Published in final edited form as:
Sex Transm Dis. 2020 March ; 47(3): 165–170. doi:10.1097/OLQ.0000000000001117.

County-Level Social Capital and Bacterial Sexually Transmitted Infections in the United States

Kwame Owusu-Edusei Jr.[1], **Bryttany McClendon-Weary**[2], **Lara Bull**[1], **Thomas L. Gift**[1], **Sevgi O. Aral**[1]

[1]National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention, Centers for Disease Control and Prevention, Atlanta, Georgia, USA

[2]Howard University, Washington DC, USA

Abstract

Background: The association between county-level social capital indices (SCIs) and the three most commonly reported sexually transmitted infections (STIs) in the United States is lacking. In this study, we determined and examined the association between two recently developed county-level SCIs (i.e., Penn State social capital index [PSSCI] vs. United States Congress social capital index [USCSCI]) and the three most commonly reported bacterial STIs (chlamydia, gonorrhea and syphilis) using spatial and non-spatial regression techniques.

Methods: We assembled and analyzed multi-year (2012–2016) cross-sectional data on STIs and two SCIs (PSSCI vs. USCSCI) on counties in all 48 contiguous states. We explored two non-spatial regression models (univariate and multiple generalized linear models) and three spatial regression models (spatial lag model, spatial error model and the spatial autoregressive moving average model) for comparison.

Results: Without exception, all the SCIs were negatively associated with all three STI morbidity. A one-unit increase in the SCIs were associated with at least 9% ($p<0.001$) decrease in each STI. Our test of the magnitude of the estimated associations indicated that the USCSCI was at least two-times higher than the estimates for the PSSCI for all STIs (highest p-value=0.01).

Conclusions: Overall, our results highlight the potential benefits of applying/incorporating social capital concepts to STI control and prevention efforts. In addition, our results suggest that for the purpose of planning, designing and implementing effective STI control and prevention interventions/programs, understanding the communities' associational life (as indicated by the factors/data used to develop the USCSCI) may be important.

SUMMARY

Correspondence: Kwame Owusu-Edusei, Jr., 658 Chestnut St E, Souderton, PA 18964, Kowedus@gmail.com.

Conflict of interest: None declared.

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.

Analyses of two county-level SCIs indicated they were negatively associated with STI morbidity, although the association was higher for the United States Congress SCI compared to the Penn State SCI.

Keywords

County-level social capital; sexually transmitted infections; spatial regression

---

INTRODUCTION

Social capital (SC) was defined as the resources to which individuals and groups have access through their social networks in one of the earliest published works on this topic.[1] Following Bourdieu's work, other versions of the definition of SC have emerged.[2, 3] Although there is no consensus on the definition of SC,[4] most versions include two major domains—cognitive/attitudinal (such as perceived interpersonal trust and reciprocity) and structural/behavioral (such as civic participation and volunteering).[5] By and large, scholars define SC as a community-level attribute that measures the resources, social relations and connections among people and social organizations accessed and used to achieve common purposive ends.[6]

Before the end of the twentieth century, SC was a concept that was largely talked about in the fields of sociology,[1, 2] economics,[7] and political science.[3] However, in the last two decades, there has been a surge in the application of the SC concept to public health phenomena.[4] Kawachi and Berkman hypothesized that through positive social norms, social networks, social support and the availability of strong organizational processes that influence the availability and use of health care services, higher SC is associated with better health outcomes.[8] Prompt diffusion of health information, adoption of healthy norms, and social control of risky behaviors present other pathways through which SC is hypothesized to influence better health outcomes.[9] However, it is noteworthy that the concept of SC is double-edged—it can also reinforce negative/bad outcomes. In other words, the resources (social relations, connections among people and social organizations) can be used to achieve common purposive ends that are bad for individuals or the community as a whole.[10]

Social capital and health outcomes

Numerous studies have demonstrated the positive effects of SC on (or associations with) health outcomes. For example, SC was reported to be associated with positive health outcomes for common cold,[11] mortality, self-rated health,[12] obesity,[12] and chronic illnesses.[13]

Social capital and sexually transmitted infections (STIs)

In the area of STIs, we found three published studies that examined the association between SC and STIs—two of them used state-level data,[6, 14] while the third used neighborhood data from within a large city.[15] These studies found that—for the most part—higher SC were associated with lower STI morbidity. We did not find any study that examined the association between county SC measure and STI morbidity.

Measures of social capital

The corollary to the lack of consensus on the definition of SC is the lack of agreement on how to measure it. As a result, following the original SC measure developed by Putnam[3] in the United States (US), several social capital indices (SCIs) have been developed over the years, although they were all at the state-level.[12] These SCI methods were largely determined by the developer's definition of SC as well as their area of interest as evidenced by the indicators/factors they considered relevant to include in developing their indices. These differing versions of measuring SC are important, because researchers/scholars may come to different quantitative and/or qualitative conclusions about the association between SC and health outcomes depending on which measures are used.[5]

As at the beginning/conceptualization of this study (early 2018), only two county-level SCIs were available—the 2014 Penn State SCI[16] and the United States Congress SCI.[17] An important distinction between the two county-level SCIs is that one of the four factors used in developing the Penn State SCI focused on information from social/business/economic entities using data from the North American Industry Classification System (NAICS).[16] Specifically, the PSSCI used 2014 data on religious, civic, business, political, professional, labor, recreation and sports from NAICS and non-profit organizations, as well as 2012 voter turnout and 2010-census response rate.[16]

On the other hand, the US Congress SCI kept associational life (family and community) central in the development of their index.[17] Specifically, the USCSCI was developed from four sub-indices—*family unity, community health, institutional health* and *collective efficacy*. *Family unity* sub-index was developed from 2012–2016 data on the proportion of births to unmarried women, proportion of unmarried women and the proportion of children living with single parent. The *Community health* sub-index was developed from 2015 data on registered non-religious entities, religious congregations and informal civil society index. The *institutional health* sub-index was developed from votes in the 2012 and 2016 presidential elections, 2010-census response rate, and 2013 data on confidence in institutions. The *collective efficacy* sub-index was the 2008–2014 crime rate.[17] In their validation analyses, the authors of the USCSCI reported a correlation of 0.56 between their index and the PSSCI.[17]

