Nicotine & Tobacco Research Advance Access published March 22, 2015

Nicotine & Tobacco Research, 2015, 1–9
doi:10.1093/ntr/ntv046
Original investigation

OXFORD

Original investigation

Is There a Relationship Between the Concentration of Same-Sex Couples and Tobacco Retailer Density?

Joseph G. L. Lee MPH[1], William K. Pan DrPH[2], Lisa Henriksen PhD[3], Adam O. Goldstein MD, MPH[4,5], Kurt M. Ribisl PhD[1,5]

[1]Department of Health Behavior, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC; [2]Nicholas School of Environment and Duke Global Health Institute, Duke University, Durham, NC; [3]Stanford Prevention Research Center, Stanford School of Medicine, Palo Alto, CA; [4]Department of Family Medicine, School of Medicine, University of North Carolina at Chapel Hill, Chapel Hill, NC; [5]Lineberger Comprehensive Cancer Center, School of Medicine, University of North Carolina at Chapel Hill, Chapel Hill, NC

Corresponding Author: Joseph G. L. Lee, MPH, Department of Health Behavior, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, CB 7440 Chapel Hill, NC 27599, USA. Telephone: 919-966-2807; Fax: 919-966-2921; E-mail: jose.lee@unc.edu

Abstract

Background: Tobacco use is markedly higher among lesbian, gay, and bisexual populations than heterosexuals. Higher density of tobacco retailers is found in neighborhoods with lower income and more racial/ethnic minorities. Same-sex couples tend to live in similar neighborhoods, but the association of this demographic with tobacco retailer density has not been examined.
Methods: For a national sample of 97 US counties, we calculated the number of tobacco retailers per 1000 persons and rates of same-sex couples per 1000 households in each census tract (n = 17 941). Using spatial regression, we examined the association of these variables in sex-stratified models, including neighborhood demographics and other environmental characteristics to examine confounding.
Results: Results from spatial regression show that higher rates of both female and male same-sex couples were associated with a higher density of tobacco retailers. However the magnitude of this association was small. For female couples, the association was not significant after controlling for area-level characteristics, such as percent black, percent Hispanic, median household income, the presence of interstate highways, and urbanicity, which are neighborhood correlates of higher tobacco retailer density. For male couples, the association persisted after control for these characteristics.
Conclusion: Same-sex couples reside in areas with higher tobacco retailer density, and for men, this association was not explained by neighborhood confounders, such as racial/ethnic composition and income. While lesbian, gay, and bisexual disparities in tobacco use may be influenced by neighborhood environment, the magnitude of the association suggests other explanations of these disparities remain important areas of research.

Introduction

The lesbian, gay, and bisexual (LGB) population is routinely found to have a large, persistent disparity in tobacco use.[1] In the 2012–2013 US Adult Tobacco Survey, the prevalence of any tobacco use among LGB adults was 36% compared to 24% for heterosexual adults.[2] Transgender adults also have high tobacco use prevalence[3] but given the lack of neighborhood-level data are not discussed further here. Explanations for LGB tobacco use disparities typically focus on

discrimination, structural stigma, and resulting stress.[4] Media influence is another prominent explanation: LGB populations report high exposure[5,6] and receptivity[7] to targeted tobacco industry marketing.[8] Tobacco use is also normative in LGB print[9] and entertainment[10] media. Other environmental influences have received too little attention, including the retail environment and concentration of stores that sell tobacco products ("tobacco retailers") in neighborhoods. Emerging evidence shows that LGB people have unique patterns of migration and neighborhood selection.[11–13] Yet, a systematic review of the literature reveals no research examining whether tobacco retailers are more or less present in places where LGB people are more likely to live.[4]

Theories of neighborhood health disparities applied to tobacco retailer density suggest that tobacco retailers represent a physical presence that can hinder health by promoting ready access to tobacco products. Additionally these physical locations provide a channel for tobacco industry marketing and decrease search costs for tobacco products.[14,15] Tobacco retailers provide ubiquitous cues to smoke.[16–19] Proximity to tobacco retailers is associated with decreased success in tobacco use cessation,[20,21] although this may be true only in lower socioeconomic status neighborhoods.[22] Tobacco retailer density has been associated with smoking behaviors[23–25] and with youth initiation;[26] however, some findings are mixed.[21,25,27]

There are both regional and local patterns of same-sex couple migration and neighborhood selection in the United States.[11] (We use the term same-sex couple to discuss migration and other aspects of research using census data, as individual sexual orientation is not ascertained in the US Census. In discussing broader literature regarding sexual orientation identity, we use LGB.) Indeed, similar levels of neighborhood segregation exist for same-sex couple households as for household income, although less than exist for race.[12] Same-sex couples, like other couples, tend to migrate toward regions with better jobs, more temperate weather, lower crime, and cultural amenities.[28,29] Yet, the political environment also matters for same-sex couples, with greater concentrations of same-sex couples in less conservative places[30,31] and in regions with higher concentrations of other same-sex couples.[29] Within these regions, however, neighborhood selection can be influenced by several factors: Qualitative research finds strong evidence of the importance of other same-sex couples in neighborhood selection.[32,33] These patterns of neighborhood selection differ somewhat by sex, with greater concentrations of same-sex male couples into fewer, more dense neighborhoods than for female same-sex couples.[13] Same-sex couples, and male couples in particular, were more likely than opposite-sex couples to live in urban area zip codes, and in more racially/ethnically diverse zip codes with lower median household income.[11]

Existing evidence suggests racial minority and lower income neighborhoods have a disproportionately higher density of tobacco retailers. The first report of a disparity in tobacco retailer density found greater density of tobacco retailers in lower socioeconomic status and higher proportion black census tracts by quartile in a single New York county.[34] Similar findings have been identified in Iowa;[35] New Jersey with added disparities for tracts with more Hispanic residents;[36–39] New York state;[40] for poverty and Hispanic residents in Chicago, Illinois;[41] and, for Hispanic residents and lower income, Omaha, Nebraska.[42] In one national study, tobacco retailer density was related to Hispanic ethnicity, poverty, and other indicators of lower socioeconomic status.[43]

In this national study, we sought to identify if same-sex couples live in areas with higher tobacco retailer density and to assess if the association is independent from other neighborhood characteristics.

