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SPATIAL DISTRIBUTION OF PARTNER-SEEKING MEN WHO HAVE SEX WITH MEN (MSM): AN EPIDEMIOLOGIC STUDY USING MSM GEOSOCIAL NETWORKING APPLICATIONS

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SPATIAL DISTRIBUTION OF PARTNER-SEEKING MEN WHO HAVE SEX WITH MEN (MSM): AN EPIDEMIOLOGIC STUDY USING MSM GEOSOCIAL NETWORKING APPLICATIONS

CAPSTONE PROJECT PAPER

A paper submitted in partial fulfillment of the requirements for the degree of
Master of Public Health
in the
University of Kentucky College of Public Health
By
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April 2, 2017

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Abstract

Background: Geosocial networking (GSN) applications (apps) have made finding sexual partners easier for partner-seeking MSM, raising challenges for HIV/STI prevention but also providing opportunities for research. To date, little is known about app usage in smaller cities where there may be more stigma surrounding MSM.

Objective: This study uses GSN apps to identify areas with high density partner-seeking MSM, and to characterize these areas using Census block group demographic measures in a Southern mid-sized city.

Methods: Data collection points (n=62) were spaced in two-mile increments along nine routes (112 miles) covering the area. At each point, staff recorded the number of GSN app users within one mile using three GSN apps during two time periods. Data was entered into ArcGIS and empirical Bayesian kriging was used to create a raster estimating the number of app users throughout the county. Raster values were summarized for each of the county's 208 census block groups and used as the outcome measure (i.e., GSN app usage). Using SAS v 9.4, Wilcoxon signed rank sum was used to examine temporal differences in app usage and negative log binomial regression examined census block group variables associated with GSN app usage.

Results: In adjusted analyses of census block group data, median income ($p < 0.001$) and percent Hispanic ethnicity ($p < 0.001$-0.045) were found to be negatively associated with spatial density of GSN app-using MSM for all times and GSN apps in the final models. The presence of business zoning ($p < 0.001$) and population density ($p < 0.001$-0.045) were found to be positively associated with spatial density of GSN app-using MSM for all times and GSN apps in the final models.

Conclusion: In this mid-sized city, GSN app usage was highest in areas with lower income but lowest in areas with larger Hispanic populations. This implies that

interventions using GSN apps could effectively be targeting lower income populations, but missing largely Hispanic communities.

Introduction

Human Immunodeficiency Virus (HIV) in the United States continues to disproportionately affect men who have sex with men (MSM) despite extensive preventative measures taken by public health officials. [1] Although MSM comprise 3.6% of men in the United States[2], they make up 66% percent of all new HIV infections annually.[1] Additionally among MSM, rates of sexually transmitted infections (STIs) (i.e. syphilis, gonorrhea) are on the rise.[3] This increase is important as STIs are shown to increase susceptibility to HIV infection.[4] Previous research has found studying geosocial networking (GSN) applications (i.e. "apps") in partner seeking MSM as a topic of increased importance for HIV/STI prevention research.

GSN apps provide information on geographic proximity between users making the search for sexual partners easier.[5-8] A variety of GSN apps for users searching for partners, including apps for MSM, are available on most smartphones. Reportedly, GSN apps for partner-seeking MSM have more than 6 million total users and 10,000 new users added daily.[9] Research among MSM who use apps to find sex partners have shown mixed results regarding the relationship between GSN app use and risky sexual practices. Some research suggests that using GSN apps to find sex partners is associated with an increase in condomless anal intercourse (CAI),[7,10,11] drug use (i.e. methamphetamine, Viagra, poppers, painkillers),[8,10,12] number of partners,[8,10,13,14] and history of STI diagnosis.[12,13,15-18] Yet, other research has not found an association between GSN app use to find sex partners and risky sexual practices.[12,18-20] Current literature has pointed to the need for more research that can lead to interventions utilizing these apps.[12,17,21]