Purpose

In this study, we analyze multi-year cross-sectional county-level data to determine and examine the qualitative and quantitative association between the two SCIs (Penn State social capital index and the US Congress social capital index) discussed above and the three most commonly reported STIs (chlamydia, gonorrhea and syphilis) in the US using spatial regression techniques. The results from our study can improve our understanding of the association between the available county-level SCIs and bacterial STIs, and ultimately inform the planning, designing and implementation of effective STI control and prevention interventions/programs. We focused on county-level measures—rather than state-level—for several reasons:

1. Size of geographic unit: as pointed out by many scholars, SC is a community-level attribute of local phenomena.[16] Thus, the attributes are likely better captured at smaller geographic units than at the state-level.
2. Data availability: counties are the smallest geographic unit for which the SCI and STI data for the entire US are publicly available.
3. Sample size: county-level data offers far larger sample size and more variability.
4. Research gap: while there are published studies on the association between SC and STIs at the state-level, research on this (SC-STI) association at the county-level is lacking.

MATERIALS AND METHODS

To examine the quantitative and qualitative association between SCI and bacterial STIs at the county-level, we analyzed multi-year cross-sectional data and used state-specific fixed-effects spatial generalized linear regression models that controlled for other social determinants reported in the published literature. Our choice of the control variables was based on numerous published studies that have comprehensively discussed the rationale (pathways/theories) for their inclusion in STI ecological analyses.[6, 18–22]

Data

We obtained the 2014 county-level Penn State social capital index (PSSCI) from their website (https://aese.psu.edu/nercrd/community/social-capital-resources/social-capital-variables-for-2014/social-capital-variables-spreadsheet-for-2014/view16), and the United States Congress social capital index (USCSCI) data were obtained from their website.[17]

Given that the data used to develop the SCIs were from multiple years (largely 2012–2016) and the more complete sociodemographic and economic data at the county-level were the five-year estimates from the American Community Surveys (ACS), we assumed that the relevant corresponding years of STI morbidity data were the 2012–2016 data. As a result, we assembled 2012–2016 data on the reported total (all age groups, races/ethnicities and both sexes) county-level cases of chlamydia, gonorrhea, and primary and secondary (P&S) syphilis from all the counties in the contiguous states in the US from the AtlasPlus web tool.[23] We computed temporally smoothed rates by adding the cases and dividing by the sum of the population estimates for each year, and multiplied the result by 100,000.[20]

From the ACS, we obtained five-year estimates (2012–2016) of county-level sociodemographic and economic data[24] based on preliminary exploratory analyses as well as variables used in previously published county-level STI studies.[18–22] The sociodemographic and economic variables included percent Black (non-Hispanic), percent Hispanic/Latino, percent Asian, percent American Indian and Alaska Native (AIAN), percent Native Hawaiian and Other Pacific Islander (NHOPI), commute index (i.e., percent with >1 hour commute time), income inequality (i.e., Gini coefficient), population density (i.e., residents/square mile), sex ratio (i.e., male-to-female ratio), median household income, birth rate, percent of residents aged 15–24 years and 25–29 years. Although crime rate has been shown to improve STI ecologic regression models,[20] we did not use crime rate because it was highly correlated with the USCSCI—as described above, crime rate was one of the sub-indices used in its (USCSCI) development.

Summary statistics of data used

Table 1 presents the summary statistics of the final set of data on all the variables used in our analyses. Upon close inspection of the PSSCI data, we found an outlier—while the rest of the PSSCIs ranged from −3.183 to 9.149, one county (Edgefield, South Carolina) had an index of 21.809. As a result, we dropped Edgefield, South Carolina from our analyses. The USCSCI ranged from −4.315 to 2.971. However, because of lack of complete data for some of the sub-indices used in developing the USCSCI, the total number of usable observations was slightly lower than those for the PSSCI—2,937 (≈ 94% of all the counties and county equivalents in the US) vs. 3,073 (≈ 98% of all the counties and county equivalents in the US) (see Table 1).

Statistical Analyses (spatial regression)

Previous county/state-level STI ecologic regression analyses have used log-linear/log-log models that require transforming the STI rates into natural logs.[6, 19, 20, 22] However, this approach presents challenges because quite a substantial number of counties may have zero rates (especially syphilis, in our case) and the log of zero is undefined, but dropping the zero observations may mean losing important information. The generalized linear model (GLM) with log link uses a log-link function that eliminates this problem because it does not require data transformation.[25] In addition, because all the rates were non-negative, skewed and right-tailed, we specified gamma distribution—GLM with log link and gamma distribution.

For completeness of model evaluation, we explored all the available spatial models—spatial lag model (SLM), spatial error model (SEM), spatial Durbin model (SDM) and the spatial auto-regressive moving average model (SARMAM), which is a combination of the SLM and SEM.[26, 27] While SDMs usually include lags of the independent variables, we focused on the spatial lags of the variables of interest in this study (PSSCI and USCSCI). However, after preliminary assessment, the SDMs were dropped because the lagged SCIs were highly correlated with the SCIs (69% for the PSSCI; 74% for the USCSCI). Because of the high correlation between the two SCIs, and to enable independent estimation/interpretation of their association with the STIs, we conducted separate regression analyses for each (i.e., we did not include both in any of the regression models). We estimated crude (unadjusted estimates obtained from simple [univariate] GLM regression) and multivariate GLM regression for each SCI and STI for the purpose of comparison. Thus, there were ten regression results for each STI from five models (univariate GLM, multivariate GLM, SLM, SEM and SARMAM) and two separate regressions, one for each SCI. Apart from the univariate regression, all the other models included state-level fixed-effects intercepts.

