Published in final edited form as:

Sex Transm Dis. 2018 February ; 45(2): 81–86. doi:10.1097/OLQ.0000000000000692.

The Spatial Association Between Federally Qualified Health Centers and County-Level Reported Sexually Transmitted Infections: A Spatial Regression Approach

Kwame Owusu-Edusei Jr., PhD, Thomas L. Gift, PhD, Jami S. Leichliter, PhD, Raul A. Romaguera, DMD

Centers for Disease Control Prevention, Atlanta, GA

Abstract

Background: The number of categorical sexually transmitted disease (STD) clinics is declining in the United States. Federally qualified health centers (FQHCs) have the potential to supplement the needed sexually transmitted infection (STI) services. In this study, we describe the spatial distribution of FQHC sites and determine if reported county-level nonviral STI morbidity were associated with having FQHC(s) using spatial regression techniques.

Methods: We extracted map data from the Health Resources and Services Administration data warehouse on FQHCs (ie, geocoded health care service delivery [HCSD] sites) and extracted county-level data on the reported rates of chlamydia, gonorrhea and, primary and secondary (P&S) syphilis (2008–2012) from surveillance data. A 3-equation seemingly unrelated regression estimation procedure (with a spatial regression specification that controlled for county-level multiyear (2008–2012) demographic and socioeconomic factors) was used to determine the association between reported county-level STI morbidity and HCSD sites.

Results: Counties with HCSD sites had higher STI, poverty, unemployment, and violent crime rates than counties with no HCSD sites ($P < 0.05$). The number of HCSD sites was associated ($P < 0.01$) with increases in the temporally smoothed rates of chlamydia, gonorrhea, and P&S syphilis, but there was no significant association between the number of HCSD per 100,000 population and reported STI rates.

Conclusions: There is a positive association between STI morbidity and the number of HCSD sites; however, this association does not exist when adjusting by population size. Further work may determine the extent to which HCSD sites can meet unmet needs for safety net STI services.

Chlamydia, gonorrhea, and syphilis are the most commonly reported curable sexually transmitted infections (STIs) in the United States (US),^{1,2} costing over \$750 million (2015 US dollars) in annual lifetime cost altogether.³ One of the effective ways to break

---

Correspondence: Kwame Owusu-Edusei Jr., PhD, Program and Performance Improvement Office Centers for Disease Control and Prevention 1600, Clifton Road, MS E-07, Atlanta, GA 30329. Kowusuedusei@cdc.gov.

Publisher's Disclaimer: Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the United States Centers for Disease Control and Prevention (CDC). Mention of company names or products does not imply endorsement by CDC.

Conflict of interest and sources of funding: None declared.

transmission of these bacterial STIs is early detection and treatment. Early detection and treatment require the availability of (and access to) STI services. Traditionally, sexually transmitted disease (STD) clinics have played a major role in the control and prevention of STIs through the provision of diagnostic and treatment services.^{4,5} However, recent studies have reported substantial decline in the number of categorical STD clinics in the last decade due primarily to budget reductions at both the federal and state levels.^{6,7} This decline in the number of STD clinics has contributed—in part—to the declining proportion of the overall number of chlamydia, gonorrhea and syphilis cases reported by STD clinics to the US Centers for Disease Control and Prevention.⁸

The Congressional Budget Office has estimated that, under current law, 9% to 10% of the nonelderly population will remain uninsured through 2025.⁹ Thus, it is important to consider availability of safety net STI services in the US. Additionally, from 2002 to 2006 to 2010, receipt of STI services among US women increased among most subpopulations with the exception of uninsured women (and adolescents).¹⁰ Given the number of uninsured persons and fewer STD clinics providing needed safety net STI services, it is especially important to assess the role of potential providers of safety net STI services in various jurisdictions who can aid in the control and prevention of STIs.

Federally qualified health centers (FQHCs) are nonprofit private or public entities that provide comprehensive primary care services to designated medically underserved populations or geographic areas. The FQHCs are required by statute to provide primary care and preventive services, including screening for communicable diseases.¹¹ Additionally, FQHCs offer a sliding fee scale and qualify for enhanced reimbursement from Medicare and Medicaid.¹¹ Given their geographic coverage across the US and the services they offer, it has been suggested that FQHCs might have the potential to expand access to STI services (testing and treatment) to complement existing categorical STI service providers, particularly in under-served areas. However, studies on the spatial distribution of FQHCs in relation to the burden of STIs are lacking. In this study, we sought to describe the spatial distribution of FQHCs and to determine if reported county-level nonviral STI morbidity (chlamydia, gonorrhea and syphilis) were associated with having FQHC(s) using spatial regression techniques.