Though many studies have surveyed MSM to examine the use of GSN apps to find sex partners,[8,10-13,15-21] few studies have utilized the geospatial capabilities of these apps. Previous research in Atlanta, GA described a methodology for using the geolocation features of a GSN app as a novel approach to calculate the estimated spatial density of GSN app-using MSM. That study collected information on the closest 50 users or all users within a 2-mile radius of each collection point. The data was then used to create race-stratified maps that highlighted areas of high spatial densities of MSM for future geotargeted prevention resources and HIV behavioral surveillance.[9] By calculating the spatial density of GSN app-using MSM, researchers can demonstrate geographic areas where this at-risk population is concentrated. The analysis of geographic information has been seen as an emerging tool for planning public health interventions to evaluate the geographic epidemiology of sexually transmitted infections and HIV risk in some populations.[22-24]

To date, most research on MSM usage of apps focuses on large cities.[9,10,12-14,17,21,25] In general, though projects in larger cities have shown interesting results, they have limitations in their generalizability. Smaller cities often differ from larger cities in terms of stigma against MSM[26,27] and availability of visible gay spaces.[28,29] In past research conducted in smaller cities in the Northeastern U.S., MSM face sexual minority stigma and have few spaces for gay life in their communities.[28-30] The lack of visible gay spaces for gay life in smaller cities can make reaching MSM for research and intervention more difficult, but using GSN apps in these areas may provide a useful alternative for locating GSN app-using MSM.

The present study helps address limitations and suggestions made in previous research to conduct GSN app research in cities of varying sizes.[31,32] This study is among the first to provide insights on the use of GSN apps by MSM in a mid-sized city. The purpose of this study was to identify areas with high spatial density of GSN app-using MSM in a mid-size city in Kentucky and to identify geographic and demographic factors associated with areas of high density of app usage.

Methods

We collected publicly available GSN app profile data from three different geospatial applications using a geographically systematic sample of points in Fayette County.[33] Fayette County has a population of 295,805 people, who are predominately white (75.7%) and non-Hispanic (93.1%).(Bureau, 2010 #50) Routes were selected systematically by using *GoogleMaps*[34] to find roads that spanned the whole county. Data collection points (n= 62) were spaced in two-mile increments along nine routes (112 miles) in the mid-sized city (Figure 1). We visited each point twice: once during the day time (Monday- Friday, 8:00AM-4:00PM) and once during the evening (Friday/Saturday, 8:00PM-12:00AM). At each point, we logged into a blank profile created for study purposes on each of the three GSN apps. Once logged into the profile, the app displayed the number of users with varying distances from the collection point. We recorded the number of users within one mile on each app, the time of collection, and the geocoded location at that collection point (latitude, longitude) on a paper form and via the app *Fulcrum.*[35]

Analysis

Of the 62 data collection locations, 61 had cell service to access apps for data collection. The point with no service was excluded from data analysis. We conducted spatial analyses using *ArcMap 10.3.1* (ESRI, Redlands, CA) and negative log binomial regression and Wilcoxon signed rank sum tests using *SAS version 9.4* (SAS Institute, Inc, Cary NC).

Spatial Analyses. We constructed maps utilizing *ArcMap* to illustrate differences in the spatial density of app-using MSM between applications and at different time periods. The Fayette County shapefile used in the depictions was procured from the Census Bureau.[36] We used Empirical Bayesian kriging (EBK) for spatial interpolation as it predicts values for areas where data has not been collected, based upon the specific values at each collected observation points and their relative proximity to other points. Raster surfaces resulting from the EBK analysis were overlaid with collection points, which were symbolized based on the number of app users at each location and time period for visual analysis (Figure 2). We converted the EBK raster grid cell values to point data to facilitate calculation of the average number of GSN app users within each Census block group. We used this average, rounded to the nearest whole number, in each block group as the dependent variable in a negative log binomial regression analysis and to calculate differences in day/night use and between apps in spatial density of GSN app-using MSM (Figure 3).