Methods

Data Sources: Tobacco Retailers

This is a secondary analysis of data from Advancing Science and Policy in the Retail Environment, funded by the National Cancer Institute's State and Community Tobacco Control Research Initiative. Advancing Science and Policy in the Retail Environment is a consortium of the Center for Public Health Systems Science at Washington University in St. Louis, the Stanford Prevention Research Center, and the University of North Carolina Gillings School of Global Public Health. The selection of counties for a nationally representative sample of US tobacco retailers was based on all counties in the contiguous 48 states. The sample of counties was selected using a probability proportionate to size method developed by Chromy.[44] This resulted in 97 unique counties (Figure 1) in which 26% of the US population (79 million people) resides.[45]

Retailer address and phone data were purchased in 2012 from two sources: North American Industry Classification System (NAICS) Association and ReferenceUSA. We requested lists of stores with primary or secondary classification as one of the following: supermarkets and other grocery (except convenience) stores; convenience stores; tobacco stores; gasoline stations with convenience stores; warehouse clubs and supercenters; news dealers and newsstands; beer, wine, and liquor stores; pharmacies and drug stores; discount department stores; and other gasoline stations. Vape shops and e-cigarette retailers are classified in multiple different NAICS codes, often as tobacco stores; where they were identified in the store types above they were included in this study.

Data cleaning removed stores without addresses, removed punctuation and spaces, removed suite numbers, replaced PO boxes, and removed non-street address (eg, airport) stores. The cleaning process eliminated discount department stores other than Walmart, separate stores within Walmarts (eg, Walmart Bakery), retained only the top 50 pharmacy chains, and removed stores known to not sell tobacco (eg, state-controlled liquor stores, Aldi, Trader Joe's, Whole Foods). This was conducted separately for NAICS Association and ReferenceUSA lists. Lists were then merged by zip code and address and de-duplicated. We retained approximately 58% of the initial address lists for the 97 counties after de-duplicating addresses within and between lists.

A national review of food stores found that commercial lists like those used in this study are a viable data source for large-scale studies[46] and the use of these commercial databases has been validated using ground truthing in a state without tobacco retail licensing.[47] Previous research has also validated the use of commercial lists to measure tobacco retailer density, finding that commercial lists did not show disproportionate under- or over-reporting of state-licensed tobacco retailers by area demographics in Washington State.[43]

Data Sources: Same-Sex Couples

Data on same-sex couples came from the 2010 US Census, which included a question on relationship to the owner or renter of the household ("How is this person related to Person 1?"). By aggregating responses of "Husband or wife" and "Unmarried partner" and comparing to the sex of each person, same-sex couples were computed by the Census Bureau as a subcategory of unmarried partner households, where "an adult who is unrelated to the householder, but shares living quarters and has a close personal relationship with the householder" is present.[48] Census 2010 includes same-sex couples

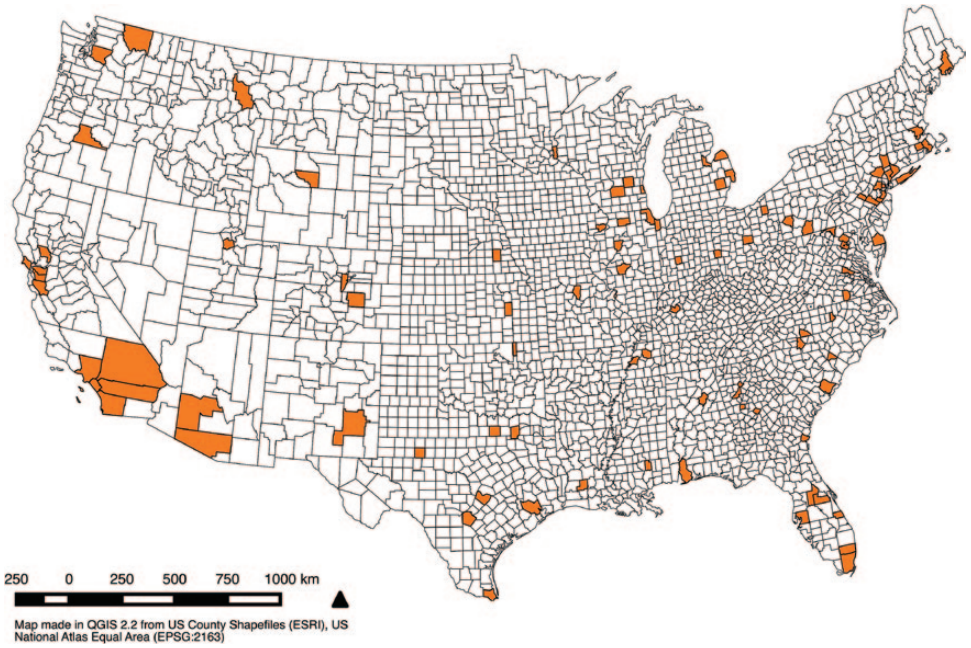

Figure 1. Counties included in sampling frame, $n = 97$.

as unmarried partners even when they are legally married and live in states with provisions for same-sex marriage or other legal recognition. An important questionnaire design issue has been identified in Census 2010 that caused misclassification of sex in door-to-door data collection by census workers, thereby causing some estimates of same-sex couples to exceed the total possible number.[49,50] To correct for this error, we applied a state-level error-rate correction developed and recommended by Gates.[51]

Data Sources: Census Tract Characteristics

Census tract demographic variables on race/ethnicity and total population were available from Census 2010.[52] We used the Census Bureau's American Community Survey, 5-Year Estimates, 2008–2012, for income.[53] American Community Survey data were unavailable for eight census tracts.

Measures

Following earlier research,[34,37,39,40,42] we conducted all analyses at the census tract level. Census tracts represent the best available area unit to reflect neighborhood processes for our purposes, having been designed to define homogenous community areas,[54] and provide a large enough population to also analyze small subgroups (ie, same-sex couples). Measure definitions are reported in Table 1 by their role as dependent variable, independent variables, and explanatory variables. Percentages were divided by 10 (eg, 12% = 1.2) for scaling purposes.

Tobacco retailer density was computed as the number of tobacco retailers divided by 1000 population in a given census tract. Because of non-normality in the distribution of tobacco retailer density (skew: 7.9, $P = .02$; kurtosis: 139.3, $P = .04$), we tested various transformations with an offset of 0.3 to see which transformation's Pearson correlation with same-sex couple rates best approximated a nonparametric correlation coefficient between the female and male same-sex couple household rates with tobacco retailer density, respectively, $r_{s(n = 17,675)} = 0.09$ ($P < .001$) and 0.14 ($P < .001$). Of these, a square-root transformation provided the best option (skew: 1.8, $P = .02$; kurtosis: 9.5, $P = .04$). We then ran analyses using both transformed and untransformed dependent variables. As patterns of significance and direction were not sensitive to the transformation, like Loomis and colleagues,[40] we left our dependent variable untransformed so as to facilitate interpretation.