We chose county-level geographic units for two major reasons. First, STI morbidity data are not publicly available below county geographic units (such as census blocks, census tracts and cities). Thus, using county-level data makes our study/analyses replicable. Second, the number and spatial distribution of FQHCs (~9000) compared with the number of counties (~3000) permitted using a simpler easily operationalizable measure of spatial relationship (ie, point features [FQHCs] within polygon features [counties]), especially, given that we were doing this from a national perspective.

METHODS

Study Design

We designed a multiyear cross-sectional study that examined the spatial association between reported county-level nonviral STI morbidity and the existence of FQHC(s) using spatial regression techniques.

Data

For the purpose of this study, we focused on only the counties in the 48 contiguous states in the US. To obtain complete spatial data on the FQHCs (ie, geocoded health care service delivery [HCSD] sites), we connected to the Health Resources and Service Administration (HRSA) map service server using their ArcCatalog configuration specifications.¹² This process allowed us to identify all the FQHCs in the database in 2014 (hereafter referred to as HCSD sites) found in each county in the 48 contiguous states. Because we were interested in service delivery sites that could potentially expand access to STI services, we dropped HCSD site types that were “administrative” only (ie, we focused on those that were “administrative/service delivery” or “service delivery”). We also dropped HCSD sites with location setting descriptions that were categorized as “domestic violence” or “nursing home.” Our final analyses included 8798 unique HCSDs in the contiguous 48 states (out of a grand total of 9730 extracted from the HSRA data warehouse¹²). Next we determined two variables of interest—(1) the number of unique HCSD sites found in each county and (2) the number of unique HCSD sites per 100,000 county residents. We created a choropleth map of the number of unique HCSD sites found in each county (Fig. 1A).

Next, we obtained county-level annual reported chlamydia, gonorrhea, and primary and secondary (P&S) syphilis rates (all ages and sexes) from the surveillance data for 2008 to 2012 and computed temporally smoothed rates for each county. The temporally smoothed rates were calculated as the sum of cases for each disease over the 5-year period analyzed divided by the sum of the resident population across the same time frame, and then multiplied by 100,000.^{13–15} Figures 1B–D represent choropleth maps of the temporally smoothed chlamydia, gonorrhea, and syphilis rates, respectively. We used temporally smoothed rates for the years selected for 3 reasons. First, population estimates for years close to the decennial census population counts (ie, 2010 in this case) are more accurate. Second, they reduced the small population problem that might be associated with small counties and provide a more representative measure of the burden of the disease over time.^{14,16} Finally, the demographic and socioeconomic variables that are available for all the counties in the US for the years we analyzed—which has increased statistical reliability for small areas/populations¹⁷—were the 5-year estimates provided by the American Community Surveys from [Census.gov](https://www.census.gov).¹⁸

Based on previously published studies,^{5,13–16,19,20} we extracted select county-level demographic and socioeconomic variables from [Census.gov](https://www.census.gov). The control variables included percent black, percent white (referent race category), percent Hispanic, percent American Indian, percent American Asian, percent unemployed, percent aged 18 to 24 years, percent aged 25 to 44 years, percent completing high school, percent with a bachelor’s degree, per

capita and median household incomes, birth rate, population density, male-female population ratio, and a commute index (ie, percent with > 1 hour commute time; this was included to differentiate counties with a larger proportion of workers who traveled a relatively large distance for work from counties where workers' places of employment were close to where they lived).^{5,13,16} We included the 2013 rural-urban continuum codes developed by the United States Department of Agriculture—Economic Research Services as a categorical variable to differentiate rural-urban counties according to their degree of urbanicity and proximity to metropolitan areas.²¹ We also examined metro/nonmetro as a dichotomous variable (designating the USDA codes 1–3 as metro with the others designated as nonmetro). We compared the means of all the continuous variables in counties with and without HCSD sites and assessed statistical significance using *t* tests and large-sample tests for equality of proportions.

