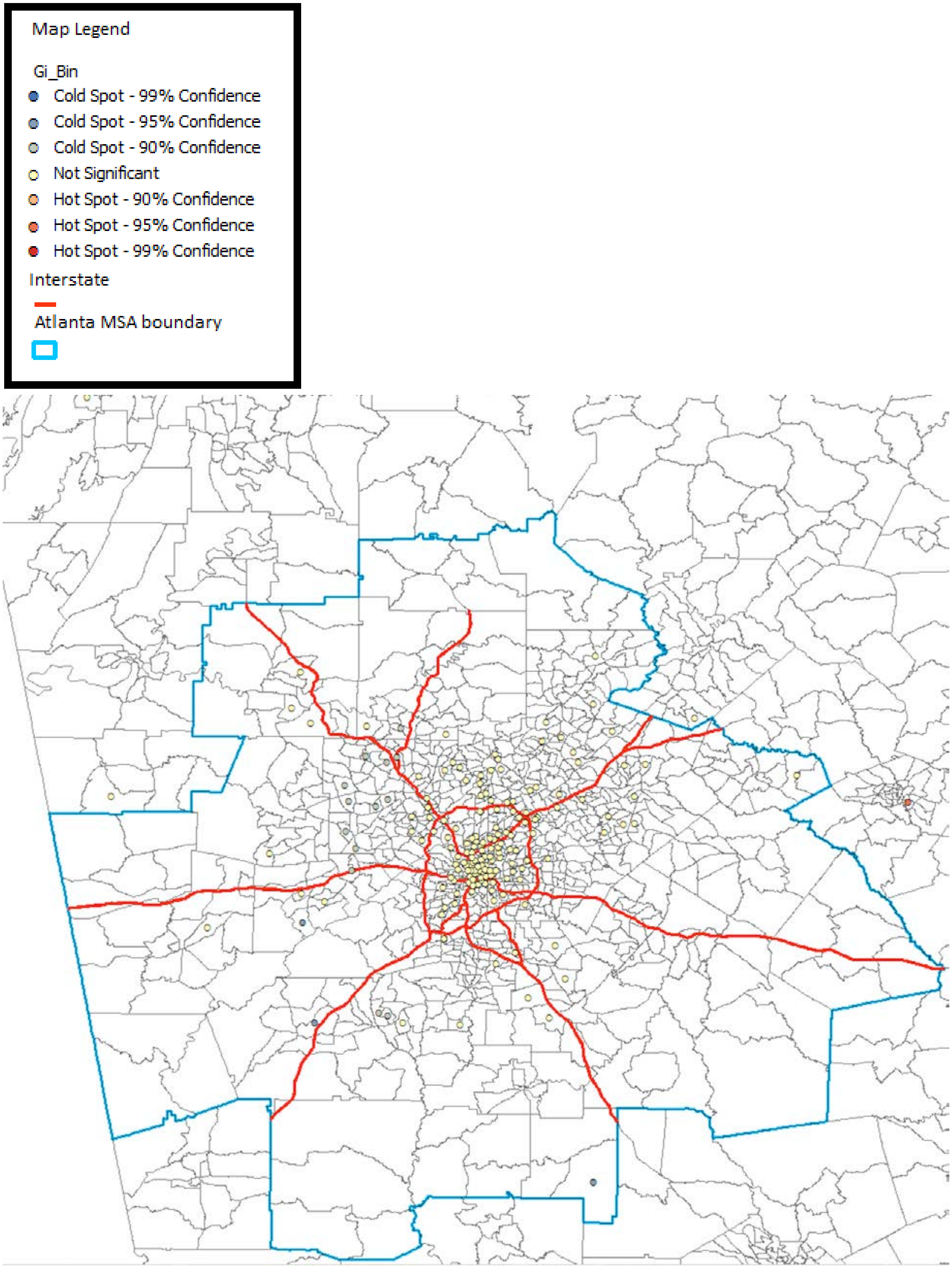


Figure 3. White Participants– Hot spot map of fully-assortive partnership



Appendices

Appendix 1. P-values for Computed Assortativity Variable Across Atlanta Census Tract, All Participants

FID	Shape *	SOURCE_ID	FATOTPCT	GiZScore	GiPValue	Gi_Bin
0	Point	0	1	0.578574	0.562877	0
1	Point	1	1	0.07634	0.939149	0
2	Point	2	1	0.4566	0.647958	0
3	Point	3	1	1.46928	0.141757	0
4	Point	4	0	1.416457	0.156642	0
5	Point	5	0	1.416457	0.156642	0
6	Point	6	0	2.035005	0.04185	2
7	Point	7	0	1.406256	0.159648	0
8	Point	8	0	1.406256	0.159648	0
9	Point	9	0	1.405791	0.159786	0
10	Point	10	0	-0.414541	0.678478	0
11	Point	11	0	-0.775467	0.438064	0
12	Point	12	1	-1.133264	0.257104	0
13	Point	13	1	-1.133264	0.257104	0
14	Point	14	0	-0.329467	0.741803	0
15	Point	15	0	-1.133264	0.257104	0
16	Point	16	0.5	0.991313	0.321533	0
17	Point	17	1	0.501121	0.616286	0
18	Point	18	1	-0.329467	0.741803	0
19	Point	19	1	-1.133264	0.257104	0
20	Point	20	1	-0.329467	0.741803	0
21	Point	21	0	-0.775467	0.438064	0
22	Point	22	1	1.310351	0.190077	0
23	Point	23	1	0.580334	0.561689	0
24	Point	24	1	0.580334	0.561689	0
25	Point	25	1	2.035005	0.04185	2
26	Point	26	1	0.991313	0.321533	0
27	Point	27	1	-0.775467	0.438064	0
28	Point	28	1	-0.329467	0.741803	0
29	Point	29	1	-0.329467	0.741803	0
30	Point	30	0	-0.329467	0.741803	0
31	Point	31	0.666667	-0.329467	0.741803	0
32	Point	32	1	-0.775467	0.438064	0
33	Point	33	0	-0.775467	0.438064	0
34	Point	34	0.5	0.501121	0.616286	0