Finally, we examined potential differences in the magnitude of the SCI coefficients for each STI (PSSCI vs. USCSCI) using the seemingly unrelated estimation procedure chi-square test for parameter estimates across models.[28] However, it is conceivable that the elimination of the counties from the USCSCIs models due to lack of data (a total of 136 counties) may have been systematic rather than random. If so, then there exist the potential for some form of selection bias in comparing the magnitude of the coefficients on the PSSCI and USCSCI. In other words, the difference in the magnitude of the coefficients between the two SCIs (PSSCI vs. USCSCI) may be due to the difference in the datasets used (3073 for PSSCI and 2937 for USCSCI). To eliminate this potential bias, we re-estimated and examined the PSSCI results using data on the same counties that were used for the USCSCI analyses (n=2937). As a result, our final results were obtained from a total of 45 regression analyses.

For the purpose of this study, the discussion of the results was restricted to the estimated coefficients on the two variables of interest (USCSCI and PSSCI). Because several other recent studies have presented comprehensive discussions on the association between STIs and the sociodemographic and economic variables used in this study.[19–22] Because we used the log link function in the GLM estimation, the estimated coefficients on the SCIs were interpreted as percent change (coefficient × 100) in the STI rate associated with a 1-unit change in the SCIs.[25]

Based on preliminary analyses and given that the SCIs were developed from several sociodemographic and economic data that may be correlated with the control variables that we used, we mean-centered (i.e., by subtracting the mean from each value) all the control variables to eliminate/reduce the potential for multicollinearity problems, and then recomputed (and evaluated) centered variance inflation factors (VIFs).[29] These were done to ensure that the VIFs (<10) and condition numbers (<30) were below their recommended limits.[30] Eliminating/reducing multicollinearity was important because high VIF signals possible multicollinearity problems that might result in spurious quantitative and/or qualitative results which can lead to specious interpretation of the estimated coefficients[30]—in this case, the interpretation of the association between the SCIs (PSSCI/USCSCI) and STIs.

All the preliminary spatial regression analyses and the creation of spatial variables (lags and contiguity weight matrices) were conducted using GeoDa version 0.9.5-I, and the final regression analyses including diagnostics were performed in STATA version 14.2 (StataCorp LP, College Station, Texas). We used first-order queen contiguity weights for the spatial relationships between the counties. Spatial dependence tests were performed using the robust LaGrange Multiplier (LM) tests.[6]

RESULTS

Statistical analyses (spatial regression)

Based on the number of final regression analyses conducted (45 in total) and the focus of this study, we presented a summary of the estimated coefficients from all the regression analyses in Table 2 for the PSSCIs and USCSCIs. Additional results and associated information from all the final regression analyses conducted using the full dataset for each SCI (30 in total) have been provided in the Appendix (Tables I–VI). Full results for the remaining 15 PSSCI regressions that used data on the same counties as the USCSCI analyses are available from the lead author. Our test for multicollinearity in the control variables indicated that there were no potential problems as evidenced by the associated

VIFs (all were <3; limit is 10) and condition numbers (all were <4; limit is 30).[30] In addition, the estimated coefficients on all the control variables had the expected signs, and were—for the most part—consistent across the models (Appendix Tables I–VI). The robust LM tests for spatial dependence indicated that there was no spatial dependence in our final SARMAMs.

All the results (estimated unadjusted and adjusted coefficients) show that the SCIs were negatively associated with bacterial STI burden (Table 2)—higher SCIs were associated with positive STI outcomes (lower STI burden). With the exception of the PSSCI coefficients for P&S syphilis, the magnitude of estimated coefficients were similar across all the four adjusted models (GLM and the spatial regression models). The estimated coefficients indicated that a one-unit increase in the PSSCI and the USCSCI were associated with a 9% (p<0.001) and 30% (p<0.001) decrease in the smoothed chlamydia rate, respectively (Table 2). The estimated coefficients indicated that a one-unit increase in the PSSCI and the USCSCI were associated with a 18% (p<0.001) and 57% (p<0.001) decrease in the smoothed gonorrhea rate, respectively (Table 2). The estimated coefficients indicated that a one-unit increase in the PSSCI and the USCSCI were associated with a 15% (p<0.001) and 43% (p<0.001) decrease in the smoothed P&S syphilis rate, respectively (Table 2).

Finally, our test of the magnitude of the estimated coefficients for the PSSCI vs. the USCSCI indicated that they were significantly different (highest p-value=0.0032) for each STI (Table 2). When we restricted the PSSCI analyses to the same counties as were used for the USCSCI analyses (n=2,937), we found that the coefficients were very similar for the chlamydia models, while the gonorrhea and the P&S syphilis model coefficients were slightly different. However, they were not significantly different from the full-data PSSCI coefficients, but they remained significantly (highest p-value=0.01) different from the USCSCI estimates (Table 2).

DISCUSSION

In this study, we determined and compared the county-level association between the two available SCIs and the three most commonly reported bacterial STIs (chlamydia, gonorrhea and syphilis) using spatial regression techniques that controlled for select sociodemographic and economic factors for counties in all the 48 contiguous states (where applicable) in the US. Our results indicated that—without exception—the two SCIs that we focused on (county-level PSSCI and USCSCI) were negatively associated with county-level bacterial STI burden in the US. In other words, high SC were associated with favorable STI outcomes (lower STI burden).

Based on the full usable data results, we estimated that a one-unit increase in the SCIs were associated with at least 9% decrease in the STI burden. Additionally, the estimated coefficients for the USCSCIs were at least two-times higher than those for the PSSCI’s for each STI.

Qualitatively, our results—for the most part—are consistent with results from similar studies that examined the association between SC and STIs.[6, 14, 15] According to the USCSCI authors, the PSSCI is the first of its kind developed at the county-level.[17] This implies that the USCSCI (developed in early 2018) was the second one available at this geographic level. As a result, we did not find any published studies that examined their association with STIs, therefore, we are unable to discuss/compare our quantitative results with published reports.