Spatial Regression Analysis

We also conducted a multivariate analysis of the potential association between county-level STI morbidity and HCSD sites. We used a mixed log-log/semi-log spatial regression technique (specifically, the spatial error model [SEM]) to account for spatial autocorrelation/dependence in a state-specific fixed-effect specification (after a Hausman test confirmed that the fixed-effect models were superior to the random effects model²²). However, because some counties had no reported cases of the STIs analyzed (especially for syphilis), and some counties had no HCSD sites, we added 1 to the calculated smoothed case rates for each STI and the number of HCSD sites.^{14,23} The resulting smoothed case rates and number of HCSD sites were then transformed into natural logs.^{14,16,23} We also transformed the median household income, birth rate, population density, and male-female population ratio into natural logs. Based on these transformations, the resulting coefficients were converted as (coefficient $\times$ 100) and interpreted as the percentage change in the smoothed rates for a percent change in the continuous independent variables and as $(\exp^{\text{coefficient}} - 1) \times 100$ for the logs. Due to high multicollinearity, we dropped per capita income, percent below the poverty line, proportion uninsured, and proportion with bachelor's degree in the spatial regressions.¹⁴ Also, because of unavailable data from 2 large states (Illinois and Florida), we did not include the crime rate in the spatial regressions. Our final model was informed—for the most part—by several previously published STI ecological analyses studies that used spatial regression techniques.^{5,13–16,25}

We also used the variance inflation factor as a guide to reduce multicollinearity among the numerous control variables.²⁶ Because the 3 nonviral STIs (chlamydia, gonorrhea and syphilis) are closely related, our final regression analyses involved a 3-equation seemingly unrelated regression estimation (SURE) procedure.^{16,27} The SURE procedure estimated all 3 equations simultaneously accounting for the correlated errors at the same time and provided more efficient estimates of the coefficients and standard errors. GeoDa version 0.9.5-I²⁸ was used to create spatial lags for preliminary spatial regression analyses. Because we were examining infectious/contagious processes, we used first-order Queen Contiguity weights.²⁹ We used ArcMap version 10.3 (ESRI Redland, CA) for mapping the number of unique HCSD sites found in each county and for creating the choropleth maps for all the STIs. We

used STATA version 11.2 (StataCorp LP, College Station, Texas) for all statistical analyses, including diagnostics and result validation.

RESULTS

Based on the spatial data on HCSD sites that we extracted from the HRSA data warehouse, we found no HCSD sites in 43% ($n = 1329$) of the counties in the 48 contiguous states. Most of the counties without any HCSD sites were found in the Midwestern (North and South Dakota, Minnesota, Nebraska, Iowa, and Kansas) and Southern (Oklahoma and Texas) regions (Fig. 1A). On the other hand, the top 10 counties with the largest number of unique HCSD sites included Los Angeles County, California ($n = 312$), Cook County, Illinois ($n = 247$), Dade County, Florida ($n = 153$), New York County, New York ($n = 119$), San Diego County, California ($n = 118$), Alameda County, California ($n = 117$), Kings County, New York ($n = 96$), King County, Washington ($n = 93$), Bronx County, New York ($n = 84$), and Suffolk County, Massachusetts ($n = 81$). However, when we sorted the counties by the number of HCSD sites per 100,000 residents, none of the top 10 with the largest number of HCSD sites described above was in the first 50.

In bivariate analysis, counties with HCSD sites had higher STI, poverty, unemployment, and violent crime rates, as well as lower per capita income and median household income than counties with no HCSD sites (differences significant at $P < 0.05$ or lower, Table 1). The population density of counties with HCSD sites and the proportion of the population that was other than white non-Hispanic were higher than that in counties with no HCSD sites ($P < 0.01$). Many of these differences between counties with HCSD sites and with no HCSD sites persisted and were statistically significant when considering metro and nonmetro counties separately (not shown).