There are multiple ways to calculate the density of same-sex couples, and they are very highly correlated.[30] We choose to follow an approach used by Walther *et al.*,[31] that calculates a same-sex couple rate per 1000 coupled households, shown for male couples:

$$\left(\frac{\text{Number of male same sex couple households}}{\begin{array}{c}\text{Number of same sex couple households} \\ +\text{Number of opposite sex unmarried couple} \\ \text{households} + \text{Number of married couple households}\end{array}} \right) \times 1000$$

Data from an earlier study[55] showed that, particularly in suburban and rural areas, retailers clustered at exits along interstate highways. Thus we created a dichotomous measure of presence of an interstate highway within a tract.[56] We used US Department of Agriculture's 2013 Rural–Urban Continuum Codes for county urbanicity.[57] Data management was conducted in SPSS v. 22 (IBM, Chicago, Illinois) and QGIS v. 2.2 (www.qgis.org). Data analysis was conducted with GeoDa v. 1.6.0 (Arizona State University, Tempe, Arizona).

Analysis Strategy

Because some census tracts are not residential or have very few people, rates of demographic characteristics can be unstable. We thus excluded census tracts with fewer than 250 households ($n = 266$ tracts) and retained 17 675 tracts (or 98.5% of the original sample). We then excluded eight tracts for which no economic data were available. All model results are reported using $n = 17\,667$ tracts.

Table 1. Key Measures and Definitions

Variable	Item details
Dependent variable	
Tobacco retailer density	Total number of tobacco retailers in a census tract divided by total population and multiplied by 1000
Block 1: independent variable	
Same-sex couple households, female, per 1000 coupled households	Number of female householders with female partner divided by total married and unmarried coupled households and multiplied by 1000
Same-sex couple households, male, per 1000 coupled households	Number of male householders with male partner divided by total married and unmarried coupled households and multiplied by 1000
Block 2: explanatory variables	
Percentage black population in 10-point increments	Percentage of the total population reporting black or African-American race alone or in combination with another race divided by 10
Percentage hispanic ethnicity in 10-point increments	Percentage of the total population reporting Hispanic or Latino origin divided by ten
Median annual household income, adjusted to 2012 USD	Median household income in the past 12 months, in 2012 inflation-adjusted dollars divided by 1000
Block 3: explanatory variables	
Presence of interstate highway	Dichotomous (0 = No, 1 = Yes)
Rurality	County-level ordinal US Department of Agriculture urban–rural continuum codes (range 1–9, from most to least urban)

Given gendered differences in spatial patterns of same-sex couple migration, we stratified all analyses by sex of same-sex couple. When statistically modeling phenomena with a spatial component, key tenets of linear regression are violated by nonindependence of observations based on shared characteristics due to their proximity.[58] We identified spatial clustering of the dependent variable (Moran's I = 0.10, P = .001). Indeed, ordinary least squares regression residuals showed significant spatial clustering (Female: Moran's I = 0.08, P = .001; Male: Moran's I = 0.07, P = .001). Therefore, we used spatial regression models to account for spatial dependence in our data. We examined models with multiple contiguity weights matrices, selecting a second order queen weights matrix. Two common approaches to spatial dependence include spatial lag and spatial error models. Spatial lag models address the influence of the dependent variable in one location on nearby locations. Spatial error models address the influence of omitted independent variables over space. Past tobacco retailer density analyses have used a spatial lag approach.[39,40] Lagrange Multiplier Tests indicated the spatial error model was more appropriate for our data. We set all critical values at α = 0.05 and used two-tailed tests. Finally, we graphically displayed results using a dot and 95% confident interval plot, using Jenks natural breaks in the data.[59]

Modeling Approach

We selected variables for model building based on the existing literature of tobacco retailer density and same-sex couple demography discussed above. We approached modeling in three blocks, stratifying by sex. First, we entered the same-sex couple household rates, defined as same-sex coupled households per 1000 coupled households. We then added tract-level characteristics for income and racial/ethnic composition. Lastly, we added variables for the presence of interstates and rurality, as indicated by US Department of Agriculture Rura–Urban Continuum Codes (Table 1). We compared models using changes in R^2 and likelihood ratio tests. Lastly, we conducted sensitivity analyses for edge effects (ie, a boundary problem in spatial analysis), where the lack of data on neighboring units at the borders of the area under study can influence results.[60]

As there were no human subjects, the UNC Office of Human Research Ethics exempted this research from further review (#13–2602).

Results

Same-Sex Couples and Tobacco Retailer Density

At the census tract level, the average density was 1.27 tobacco retailers per 1000 population (range 0 to 50.96, SD = 1.55, median = 0.96). The average rate of same-sex households per 1000 coupled households was 6.66 for same-sex female couples (range 0 to 68.74, SD = 5.96, median = 5.21) and 10.07 for same-sex male couples (range 0 to 562.35, SD = 23.77, median = 3.26).

Results from spatial regression show that higher rates of both female and male same-sex couple were associated with a higher density of tobacco retailers (Table 2). However, the magnitude of this association was small: For each additional same-sex household per 1000 households, the number of tobacco retailers per 1000 people increased by one one-hundredth. For both sexes, the first model explained only 6% of variance. Figure 2 illustrates the bivariate relationship in natural breaks of same-sex couple rates, showing an increase in density with greater rates of female same-sex couples. Male same-sex couples showed a similar pattern albeit with greater overall density and a possible plateau in density starting with >43 couples per 1000 coupled households. It is of note that the rates of same-sex male couples are much higher than for same-sex female couples as shown in the x-axis.

We examined whether including area-level demographic characteristics of race, ethnicity, and income explained the bivariate association in model 1. For female same-sex couples, the addition of other neighborhood indicators explained the relationship between same-sex couple households and tobacco retailer density. For male same-sex couples, however, a significant positive association of same-sex households and tobacco retailer density was independent of other neighborhood demographics.

A third block of variables looked at if physical area-level characteristics would offer additional explanation of this association. Thus, in this third model, we included variables for the presence of

Table 2. Same-Sex Couple Household Rate per 1000 Coupled Households Predicting Tobacco Retailer Density per 1000 Population in Census Tracts (n = 17 667), 97 Counties, United States, Respectively, Stratified by Sex of Couple