Statistical Analyses. We used Wilcoxon signed rank sum tests to examine differences in app usage between the three apps and between day/evening data collection periods because the outcome variables were paired and non-parametric. Negative log binomial regression was used to examine geographic and demographic factors associated with areas of high spatial density of GSN app-using MSM at the Census block group level because the distribution of the data was positively skewed and over dispersed. Negative log binomial regression has an extra parameter that models the over dispersed count data that Poisson regression does not analyze. Variables included in the regression model were derived from the 2011-2015 American Community Survey 5-year estimates,[37] the 2010 Census data from the U.S. Census Bureau,[38] and the Lexington-Fayette Urban County Government Open Data Web Portal.[39] Independent variables in the model included: block group population density, median age, median income, percent white, percent Hispanic, and business zoning amounting to greater or less than 1% of the area of the block group (binary). To assess for confounding, we compared crude risk ratios with the adjusted risk ratios. We considered associations as confounded if the risk ratios changed by more than 10% when the potential confounder was included in the model. Through the confounding analysis, we found that all variables were important to include in the final model. All variables seemed important to include in the model as they all act as confounders in the association of other variables with the outcome. To examine for collinearity, we ran the *PROC REG* collinearity diagnostic *collinoint*[40] to determine how related each variable is to each other in the presence of all other variables. A condition index >30 was considered to be indicative of collinearity. The analysis for collinearity showed that none of the independent variables were collinear and all could be included in the same final model.

Results

Descriptive

The median number of estimated GSN app users in each Census block group in Fayette County during day and night time varied by app (10.0, 2.0, 10.5 and 10.0 ,1.0 ,9.0, respectively). No significant temporal differences were detected within apps (p=0.387-0.946). Between apps, App 1 and App 3 were found to be significantly different than App 2 in both day (p<0.001) and night times (p<0.001). However, there was no significant difference between App 1 and App 3 in both day (p=0.464) and night times (p=0.458).

We identified differences in the spatial density of GSN app-using MSM using choropleth maps to view temporal difference and between-app differences by quintile (Figure 3). From day to night, the spatial density of app-using MSM decreased in the southeast and increased in the northwest part of the city for App 1, decreased in the southwest suburbs and increased in the center of downtown in App 2, and decreased in the east suburbs and increased in the northwest of downtown in App 3. During evening and day times the number of GSN app-using MSM downtown was higher for App 1 and 3 than App 2 compared to the areas farther from downtown where the number of GSN app using MSM was more similar. During the day time, App 1 had a larger number of GSN app using MSM in downtown and in the northeast where App 3 had more GSN app using MSM directly south of downtown. During the evening, App 1 had a larger number of app-using MSM in the northern part of downtown, the eastern suburbs, and the southern residential areas where App 3 had a larger number of app-using MSM in the southern part of downtown and in the southwestern suburbs.

Block Group Regression Analysis

Fayette County is comprised of 208 census block groups. Based on the dependent variable of estimated number of GSN app users in each census block group, negative log binomial regression was run on individual variables with each app stratified by time of collection to estimate crude risk ratios (Table 2). In all combinations of apps and collection times, decreased median age ($p < 0.001$-0.034), increased population density ($p<0.001$), decreased median income ($p<0.001$), and presence of business zoning >1% of the block group area ($p<0.001$) were positively associated with increased spatial density of GSN app-using MSM. For every year increase in median age, spatial density of GSN app-usage decreased by 1.5-3%. For every 100 persons per square mile increase in population density, spatial density of GSN app-usage increased by 1.1-1.5%. For every $5,000 increase in median income, spatial density of GSN app-usage decreased by 5.7-8.9%. In the presence of business zoning >1% of the block group area, spatial density of GSN app-usage increased by 106%- 188%.

Percent Hispanic ethnicity was not significantly associated ($p = 0.199$-0.986) with the spatial density of GSN app-using MSM in any app or time combinations. The statistical significance of the association of percent white race ($p <0.001$-0.134) with spatial density of GSN app-using MSM varied between app and collection time; percent white race was negatively associated with spatial density of GSN app usage for App 1 and App 3 during the day, and App 1 and App 2 during the evening, but not for App 2 during the day, nor App 3 during the evening.

The multivariable models are shown in Table 3. In all combinations of app and collection time, decreased median income ($p <0.001$), increased business zoning ($p <0.001$), increased population density ($p <0.001$-0.045), and decreased percent Hispanic ethnicity ($p <0.001$-0.045) were found to be positively associated with spatial density of GSN app-using MSM in the final model, adjusting for all other variables. The statistical significance of the association of median age ($p <0.001$-0.458) and percent white race ($p =0.015$-0.772) with the outcome of interest varied between app and collection time in the final model; median age was positively associated with spatial density of GSN app usage for App 1 during the day, but not for any other time/app. Percent white race was negatively associated with spatial density of GSN app usage for App 1 during the day and App 2 during the night, but not for any other time/app.