Spatial regression

The summary results from our 3-equation SURE spatial regression analyses are presented in Table 2. The multicollinearity check was within the recommended limit of 10—the highest variance inflation factor was 5.69 (mean = 2.42) for all disease models. The spatial error lag was also significant ($P < 0.01$) for each disease model, implying that spatial dependence was fairly accounted for in the regression.^{14–16,28,30} The estimated r -squares were at least 60%. This implies that at least 60% of the variations in the transformed total incidence rates for all 3 diseases were explained by the variations in the control variables included in the regression. Additionally, the signs of the coefficients were consistent with previous studies (Table 2).^{13–16,20,25,31}

When we included the log of the number of HCSD sites, the resulting coefficients showed that the transformed temporally smoothed rates were significantly (and positively) associated with county-level STI morbidity. The results show that—on average—a 1% increase in the number of HCSD sites was associated with a 3% ($P < 0.01$) increase in the temporally smoothed rate of chlamydia, 6% ($P < 0.01$) increase in the temporally smoothed rate of gonorrhea and 8% ($P < 0.01$) increase in the temporally smoothed rate of P&S syphilis. However, when we replaced the log of the number of HCSD sites with the log of

number of HCSD sites per 100,000 residents, the resulting coefficients were not statistically significant in any of the disease models (results not shown).

DISCUSSION

In this study, we described the spatial distribution of HCSD sites in relation to the morbidity of 3 nonviral STIs (chlamydia, gonorrhea and syphilis) and determined the association between HCSD sites and STI morbidity at the county level while controlling for demographic and socioeconomic factors. Our results indicate significant association between county-level reported chlamydia, gonorrhea and syphilis morbidity rates, and the number of HCSD sites. Although this could indicate a higher diagnosis rate due to improved access to screening and other STD services, when we replaced the number of HCSD sites with the number of HCSD sites per 100,000 population, there was no association. This suggests that in terms of the number of HCSD sites per capita, the number (and potentially the availability) of HCSD sites was not higher in high-morbidity areas. An increase in the number of sites in high-morbidity areas (and thus an increase in the number of sites per 100,000 population) could improve access for patients, but more data would be needed to determine the relationship between the number of HCSD sites per 100,000 population and access.

As previously highlighted, the need for safety net STI services is expected to remain because of lack of insurance, the desire for confidential services, and other reasons.³² One study estimated that over 4.5 million persons will require safety net STI clinical services in 2023 at a cost of over US \$150 million.³³ Across jurisdictions, providers of safety net STI services include STD clinics, public clinics, family planning clinics, and FQHCs.³³ With the closure of several STD clinics, public health officials and practitioners are tasked with identifying appropriate safety net STI services to reduce further transmission of STIs.

Our study has several limitations that are noteworthy. Notable among them is the usual limitation associated with STI surveillance data: reported cases do not necessarily match true morbidity because of the asymptomatic nature of STIs, relatively low screening coverage, and incomplete reporting.^{1,2} Also, we found some cases that were assigned to missing or unknown counties.² Reporting practices may vary between states and between jurisdictions within states; therefore, there may be varying levels of underreporting for some jurisdictions, and the degree of underreporting might vary by jurisdiction and/or race. Screening rates may vary across states, which would also impact reported STI rates.³⁴ Another factor is that STI rates may be impacted by the number of HCSD sites in the county, which would impact the coefficients in the regression equations.

Although it would be too strong to say that we assumed all HCSD sites have the same capacity in terms of the number of patient visits that can be accommodated, these analyses did implicitly assume that increasing numbers of sites implied increasing capacity (on either a raw number or per capita basis). That is not necessarily true because HCSD sites may vary. Our analyses also assumed that the presence of a HCSD site implies physical access (close proximity) by all (safety net) STI patients within the county. This is not realistic given that some counties are very large and the available HCSD sites might be several miles away. Also, we did not explicitly account for cross-county service access/availability—there are

several HCSD sites that might be physically accessible to residents in contiguous/adjoining counties.⁵ This limitation is primarily the result of the scale at which this study was done—county-level for all 48 contiguous states. Finer/smaller scale analysis (census block or city-level) would provide more detailed information and help to minimize the limitation due to the scale of the analyses. However, because we corrected for spatial dependence, this problem was reduced somewhat. Finally, our study did not account for spatial heterogeneity (ie, parameter coefficients were not allowed to vary by region or state^{14,28,30}) in our spatial regression analyses. Nonetheless, we used a state-specific fixed-effect estimation procedure, which—to some extent—reduced the impact of this limitation on our results.^{14,15}