		Female			Male		
Model	Variable	Estimate	*SE*	*P*	Estimate	*SE*	*P*
1	Constant	**1.18**	0.03	<.001	**1.17**	0.02	<.001
	Same-sex couple rate	**0.01**	<0.01	<.001	**0.01**	<0.01	<.001
	Lag coefficient, lambda	**0.44**	0.02	<.001	**0.40**	0.02	<.001
	Overall model		R^2 = 0.06; AIC = 64 849			R^2 = 0.06; AIC = 64 714	
2	Constant	**1.83**	0.06	<.001	**1.71**	0.05	<.001
	Same-sex couple rate	<0.01	<0.01	.19	**0.01**	<0.01	<.001
	% Black race (10 points)	<0.01	0.01	.82	0.01	0.01	.35
	% Hispanic ethnicity (10 points)	**–0.04**	0.01	<.001	**–0.03**	0.01	<.001
	Median household income (1000s)	**–0.01**	<0.01	<.001	**–0.01**	<0.01	<.001
	Lag coefficient, lambda	**0.43**	0.02	<.001	**0.39**	0.02	<.001
	Overall model		R^2 = 0.07; AIC = 64 613			R^2 = 0.08; AIC = 64 448	
3	Constant	**1.73**	0.08	<.001	**1.57**	0.07	<.001
	Same-sex couple rate	<0.01	<0.01	.15	**0.01**	<0.01	<.001
	% Black race (10s)	<0.01	0.01	.83	0.01	0.01	.30
	% Hispanic ethnicity (10s)	**–0.04**	0.01	<.001	**–0.03**	0.01	<.001
	Median household income (1000s)	**–0.01**	<0.01	<.001	**–0.01**	<0.01	<.001
	Presence of interstate highway	**0.26**	0.03	<.001	**0.27**	0.03	<.001
	Rurality level	0.01	0.04	.70	0.04	0.03	.22
	Lag coefficient, lambda	**0.43**	0.02	<.001	**0.38**	0.02	<.001
	Overall model		R^2 = 0.08; AIC = 64 483			R^2 = 0.08; AIC = 64 348	

AIC = Akaike information criterion, *SE* = standard error. Using a row-standardized second order (including lower orders) queen weights matrix and a spatial error model.

an interstate and rurality level. These did not fully explain the relationship between male same-sex couples and tobacco retailer density but did offer significant improvements in both models.

The addition of each block of variables significantly improved model fit based on likelihood ratio tests, $P < .001$. Nonetheless, our final models explained only a modest amount of variance in the tobacco retailer density, 8%.

Sensitivity Analysis

To assess the sensitivity of our findings to edge effects, which can influence results in spatial analysis,[60] we re-ran all analyses in a subset of 15 085 tracts, after removing all census tracts at the edges of counties. Our findings were sensitive to the removal of edge tracts. For female same-sex couples, excluding edge tracts, there was a negative association with tobacco retailer density, which is in the opposite direction of our main findings. Estimates became more pronounced: –0.05 in model 1 and –0.07 in models 2 and 3. Significance was maintained between female same-sex couples and tobacco retailer density in each model ($P < .01$). For men, estimates were similar for each model (0.01), but control for tract demographics and physical characteristics resulted in a marginally significant relationship between male same-sex couple rate and tobacco retailer density in models 2 ($P = .07$) and 3 ($P = .08$). Thus, our findings for female same-sex couples show substantive differences when edge tracts are removed while the removal of edge tracts has less influence on our findings for male same-sex couples.

Further examination revealed quantitative differences in edge versus non-edge tracts, all $P < .01$: Edge tracts have fewer black residents (M = 11% vs. 15%), fewer Hispanic residents (M = 15% vs. 29%), higher median income ($74 379 vs. $63 489), lower population density per square mile (M = 4737 vs. 8895), and a lower same-sex couple household rate than non-edge tracts (M = 6.05 vs. 6.75 female and 8.64 vs. 10.53 male couples per 1000 coupled households). These findings appear to be consistent with historical patterns of residential segregation in urban areas.[61] These sensitivity analyses indicate that we cannot rule out the possibility of edge effects, but differences from the main model may be driven by patterns of residential segregation. Future research using areas with fewer edges (eg, an entire state instead of a sample of noncontiguous counties) is indicated.

Discussion

Principal Findings

Same-sex couples tend to live in neighborhoods where tobacco retailer density is greater, and for male same-sex couples this association persists even after adjustments for other neighborhood income, race/ethnicity and other correlates of higher retailer density. An increase of 100 same-sex couple households in the rate of same-sex households was associated with an additional tobacco retailer for every 1000 residents in census tracts. Although the association between the density of same-sex households and tobacco retailers was relatively small, such findings matter to our understanding of population-level influences on health.[62] This study is the first to suggest a role for neighborhoods in understanding the etiology of LGB tobacco-related health disparities.

That the relationship between same-sex couples and tobacco retailer density can be explained by area demographics for female same-sex couples but not for male same-sex couples suggests differences by sex in the mechanisms by which same-sex couple households come to be associated with tobacco retailer density. Two processes may be involved in this. First, retailer density can be explained by theories of organizational ecology,[63] which consider available resources to promote the founding, evolution, and closing