Discussion

This study revealed that median income and percent Hispanic ethnicity were found to be negatively associated with spatial density of GSN app-using MSM for all times and GSN apps in the final models. It was also found that the presence of business zoning and population density were found to be positively associated with spatial density of GSN app-using MSM for all times and GSN apps in the final models. One implication of this finding could be that using apps for interventions could effectively target app users in areas of low socioeconomic status in this mid-sized city. Targeting populations of low socioeconomic status should remain a priority for public health officials as research has shown that low annual household income and poverty are positively associated with increased risk of HIV.[41] Increased app usage in areas with the presence of business zoning could imply that app users may be utilizing these apps in areas of economic activity (i.e. bars, restaurants, stores, etc.). Another implication of this finding was that apps for interventions may not effectively be targeting areas with larger Hispanic populations, which is notable given that Hispanic populations are disproportionately affected by HIV.[42]

By utilizing both Wilcoxon signed rank sum tests and choropleth maps of the differences on the spatial density of GSN app-using MSM by quintiles, we determined that the total number of users between day and night times did not change, but that specific areas within the county could be experiencing user density change between these two time periods. This could imply either that the same users are temporally migrating to different areas, that other users at different locations are logging in at different times, or a combination of the two. This could be informative to local health departments because instead of using mobile HIV testing units only during evening hours at nightlife venues, these units could also be used at specified hotspots during day time weekday hours.

The novel methods of data collection utilized in this study addressed some of the limitations of past GSN app research. To date, research utilizing GSN apps for data collection only utilized one app, but this study utilized three apps. By using more than one app, researchers were able to detect significant differences between apps which suggests a multi-app approach may be important in future research. Data on the usage of GSN apps is also novel in the context of mid-sized cities as most studies to date have focused solely on larger cities.[9,10,12-14,17,21,25] Collecting data on GSN apps for MSM in midsized cities could be of increased importance because the lack of visible gay spaces in this context make locating areas of increased MSM harder to identify for research and intervention purposes.

Limitations

Although the results showed maps with estimated GSN app usage throughout the study area, more data collection points could be added to increase the accuracy of the EBK estimation. To minimize this limitation, researchers strategically placed collection points on routes that covered the county (Figure 1). This study utilized a multi-application approach for data collection, but there were other GSN apps that were not unmeasured. By partnering with the GSN app companies, future research may have the opportunity to utilize more apps for data collection. In respect of privacy policies, we did not record identifying information about GSN app users, thus preventing us from determining the extent to which GSN app-using MSM were utilizing more than one app and whether the difference between the maps in Figure 3 was due to the temporal migration of the same users to different locations or if other app users in different locations were logging on at different times.

Conclusion

This study utilized novel data collection methods of employing a multiapplication approach. In multivariable analysis, decreased median income, increased business zoning, increased population density, and decreased percent Hispanic ethnicity were positively associated with high spatial density of GSN app-using MSM. This implies that using apps for interventions could effectively be targeting app users in areas of low socioeconomic status which have a higher burden of HIV infection, but may not effectively be reaching areas with high Hispanic populations. Methodology utilizing geospatial data and area demographic data can lead to insights for tailored and targeted interventions to support better health outcomes in underserved populations. Partnering with GSN app companies for future research can improve future research and provide opportunity for collaboration to improve MSM health.