Conclusions

Even with all the limitations outlined above, our study provides essential information on the geographic distribution of the HCSD sites in all the 48 contiguous states and their association with chlamydia, gonorrhea, and syphilis rates. The association between STI morbidity and HCSD sites disappeared when we adjusted for population—this suggests that the existing FQHC infrastructure may not be sufficient to provide all STD safety net services needed in some jurisdictions. The results from this study can provide useful information for local public health officials considering alternative safety net STI service providers within their jurisdictions. Given that the scale at which we conducted this study might have resulted in the loss of important physical accessibility information, future studies may improve upon these estimates by examining the association between STI morbidity and the availability of HCSD sites at smaller subcounty levels. Determining the magnitude of the unmet need for safety net STI services and the ability of the existing HCSD sites to meet that need is an important area for further work.

REFERENCES

1. Satterwhite CL, Torrone E, Meites E, et al. Sexually transmitted infections among US women and men: Prevalence and incidence estimates, 2008. *Sex Transm Dis* 2013; 40:187–193. [PubMed: 23403598]
2. Centers for Disease Control and Prevention. Sexually transmitted disease surveillance, 2015. Atlanta, GA: U.S. Department of Health and Human Services; 2016.
3. Owusu-Edusei K Jr., Chesson HW, Gift TL, et al. The estimated direct medical cost of selected sexually transmitted infections in the United States, 2008. *Sex Transm Dis* 2013; 40:197–201. [PubMed: 23403600]
4. Chorba T, Scholes D, BlueSpruce J, et al. Sexually transmitted diseases and managed care: an inquiry and review of issues affecting service delivery. *Am J Med Qual* 2004; 19:145–156. [PubMed: 15368779]
5. Owusu-Edusei K Jr, Doshi SR. Assessing spatial gaps in sexually transmissible infection services and morbidity: An illustration with Texas county-level data from 2007. *Sex Health* 2012; 9:334–340. [PubMed: 22877592]
6. Fact Sheet: STD program capacity and preparedness in the United States: Results of a National Survey, 2009 National Coalition of STD Directors, 2011 Available at: http://www.ncsddc.org/sites/default/files/fact_sheet_std_program_capacity_and_preparedness_in_the_united_states_results_of_a_national_survey_2009.pdf. Accessed August 8, 2017.
7. Golden MR, Kerndt PR. Improving clinical operations: Can we and should we save our STD clinics? *Sex Transm Dis* 2010; 37:264–265. [PubMed: 20182405]