The large difference in the magnitude of the associations between the two SCIs and all three commonly reported STIs can be attributed to one or a combination of two factors. First, there was a temporal difference in the data used to develop them—the PSSCI represented the 2014 calendar year,[16] while the USCSCI reflected multi-year (2008–2016) measure that were consistent with the STI data (2012–2016) that we used. Second, the factors (and data) that were used to develop them were very different and reflected the developers' interest (and/or motivation) as was explicitly discussed in their reports. While the PSSCI developers (mostly economists) were interested in SC and its contribution to economic growth and development of communities,[16] the USCSCI developers were interested in an index that reflected associational life—family unity, family interaction, social support as well as community, institutional and philanthropic health.[17]

The difference in the association between the SCIs that we found is consistent with the statement that different aspects/types of SC have different effects on (or associations with) health outcomes[6] which may result in researchers arriving at different conclusions.[5] However, in this case the difference in the association between the two county-level SCIs (PSSCI vs. USCSCI) and STIs were only quantitative. Nonetheless, our results reinforce the potential benefits of applying/incorporating social capital concepts (i.e., network-related, population-based, and community-level approaches) in our efforts to control and prevent STIs.[6] Additionally, our results suggest that for the purpose of planning, designing and implementing effective STI control and prevention interventions/programs, understanding the communities' associational life (as indicated by the factors/data used to develop the USCSCI) may be important.

The relative magnitude of the association between SC and the three STIs may be related to the differences in sexual network concentration. Chlamydia has the least network concentration (more evenly distributed) while gonorrhea and syphilis have networks that are more concentrated.[31] In addition, most reported cases of syphilis are among men who have sex with men, and their networks are different.[32]

Limitations

All the limitations associated with the data we used are applicable. The STI surveillance data contained missing/unknown data for some counties. In addition, there are inconsistencies in the testing and reporting of STI data.[33] Higher reported STI rates may be indicative of higher screening coverage rather than higher rates of disease; this is particularly true with STIs that are largely asymptomatic and unlikely to be diagnosed or reported in the absence of preventive health care. For example, available data indicate state-level variations in chlamydia screening among sexually-active women enrolled in health plans reporting data to the National Commission on Quality Assurance.[34] However, complete county-level screening data for all three STIs in both sexes are unavailable. All of the data used to develop the SCIs also have various problems, including inconsistent data collection/

reporting systems and/or measurement errors. Although the individual factors (or data) are combined to produce a composite value in the form of principal components, the effect of any systemic/measurement errors may still linger in the resulting indices. Due to lack of data on some of the sub-indices used to develop the USCSCI, there were missing values for some of the counties.[17] This prevented us from using a more complete dataset, although we were able to use data on a very high majority (>93%). Because we used cross-sectional data, our result cannot be interpreted as causal. Finally, reverse association may be at play as well.[6]

Strengths

In spite of the limitations discussed above, there are several strengths in this study. To our knowledge, this is the first study that determined and compared the qualitative and quantitative association between two SCIs and the three most commonly reported STIs (chlamydia, gonorrhea, and syphilis) at the county-level in the contiguous states in the US using data on over 93% of counties. All the data used in this study are publicly available, making our analyses replicable. Our comprehensive analytical approach explored and presented all the available modeling methods in ecologic regression analyses— simple (univariate), multiple and spatial regression models (SLM, SEM and SARMAM) that controlled for several sociodemographic and economic factors. The exploration of all the above-mentioned models was very important for our study, because our results showed the robustness of the association between the SCIs and STIs as evidenced by the consistency of the qualitative and quantitative results across all the five models we estimated for each STI. In addition, the difference in the magnitude of the estimated association (PSSCI vs. USCSCI) persisted even when we re-estimated using data on the same counties. Our use of temporally smoothed rates for the STIs increased the robustness of the measure of morbidity of all the STIs for each county. Finally, to avoid qualitatively and/or quantitatively implausible estimates of the association between SCIs and the three STIs, we used mean-centered values for the control variables to reduce potential multicollinearity problems.[29] As a result of this approach, the estimated VIFs and condition numbers were well below their recommended limits.

Conclusion

This study used spatial regression techniques to determine and examine the association between two recently developed county-level social capital indices (Penn State social capital index [PSSCI] and the United States Congress social capital index [USCSCI]) and the three most commonly reported bacterial sexually transmitted infections (chlamydia, gonorrhea and syphilis) in the 48 contiguous states in United States. Our results showed that—without exception—social capital (as measured by the two recently developed indices ([PSSCI and USCSCI]) was associated with positive health outcomes. The higher the SCI, the lower the STI burden. A one-unit increase in the SCIs were associated with at least 9% (p<0.01) decrease in the STI rate. In addition, the magnitude of the associations were at least two-times higher for the USCSCI than for the PSSCI. Because our results showed that higher social capital was associated with lower STI burden (without exception and regardless of the index), applying/incorporating social capital concepts (i.e., network-related, population-based, and community-level approaches) in the planning, designing and implementation of STI control and prevention interventions can be beneficial. Additionally, these findings suggest that understanding the communities' associational life (as indicated by the factors/data used to develop the USCSCI) may be important for planning, designing and implementing effective STI prevention and control interventions/programs.

Funding:

None declared.

APPENDIX

Table I.