Figure 1. Data collection points with 1-mile coverage buffers

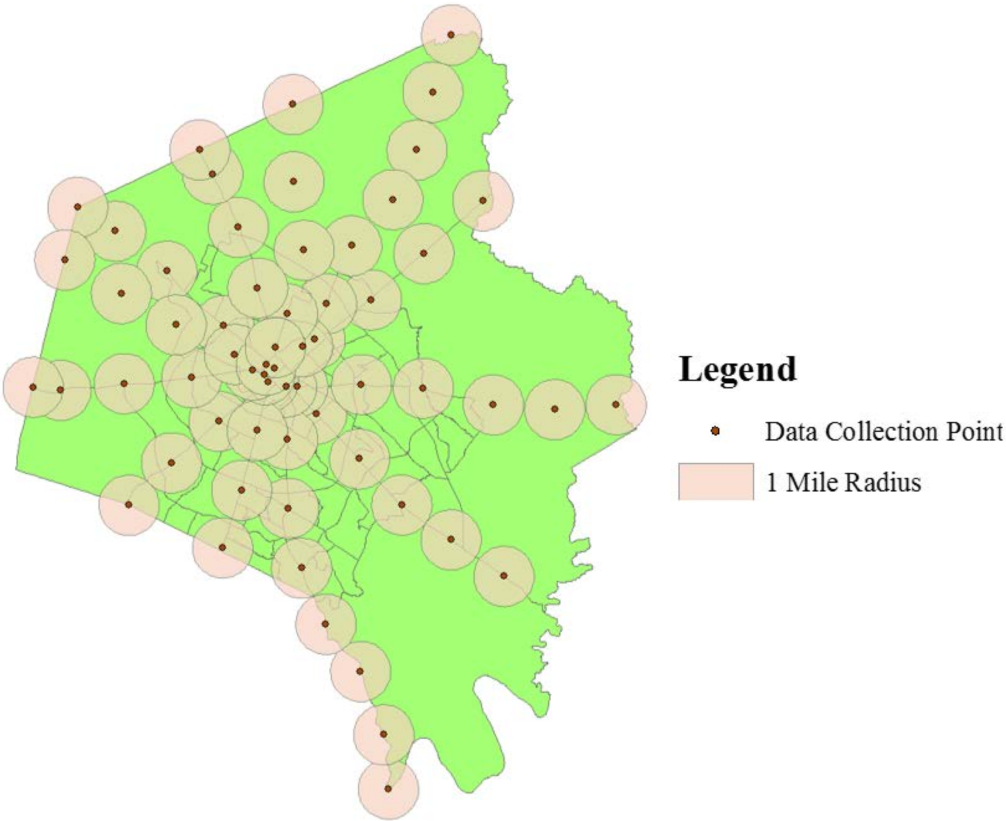

Figure 2. Empirical Bayesian kriging analysis of the estimated spatial distribution of GSN app users by time and app