35	Point	35	1	-0.775467	0.438064	0
36	Point	36	0	-1.133264	0.257104	0
37	Point	37	1	-0.073224	0.941628	0
38	Point	38	0	-0.329467	0.741803	0
39	Point	39	0	-0.329467	0.741803	0
40	Point	40	1	-0.329467	0.741803	0
41	Point	41	0	-0.329467	0.741803	0
42	Point	42	1	-0.329467	0.741803	0
43	Point	43	0.333333	-0.329467	0.741803	0
44	Point	44	0	0.580334	0.561689	0
45	Point	45	1	0.501121	0.616286	0
46	Point	46	0	-0.775467	0.438064	0
47	Point	47	0	-0.073224	0.941628	0
48	Point	48	0	-0.775467	0.438064	0
49	Point	49	0	-0.287655	0.773611	0
50	Point	50	0	-0.775467	0.438064	0
51	Point	51	0.666667	-0.775467	0.438064	0
52	Point	52	0	-0.775467	0.438064	0
53	Point	53	0	-0.775467	0.438064	0
54	Point	54	0	-0.329467	0.741803	0
55	Point	55	1	2.046854	0.040672	2
56	Point	56	0	1.470205	0.141506	0
57	Point	57	0	1.077834	0.281108	0
58	Point	58	0	1.889818	0.058782	1
59	Point	59	1	2.046854	0.040672	2
60	Point	60	1	1.889818	0.058782	1
61	Point	61	0	1.591425	0.111514	0
62	Point	62	1	1.889818	0.058782	1
63	Point	63	1	0.986815	0.323733	0
64	Point	64	0	0.991313	0.321533	0
65	Point	65	1	1.013803	0.310677	0
66	Point	66	1	0.986815	0.323733	0
67	Point	67	1	0.986815	0.323733	0
68	Point	68	1	2.046854	0.040672	2
69	Point	69	0.5	0.986815	0.323733	0
70	Point	70	1	2.046854	0.040672	2
71	Point	71	0	2.046854	0.040672	2
72	Point	72	1	1.013803	0.310677	0
73	Point	73	1	1.889818	0.058782	1
74	Point	74	1	1.405791	0.159786	0
75	Point	75	0	1.470205	0.141506	0

76	Point	76	1	0.986815	0.323733	0
77	Point	77	0.8	0.580334	0.561689	0
78	Point	78	0	0.986815	0.323733	0
79	Point	79	1	1.80853	0.070524	1
80	Point	80	1	1.470205	0.141506	0
81	Point	81	0	1.764969	0.077569	1
82	Point	82	0	1.405791	0.159786	0
83	Point	83	1	1.406256	0.159648	0
84	Point	84	1	1.11721	0.263905	0
85	Point	85	0	2.320215	0.020329	2
86	Point	86	0	1.684111	0.09216	1
88	Point	88	1	0.710426	0.47744	0
89	Point	89	1	-0.073224	0.941628	0
90	Point	90	1	0.219075	0.826591	0
91	Point	91	1	0.092808	0.926056	0
92	Point	92	1	0.774534	0.438615	0
93	Point	93	1	0.023653	0.981129	0
94	Point	94	1	0.991313	0.321533	0
95	Point	95	1	-0.073224	0.941628	0
96	Point	96	1	1.035089	0.300628	0
97	Point	97	0.5	1.035089	0.300628	0
98	Point	98	0	1.035089	0.300628	0
99	Point	99	0	0.580334	0.561689	0
100	Point	100	1	0.219075	0.826591	0
101	Point	101	0	1.077834	0.281108	0
102	Point	102	1	1.035089	0.300628	0
103	Point	103	1	1.035089	0.300628	0
104	Point	104	0	0.774534	0.438615	0
105	Point	105	0.5	1.035089	0.300628	0
106	Point	106	1	1.035089	0.300628	0
107	Point	107	1	1.035089	0.300628	0
108	Point	108	1	1.035089	0.300628	0
109	Point	109	1	0.580334	0.561689	0
110	Point	110	0	-0.073224	0.941628	0
111	Point	111	0	0.501121	0.616286	0
112	Point	112	0	0.092808	0.926056	0
113	Point	113	0	-0.073224	0.941628	0
114	Point	114	1	-0.073224	0.941628	0
115	Point	115	0	-0.073224	0.941628	0
116	Point	116	0	-0.073224	0.941628	0
117	Point	117	1	-0.329467	0.741803	0

118	Point	118	1	0.986815	0.323733	0
119	Point	119	1	0.986815	0.323733	0
120	Point	120	0.5	0.986815	0.323733	0
121	Point	121	0.8	1.591425	0.111514	0
122	Point	122	0.6	1.591425	0.111514	0
123	Point	123	1	1.591425	0.111514	0
124	Point	124	1	0.986815	0.323733	0
125	Point	125	0.666667	0.407979	0.683289	0
126	Point	126	0.5	0.287655	0.773611	0
127	Point	127	0.333333	0.986815	0.323733	0
128	Point	128	0	-0.805305	0.420644	0
129	Point	129	1	0.986815	0.323733	0
130	Point	130	1	1.035089	0.300628	0
131	Point	131	0	1.591425	0.111514	0
132	Point	132	0.727273	0.287655	0.773611	0
133	Point	133	0.25	-0.329467	0.741803	0
134	Point	134	1	-0.329467	0.741803	0
135	Point	135	0.75	-0.329467	0.741803	0
136	Point	136	0.25	-0.329467	0.741803	0
137	Point	137	0.588235	-0.329467	0.741803	0
138	Point	138	0.411765	-0.329467	0.741803	0
139	Point	139	0.75	-0.329467	0.741803	0
140	Point	140	1	-0.329467	0.741803	0
141	Point	141	0.75	-0.329467	0.741803	0
142	Point	142	1	-0.329467	0.741803	0
143	Point	143	0.666667	0.287655	0.773611	0
144	Point	144	0	-0.329467	0.741803	0
145	Point	145	0.6	-0.329467	0.741803	0
146	Point	146	0.545455	-0.329467	0.741803	0
147	Point	147	1	-0.329467	0.741803	0
148	Point	148	1	0.287655	0.773611	0
149	Point	149	0	0.986815	0.323733	0
150	Point	150	0.75	-0.329467	0.741803	0
151	Point	151	1	1.591425	0.111514	0
152	Point	152	0.666667	0.287655	0.773611	0
153	Point	153	0.75	0.287655	0.773611	0
154	Point	154	0.5	-0.329467	0.741803	0
155	Point	155	1	0.287655	0.773611	0
156	Point	156	0	0.287655	0.773611	0
157	Point	157	0.5	-0.329467	0.741803	0
158	Point	158	1	-0.073224	0.941628	0

159	Point	159	1	-0.073224	0.941628	0
160	Point	160	1	1.035089	0.300628	0
161	Point	161	0	0.986815	0.323733	0
162	Point	162	1	0.986815	0.323733	0
163	Point	163	1	0.986815	0.323733	0
164	Point	164	1	0.580334	0.561689	0
165	Point	165	0	-0.775467	0.438064	0
166	Point	166	0	-0.329467	0.741803	0
167	Point	167	0.5	-0.329467	0.741803	0
168	Point	168	0.4	-0.329467	0.741803	0
169	Point	169	0.166667	-0.329467	0.741803	0
170	Point	170	0.4	-0.329467	0.741803	0
171	Point	171	0.333333	-0.329467	0.741803	0
172	Point	172	0.529412	-0.329467	0.741803	0
173	Point	173	0.5	0.407979	0.683289	0
174	Point	174	1	-0.073224	0.941628	0
175	Point	175	1	0.501121	0.616286	0
176	Point	176	0.5	-0.329467	0.741803	0
177	Point	177	0	-0.329467	0.741803	0
178	Point	178	0.5	-0.329467	0.741803	0
179	Point	179	1	0.986815	0.323733	0
180	Point	180	0.285714	-0.329467	0.741803	0
181	Point	181	0.5	-0.329467	0.741803	0
182	Point	182	1	-0.329467	0.741803	0
183	Point	183	1	0.287655	0.773611	0
184	Point	184	0.8	0.287655	0.773611	0
185	Point	185	0.333333	0.287655	0.773611	0
186	Point	186	0.666667	-0.329467	0.741803	0
187	Point	187	1	0.407979	0.683289	0
188	Point	188	1	0.991313	0.321533	0
189	Point	189	0.666667	0.501121	0.616286	0
190	Point	190	1	0.501121	0.616286	0
191	Point	191	0	0.580334	0.561689	0
192	Point	192	0	-0.775467	0.438064	0
193	Point	193	0.8	-0.329467	0.741803	0
194	Point	194	0.4	0.287655	0.773611	0
195	Point	195	0.666667	-0.329467	0.741803	0
196	Point	196	0	0.287655	0.773611	0
197	Point	197	1	1.035089	0.300628	0
198	Point	198	1	0.287655	0.773611	0
199	Point	199	0	0.287655	0.773611	0