Full unadjusted and adjusted regression results for estimating the association between the Penn State social capital index and smoothed chlamydia rate (n = 3,073)

	Unadjusted	**Adjusted**				
	Univariate GLM	**Multivariate GLM**	**Spatial Lag Model**	**Spatial Error Model**	**SARMAM**	
Independent Variables	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**VIF**
Penn State SCI	−0.209 *** −0.228,−0.189)	−0.100 *** (−0.115,−0.084)	−0.093 *** (−0.108,0.077)	−0.096 *** (−0.112,0.080)	−0.091 *** (−0.107,−0.076)	1.34
Mean-Centered Control Variables						
% Black non-Hispanic		0.026 *** (0.025,0.028)	0.024 *** (0.023,0.026)	0.026 *** (0.025,0.028)	0.024 *** (0.023,0.026)	2.04
% Hispanic/ Latino		0.007 *** (0.006,0.009)	0.007 *** (0.006,0.009)	0.008 *** (0.006,0.009)	0.007 *** (0.006,0.009)	1.25
% Asian		0.008 * (−0.001,0.017)	0.008 * (−0.001,0.017)	0.007 (−0.002,0.016)	0.008 * (−0.001,0.017)	1.83
% AIAN		0.024 *** (0.021,0.026)	0.023 *** (0.021,0.026)	0.024 *** (0.021,0.026)	0.023 *** (0.021,0.026)	1.07
% NHOPI		0.186 *** (0.103,0.269)	0.196 *** (0.113,0.278)	0.189 *** (0.106,0.272)	0.197 *** (0.114,0.280)	1.08
Income inequality		0.265 (0.217,0.747)	0.385 (−0.096,0.866)	0.278 (−0.203,0.759)	0.380 (−0.101,0.860)	1.5
Median income[a]		−0.001 (−0.017,0.014)	−0.006 (−0.022,0.009)	0.000 (−0.015,0.016)	−0.007 (−0.022,0.009)	1.78
% commuting > 1 hour		−1.586 *** (−1.891,−1.280)	−1.556 *** (−1.860,1.252)	−1.583 *** (−1.888,1.279)	−1.556 *** (−1.859,1.253)	1.17
Sex ratio		−0.006 *** (−0.007,−0.005)	−0.006 *** (−0.007,−0.004)	−0.006 *** (−0.007,0.005)	−0.006 *** (−0.007,0.004)	1.06
Birth rate[a]		−0.017 (−0.082,0.048)	−0.008 (−0.072,0.057)	−0.015 (−0.080,0.050)	−0.006 (−0.071,0.059)	1.07
Population density[a]		0.307 *** (0.133,0.481)	0.394 *** (0.212,0.576)	0.352 *** (0.172,0.531)	0.380 *** (0.198,0.561)	1.3
% aged 25–29 years		0.034 *** (0.030,0.038)	0.035 *** (0.030,0.039)	0.034 *** (0.030,0.039)	0.035 *** (0.030,0.039)	1.22
Spatial lag (rho)			0.0005 *** (0.0004,0.0007)		0.0005 *** (0.0004,0.0007)	1.76
Spatial error lag (lambda)				0.0005 *** (0.0003,0.0007)	0.0004 *** (0.0002,0.0007)	1.02

	Unadjusted	**Adjusted**				
	Univariate GLM	**Multivariate GLM**	**Spatial Lag Model**	**Spatial Error Model**	**SARMAM**	
Independent Variables	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**VIF**
Mean VIF					1.37	
Condition number					2.84	

***p<0.01

**p<0.05

*p<0.1

GLM, generalized linear model; SCI, social capital index; β = coefficient; CI, confidence interval; VIF, variance inflation factor

AIAN, American Indian and Alaska Native; NHOPI, Native Hawaiian and other Pacific Islander

ARMAM, spatial auto-regressive moving average model;

[a] Units were changed to obtain meaningful interpretation of the coefficients.

Table II.

Full unadjusted and adjusted regression results for estimating the association between the United States Congress social capital index and smoothed chlamydia rate (n = 2,937)

	Unadjusted	**Adjusted**				
	Univariate GLM	**Multivariate GLM**	**Spatial Lag Model**	**Spatial Error Model**	**SARMAM**	
Independent Variables	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**VIF**
United States Congress SCI	−0.401*** (−0.417,−0.385)	−0.297*** (−0.321,−0.274)	−0.299*** (−0.322,−0.275)	−0.295*** (−0.319,−0.272)	−0.297*** (−0.320,−0.273)	2.32
Mean-Centered Control Variables						
% Black non-Hispanic		0.018*** (0.016,0.019)	0.015*** (0.014,0.017)	0.018*** (0.016,0.019)	0.015*** (0.014,0.017)	2.29
% Hispanic/ Latino		0.006*** (0.004,0.007)	0.005*** (0.004,0.006)	0.006*** (0.005,0.007)	0.005*** (0.004,0.007)	1.36
% Asian		0.008** (0.001,0.016)	0.010** (0.002,0.018)	0.008** (0.000,0.016)	0.009** (0.002,0.017)	1.85
% AIAN		0.017*** (0.015,0.020)	0.016*** (0.013,0.019)	0.018*** (0.015,0.020)	0.016*** (0.014,0.019)	1.09
% NHOPI		0.136*** (0.062,0.210)	0147*** (0.073,0.221)	0.139*** (0.065,0.212)	0.148*** (0.075,0.222)	1.09
Income inequality		−0.024 (−0.455,0.407)	0.135 (−0.295,0.564)	−0.009 (−0.437,0.420)	0.142 (−0.286,0.569)	1.54
Median income[a]		0.050*** (0.036,0.065)	0.042*** (0.028,0.057)	0.050*** (0.036,0.064)	0.043*** (0.028,0.057)	2.03
% commuting > 1 hour		−1.154*** (−1.426,−0.882)	−1.141*** (−1.411,−0.871)	−1.166*** (−1.437,−0.895)	−1.152*** (−1.420,−0.883)	1.09
Sex ratio		−0.005*** (−0.006,−0.004)	−0.005*** (−0.006,−0.004)	−0.005*** (−0.006,−0.004)	−0.005*** (−0.006,−0.004)	1.06

	Unadjusted	Adjusted				
	Univariate GLM	Multivariate GLM	Spatial Lag Model	Spatial Error Model	SARMAM	
Independent Variables	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**VIF**
Birth rate[a]		−0.036 (−0.097,0.025)	−0.027 (−0.088,0.033)	−0.034 (−0.094,0.027)	−0.025 (−0.086,0.035)	1.09
Population density[a]		0.085 (−0.052,0.221)	0.115* (−0.022,0.253)	0.073 (−0.062,0.208)	0.104 (−0.032,0.240)	1.32
% aged 25–29 years		0.033*** (0.029,0.037)	0.033*** (0.029,0.037)	0.033*** (0.029,0.036)	0.033*** (0.029,0.036)	1.17
Spatial lag (rho)			0.0006*** (0.00005,0.0008)		0.0006*** (0.0005,0.0007)	1.79
Spatial error lag (lambda)				0.0006*** (0.0003,0.0008)	0.0005*** (0.0003,0.0007)	1.03
Mean VIF					1.48	
Condition number					3.30	

*** p<0.01

** p<0.05

* p<0.1

GLM, generalized linear model; SCI, social capital index; β, coefficient; CI, confidence interval; VIF, variance inflation factor

AIAN, American Indian and Alaska Native; NHOPI, Native Hawaiian and other Pacific Islander

SARMAM, spatial auto-regressive moving average model;

[a] Units were changed to obtain meaningful interpretation of the coefficients.