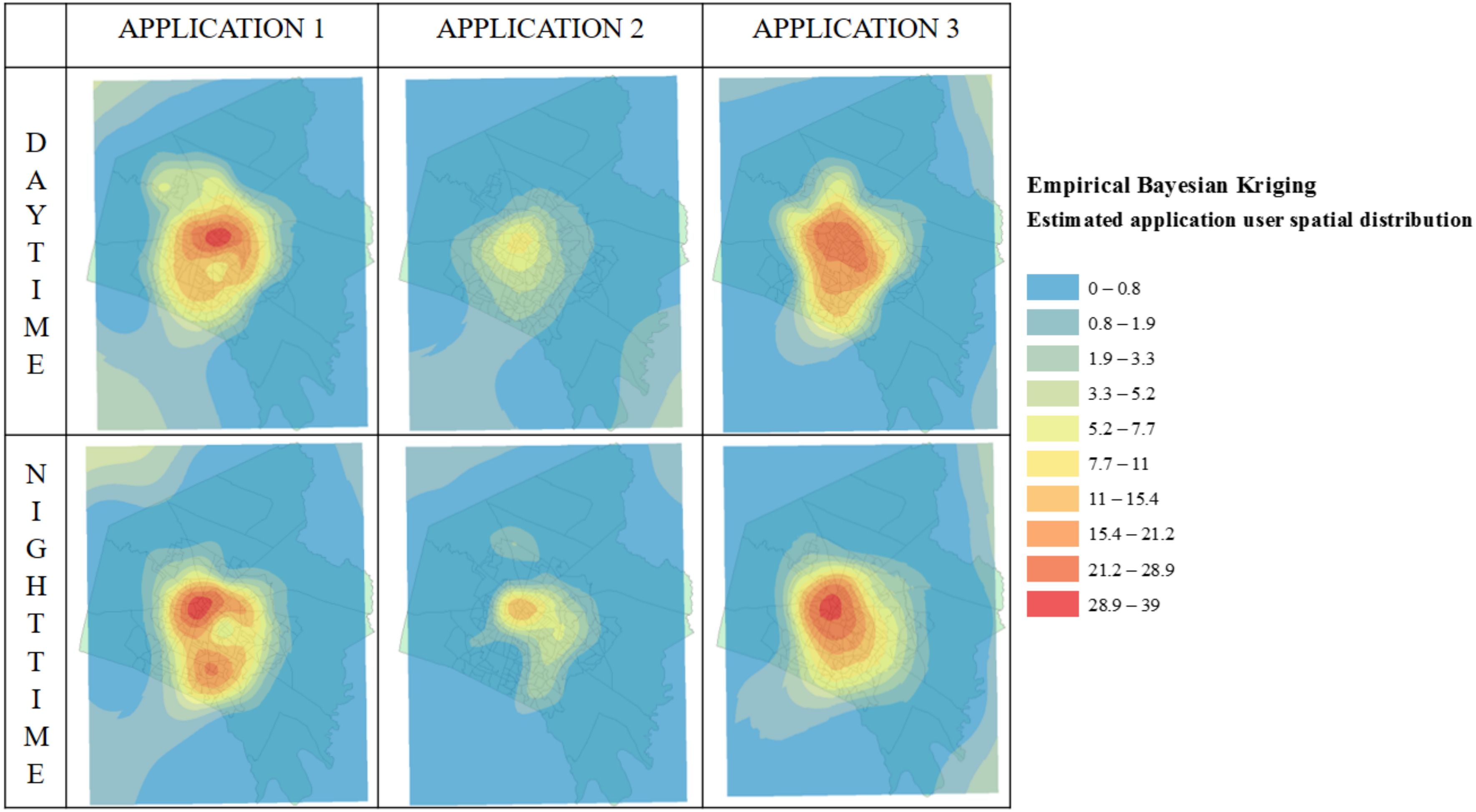

Figure 3. Quintile map of the differences of app users between different times and GSN app