200	Point	200	0.6	0.287655	0.773611	0
201	Point	201	1	0.991313	0.321533	0
202	Point	202	0.666667	0.501121	0.616286	0
203	Point	203	0	1.422036	0.155016	0
204	Point	204	0	1.422036	0.155016	0
205	Point	205	1	1.406256	0.159648	0
206	Point	206	1	-0.775467	0.438064	0
207	Point	207	0.666667	1.035089	0.300628	0
208	Point	208	1	0.287655	0.773611	0
209	Point	209	1	0.287655	0.773611	0
210	Point	210	1	0.287655	0.773611	0
211	Point	211	0.5	0.287655	0.773611	0
212	Point	212	0	0.287655	0.773611	0
213	Point	213	1	0.287655	0.773611	0
214	Point	214	0	0.986815	0.323733	0
215	Point	215	0	-0.775467	0.438064	0
216	Point	216	0.333333	-0.329467	0.741803	0
217	Point	217	0.571429	-0.329467	0.741803	0
218	Point	218	0.352941	-0.329467	0.741803	0
219	Point	219	0.6	-0.329467	0.741803	0
220	Point	220	0.333333	-0.329467	0.741803	0
221	Point	221	0.857143	0.287655	0.773611	0
222	Point	222	0.5	0.287655	0.773611	0
223	Point	223	0.8	0.287655	0.773611	0
224	Point	224	1	0.287655	0.773611	0
225	Point	225	1	-0.329467	0.741803	0
226	Point	226	0.75	-0.329467	0.741803	0
227	Point	227	0	1.640114	0.100982	0
228	Point	228	1	-0.329467	0.741803	0
229	Point	229	0.5	-0.329467	0.741803	0
230	Point	230	1	-0.329467	0.741803	0
231	Point	231	0.6	-0.329467	0.741803	0
232	Point	232	0	1.035089	0.300628	0
233	Point	233	1	0.287655	0.773611	0
234	Point	234	1	1.035089	0.300628	0
235	Point	235	0.5	0.287655	0.773611	0
236	Point	236	0.5	0.287655	0.773611	0
237	Point	237	0	-0.252815	0.800411	0
238	Point	238	1	-0.329467	0.741803	0
239	Point	239	0.25	-0.329467	0.741803	0
240	Point	240	0	-0.329467	0.741803	0

241	Point	241	1	-0.329467	0.741803	0
242	Point	242	1	1.035089	0.300628	0
243	Point	243	0.5	0.287655	0.773611	0
244	Point	244	0.5	0.287655	0.773611	0
245	Point	245	1	-0.329467	0.741803	0
246	Point	246	0	-0.329467	0.741803	0
247	Point	247	1	-0.329467	0.741803	0
248	Point	248	1	2.146452	0.031837	2
249	Point	249	1	0.501121	0.616286	0
250	Point	250	0.5	1.013803	0.310677	0
251	Point	251	0	0.45602	0.648376	0
252	Point	252	0	0.595194	0.551714	0
253	Point	253	0	1.422036	0.155016	0
254	Point	254	0.5	1.422036	0.155016	0
255	Point	255	1	1.013803	0.310677	0
256	Point	256	0	0.991313	0.321533	0
257	Point	257	1	1.043994	0.296488	0
258	Point	258	0.75	1.956484	0.050408	1
259	Point	259	0	1.956484	0.050408	1
260	Point	260	0	-0.329467	0.741803	0
261	Point	261	0.5	0.407979	0.683289	0
262	Point	262	0	1.035089	0.300628	0
263	Point	263	0	0.407979	0.683289	0
264	Point	264	1	1.035089	0.300628	0
265	Point	265	0.5	0.407979	0.683289	0
266	Point	266	0.5	1.035089	0.300628	0
267	Point	267	0.333333	0.407979	0.683289	0
268	Point	268	1	1.956484	0.050408	1
269	Point	269	1	1.956484	0.050408	1
270	Point	270	0.5	1.035089	0.300628	0
271	Point	271	1	1.035089	0.300628	0
272	Point	272	1	1.035089	0.300628	0
273	Point	273	0.5	1.035089	0.300628	0
274	Point	274	1	1.035089	0.300628	0
275	Point	275	1	1.956484	0.050408	1
276	Point	276	1	0.407979	0.683289	0
277	Point	277	1	0.407979	0.683289	0
278	Point	278	1	1.956484	0.050408	1
279	Point	279	0.5	1.591425	0.111514	0
280	Point	280	0.75	1.035089	0.300628	0
281	Point	281	1	-0.329467	0.741803	0

282	Point	282	0.4	1.035089	0.300628	0
283	Point	283	0.25	1.035089	0.300628	0
284	Point	284	0	1.035089	0.300628	0
285	Point	285	0	0.407979	0.683289	0
286	Point	286	0	1.035089	0.300628	0
287	Point	287	1	1.035089	0.300628	0
288	Point	288	0	-0.329467	0.741803	0
289	Point	289	0	-0.329467	0.741803	0
290	Point	290	0	0.287655	0.773611	0
291	Point	291	0	1.035089	0.300628	0
292	Point	292	0	-0.329467	0.741803	0
293	Point	293	1	1.035089	0.300628	0
294	Point	294	0.333333	1.035089	0.300628	0
295	Point	295	1	1.035089	0.300628	0
296	Point	296	1	1.956484	0.050408	1
297	Point	297	1	1.035089	0.300628	0
298	Point	298	0.75	1.035089	0.300628	0
299	Point	299	0	1.591425	0.111514	0
300	Point	300	1	1.956484	0.050408	1
301	Point	301	0	1.035089	0.300628	0
302	Point	302	1	1.956484	0.050408	1
303	Point	303	0	1.956484	0.050408	1
304	Point	304	0.5	1.035089	0.300628	0
305	Point	305	0	0.407979	0.683289	0
306	Point	306	0.5	1.956484	0.050408	1
307	Point	307	0	1.035089	0.300628	0
308	Point	308	0	1.956484	0.050408	1
309	Point	309	0	1.035089	0.300628	0
310	Point	310	1	1.035089	0.300628	0
311	Point	311	1	0.407979	0.683289	0
312	Point	312	0.5	-0.329467	0.741803	0
313	Point	313	1	0.407979	0.683289	0
314	Point	314	1	1.035089	0.300628	0
315	Point	315	0	1.035089	0.300628	0
316	Point	316	0.333333	1.035089	0.300628	0
317	Point	317	1	1.035089	0.300628	0
318	Point	318	1	1.956484	0.050408	1
319	Point	319	1	1.035089	0.300628	0
320	Point	320	1	1.035089	0.300628	0
321	Point	321	0.5	1.035089	0.300628	0
322	Point	322	0.5	0.407979	0.683289	0