8. Owusu-Edusei K, Sayegh BJ, Harvey AJ, et al. Declining trends in the proportion of non-viral sexually transmissible infections reported by STD clinics in the US, 2000–10. *Sex Health* 2014; 11:340–344. [PubMed: 25131645]
9. Effects of the Affordable Care Act on Health Insurance Coverage—Baseline Projections. Congressional Budget Office, 2015 (Accessed February 10, 2016, at <https://www.cbo.gov/publication/43900>).
10. Haderxhanaj LT, Gift TL, Loosier PS, et al. Trends in receipt of sexually transmitted disease services among women 15 to 44 years old in the United States, 2002 to 2006–2010. *Sex Transm Dis* 2014; 41: 67–73. [PubMed: 24335746]
11. What are Federally Qualified Health Centers (FQHCs)? Health Resources and Services Administration, 2015 (Accessed June 12, 2015, at <http://www.hrsa.gov/healthit/toolbox/RuralHealthITtoolbox/Introduction/qualified.html>).
12. Connect to HDW Map Data with ArcCatalog. Health Resources and Services Administration, 2015 (Accessed June 12, 2015, at <http://datawarehouse.hrsa.gov/data/dataservices/arccatalogconnection.aspx>).
13. Owusu-Edusei K Jr, Doshi SR. County-level sexually transmitted disease detection and control in Texas: Do sexually transmitted diseases and family planning clinics matter? *Sex Transm Dis* 2011; 38: 970–975. [PubMed: 21934575]
14. Owusu-Edusei K Jr., Chesson HW, Leichliter JS, et al. The association between racial disparity in income and reported sexually transmitted infections. *Am J Public Health* 2013; 103:910–916. [PubMed: 23488482]
15. Chang BA, Pearson WS, Owusu-Edusei K Jr. Correlates of county-level nonviral sexually transmitted infection hot spots in the US: Application of hot spot analysis and spatial logistic regression. *Ann Epidemiol* 2017; 27:231–237. [PubMed: 28302356]
16. Owusu-Edusei K Jr, Chesson HW. Using spatial regression methods to examine the association between county-level racial/ethnic composition and reported cases of chlamydia and gonorrhea: An illustration with data from the state of Texas. *Sex Transm Dis* 2009; 36:657–664. [PubMed: 19734821]
17. A Compass for Understanding and Using American Community Survey Data: What General Data Users Need to Know. United States Census Bureau; 2008 Available at: <https://www.census.gov/content/dam/Census/library/publications/2008/acs/ACSGeneralHandbook.pdf>. Accessed August 8, 2017.
18. American FactFinder: 2008–2012 American Community Survey. United States Census Bureau's American Community Survey Office. 2015.
19. Chesson HW, Sternberg M, Leichliter JS, et al. The distribution of chlamydia, gonorrhoea and syphilis cases across states and counties in the USA, 2007. *Sex Transm Infect* 2010; 86 Suppl 3: iii52–iii57. [PubMed: 21098057]
20. Kilmarx PH, Zaidi AA, Thomas JC, et al. Sociodemographic factors and the variation in syphilis rates among US counties, 1984 through 1993: An ecological analysis. *Am J Public Health* 1997; 87:1937–1943. [PubMed: 9431280]
21. Rural Urban Continuum. 2013 (Accessed February 10, 2016, at <http://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx>).
22. Greene WH. *Econometric Analysis*. 4 ed Upper Saddle River, New Jersey: Prentice-Hall, 2003.
23. van Belle G, Heagerty PJ, Fisher LD, et al. *Biostatistics: A methodology for the health sciences*. 2nd ed New York: Wiley-Interscience, 2004.
24. Kennedy P *A guide to econometrics*. 6 ed Malden, Massachussets: Blackwell Publishing, 2008.
25. Chesson H, Owusu-Edusei K Jr. Examining the impact of federally-funded syphilis elimination activities in the USA. *Soc Sci Med* 2008; 67:2059–2062. [PubMed: 18952341]
26. Belsley DA, Kuh E, Welsch RE. *Regression Diagnostics*. New York: John Wiley & Sons, 1980.
27. Zellner A An efficient method for estimating seemingly unrelated regressions and tests of aggregation bias. *J Am Stat Assoc* 1962; 28:977–992.
28. Anselin L, Syabri I, Kho Y. *GeoDa: An introduction to spatial data analysis*. *Geogr Anal* 2006; 38:5–22.

29. Modeling spatial relationships. Environmental Systems Research Institute (ESRI) Inc., 2016 (Accessed February 2, 2017, at <http://resources.arcgis.com/en/help/main/10.1/index.html#//005p0000000500000000>).
30. Econometric Toolbox. 2010 (Accessed 21 January 2016, 2016, at www.spatial-econometrics.com).
31. Semaan S, Sternberg M, Zaidi A, et al. Social capital and rates of gonorrhea and syphilis in the United States: spatial regression analyses of state-level associations. *Soc Sci Med* 2007; 64:2324–2341. [PubMed: 17400352]
32. Cramer R, Leichter JS, Gift TL. Are safety net sexually transmitted disease clinical and preventive services still needed in a changing health care system? *Sex Transm Dis* 2014; 41:628–630. [PubMed: 25211261]
33. Gift TL, Haderxhanaj LT, Torrone EA, et al. Estimating the size and cost of the STD prevention services safety net. *Public Health Rep* 2015; 130:602–609. [PubMed: 26556931]
34. Tao G, Patel CG. State variation in enrollment gap, sexual activity, and chlamydia testing rate among young medicaid women. *Sex Transm Dis* 2016; 43:595–598. [PubMed: 27626186]

Figure 1. County-level choropleth maps of the number of HCSD sites and sexually transmitted infections. A, HCSD sites, 2014. B, Temporally smoothed chlamydia rate, 2008–2012. C, Temporally smoothed gonorrhea rate, 2008–2012. D, Temporally smoothed P&S syphilis rate (2008–2012).