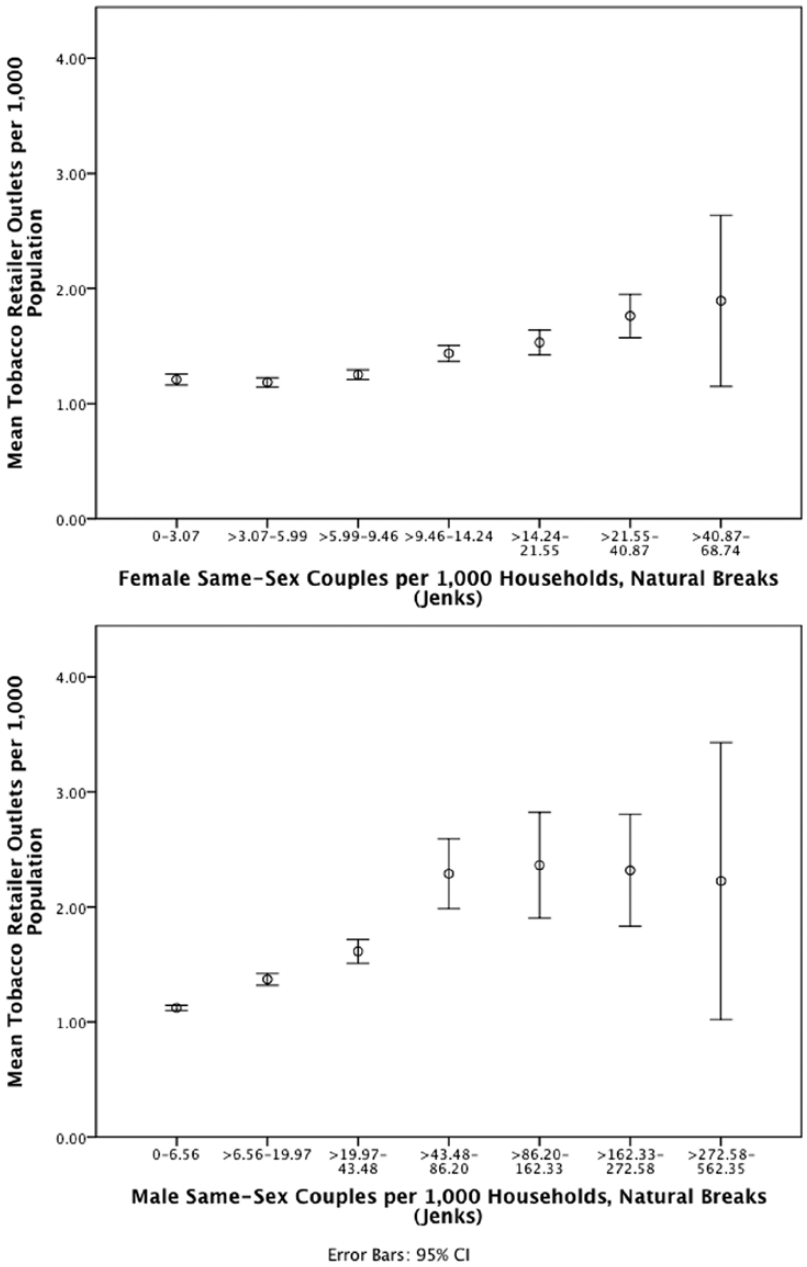

Figure 2. Same-sex couples per 1000 partnered households classified by natural breaks (Jenks) and mean number of tobacco retailers per 1000 population, census tracts (n = 17 667), 97 counties, United States, in 2010 and 2012, respectively, by sex of couples.

of retail locations. Neighborhood resources for retailers may be influenced by historical underinvestment in more urban, more black neighborhoods.[64] With fewer large and chain stores, more smaller corner stores may be present.[65,66] Second, neighborhood selection choices of same-sex couples may be related to selection into neighborhoods that, for other reasons, have more tobacco retailer density. Mechanisms could include differences in childrearing (less for male couples)[67] and interest in school quality; in perceived safety of neighborhoods, which may differ by gender,[68] although some studies find no differences for lesbian women and gay men;[69] and, in income (lower for women).[70] There is evidence that LGB people are subject to wage and hiring discrimination, the latter of which may differ by state.[71–73] Same-sex couples are not as wealthy as the popular imagination holds.[74] Lesbian couples are also affected by gender-based inequity in pay compared to heterosexual couples and gay male couples.[70]

Early research on gay neighborhoods described a process of territorialization, rooted in masculine behavior and need to create gay (male) space.[75] Others describe a process by which gay male neighborhoods were created out of red light districts.[76,77] In qualitative research, these patterns of neighborhood formation do not parallel the formation of lesbian neighborhoods.[32,33,78,79] Alternatively, declining residential segregation for same-sex couples[12] and rural and suburban neighborhood selection[80–82] as well as the feasibility of returning to communities of origin with growing social acceptance[83] could be different by gender and result differences in our models.

Regardless of the different mechanisms, our findings show both the rate of male and female same-sex couples are associated with greater tobacco retailer density.

In sensitivity analyses to assess edge effects, our results differ, particularly for female same-sex couple models. However, because the counties included in our study are more urban than the typical county, edge tracts appear to be qualitatively different than core tracts. Thus, we cannot rule out the possibility of edge effects. For many included counties, a central city occupies the center of the tract and many edge tracts are larger and suburban in nature. Future research should explore this more fully.

Strengths and Weaknesses of the Study

There are several strengths and limitations to this research. We selected an area unit we viewed to be most conceptually appropriate for neighborhoods and selected variables for model building *a priori* based on the existing literature. The statistical approach explicitly modeled spatial dependence. We note two important limitations: First, census data only provide information on same-sex couples; were data on individual sexual orientation available they might provide different results. Individuals who are partnered may be quite different in their neighborhood selection and health behaviors, and this research is not generalizable to individual LGB people. However, the limited data available show similar disparities in smoking prevalence for same-sex couples compared to opposite-sex couples (53% and 35% higher for same-sex female and male couples than their opposite-sex counterparts, respectively).[84] Although the census undercounts some racial/ethnic minorities,[85] census data represent a high quality data source. Second, there is no national licensing of tobacco retailers. While we used a unique, high quality list of tobacco retailers that has been validated in similar studies,[43,47] there is an unknown amount of error in identifying current tobacco retailers. Additionally, we did not have information on retailer type.

Future research should examine (1) differences in tobacco retailer density where people live, work, and play (ie, activity space)[86] as we only had data on rates of households based on where people live, (2) the potential role of edge effects as we were unable to rule them out, (3) the role of tobacco retailer policy interventions on density for neighborhoods with more same-sex couples, and (4) changes in gay and lesbian neighborhoods[12,87] in relation to tobacco retailer density.

Conclusion

This is the first study to examine tobacco retailer density in relation to same-sex couples, thus providing new information to our understanding of LGB disparities in tobacco use. Much of the literature on tobacco dependence disparities for LGB populations is based on a minority stress model.[4] Our work suggests a small role for an environmental factor that may also contribute to disparities, differences in neighborhood tobacco retailer density. The positive relationship between tobacco retailer density and same-sex couples at the tract level suggests that this may play a part in population-level disparities in tobacco use for LGB adults. The extent and quantification of that role requires further research. Given the lack of tobacco control interventions that reduce disparities,[88] identifying pro-equity interventions is an important area of future research. Policy interventions[89–91] to limit the density of tobacco retailers should be assessed for their impact on LGB tobacco use disparities.

Funding

Research reported in this publication was supported by the National Cancer Institute of the US National Institutes of Health under award numbers F31CA186434 and U01CA154281. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Declaration of Interests

JGLL and KMR received compensation from a store audit/compliance and mapping system, which is owned by the University of North Carolina at Chapel Hill and distributed by Counter Tools (http://countertools.org). The tools and audit mapping system were not used in this study.

Acknowledgments

Appreciation to Paul Voss for early spatial statistics consultations. Kate McFarland Bruce of Wake Forest University kindly provided syntax for the same-sex couple rate correction. Many thanks to my dissertation committee, J. Michael Bowling and H. Luz McNaughton-Reyes for thoughtful help, and the ASPiRE study team, in particular, Nina Schleicher, for help with data and encouragement.