323	Point	323	1	1.035089	0.300628	0
324	Point	324	0	1.956484	0.050408	1
325	Point	325	1	1.035089	0.300628	0
326	Point	326	1	1.035089	0.300628	0
327	Point	327	0.428571	-0.329467	0.741803	0
328	Point	328	0	-0.329467	0.741803	0
329	Point	329	0.5	1.035089	0.300628	0
330	Point	330	0.5	1.956484	0.050408	1
331	Point	331	1	1.035089	0.300628	0
332	Point	332	1	1.035089	0.300628	0
333	Point	333	1	1.035089	0.300628	0
334	Point	334	1	1.956484	0.050408	1
335	Point	335	1	1.956484	0.050408	1
336	Point	336	0.333333	1.035089	0.300628	0
337	Point	337	1	1.035089	0.300628	0
338	Point	338	0.6	0.407979	0.683289	0
339	Point	339	1	-0.329467	0.741803	0
340	Point	340	0.5	1.956484	0.050408	1
341	Point	341	1	1.035089	0.300628	0
342	Point	342	0.25	0.407979	0.683289	0
343	Point	343	1	-0.073224	0.941628	0
344	Point	344	0	-0.261368	0.793809	0
345	Point	345	1	-0.467964	0.639811	0
346	Point	346	1	0.398668	0.690138	0
347	Point	347	0	1.625587	0.104038	0
348	Point	348	1	0.650739	0.515215	0
349	Point	349	1	1.422036	0.155016	0

Appendix 2. P-values for Computed Assortativity Variable Across Atlanta Census Tract, Black Participants

FID	Shape *	SOURCE_ID	B_FA_PCT	GiZScore	GiPValue	Gi_Bin
0	Point	0	1	1.850275	0.064274	1
1	Point	1	1	0.159394	0.873359	0
2	Point	8	0	0.360447	0.718513	0
3	Point	9	0	1.426117	0.153835	0
4	Point	14	0	-1.05572	0.291096	0
5	Point	15	0	-3.32047	0.000899	-3
6	Point	16	0	-0.340833	0.73323	0
7	Point	17	1	-0.792132	0.428284	0
8	Point	29	0.75	-2.692541	0.007091	-3
9	Point	31	0.333333	-1.933353	0.053193	-1
10	Point	32	1	-2.270258	0.023192	-2
11	Point	33	0	-2.330543	0.019777	-2
12	Point	34	0.5	-1.547395	0.121768	0
13	Point	35	1	-2.271001	0.023147	-2
14	Point	36	0	-2.794416	0.005199	-3
15	Point	37	1	-0.858918	0.390386	0
16	Point	38	0	-2.069982	0.038454	-2
17	Point	40	1	-1.369895	0.17072	0
18	Point	41	0	-3.002909	0.002674	-3
19	Point	42	1	-2.982139	0.002862	-3
20	Point	43	0.333333	-2.157608	0.030958	-2
21	Point	46	0	-2.805038	0.005031	-3
22	Point	47	0	-2.122947	0.033758	-2
23	Point	52	0	-2.870865	0.004094	-3
24	Point	53	0	-3.502952	0.00046	-3
25	Point	55	1	1.235152	0.216774	0
26	Point	56	0	1.73756	0.082288	1
27	Point	57	0	0.55101	0.581627	0
28	Point	59	1	1.907112	0.056506	1
29	Point	61	0	1.177665	0.23893	0
30	Point	62	1	1.861304	0.062701	1
31	Point	63	1	1.628087	0.103506	0
32	Point	64	0	2.43434	0.014919	2
33	Point	65	1	2.335842	0.019499	2
34	Point	66	1	1.409435	0.158707	0
35	Point	67	1	1.297794	0.194358	0
36	Point	68	1	1.787015	0.073935	1
37	Point	69	0.5	1.361197	0.173452	0

38	Point	70	1	1.811286	0.070097	1
39	Point	71	0	1.486769	0.137076	0
40	Point	72	1	1.877002	0.060518	1
41	Point	73	1	2.28916	0.02207	2
42	Point	74	1	2.809995	0.004954	3
43	Point	75	0	1.954439	0.050649	1
44	Point	76	1	2.155016	0.031161	2
45	Point	77	0.8	2.458292	0.01396	2
46	Point	78	0	1.869397	0.061568	1
47	Point	83	1	1.537627	0.12414	0
48	Point	86	0	-1.891571	0.058548	-1
49	Point	89	1	1.878882	0.060261	1
50	Point	90	1	2.362787	0.018138	2
51	Point	91	1	1.368819	0.171056	0
52	Point	93	1	0.988884	0.32272	0
53	Point	94	1	1.937228	0.052717	1
54	Point	95	1	1.639362	0.101138	0
55	Point	96	1	-1.325675	0.184947	0
56	Point	98	0	-2.013678	0.044043	-2
57	Point	102	1	-1.444077	0.148717	0
58	Point	103	1	-1.801091	0.071689	-1
59	Point	104	0	0.041386	0.966989	0
60	Point	105	0.5	-0.482982	0.629108	0
61	Point	108	1	-1.424407	0.154329	0
62	Point	111	0	2.001049	0.045387	2
63	Point	114	1	1.216785	0.223686	0
64	Point	118	1	0.801149	0.423046	0
65	Point	119	1	0.214116	0.830457	0
66	Point	120	0.5	-0.174289	0.861639	0
67	Point	121	0.6	0.693796	0.48781	0
68	Point	123	1	0.233941	0.815031	0
69	Point	124	1	-0.060078	0.952093	0
70	Point	125	0.666667	-1.006548	0.314152	0
71	Point	126	0.5	1.929272	0.053697	1
72	Point	127	0.333333	-0.148914	0.881621	0
73	Point	128	0	-1.891571	0.058548	-1
74	Point	129	1	-0.576328	0.564393	0
75	Point	130	1	0.694712	0.487236	0
76	Point	131	0	1.047844	0.294711	0
77	Point	132	0.727273	1.217405	0.22345	0
78	Point	133	0	-0.172704	0.862884	0