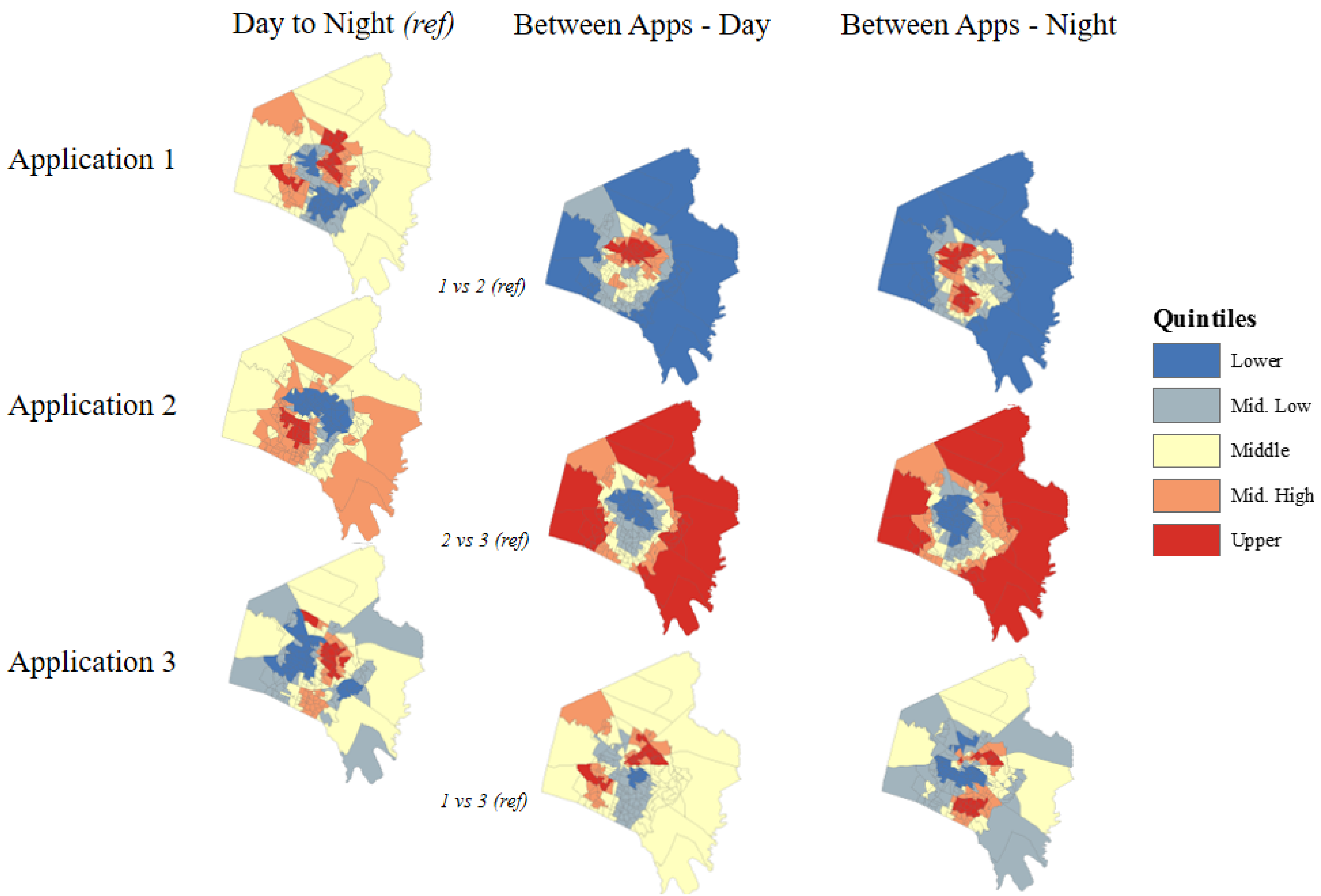

Table 1. Descriptive statistics of estimated Census block group GSN app usage averages

	Day Median (Q1,Q3)	Night Median (Q1,Q3)	p-value
Application 1	10.0 (4.0,15.0)	10.0 (3.0,17.0)	P=0.946
Application 2	2.0 (1.0,4,0)	1.0 (0.0,5.0)	P=0.387
Application 3	10.5 (3.0,18.5)	9.0 (4.0,18.0)	P=0.649
Day			
App 1 vs. App 2 (ref)	7.0 (3.0,11.0)	-	P<0.001*
App 2 vs. App 3 (ref)	-8.0 (-14.0, -2.0)	-	P<0.001*
App 1 vs. App 3 (ref)	0.0 (-3.0,2.0)	-	P=0.464
Night			
App 1 vs. App 2 (ref)	-	7.0 (2.0,14.0)	P<0.001*
App 2 vs. App 3 (ref)	-	-7.0 (-14.0, -3.0)	P<0.001*
App 1 vs. App 3 (ref)	-	-1.0 (-3.0, 2.5)	P=0.458

*Indicates significant difference between applications; ref: reference group

Table 2. Unadjusted analysis of areas with high spatial density of GSN app-using MSM

	App 1- Day	App 1- Night	App 2- Day	App 2- Night	App 3- Day	App 3- Night
Median Age (per year)	0.985* (0.971 ,0.999)	0.972** (0.958, 0.986)	0.981* (0.969, 0.993)	0.970* (0.952, 0.989)	0.981* (0.966, 0.996)	0.978* (0.966, 0.992)
Percent White (per 1%)	0.988** (0.983, 0.994)	0.991* (0.984, 0.997)	0.996 (0.991, 1.001)	0.986* (0.977, 0.995)	0.993* (0.987, 1.000)	0.995 (0.989, 1.001)
Percent Hispanic (per 1%)	1.010 (0.995, 1.025)	1.001 (0.986, 1.016)	1.000 (0.988, 1.012)	0.995 (0.974, 1.017)	1.004 (0.989,1.020)	1.003 (0.991, 1.017)
Median Income (per $5,000)	0.924** (0.910, 0.939)	0.930** (0.915, 0.945)	0.926** (0.910, 0.943)	0.911** (0.888, 0.935)	0.943* (0.927, 0.959)	0.940** (0.926, 0.954)
Population (per 100 per mi^2)	1.011** (1.007, 1.016)	1.015** (1.010, 1.020)	1.012** (1.008, 1.015)	1.015** (1.007, 1.018)	1.012* (1.007, 1.018)	1.012** (1.008, 1.016)
Business Zoning (ref=0)	2.240** (1.824, 2.751)	2.056** (1.639, 2.581)	2.275** (1.894, 2.732)	2.883** (2.128, 3.905)	2.116* (1.669, 2.683)	2.257** (1.848, 2.756)