References

1. Lee JG, Griffin GK, Melvin CL. Tobacco use among sexual minorities in the USA, 1987 to May 2007: a systematic review. *Tob Control*. 2009;18(4):275–282. doi:10.1136/tc.2008.028241.
2. Agaku IT, King BA, Husten CG, et al. Tobacco product use among adults—United States, 2012–2013. *MMWR Morb Mortal Wkly Rep*. 2014;63(25):542–547. www.cdc.gov/mmwr/preview/mmwrhtml/mm6325a3.htm. Accessed December 30, 2014.
3. Grant J, Mottet L, Tanis J, Herman J, Harrison J, Keisling M. *National Transgender Discrimination Survey: Report on Health and Health Care*. Washington, DC: National Center for Transgender Equality and the National Gay and Lesbian Task Force; 2010.
4. Blosnich J, Lee JG, Horn K. A systematic review of the aetiology of tobacco disparities for sexual minorities. *Tob Control*. 2013;22(2):66–73. doi:10.1136/tobaccocontrol-2011-050181.
5. Washington HA. Burning love: big tobacco takes aim at LGBT youths. *Am J Public Health*. 2002;92(7):1086–1095. doi:10.2105/AJPH.92.7.1086.
6. Smith EA, Malone RE. The outing of Philip Morris: advertising tobacco to gay men. *Am J Public Health*. 2003;93(6):988–993. doi:10.2105/AJPH.93.6.988.
7. Dilley JA, Spigner C, Boysun MJ, Dent CW, Pizacani BA. Does tobacco industry marketing excessively impact lesbian, gay and bisexual communities? *Tob Control*. 2008;17(6):385–390. doi:10.1136/tc.2007.024216.
8. Stevens P, Carlson LM, Hinman JM. An analysis of tobacco industry marketing to lesbian, gay, bisexual, and transgender (LGBT) populations: strategies for mainstream tobacco control and prevention. *Health Promot Pract*. 2004;5(suppl 3):129S–134S. doi:10.1177/1524839904264617.
9. Smith EA, Offen N, Malone RE. Pictures worth a thousand words: noncommercial tobacco content in the lesbian, gay, and bisexual press. *J Health Commun*. 2006;11(7):635–649. doi:10.1080/10810730600934492.
10. Lee JG, Agnew-Brune CB, Clapp JA, Blosnich JR. Out smoking on the big screen: tobacco use in LGBT movies, 2000–2011. *Tob Control*. 2014;23(e2):e156–158. doi:10.1136/tobaccocontrol-2013-051288.
11. Gates GJ, Ost J. *The Gay and Lesbian Atlas*. Washington, DC: Urban Institute Press; 2004.
12. Spring AL. Declining segregation of same-sex partners: evidence from census 2000 and 2010. *Pop Res and Policy Rev*. 2013;32(5):687–716. doi:10.1007/s11113-013-9280-y.
13. Hayslett KL, Kane MD. "Out" in Columbus: a geospatial analysis of the neighborhood-level distribution of gay and lesbian households. *City Community*. 2011;10(2):131–156. doi:10.1111/j.1540-6040.2010.01353.x.