79	Point	134	1	-0.327025	0.743649	0
80	Point	135	0.25	1.086421	0.277293	0
81	Point	136	0	0.896375	0.370053	0
82	Point	137	0.176471	1.27311	0.202979	0
83	Point	138	0.058824	1.463359	0.143369	0
84	Point	139	0.5	0.975862	0.329133	0
85	Point	140	0.333333	0.062454	0.950201	0
86	Point	142	1	-3.655689	0.000256	-3
87	Point	143	0.333333	1.978684	0.047852	2
88	Point	144	0	-3.1904	0.001421	-3
89	Point	145	0.6	-4.110121	0.00004	-3
90	Point	146	0.181818	0.145482	0.884331	0
91	Point	147	1	-0.414667	0.678386	0
92	Point	148	1	0.831841	0.405499	0
93	Point	150	0.75	-0.460234	0.645348	0
94	Point	151	1	0.607822	0.543305	0
95	Point	152	0.5	1.57101	0.11618	0
96	Point	153	0.5	1.792654	0.073028	1
97	Point	154	0.5	1.27311	0.202979	0
98	Point	155	1	1.217405	0.22345	0
99	Point	156	0	1.217405	0.22345	0
100	Point	157	0.5	-4.100347	0.000041	-3
101	Point	159	1	-2.597671	0.009386	-3
102	Point	160	1	1.456631	0.145218	0
103	Point	161	0	2.015552	0.043847	2
104	Point	162	1	1.549805	0.121188	0
105	Point	163	1	2.06499	0.038924	2
106	Point	165	0	-4.100072	0.000041	-3
107	Point	169	0	0.833631	0.404489	0
108	Point	170	0.1	0.706641	0.47979	0
109	Point	171	0	1.125719	0.260285	0
110	Point	172	0.117647	1.004562	0.315108	0
111	Point	173	0.5	-1.002162	0.316265	0
112	Point	174	1	-1.471391	0.141185	0
113	Point	175	1	-1.028095	0.303905	0
114	Point	176	0.5	-4.168552	0.000031	-3
115	Point	178	0.5	-0.016828	0.986574	0
116	Point	179	1	0.032492	0.97408	0
117	Point	180	0.142857	1.125719	0.260285	0
118	Point	181	0.25	0.498673	0.61801	0
119	Point	182	0.5	-0.479831	0.631348	0

120	Point	183	1	2.726078	0.006409	3
121	Point	186	0.333333	1.672759	0.094375	1
122	Point	187	1	-1.742666	0.081392	-1
123	Point	188	1	2.503635	0.012292	2
124	Point	189	0.666667	-0.441961	0.658518	0
125	Point	190	1	-1.476775	0.139736	0
126	Point	193	0.8	1.393005	0.163618	0
127	Point	194	0	1.860868	0.062763	1
128	Point	197	1	1.235854	0.216513	0
129	Point	198	1	2.154256	0.03122	2
130	Point	199	0	1.976331	0.048117	2
131	Point	200	0.4	1.957964	0.050234	1
132	Point	201	1	2.410586	0.015927	2
133	Point	202	0.666667	-0.727961	0.466637	0
134	Point	203	0	3.385853	0.00071	3
135	Point	204	0	3.37197	0.000746	3
136	Point	205	1	0.761275	0.446493	0
137	Point	207	0.666667	1.539365	0.123715	0
138	Point	208	1	1.420958	0.155329	0
139	Point	209	1	1.267488	0.204981	0
140	Point	210	1	1.374563	0.169267	0
141	Point	211	0.5	1.976331	0.048117	2
142	Point	212	0	1.619257	0.105392	0
143	Point	213	0.5	1.567836	0.116919	0
144	Point	214	0	2.253835	0.024207	2
145	Point	216	0.333333	-3.853029	0.000117	-3
146	Point	217	0.238095	1.453906	0.145972	0
147	Point	218	0.058824	1.444582	0.148575	0
148	Point	219	0.4	1.463359	0.143369	0
149	Point	220	0.333333	1.382713	0.166753	0
150	Point	221	0.857143	1.424402	0.15433	0
151	Point	223	0.8	0.623084	0.533229	0
152	Point	224	1	1.034693	0.300812	0
153	Point	225	1	1.205283	0.228094	0
154	Point	226	0.75	1.015207	0.310007	0
155	Point	228	1	-4.010071	0.000061	-3
156	Point	229	0.25	-0.828379	0.407456	0
157	Point	231	0.6	1.086421	0.277293	0
158	Point	233	1	0.56473	0.572257	0
159	Point	234	1	-0.007272	0.994198	0
160	Point	236	0.5	2.192303	0.028358	2

161	Point	237	0	-1.891571	0.058548	-1
162	Point	239	0.25	0.191477	0.848152	0
163	Point	240	0	0.191477	0.848152	0
164	Point	241	0.5	-0.016828	0.986574	0
165	Point	243	0.5	1.04839	0.294459	0
166	Point	244	0.5	-0.154876	0.876919	0
167	Point	246	0	0.198757	0.842453	0
168	Point	247	1	-1.055737	0.291089	0
169	Point	248	1	-0.192016	0.847729	0
170	Point	249	1	0.075749	0.939618	0
171	Point	250	0	2.399734	0.016407	2
172	Point	251	0	-2.321616	0.020254	-2
173	Point	253	0	2.718096	0.006566	3
174	Point	254	0.5	1.890135	0.05874	1
175	Point	258	0.75	0.041913	0.966568	0
176	Point	259	0	0.589958	0.555219	0
177	Point	260	0	0.463206	0.643217	0
178	Point	261	0	1.058667	0.289752	0
179	Point	262	0	0.136969	0.891055	0
180	Point	266	0.5	0.954216	0.339974	0
181	Point	267	0.333333	0.883911	0.376744	0
182	Point	268	1	-0.695654	0.486645	0
183	Point	269	1	0.685098	0.493282	0
184	Point	270	0.5	1.720052	0.085423	1
185	Point	271	1	1.396249	0.16264	0
186	Point	272	1	1.910115	0.056118	1
187	Point	273	0.5	1.740982	0.081687	1
188	Point	274	1	1.751597	0.079843	1
189	Point	275	1	1.329374	0.183725	0
190	Point	277	0.5	0.834687	0.403894	0
191	Point	278	1	1.24009	0.214942	0
192	Point	279	0.5	1.504745	0.13239	0
193	Point	280	0.5	1.752892	0.079621	1
194	Point	282	0.1	1.894491	0.05816	1
195	Point	283	0	1.584329	0.113119	0
196	Point	286	0	-0.039238	0.968701	0
197	Point	288	0	0.012628	0.989925	0
198	Point	294	0.333333	2.420285	0.015508	2
199	Point	295	1	1.534634	0.124874	0
200	Point	296	1	1.70478	0.088235	1
201	Point	297	1	1.558597	0.119092	0