Table III.

Full unadjusted and adjusted regression results for estimating the association between the Penn State social capital index and smoothed gonorrhea rate (n = 3,073)

	Unadjusted	Adjusted				
	Univariate GLM	Multivariate GLM	Spatial Lag Model	Spatial Error Model	SARMAM	
Independent Variables	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**VIF**
Penn State SCI	−0.398*** (−0.436,−0.360)	−0.188*** (−0.219,−0.156)	−0.179*** (−0.210,−0.147)	−0.186*** (−0.218,−0.155)	−0.178*** (−0.210,−0.147)	1.32
Mean-Centered Control Variables						
% Black non-Hispanic		0.044*** (0.041,0.047)	0.037*** (0.034,0.041)	0.044*** (0.041,0.047)	0.038*** (0.035,0.042)	2.52
% Hispanic/ Latino		0.004** (0.001,0.007)	0.004*** (0.001,0.008)	0.004*** (0.001,0.008)	0.005*** (0.002,0.008)	1.19
% Asian		0.017 (−0.003,0.037)	0.019* (−0.001,0.040)	0.015 (−0.005,0.035)	0.018* (−0.002,0.038)	1.83
% AIAN		0.038*** (0.033,0.044)	0.036*** (0.031,0.042)	0.038*** (0.032,0.043)	0.036*** (0.031,0.042)	1.08

	Unadjusted	**Adjusted**				
	Univariate GLM	**Multivariate GLM**	**Spatial Lag Model**	**Spatial Error Model**	**SARMAM**	
Independent Variables	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**VIF**
% NHOPI		0.306[***] (0.133,0.480)	0.324[***] (0.150,0.497)	0.325[***] (0.152,0.499)	0.336[***] (0.163,0.509)	1.08
Income inequality		1.513[***] (0.508,2.518)	1.840[***] (0.826,2.854)	1.586[***] (0.587,2.585)	1.863[***] (0.855,2.871)	1.51
Median income[a]		0.060[***] (0.027,0.093)	0.043[**] (0.010,0.077)	0.060[***] (0.027,0.093)	0.045[***] (0.012,0.079)	1.79
% commuting > 1 hour		−3.422[***] (−4.028,−2.816)	−3.189[***] (−3.799,−2.580)	−3.381[***] (−3.986,−2.775)	−3.182[***] (−3.791,−2.573)	1.17
Sex ratio		−0.009[***] (−0.011,−0.007)	−0.008[***] (−0.011,−0.006)	−0.009[***] (−0.011,−0.007)	−0.009[***] (−0.011,−0.007)	1.06
Birth rate[a]		−0.074 (0.211,0.063)	−0.055 (−0.192,0.082)	−0.079 (−0.215,0.057)	−0.061 (−0.198,0.075)	1.07
Population density[a]		0.939[***] (0.476,1.402)	0.991[***] (0.519,1.463)	0.896[***] (0.440,1.351)	0.948[***] (0.483,1.412)	1.3
% aged 25–29 years		0.029[***] (0.020,0.038)	0.031[***] (0.022,0.041)	0.029[***] (0.020,0.038)	0.031[***] (0.022,0.040)	1.22
Spatial lag (rho)			0.003[***] (0.002,0.004)		0.003[***] (0.002,0.004)	2.27
Spatial error lag (lambda)				0.004[***] (0.003,0.005)	0.003[***] (0.002,0.004)	1.08
Mean VIF					1.43	
Condition number					3.24	

[***] p<0.01

[**] p<0.05

[*] p<0.1

GLM, generalized linear model; SCI, social capital index; β, coefficient; CI, confidence interval; VIF, variance inflation factor

AIAN, American Indian and Alaska Native; NHOPI, Native Hawaiian and other Pacific Islander

SARMAM, spatial auto-regressive moving average model;

[a] Units were changed to obtain meaningful interpretation of the coefficients.

Table IV.

Full unadjusted and adjusted regression results for estimating the association between the United States Congress social capital index and smoothed gonorrhea rate (n = 2,937)

	Unadjusted	**Adjusted**				
	Univariate GLM	**Multivariate GLM**	**Spatial Lag Model**	**Spatial Error Model**	**SARMAM**	
Independent Variables	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**VIF**