14. Bernard P, Charafeddine R, Frohlich KL, Daniel M, Kestens Y, Potvin L. Health inequalities and place: a theoretical conception of neighbourhood. *Soc Sci Med*. 2007;65(9):1839–1852. doi:10.1016/j.socscimed.2007.05.037.
15. Shareck M, Dassa C, Frohlich KL. Improving the measurement of neighbourhood characteristics through systematic observation: inequalities in smoking as a case study. *Health Place*. 2012;18(3):671–682. doi:10.1016/j.healthplace.2011.11.008.
16. Carter OB, Mills BW, Donovan RJ. The effect of retail cigarette pack displays on unplanned purchases: results from immediate postpurchase interviews. *Tob Control*. 2009;18(3):218–221. doi:10.1136/tc.2008.027870.
17. Wakefield MA, Germain D, Henriksen L. The effect of retail cigarette pack displays on impulse purchase. *Addiction*. 2008;103(2):322–328. doi:10.1111/j.1360-0443.2007.02062.x.
18. Paynter J, Edwards R. The impact of tobacco promotion at the point of sale: a systematic review. *Nicotine Tob Res*. 2009;11(1):25–35. doi:10.1093/ntr/ntn002.
19. Robertson L, McGee R, Marsh L, Hoek J. A systematic review on the impact of point-of-sale tobacco promotion on smoking [published online ahead of print September 1, 2014]. *Nicotine Tob Res*. 2014. doi:10.1093/ntr/ntu168.
20. Halonen JI, Kivimaki M, Kouvonen A, et al. Proximity to a tobacco store and smoking cessation: a cohort study. *Tob Control*. 2014;23(2):146–151. doi:10.1136/tobaccocontrol-2012-050726.
21. Reitzel LR, Cromley EK, Li Y, et al. The effect of tobacco outlet density and proximity on smoking cessation. *Am J Public Health*. 2011;101(2):315–320. doi:10.2105/ajph.2010.191676.
22. Cantrell J, Anesetti-Rothermel A, Pearson JL, Xiao H, Vallone D, Kirchner TR. The impact of the tobacco retail outlet environment on adult cessation and differences by neighborhood poverty. *Addiction*. 2015;110(1):152–61. doi:10.1111/add.12718.
23. Chuang YC, Cubbin C, Ahn D, Winkleby MA. Effects of neighbourhood socioeconomic status and convenience store concentration on individual level smoking. *J Epidemiol Community Health*. 2005;59(7):568–573. doi:10.1136/jech.2004.029041.
24. Scully M, McCarthy M, Zacher M, Warne C, Wakefield M, White V. Density of tobacco retail outlets near schools and smoking behaviour among secondary school students. *Aust N Z J Public Health*. 2013;37(6):574–578. doi:10.1111/1753-6405.12147.
25. Shortt NK, Tisch C, Pearce J, Richardson EA, Mitchell R. The density of tobacco retailers in home and school environments and relationship with adolescent smoking behaviours in Scotland [published online ahead of print November 4, 2014]. *Tob Control*. 2014. doi:10.1136/tobaccocontrol-2013-051473.
26. Lipperman-Kreda S, Grube JW, Friend KB. Local tobacco policy and tobacco outlet density: associations with youth smoking. *J Adolesc Health*. 2012;50(6):547–552. doi:10.1016/j.jadohealth.2011.08.015.
27. Han T, Alexander M, Niggebrugge A, Hollands GJ, Marteau TM. Impact of tobacco outlet density and proximity on smoking cessation: a longitudinal observational study in two English cities. *Health Place*. 2014;27:45–50. doi:10.1016/j.healthplace.2014.01.008.
28. Black D, Gates GJ, Sanders S, Taylor L. Why do gay men live in San Francisco? *J Urban Econ*. 2002;51(1):54–76. doi:10.1006/juec.2001.2237.
29. Cooke TJ, Rapino M. The migration of partnered gays and lesbians between 1995 and 2000. *Prof Geogr*. 2007;59(3):285–297. doi:10.1111/j.1467-9272.2007.00613.x.
30. Walther CS, Poston DL Jr. Patterns of gay and lesbian partnering in the larger metropolitan areas of the United States. *J Sex Res*. 2004;41(2):201–214. doi:10.2307/3813654.
31. Walther CS, Poston DL Jr, Gu Y. Ecological analyses of gay male and lesbian partnering in the metropolitan United States in 2000. *Pop Res Policy Rev*. 2011;30(3):419–448. doi:10.1007/s11113-010-9195-9.
32. Rothenberg T. 'And she told two friends': lesbians creating urban social space. In: Bell D, Valentine G, eds. *Mapping Desire: Geographies of Sexualities*. New York, NY: Routledge; 1995:165–181.
33. Gieseking JJ. Queering the meaning of 'neighborhood': reinterpreting the lesbian-queer experience of Park Slope, Brooklyn, 1983–2008. In: Taylor Y, Addison M, eds. *Queer Presences and Absences*. New York, NY: Palgrave Macmillan; 2013:178–200.
34. Hyland A, Travers MJ, Cummings KM, Bauer J, Alford T, Wieczorek WF. Tobacco outlet density and demographics in Erie County, New York. *Am J Public Health*. 2003;93(7):1075–1076. doi:10.2105/AJPH.93.7.1075.
35. Schneider JE, Reid RJ, Peterson NA, Lowe JB, Hughey J. Tobacco outlet density and demographics at the tract level of analysis in Iowa: implications for environmentally based prevention initiatives. *Prev Sci*. 2005;6(4):319–325. doi:10.1007/s11121-005-0016-z.
36. Fakunle D, Morton CM, Peterson NA. The importance of income in the link between tobacco outlet density and demographics at the tract level of analysis in New Jersey. *J Ethn Subst Abuse*. 2010;9(4):249–259. doi:10.1080/15332640.2010.522890.
37. Peterson NA, Yu D, Morton CM, Reid RJ, Sheffer MA, Schneider JE. Tobacco outlet density and demographics at the tract level of analysis in New Jersey: a statewide analysis. *Drugs (Abingdon Engl)*. 2011;18(1):47–52. doi:10.3109/09687630903514891.
38. Yu D, Peterson NA, Reid RJ. Exploring the impact of non-normality on spatial non-stationarity in geographically weighted regression analysis: tobacco outlet density in New Jersey. *GIsci Remote Sens*. 2009;46(3):329–346. doi:10.2747/1548-1603.46.3.329.
39. Yu D, Peterson NA, Sheffer MA, Reid RJ, Schnieder JE. Tobacco outlet density and demographics: analysing the relationships with a spatial regression approach. *Public Health*. 2010;124(7):412–416. doi:10.1016/j.puhe.2010.03.024.
40. Loomis BR, Kim AE, Goetz JL, Juster HR. Density of tobacco retailers and its association with sociodemographic characteristics of communities across New York. *Public Health*. 2013;127(4):333–338. doi:10.1016/j.puhe.2013.01.013.
41. Novak SP, Reardon SF, Raudenbush SW, Buka SL. Retail tobacco outlet density and youth cigarette smoking: a propensity-modeling approach. *Am J Public Health*. 2006;96(4):670–676. doi:10.2105/ajph.2004.061622.
42. Siahpush M, Jones PR, Singh GK, Timsina LR, Martin J. Association of availability of tobacco products with socio-economic and racial/ethnic characteristics of neighbourhoods. *Public Health*. 2010;124(9):525–529. doi:10.1016/j.puhe.2010.04.010.
43. Rodriguez D, Carlos HA, Adachi-Mejia AM, Berke EM, Sargent JD. Predictors of tobacco outlet density nationwide: a geographic analysis. *Tob Control*. 2013;22(5):349–355. doi:10.1136/tobaccocontrol-2011-050120.
44. Chromy JR. Sequential sample selection methods. *Proceedings of the Survey Research Methods Section*. 1979;1979(1):401–406. www.amstat.org/sections/SRMS/Proceedings/papers/1979_081.pdf. Accessed December 30, 2014.
45. Social Explorer. Census 2010, Total Population (Social Explorer Table T001_001). 2014. www.socialexplorer.com/pub/reportdata/HtmlResults.aspx?reportid=R10789430. Accessed September 19, 2014.
46. Fleischhacker SE, Evenson KR, Sharkey J, Pitts SB, Rodriguez DA. Validity of secondary retail food outlet data: a systematic review. *Am J Prev Med*. 2013;45(4):462–473. doi:10.1016/j.amepre.2013.06.009.
47. D'Angelo H, Fleischhacker S, Rose SW, Ribisl KM. Field validation of secondary data sources for enumerating retail tobacco outlets in a state without tobacco outlet licensing. *Health Place*. 2014;28:38–44. doi:10.1016/j.healthplace.2014.03.006.
48. U.S. Census Bureau. Documentation—Subject Definitions. 2013. www.census.gov/acs/www/data_documentation/documentation_main/. Accessed March 19, 2013.
49. DeMaio TJ, Bates N, O'Connell M. Exploring measurement error issues in reporting of same-sex couples. *Public Opin Q*. 2013;77(S1):145–158. doi:10.1093/poq/nfs066.
50. U.S. Census Bureau. Census Bureau Releases Estimates of Same-Sex Married Couples. 2011. www.census.gov/newsroom/releases/archives/2010_census/cb11-cn181.html. Accessed April 30, 2013.
51. Gates GJ. Census snapshot: 2010 methodology: Adjustment procedures for same-sex couple data. n.d. http://williamsinstitute.law.ucla.edu/wp-content/uploads/Census2010-Snapshot-Adjustment-Procedures.pdf. Accessed July 20, 2013.