202	Point	298	0.75	1.882079	0.059825	1
203	Point	299	0	1.502743	0.132905	0
204	Point	300	1	-0.414237	0.6787	0
205	Point	301	0	1.835006	0.066505	1
206	Point	302	1	0.555157	0.578788	0
207	Point	303	0	1.015665	0.309789	0
208	Point	304	0	-1.069115	0.285018	0
209	Point	306	0.5	1.071527	0.283933	0
210	Point	307	0	1.550762	0.120959	0
211	Point	308	0	0.32881	0.742299	0
212	Point	309	0	1.841456	0.065555	1
213	Point	313	1	0.012628	0.989925	0
214	Point	314	1	0.302721	0.762103	0
215	Point	317	0.5	0.885922	0.37566	0
216	Point	318	1	0.545993	0.585071	0
217	Point	319	1	0.06237	0.950268	0
218	Point	320	1	-0.462884	0.643447	0
219	Point	321	0.5	-1.251489	0.210756	0
220	Point	322	0.5	-0.046284	0.963084	0
221	Point	323	1	0.062988	0.949776	0
222	Point	325	1	0.127997	0.898151	0
223	Point	326	1	-0.96074	0.336683	0
224	Point	327	0.285714	0.34797	0.727863	0
225	Point	328	0	-0.125829	0.899868	0
226	Point	330	0.5	-0.335267	0.737423	0
227	Point	333	0.666667	-0.857878	0.39096	0
228	Point	334	1	-0.0345	0.972478	0
229	Point	335	1	-0.943127	0.345616	0
230	Point	336	0.333333	-0.485438	0.627365	0
231	Point	337	0.5	-1.305314	0.191786	0
232	Point	338	0.4	-0.713154	0.47575	0
233	Point	340	0.5	-0.166064	0.868107	0
234	Point	341	1	1.740982	0.081687	1
235	Point	342	0.25	0.508332	0.611221	0
236	Point	347	0	0.459644	0.645772	0
237	Point	349	1	-0.081889	0.934735	0

Appendix 3. P-values for Computed Assortativity Variable Across Atlanta Census Tract, White Participants

FID	Shape *	SOURCE_ID	W_FA_PCT	GiZScore	GiPValue	Gi_Bin
0	Point	2	1	-1.353246	0.175977	0
1	Point	3	1	1.982221	0.047455	2
2	Point	4	0	-1.912103	0.055863	-1
3	Point	5	0	-1.912103	0.055863	-1
4	Point	6	0	-1.127949	0.259341	0
5	Point	7	0	-1.089038	0.276137	0
6	Point	10	0	-1.382555	0.166801	0
7	Point	11	0	-1.084863	0.277982	0
8	Point	12	1	-1.661863	0.09654	-1
9	Point	13	1	-1.661863	0.09654	-1
10	Point	16	0.5	-1.661863	0.09654	-1
11	Point	18	1	-1.084863	0.277982	0
12	Point	19	1	-1.661863	0.09654	-1
13	Point	20	1	-1.084863	0.277982	0
14	Point	21	0	-1.084863	0.277982	0
15	Point	22	1	0.407735	0.683469	0
16	Point	23	1	0.046598	0.962834	0
17	Point	24	1	0.046598	0.962834	0
18	Point	25	1	1.380157	0.167538	0
19	Point	26	1	-1.661863	0.09654	-1
20	Point	27	1	-1.661863	0.09654	-1
21	Point	28	1	-1.084863	0.277982	0
22	Point	29	0.25	-1.084863	0.277982	0
23	Point	30	0	-1.084863	0.277982	0
24	Point	31	0.333333	-1.084863	0.277982	0
25	Point	39	0	-1.084863	0.277982	0
26	Point	43	0	-1.084863	0.277982	0
27	Point	44	0	-1.661863	0.09654	-1
28	Point	45	1	-1.661863	0.09654	-1
29	Point	48	0	-1.661863	0.09654	-1
30	Point	49	0	0.312963	0.754309	0
31	Point	50	0	-1.084863	0.277982	0
32	Point	51	0.666667	-1.084863	0.277982	0
33	Point	54	0	-1.084863	0.277982	0
34	Point	58	0	-0.445133	0.656223	0
35	Point	60	1	-0.445133	0.656223	0
36	Point	69	0	-1.084863	0.277982	0

37	Point	79	1	-0.548335	0.583462	0
38	Point	80	1	-0.445133	0.656223	0
39	Point	81	0	-0.636877	0.524205	0
40	Point	82	0	-1.057896	0.290103	0
41	Point	84	1	0.083149	0.933733	0
42	Point	85	0	0.066873	0.946683	0
44	Point	88	1	-2.210969	0.027038	-2
45	Point	92	1	0.557092	0.577464	0
46	Point	97	0.5	0.316075	0.751945	0
47	Point	99	0	0.046598	0.962834	0
48	Point	100	1	0.046598	0.962834	0
49	Point	101	0	1.103965	0.269608	0
50	Point	105	0	0.316075	0.751945	0
51	Point	106	1	0.316075	0.751945	0
52	Point	107	1	0.316075	0.751945	0
53	Point	109	1	0.046598	0.962834	0
54	Point	110	0	-0.445133	0.656223	0
55	Point	112	0	0.046598	0.962834	0
56	Point	113	0	-0.445133	0.656223	0
57	Point	115	0	-0.445133	0.656223	0
58	Point	116	0	-0.445133	0.656223	0
59	Point	117	1	-1.084863	0.277982	0
60	Point	121	0.2	-0.312963	0.754309	0
61	Point	122	0.6	-0.312963	0.754309	0
62	Point	133	0.25	-1.084863	0.277982	0
63	Point	135	0.5	-1.084863	0.277982	0
64	Point	136	0.25	-1.084863	0.277982	0
65	Point	137	0.411765	-1.084863	0.277982	0
66	Point	138	0.352941	-1.084863	0.277982	0
67	Point	139	0.25	-1.084863	0.277982	0
68	Point	140	0.666667	-1.084863	0.277982	0
69	Point	141	0.75	-1.084863	0.277982	0
70	Point	143	0.333333	-0.312963	0.754309	0
71	Point	145	0	-1.084863	0.277982	0
72	Point	146	0.363636	-1.084863	0.277982	0
73	Point	149	0	-1.084863	0.277982	0
74	Point	152	0.166667	-0.312963	0.754309	0
75	Point	153	0.25	-0.312963	0.754309	0
76	Point	156	0	-0.312963	0.754309	0
77	Point	157	0	-1.084863	0.277982	0
78	Point	158	1	-0.445133	0.656223	0