	Unadjusted	Adjusted				
	Univariate GLM	**Multivariate GLM**	**Spatial Lag Model**	**Spatial Error Model**	**SARMAM**	
Independent Variables	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**VIF**
United States Congress SCI	−0.760*** (−0.792,−0.729)	−0.561*** (−0.609,−0.512)	−0.568*** (−0.616,−0.519)	−0.562*** (−0.611,−0.514)	−0.567*** (−0.615,−0.518)	2.27
Mean-Centered Control Variables						
% Black non-Hispanic		0.029*** (0.026,0.032)	0.021*** (0.018,0.025)	0.029*** (0.026,0.032)	0.022*** (0.019,0.026)	2.76
% Hispanic/ Latino		0.001 (−0.002,0.004)	0.001 (0.001,0.004)	0.001 (−0.001,0.004)	0.002 (−0.001,0.004)	1.33
% Asian		0.017* (−0.001,0.034)	0.021** (0.003,0.038)	0.016* (−0.001,0.033)	0.017* (−0.000,0.034)	1.85
% AIAN		0.030*** (0.025,0.036)	0.028*** (0.023,0.034)	0.030*** (0.025,0.036)	0.029*** (0.023,0.034)	1.09
% NHOPI		0.224*** (0.070,0.378)	0.240*** (0.086,0.394)	0.239*** (0.085,0.392)	0.250*** (0.097,0.404)	1.09
Income inequality		0.833* (−0.065,1.732)	1.226*** (0.318,2.134)	0.880* (0.011,1.772)	1.255*** (0.351,2.159)	1.54
Median income[a]		0.165*** (0.135,0.196)	0.145*** (0.114,0.176)	0.166*** (0.135,0.196)	0.150*** (0.119,0.181)	2.04
% commuting > 1 hour		−2.646*** (−3.198,−2.095)	−2.391*** (−2.945,−1.836)	−2.625*** (3.174,−2.076)	−2.411*** (−2.965,−1.858)	1.09
Sex ratio		−0.008*** (−0.010,−0.006)	−0.008*** (−0.010,−0.006)	−0.008*** (−0.010,−0.006)	−0.008*** (−0.010,−0.006)	1.06
Birth rate[a]		−0.131** (−0.259,−0.002)	−0.129** (−0.257,−0.002)	−0.133** (−0.260,−	−0.131** (−0.259,−0.004)	1.09
Population density[a]		0.407** (0.066,0.747)	0.364** (0.037,0.693)	0.322** (0.003,0.641)	0.410** (0.069,0.751)	1.31
% aged 25–29 years		0.026*** (0.018,0.034)	0.026*** (0.018,0.034)	0.026*** (0.018,0.033)	0.026*** (0.018,0.034)	1.17
Spatial lag (rho)			0.003*** (0.003,0.004)		0.003*** (0.002,0.004)	2.24
Spatial error lag (lambda)				0.004*** (0.003,0.005)	0.003*** (0.002,0.004)	1.05
Mean VIF					1.53	
Condition number					3.49	

***p<0.01

**p<0.05

*p<0.1

GLM, generalized linear model; SCI, social capital index; β, coefficient; CI, confidence interval; VIF, variance inflation factor

AIAN, American Indian and Alaska Native; NHOPI, Native Hawaiian and other Pacific Islander

SARMAM, spatial auto-regressive moving average model;

[a] Units were changed to obtain meaningful interpretation of the coefficients.

Table V.

Full unadjusted and adjusted regression results for estimating the association between the Penn State social capital index and smoothed primary and secondary syphilis rate (n = 3,073)

	Unadjusted	Adjusted				
	Univariate GLM	Multivariate GLM	Spatial Lag Model	Spatial Error Model	SARMAM	
Independent Variables	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**VIF**
Penn State SCI	−0.372*** (−0.435,−0.309)	−0.088*** (−0.145,−0.031)	−0.148*** (−0.244,−0.053)	−0.163*** (−0.258,−0.068)	−0.149*** (−0.244,−0.053)	1.36
Mean-Centered Control Variables						
% Black non-Hispanic		0.034*** (0.026,0.041)	0.030*** (0.022,0.038)	0.034*** (0.026,0.042)	0.031*** (0.022,0.039)	1.85
% Hispanic/ Latino		0.006 (−0.002,0.014)	0.003 (−0.005,0.011)	0.004 (−0.004,0.012)	0.003 (−0.005,0.011)	1.2
% Asian		−0.005 (−0.054,0.044)	−0.016 (−0.066,0.033)	−0.013 (−0.062,0.037)	−0.017 (−0.066,0.033)	1.86
% AIAN		0.040*** (0.028,0.052)	0.027*** (0.013,0.041)	0.032*** (0.019,0.046)	0.027*** (0.013,0.041)	1.11
% NHOPI		0.240 (0.204,0.685)	0.174 (0.264,0.612)	0.185 (0.256,0.625)	0.174 (−0.264,0.612)	1.09
Income inequality		0.709 (−1.829,3.246)	0.876 (−1.716,3.468)	0.878 (−1.709,3.465)	0.880 (−1.711,3.472)	1.51
Median income[a]		0.193*** (0.112,0.274)	0.1700*** (0.086,0.255)	0.200*** (0.117,0.283)	0.172*** (0.086,0.257)	1.85
% commuting > 1 hour		−2.850*** (−4.493,−1.207)	−3.202*** (−4.900,−1.504)	−3.215*** (−4.925,−1.505)	−3.201*** (−4.899,−1.503)	1.2
Sex ratio		−0.020*** (−0.027,−0.014)	−0.020*** (−0.027,−0.013)	−0.021*** (−0.027,−0.014)	−0.020*** (−0.027,−0.014)	1.19
Birth rate[a]		−0.434** (−0.813,−0.057)	−0.427** (−0.810,−0.044)	−0.416** (−0.801,−0.031)	−0.427** (−0.810,−0.044)	1.07
Population density[a]		0.839 (−0.289,1.967)	0.783 (−0.311,1.876)	0.872 (−0.262,2.005)	0.785 (−0.309,1.880)	1.34
% aged 25–29 years		0.226*** (0.152,0.300)	0.220*** (0.142,0.297)	0.212*** (0.135,0.290)	0.220*** (0.142,0.297)	1.72
Spatial lag (rho)			0.060*** (0.023,0.097)		0.058*** (0.015,0.101)	2.49
Spatial error lag (lambda)				0.041** (0.005,0.077)	0.005 (−0.044,0.053)	1.95
Mean VIF					1.52	
Condition number					3.36	

*** p<0.01

** p<0.05

* p<0.1

GLM, generalized linear model; SCI, social capital index; β, coefficient; CI, confidence interval; VIF, variance inflation factor

AIAN, American Indian and Alaska Native; NHOPI, Native Hawaiian and other Pacific Islander

SARMAM, spatial auto-regressive moving average model;

[a] Units were changed to obtain meaningful interpretation of the coefficients.