*Significant $p<0.05$, **Significant $p<.001$

Table 3. Multivariate analysis of areas with high spatial density of GSN app-using MSM

	App 1- Day	App 1- Night	App 2- Day	App 2- Night	App 3- Day	App 3- Night
Median Age (per year)	1.026** (1.013, 1.039)	1.006 (0.991, 1.022)	1.013 (0.999, 1.026)	1.010 (0.989, 1.031)	1.013 (0.999, 1.026)	1.008 (0.994, 1.023)
Percent White (per 1%)	0.994* (0.989, 1.000)	0.997 (0.990, 1.003)	1.002 (0.997, 1.007)	0.989* (0.981, 0.998)	1.002 (0.997, 1.007)	1.001 (0.995, 1.007)
Percent Hispanic (per 1%)	0.985* (0.975, 0.996)	0.978** (0.965, 0.990)	0.983* (0.972, 0.994)	0.964** (0.947, 0.982)	0.983* (0.972, 0.994)	0.987* (0.976, 0.998)
Median Income (per $5,000)	0.927** (0.910, 0.945)	0.944** (0.924, 0.964)	0.935** (0.914, 0.957)	0.934** (0.903, 0.965)	0.935** (0.914, 0.957)	0.949** (0.931, 0.968)
Population (per 100 per mi^2)	1.004* (1.000, 1.008)	1.008** (1.003, 1.013)	1.005* (1.002, 1.009)	1.006* (1.000, 1.012)	1.005* (1.002, 1.009)	1.005* (1.000, 1.009)
Business Zoning (ref=0)	1.690** (1.426, 2.002)	1.564** (1.275, 1.918)	1.769** (1.471, 2.127)	2.215** (1.672, 2.934)	1.769** (1.471, 2.127)	1.853** (1.533, 2.240)

*Significant p<0.05, **Significant p<.001

Acknowledgements:

I would firstly like to extend a large thank you to the committee chair, Dr. April Young. Her care and expertise throughout this project has made me a better public health professional and has also inspired me to continue my education in the field of Epidemiology and begin my PhD at Florida International University starting Fall 2017. I would also like to thank Dr. Jay Christian for his expertise in the geographic component of this project and Dr. Steven Fleming for his support of this research. I would like to thank my family for their continued support of my educational and research goals. You have instilled the qualities of discipline and compassion into me which have made my experience as an MPH student much more rewarding. I must thank Dr. Abby Rudolph & Patrick Ward for their guidance with geographic software techniques and analysis as well as Angela Dao for assisting with data collection. Additionally, I would like to thank the University of Kentucky graduate school for the Lyman T. Johnson Diversity fellowship that provided financial assistance during my Master's program. Finally, I would like to thank the University of Kentucky Center for Clinical and Translational Science Pilot Grant for funding this project (NIH NCRR UL1TR000117). The authors report no conflicts of interest.

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Biosketch:

Angel Algarin was born and raised in Berlin Center, Ohio. He earned his Bachelor of Arts in Spanish with a focus in Latin American studies at the Ohio State University. Currently, he is completing his Master's in Public Health with a focus in Epidemiology as well as a graduate certificate in global health as a graduate fellow under the mentorship of Dr. April Young. During his Master's program, Angel interned with UNAIDS in the Dominican Republic, received a pilot grant to extend the research done in this study to rural areas, and has received the 2016 Emerging Leaders award from the Transforming Care Conference.

The research presented in this capstone is based off of a project funded by a University of Kentucky Center for Clinical and Translational Science (CCTS) Pilot Grant and overseen by the principle investigator Dr. April Young. This project involved the data collection of publicly available geographic app data on 9 routes spanning Fayette County, Kentucky. The results of this study have been presented at the 2017 CCTS Student Research Conference. Following graduation, Angel Algarin will be continuing his education at Florida International University where he will be starting his PhD in Epidemiology.

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