79	Point	164	1	0.046598	0.962834	0
80	Point	166	0	-1.084863	0.277982	0
81	Point	167	0.5	-1.084863	0.277982	0
82	Point	168	0.4	-1.084863	0.277982	0
83	Point	169	0.166667	-1.084863	0.277982	0
84	Point	170	0.3	-1.084863	0.277982	0
85	Point	171	0.333333	-1.084863	0.277982	0
86	Point	172	0.411765	-1.084863	0.277982	0
87	Point	177	0	-1.084863	0.277982	0
88	Point	178	0	-1.084863	0.277982	0
89	Point	180	0.142857	-1.084863	0.277982	0
90	Point	181	0.25	-1.084863	0.277982	0
91	Point	182	0.5	-1.084863	0.277982	0
92	Point	184	0.8	-0.312963	0.754309	0
93	Point	185	0.333333	-0.312963	0.754309	0
94	Point	186	0.333333	-1.084863	0.277982	0
95	Point	191	0	0.046598	0.962834	0
96	Point	192	0	-1.084863	0.277982	0
97	Point	194	0.4	-0.312963	0.754309	0
98	Point	195	0.666667	-1.084863	0.277982	0
99	Point	196	0	-0.312963	0.754309	0
100	Point	199	0	-0.312963	0.754309	0
101	Point	200	0.2	-0.312963	0.754309	0
102	Point	206	1	-1.084863	0.277982	0
103	Point	211	0	-0.312963	0.754309	0
104	Point	212	0	-0.312963	0.754309	0
105	Point	213	0.5	-0.312963	0.754309	0
106	Point	215	0	-1.084863	0.277982	0
107	Point	217	0.333333	-1.084863	0.277982	0
108	Point	218	0.294118	-1.084863	0.277982	0
109	Point	219	0.2	-1.084863	0.277982	0
110	Point	220	0	-1.084863	0.277982	0
111	Point	222	0.5	-0.312963	0.754309	0
112	Point	226	0	-1.084863	0.277982	0
113	Point	227	0	-0.241437	0.809217	0
114	Point	229	0.25	-1.084863	0.277982	0
115	Point	230	1	-1.084863	0.277982	0
116	Point	231	0	-1.084863	0.277982	0
117	Point	232	0	-0.312963	0.754309	0
118	Point	235	0.5	-0.312963	0.754309	0
119	Point	236	0	-0.312963	0.754309	0

120	Point	238	1	-1.084863	0.277982	0
121	Point	239	0	-1.084863	0.277982	0
122	Point	241	0.5	-1.084863	0.277982	0
123	Point	242	1	-0.312963	0.754309	0
124	Point	244	0	-0.312963	0.754309	0
125	Point	245	1	-1.084863	0.277982	0
126	Point	250	0.5	-1.54755	0.121731	0
127	Point	252	0	-2.48791	0.01285	-2
128	Point	255	1	-1.54755	0.121731	0
129	Point	256	0	-1.661863	0.09654	-1
130	Point	257	1	-1.98569	0.047068	-2
131	Point	260	0	-1.084863	0.277982	0
132	Point	261	0.5	-0.445133	0.656223	0
133	Point	263	0	-0.445133	0.656223	0
134	Point	264	1	0.316075	0.751945	0
135	Point	265	0.5	-0.445133	0.656223	0
136	Point	276	1	-0.445133	0.656223	0
137	Point	277	0.5	-0.445133	0.656223	0
138	Point	280	0.25	0.316075	0.751945	0
139	Point	281	1	-1.084863	0.277982	0
140	Point	282	0.3	0.316075	0.751945	0
141	Point	283	0.25	0.316075	0.751945	0
142	Point	284	0	0.316075	0.751945	0
143	Point	285	0	-0.445133	0.656223	0
144	Point	287	1	0.316075	0.751945	0
145	Point	288	0	-1.084863	0.277982	0
146	Point	289	0	-1.084863	0.277982	0
147	Point	290	0	-0.312963	0.754309	0
148	Point	291	0	0.316075	0.751945	0
149	Point	292	0	-1.084863	0.277982	0
150	Point	293	1	0.316075	0.751945	0
151	Point	294	0	0.316075	0.751945	0
152	Point	298	0	0.316075	0.751945	0
153	Point	304	0.5	0.316075	0.751945	0
154	Point	305	0	-0.445133	0.656223	0
155	Point	310	1	0.316075	0.751945	0
156	Point	311	1	-0.445133	0.656223	0
157	Point	312	0.5	-1.084863	0.277982	0
158	Point	315	0	0.316075	0.751945	0
159	Point	316	0.333333	0.316075	0.751945	0
160	Point	317	0.5	0.316075	0.751945	0

161	Point	322	0	-0.445133	0.656223	0
162	Point	324	0	1.397948	0.162129	0
163	Point	327	0.142857	-1.084863	0.277982	0
164	Point	328	0	-1.084863	0.277982	0
165	Point	329	0.5	0.316075	0.751945	0
166	Point	331	1	0.316075	0.751945	0
167	Point	332	1	0.316075	0.751945	0
168	Point	333	0.333333	0.316075	0.751945	0
169	Point	337	0.5	0.316075	0.751945	0
170	Point	338	0.2	-0.445133	0.656223	0
171	Point	339	1	-1.084863	0.277982	0
172	Point	342	0	-0.445133	0.656223	0
173	Point	343	1	-1.084863	0.277982	0
174	Point	344	0	-1.044819	0.296107	0
175	Point	345	1	-1.661863	0.09654	-1
176	Point	346	1	-1.321796	0.186236	0
177	Point	348	1	-1.54755	0.121731	0