52. Social Explorer. *Social Explorer Tables: Census 2010*. 2013. www.socialexplorer.com/pub/reportdata/HtmlResults.aspx?reportid=R10561965. Accessed October 5, 2013.
53. Social Explorer. *Social Explorer Tables: ACS 2008 to 2012 (5-Year Estimates)*. 2014. www.socialexplorer.com/pub/reportdata/HtmlResults.aspx?reportid=R10774222. Accessed August 17, 2014.
54. U.S. Census Bureau. *Local Census Statistical Areas Committees and Other Local Assistance. Geographic Areas Reference Manual*. Washington, DC: U. S. Department of Commerce, Economics and Statistics Administration, Bureau of the Census; 1994:3-1 to 3-14.
55. Rose SW, Myers AE, D'Angelo H, Ribisl KM. Retailer adherence to Family Smoking Prevention and Tobacco Control Act, North Carolina, 2011. *Prev Chronic Dis*. 2013;10(4):E47. doi:10.5888/pcd10.120184.
56. Bureau of Transportation Statistics. U.S. National Transportation Atlas Interstate Highways. 2012. http://search.lib.unc.edu/search?R=UNCb7261593. Accessed November 14, 2014.
57. USDA. Rural-Urban Continuum Codes. 2013. www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx. Accessed November 14, 2014.
58. Cromley EK, McLafferty SL. *GIS and Public Health*. New York, NY: Guilford Press; 2012.
59. Jenks GF. The data model concept in statistical mapping. In: Frenzel K, ed. *International yearbook of cartography*. London, UK: G. Philip; 1967:186–190.
60. Fotheringham AS, Rogerson PA. GIS and spatial analytical problems. *Int J Geogr Inf Sci*. 1993;7(1):3–19. doi:10.1080/02693799308901936.
61. Rugh JS, Massey DS. Segregation in post-civil rights American: Stalled integration or end of the segregated century? [published online ahead of print October 31, 2013]. *Du Bois Rev*. 2013. doi:10.1017/S1742058X13000180.
62. Rose G. *The Strategy of Preventive Medicine*. Oxford, UK: Oxford University Press; 1993.
63. Usher JM, Evans MG. Life and death along gasoline alley: Darwinian and Lamarckian processes in a differentiating population. *Acad Manage J*. 1996;39(5):1428–1466. doi:http://www.jstor.org/stable/257004.
64. Eisenhauer E. In poor health: supermarket redlining and urban nutrition. *GeoJournal*. 2001;53(2):125–133. doi:10.1023/A:1015772503007.
65. Alwitt LF, Donley TD. Retail stores in poor urban neighborhoods. *J Consum Aff*. 1997;31(1):139–164. doi:10.1111/j.1745–6606.1997.tb00830.x.
66. Morland K, Wing S, Diez Roux A, Poole C. Neighborhood characteristics associated with the location of food stores and food service places. *Am J Prev Med*. 2002;22(1):23–29. doi:10.1016/s0749-3797(01)00403-2.
67. Gates GJ. LGBT Parenting in the United States. 2013. http://williamsinstitute.law.ucla.edu/wp-content/uploads/LGBT-Parenting.pdf. Accessed November 14, 2014.
68. Otis MD. Perceptions of victimization risk and fear of crime among lesbians and gay men. *J Interpers Violence*. 2007;22(2):198–217. doi:10.1177/0886260506295346.
69. Meyer D, Grollman EA. Sexual orientation and fear at night: gender differences among sexual minorities and heterosexuals. *J Homosex*. 2014;61(4):453–470. doi:10.1080/00918369.2013.834212.
70. Schmitt ED. Discrimination versus specialization: a survey of economic studies on sexual orientation, gender and earnings in the United States. *J Lesbian Stud*. 2008;12(1):17–30. doi:10.1300/10894160802174250.
71. Tilcsik A. Pride and prejudice: employment discrimination against openly gay men in the United States. *AJS*. 2011;117(2):586–626. doi:10.1086/661653.
72. Klawitter M. Multilevel analysis of the effects of antidiscrimination policies on earnings by sexual orientation. *J Policy Anal Manage*. 2011;30(2):334–358. doi:10.1002/pam.20563.
73. Pedulla DS. The positive consequences of negative stereotypes: race, sexual orientation, and the job application process. *Soc Psychol Q*. 2014;77(1):75–94. doi:10.1177/0190272513506229.
74. Badgett MVL. Beyond biased samples: challenging the myths on the economic status of lesbians and gay men. In: Gluckman A, Reed B, eds. *Homo Economics*. New York, NY: Routledge; 1997:65–72.
75. Castells M. *The City and the Grassroots: A Cross-Cultural Theory of Urban Social Movements*. Berkeley, CA: University of California Press; 1983.
76. Collins A. Sexual dissidence, enterprise and assimilation: Bedfellows in urban regeneration. *Urban Stud*. 2004;41(9):1789–1806. doi:10.1080/0042098042000243156.
77. Ruting B. Economic transformations of gay urban spaces: revisiting Collins' evolutionary gay district model. *Aust Geogr*. 2008;39(3):259–269. doi:10.1080/00049180802270465.
78. Podmore JA. Gone 'underground'? Lesbian visibility and the consolidation of queer space in Montréal. *Soc Cult Geogr*. 2006;7(4):595–625. doi:10.1080/14649360600825737.
79. Valentine G. Out and about: geographies of lesbian landscapes. *Int J Urban Reg Res*. 1995;19(1):96–111. doi:10.1111/j.1468–2427.1995.tb00492.x
80. Annes A, Redlin M. Coming out and coming back: rural gay migration and the city. *J Rural Stud*. 2012;28(1):56–68. doi:10.1016/j.jrurstud.2011.08.005.
81. Kirkey K, Forsyth A. Men in the valley: gay male life on the suburban-rural fringe. *J Rural Stud*. 2001;17(4):421–441. doi:10.1016/S0743-0167(01)00007-9.
82. Lynch FR. Non-ghetto gays: a sociological study of suburban homosexuals. *J. Homosex*. 1987;13(4):13–42. doi:10.1300/J082v13n04_02.
83. Lewis NM. Remapping disclosure: gay men's segmented journeys of moving out and coming out. *Soc Cult Geogr*. 2012;13(3):211–231. doi:10.1080/14649365.2012.677469.
84. Heck JE, Jacobson JS. Asthma diagnosis among individuals in same-sex relationships. *J Asthma*. 2006;43(8):579–584. doi:J4VWTH3200H50U72.
85. U.S. Census Bureau. Census Bureau Releases Estimates of Undercount and Overcount in the 2010 Census. 2012. www.census.gov/newsroom/releases/archives/2010_census/cb12-95.html. Accessed December 5, 2014.
86. Shareck M, Kestens Y, Frohlich KL. Moving beyond the residential neighborhood to explore social inequalities in exposure to area-level disadvantage: results from the Interdisciplinary Study on Inequalities in Smoking. *Soc Sci Med*. 2014;108:106–114. doi:10.1016/j.socscimed.2014.02.044.
87. Ghaziani A. *There Goes the Gayborhood?* Princeton, NJ: Princeton University Press; 2014.
88. Hill S, Amos A, Clifford D, Platt S. Impact of tobacco control interventions on socioeconomic inequalities in smoking: review of the evidence. *Tob Control*. 2014;23(e2):e89–e97. doi:10.1136/tobaccocontrol-2013-051110.
89. Ashe M, Jernigan D, Kline R, Galaz R. Government, politics, and law. Land use planning and the control of alcohol, tobacco, firearms, and fast food restaurants. *Amer J Public Health*. 2003;93(9):1404–1408. doi:10.2105/AJPH.93.9.1404.
90. Coxe N, Webber W, Burkhart J, et al. Use of tobacco retail permitting to reduce youth access and exposure to tobacco in Santa Clara County, California. *Prev Med*. 2014. 67(suppl 1):S46–550. doi:10.1016/j.ypmed.2014.01.023.
91. Public Health Law Center. Land Use/Zoning. 2010. http://publichealthlawcenter.org/topics/tobacco-control/land-usezoning. Accessed November 12, 2014.