TABLE 1.
Means and 95% Confidence Intervals for Continuous Variables in Counties With and Without HCSDs

Variables	Counties With HCSD (n = 1778)			Counties With No HCSD (n = 1329)		
	Mean	95% CI		Mean	95% CI	
CT rate	371.74	359.29	384.19	232.26	222.07	242.46
GC rate	82.07	77.52	86.63	37.67	34.53	40.80
P&S rate	2.22	2.03	2.41	0.87	0.72	1.02
Proportion white, non-Hispanic	0.81	0.79	0.82	0.89	0.88	0.91
Proportion black, non-Hispanic	0.12	0.10	0.13	0.05	0.04	0.07
Proportion Hispanic	0.10	0.08	0.11	0.07	0.05	0.08
Proportion Asian	0.01	0.01	0.02	0.01	0.00	0.01
Proportion American Indian/Alaskan Native	0.02	0.01	0.02	0.02	0.01	0.02
Proportion native Hawaiian	0.00	0.00	0.00	0.00	0.00	0.00
Proportion aged 18–24 y	0.09	0.08	0.11	0.08	0.07	0.10
Proportion aged 25–44 y	0.31	0.29	0.33	0.29	0.27	0.32
Median HH income	44984	44396	45572	46082	45519	46644
Per capita income	23055	22779	23330	23636	23381	23892
Violent crime rate	1.85	1.82	1.88	1.60	1.56	1.64
Population density	391.12	282.33	499.92	89.54	69.17	109.91
Male to female ratio	0.9948	0.9902	0.9993	1.0156	1.0083	1.0228
Birth rate	56.72	56.86	57.57	58.11	56.86	59.37
Unemployment rate	0.10	0.08	0.11	0.07	0.06	0.09
Proportion below poverty line	0.18	0.16	0.19	0.15	0.13	0.17
Proportion uninsured	0.16	0.14	0.17	0.14	0.12	0.16
Proportion completing high school	0.83	0.81	0.85	0.85	0.83	0.87
Proportion with bachelor's degree	0.20	0.18	0.22	0.19	0.17	0.21
Proportion commuting >1 h	0.08	0.06	0.09	0.07	0.06	0.09

* *P*-values determined using *t* tests for continuous variables, such as disease rates, and large-sample proportion tests of significance for percentage variables, such as the proportional race/ethnicity variables.

CT, chlamydia; GC, gonorrhea; HH, household; H, high; L, low.

TABLE 2.

Summary Spatial Regression Analyses Results: Dependent Variables Were the Logs of the Transformed Smoothed Rates From 2008 to 2012 (n = 3070) *