Appendix 4. SAS Code

```
* prepare_your_data.sas
*
* Eli Rosenberg, 2/18/2013
* Modified by Christiana Toomey, thru 12/1/15;
* Creates the dataset to map;
*
*;

libname involve "H:\THESIS\Sullivan_Data_deident\Baseline freeze -
02_18_2013";
libname library "H:\THESIS\Sullivan_Data_deident\Baseline freeze -
02_18_2013";      * so datasets can find formats;

/** Datasets need to be sorted prior to merging.
      If using the datasets available on the T:\ they are write-proected
      and cannot be sorted/edited by everybody. Luckily they have been pre-
sorted for you!

      You can, however, copy these datasets in SAS to your local computer,
which will remove the protection ;

            * copy datasets to local computer and remove write-password
protection;
                  data my_lib.status;
                        set involve.status;
                  run;

                  data my_lib.participants_survey_baseline;
                        set involve.participants_survey_baseline;
                  run;

            * Sort datasets prior to merging;
                  proc sort data = my_lib.status ;
      by study_id; run;
                  proc sort data = my_lib.participants_survey_baseline;
      by study_id; run;

**/


      /**************************************************/
/**************************************************/
 /* Special section for individual assortativity (NEWER) */
/**************************************************/
/**************************************************/




* scan each partner within a participant, determine race, and add to
appropriate count;

       data indiv_assort;
                              set involve.Partners_survey_baseline;
                              by study_id;
```

```
                                retain total_b total_w total_h total_o;

                                if first.study_id then do;
                                      total_b = 0; total_w = 0; total_h = 0;
total_o = 0;
                                end;

                                if (hispanic = 1) then total_h = total_h + 1;
                                else if (hispanic = 0) then do;
                                      if race = 2 then total_b = total_b + 1;
                                      else if race = 3 then total_w = total_w +
1;
                                      else if (race ~= .) then total_o =
total_o + 1;
                                end;
                          run;


/**************************************************/
/**************************************************/
 /* Special section for individual assortativity (older) */
/**************************************************/
/**************************************************/

data involve.indiv_assort;

      set indiv_assort;

      by study_id;

      if ~last.study_id then delete; * keep only the last row within a
participant;


      total_partners = sum(total_b, total_w, total_h, total_o);
run;


 * Prepare your analysis dataset ;
      data my_data;
            merge       involve.status
      /* can use KEEP on this line to keep only certain status variables */
                        involve.indiv_assort
                        involve.Participant_censustract_20130227
                        involve.participants_survey_baseline      (

                  /* OTHER SURVEY VARIABLES HERE */         )
                        ;
            by study_id;

            if (met_behav_crit = 1) & (double_enroll = 0) then output;  * if
you want to include the first 803/811 who should be kept in analyses;

run;
```

```
data my_data;

      * look if this person was exclusively racially assortative;
      set my_data;
      by study_id;

      if (race_inc = 1) & (total_b = total_partners) then full_assort = 1;

      else if (race_inc = 4) & (total_w = total_partners) then full_assort =
1;

      else full_assort = 0;

            * note that this method ignores partners with race=missing ;


run;

/*Added 10/12/15 -- exclusion on entire dataset for null census tract*/
data my_data;
set my_data;
 if Census_Tract=. then delete;
 run;
 *Added 12/1/15 -- exclusion for one participant who did not report partners
in p6m;
data my_data;
set my_data;
if study_id=602 then delete;

*add age category variable;
data my_data;

      set my_data;
      by study_id;
      if (age_baseline = 18) or (age_baseline=19)  then agecat_mmwr=1;
        else if (age_baseline ge 20) & (age_baseline le 24) then
agecat_mmwr=2;
        else if (age_baseline ge 25) & (age_baseline le 29) then
agecat_mmwr=3;
        else if (age_baseline ge 30) & (age_baseline le 39) then
agecat_mmwr=4;
       else if (age_baseline ge 40) & (age_baseline le 49) then
agecat_mmwr=5;
        else if (age_baseline ge 50)  then agecat_mmwr=6;
        else if (age_baseline lt 18) then agecat_mmwr=10;
        run;


 /*captures working data file*/
data involve.my_data;
set work.my_data;
run;


/*********************************************************************/
/*********************************************************************/
/* Explore the data                                                  */
```

```
/*******************************************************************/
/********************************************************************/

PROC CONTENTS DATA=involve.My_data;
RUN;
/*
Explored data prior to creatng export dataset:

proc print data=involve.My_data;
 run;

 proc freq data=involve.My_data;
tables race_inc*full_assort/list missing;
format race_inc full_assort;
run;
*/
proc sort data=involve.My_data;
by race_inc;
run;
/* Tables generated below used to generate subsets to analyze*/
/* Data were copied to Excel.*/
proc print data=involve.My_data;
where race_inc=1;
run;

proc print data=involve.My_data;
where race_inc=4;
run;

/*Pivot tables were used to count full-assortive and non-assortive tracts.*/
/*Row percents were calculated to determine prevalence of fully-assortive
partnership
per census tract.*/


/********************************************************************/
/********************************************************************/
/* Generate frequencies for desc stat                                */
/*******************************************************************/
/********************************************************************/

/* Demographic data*/
*by age;
proc freq data=involve.My_data;
tables age_baseline age_adj; *age_baseline=participant, age_adj=estimate age
group of partner;
run;

proc freq data=involve.My_data;
tables agecat_mmwr_partner; *age group of partner;
run;

proc sort data=involve.My_data;by agecat_mmwr;run;
proc freq data=involve.My_data;
format agecat_mmwr agecat_mmwr.;
tables agecat_mmwr*race_inc; *age group of participant;
run;
```

```
proc sort data=involve.My_data;by race_inc;run;

*sexual identity;
proc freq data=involve.My_data;
tables orient*race_inc/chisq;
run;

*race;
proc freq data=involve.My_data;
tables race_inc/list missing;
run;

*employment;
proc freq data=involve.My_data;
tables employed_now*race_inc/chisq;
run;

*poverty;
proc freq data=involve.My_data;
tables poverty*race_inc/chisq;
run;

*homelessness in past 12 mos;
proc freq data=involve.My_data;
tables homeless*race_inc/chisq;
run;

*arrested past 12 months;
proc freq data=involve.My_data;
tables arrested_p12m_final*race_inc/chisq;
run;

*educational attainment;
proc freq data=involve.My_data;
tables educ*race_inc/chisq;
run;

*health insurance y/n by race;
proc freq data=involve.My_data;
tables insurance*race_inc;
run;


/*Behavioral data*/


*partner negotiation;
*incl partner agreement re sex outside relationship;
proc freq data=involve.My_data;
tables agreement*race_inc/chisq;
run;




*where meet current main partner ;
proc freq data=involve.My_data;
```

```
tables  formalmeet*race_inc; *excl wheremeet in this analysis;
run;

/*Network data*/

*partner age;
proc sort data=involve.My_data;by agecat_mmwr;run;
proc freq data=involve.My_data;
tables agecat_mmwr_partner; *age group of partner;
by agecat_mmwr;
run;
proc sort data=involve.My_data;by race_inc;run;


*general grouping of age cat of partners by race;
*NB this table irrespective of participant age;
proc freq data=involve.My_data;
tables agecat_mmwr_partner*race_inc; *age group of partner;
run;



*predicted/perceived seroassort;
proc freq data=involve.My_data;
tables perc_conc*race_inc;
run;
*number of partners /concurrent;
proc freq data=involve.My_data;
tables anysex_howmanyp12m_total female_howmanyp12m male_howmanyp12m_total
male_AIp12m_bin male_AIp12m_total  male_UAIp12m_bin male_UAIp12m_total/list
missing; *age group of participant;
run;

*UAI only (by race);
proc freq data=involve.My_data;
tables male_UAIp12m_bin*race_inc;
run;

*race concordant var;
proc freq data=involve.My_data;
tables race_conc;
run;


/*********HIV Status at Baseline***********************/
proc freq data=involve.My_data;
tables baseline_hiv*race_inc;
run;

/* Census Tract level descriptive data*/

PROC MEANS DATA=my_data NWAY ;
  CLASS Census_Tract;
  VAR full_assort total_partners;
  OUTPUT OUT=ctlevel_assort MEAN=avgassort avgpartner;
RUN;
/*flat output*/
```

```
PROC PRINT DATA=ctlevel_assort;
RUN;

/*black participants only*/
PROC MEANS DATA=my_data NWAY ;
      where race_inc=1;
  CLASS Census_Tract;
  VAR full_assort total_partners;
  OUTPUT OUT=ctlevel_assort_b MEAN=avgassort avgpartner;
RUN;
PROC PRINT DATA=ctlevel_assort_b;
RUN;

/*white participants only*/
PROC MEANS DATA=my_data NWAY ;
      where race_inc=4;
  CLASS Census_Tract;
  VAR full_assort total_partners;
  OUTPUT OUT=ctlevel_assort_w MEAN=avgassort avgpartner;
RUN;
PROC PRINT DATA=ctlevel_assort_w;
RUN;


/*frequency tables for average number of partners per census tract*/
proc sort data=ctlevel_assort;by avgpartner;run;
proc freq data=ctlevel_assort; run;

proc sort data=ctlevel_assort_b;by avgpartner;run;
proc freq data=ctlevel_assort_b; run;

proc sort data=ctlevel_assort_w;by avgpartner;run;
proc freq data=ctlevel_assort_w; run;


proc freq data=my_data;
tables full_assort*race_inc/chisq;*test statistic for fully racially
assortive partnership;
run;
```