Variables	Chlamydia		Gonorrhea		P&S Syphilis	
	β (95% CI)	z	β (95% CI)	z	β (95% CI)	z
Log of HCCs	0.03 (0.01–0.05) [†]	2.91	0.06 (0.03–0.09) [†]	3.75	0.08(0.06–0.11) [†]	5.58
Percent unemployed	0.01 (0–0.02) [†]	2.85	0.01 (0–0.02)	1.57	–0.01 (–0.02 to 0) [†]	–2.71
Percent Black	0.03 (0.02–0.03) [†]	34.37	0.05 (0.04–0.05) [†]	25.00	0.02 (0.02–0.02) [†]	20.25
Percent Hispanic	0.01 (0.01–0.01) [†]	9.67	0.01 (0–0.01) [†]	3.56	0 (0–0)	0.18
Percent Asian	–0.02 (–0.03 to 0) [†]	–2.39	–0.01 (–0.03 to 0.01)	–1.03	0.01 (0–0.03) [§]	1.70
Percent American Indian	0.03 (0.02–0.03) [†]	12.18	0.04 (0.03–0.05) [†]	11.59	0 (0–0.01) [†]	2.29
Percent Native Hawaiian	0.23 (0.11–0.35) [†]	3.76	0.24 (0.06–0.41) [†]	2.64	–0.01 (–0.15 to 0.12)	–0.16
Percent aged 18–24	0.03 (0.02–0.03) [†]	7.61	0.02 (0.01–0.03) [†]	3.65	0.01 (0–0.01) [†]	3.18
Percent aged 25–44	0.02 (0.01–0.03) [†]	3.10	0.01 (0–0.03) [§]	1.92	0.01 (0–0.01) [§]	1.66
Percent completing high school	0.01 (0–0.01) [†]	2.06	0.01 (0–0.02)	1.65	0.01 (0–0.01) [†]	2.52
Percent commuting over 1 h	–0.01 (–0.01 to 0) [†]	–5.19	–0.01 (–0.02 to –0.01) [†]	–4.16	0 (–0.01 to 0)	–1.41
Log of median household income	–0.28 (–0.44 to –0.12) [†]	–3.52	–0.28 (–0.47 to –0.09) [†]	–2.93	–0.12 (–0.25 to 0.02)	–1.62
Log of birth rate	0.05 (–0.02 to 0.13)	1.40	–0.03 (–0.13 to 0.06)	–0.72	0 (–0.05 to 0.05)	0.12
Log of population density	0.12 (0.09–0.15) [†]	8.11	0.26 (0.21–0.3) [†]	12.24	0.13 (0.1–0.15) [†]	10.30
Log of male to female ratio	–0.72 (–1.13 to –0.32) [†]	–3.49	–0.68 (–1.11 to –0.24)	–3.05	–0.14 (–0.38 to 0.1)	–1.14
Rural urban continuum code						
2	0.1 (0.05–0.15) [†]	4.22	0.17 (0.07–0.27) [†]	3.62	–0.09 (–0.14 to –0.02) [†]	–2.63
3	0.21 (0.15–0.25) [†]	10.38	0.33 (0.21–0.42) [†]	8.16	–0.1 (–0.17 to –0.03) [†]	–2.71
4	0.19 (0.11–0.27) [†]	5.25	0.22 (0.11–0.33) [†]	4.56	–0.12 (–0.18 to –0.07) [†]	–4.77
5	0.29 (0.17–0.4) [†]	5.73	0.31 (0.11–0.53) [†]	3.30	–0.19 (–0.31 to –0.1) [†]	–4.15
6	0.14 (0.08–0.19) [†]	5.58	0.04 (–0.03 to 0.12)	1.17	–0.12 (–0.19 to –0.06) [†]	–3.70

	Chlamydia	Gonorrhea	P&S Syphilis
7	0.12 (0.05–0.2) $\overset{\dagger}{}$	3.38	−0.07 (−0.17 to 0.03)
8	0.04 (−0.04 to 0.13)	1.00	−0.03 (−0.14 to 0.08)
9	−0.14 (−0.23 to −0.07) $\overset{\dagger}{}$	−3.69	−0.32 (−0.51 to −0.22) $\overset{\dagger}{}$
Spatial error lag	0.4 (0.26–0.53) $\overset{\dagger}{}$	5.70	0.56 (0.49–0.63) $\overset{\dagger}{}$
R^2	0.74	0.78	0.60

Rural–urban continuum codes: 1–Counties in metro areas of 1 million population or more; 2–Counties in metro areas of 250,000 to 1 million population; 3–Counties in metro areas of fewer than 250,000 population; 4–Urban population of 20,000 or more, adjacent to a metro area; 5–Urban population of 20,000 or more, not adjacent to a metro area; 6–Urban population of 2500 to 19,999, adjacent to a metro area; 7–Urban population of 2500 to 19,999, not adjacent to a metro area; 8–Completely rural or less than 2,500 urban population, adjacent to a metro area; 9–Completely rural or less than 2500 urban population, not adjacent to a metro area.²¹

* All the coefficients for continuous variables were converted as follows: $\beta \times 100$, and interpreted as the percent change in transformed rates for a 1% change in the independent variable. Thus, a coefficient of 0.0300 implies that a 1% change in the independent variable is associated with a 3% change in the transformed rates of the dependent variable. All the coefficients for the categorical variables (ie, rural urban continuum code) were converted as follows: $(\exp(\beta - 1) \times 100)$, and interpreted as percent change in the transformed rates of the associated category when compared to the omitted/referent category (code 1²¹).

Significance levels

- [†] <0.10,
- [‡] <0.05,
- [§] <0.01.

β , regression coefficient; CI, confidence interval; z-statistics were computed using bootstrapped standard errors.