Table VI.

Full unadjusted and adjusted regression results for estimating the association between the United States Congress social capital index and smoothed primary and secondary syphilis rate (n = 2,937)

	Unadjusted	**Adjusted**				
	Univariate GLM	**Multivariate GLM**	**Spatial Lag Model**	**Spatial Error Model**	**SARMAM**	
Independent Variables	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**VIF**
United States Congress SCI	−0.657*** (−0.708,−0.605)	−0.434*** (−0.570,−0.298)	−0.427*** (−0.562,−0.293)	−0.429*** (−0.564,−0.294)	−0.427*** (−0.562,−0.293)	2.49
Mean-Centered Control Variables						
% Black non-Hispanic		0.021*** (0.014,0.029)	0.018*** (0.010,0.025)	0.022*** (0.014,0.029)	0.017*** (0.010,0.025)	2.14
% Hispanic/ Latino		0.005 (−0.002,0.012)	0.004 (−0.003,0.011)	0.005 (−0.002,0.012)	0.004 (−0.003,0.011)	1.32
% Asian		−0.005 (−0.045,0.036)	−0.015 (−0.055,0.024)	−0.011 (−0.051,0.029)	−0.015 (−0.055,0.024)	1.89
% AIAN		0.024*** (0.010,0.039)	0.023*** (0.010,0.037)	0.025*** (0.011,0.039)	0.023*** (0.009,0.037)	1.09
% NHOPI		0.278 (−0.114,0.671)	0.184 (−0.189,0.556)	0.199 (−0.180,0.577)	0.184 (−0.189,0.557)	1.1
Income inequality		3.126*** (0.842,5.410)	3.202*** (0.927,5.477)	3.066*** (0.797,5.334)	3.205*** (0.929,5.481)	1.53
Median income^{a}		0.293*** (0.217,0.368)	0.263*** (0.186,0.339)	0.298*** (0.223,0.373)	0.261*** (0.184,0.338)	2.15
% commuting > 1 hour		−1.592** (−3.040,−0.145)	−1.640** (−3.069,−0.211)	−1.623** (−3.063,−0.183)	−1.643** (−3.072,−0.214)	1.14
Sex ratio		−0.016*** (−0.022,−0.010)	−0.016*** (−0.022,−0.010)	−0.016*** (−0.022,−0.010)	−0.016*** (−0.022,−0.010)	1.21
Birth rate^{a}		−0.348** (−0.670,−0.028)	−0.370** (−0.687,−0.053)	−0.358** (−0.676,−0.040)	−0.368** (−0.685,−0.052)	1.08
Population density^{a}		0.233 (−0.503,0.968)	0.179 (−0.531,0.888)	0.311 (−0.465,1.088)	0.185 (−0.530,0.900)	1.34
% aged 25–29 years		0.210*** (0.145,0.275)	0.223*** (0.158,0.287)	0.218*** (0.153,0.283)	0.223*** (0.158,0.287)	1.79
Spatial lag (rho)			0.067*** (0.032,0.102)		0.069*** (0.033,0.106)	1.95
Spatial error lag (lambda)				0.034** (0.005,0.063)	−0.007 (−0.049,0.034)	1.40
Mean VIF					1.58	

	Unadjusted	Adjusted				
	Univariate GLM	Multivariate GLM	Spatial Lag Model	Spatial Error Model	SARMAM	
Independent Variables	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**β (95% CI)**	**VIF**
Condition number					3.41	

[***] $p<0.01$

[**] $p<0.05$

[*] $p<0.1$

GLM, generalized linear model; SCI, social capital index; β, coefficient; CI, confidence interval; VIF, variance inflation factor

AIAN, American Indian and Alaska Native; NHOPI, Native Hawaiian and other Pacific Islander

SARMAM, spatial auto-regressive moving average model;

[a] Units were changed to obtain meaningful interpretation of the coefficients.

LIST OF ABBREVIATIONS

ACS	American Community Surveys
AIAN	American Indian and Alaska Native
CDC	Centers for Disease Control and Prevention
GLM	generalized linear model
LM	Lagrange Multiplier
NAICS	North American Industry Classification System
NHOPI	Native Hawaiian and other Pacific Islander
P&S	primary and secondary
PSSCI	Penn State social capital index
SARMAM	spatial auto-regressive moving average model
SC	social capital
SCI	social capital index
SDM	spatial Durbin model
SEM	spatial error model
SLM	spatial lag model
STI	sexually transmitted infection
US	United States

USCSCI	United States Congress social capital index
VIF	variance inflation factor

REFERENCES

1. Bourdieu P The forms of social capital In: Richardson JG, ed. Handbook of theory and research for the sociology of education. New York, NY: Greenwood Press; 1985:241–58.
2. Coleman JS. Foundations of Social Theory. Cambridge, MA: Harvard University Press; 1990.
3. Putnam RD. Bowling alone: The collapse and revival of American community. New Jersey: Simon and Schuster; 2002.
4. Kawachi I, Subramanian SV, Kim D. Social capital and health. New York, NY: Springer; 2012.
5. Lee CJ, Kim D. A Comparative Analysis of the Validity of US State- and County-Level Social Capital Measures and Their Associations with Population Health. Soc Indic Res. 2013;111(1):307–26. [PubMed: 25574069]
6. 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(11): 2324–41. [PubMed: 17400352]
7. Loury G The economics of discrimination: getting to the core of the problem. Harvard Journal for African American Public Policy. 1992;1:91–110.
8. Kawachi I, Berkman LF. Social cohesion, social capital, and health In: Berkman LF, Kawachi I, eds. Social epidemiology New York, NY: Oxford University Press.; 2000:174–90.
9. Kawachi I, Kim D, Coutts A, et al. Commentary: Reconciling the three accounts of social capital. Int J Epidemiol. 2004;33(4):682–90; discussion 700–4. [PubMed: 15282222]
10. Portes A Social capital: its origins and applications in modern sociology. Annu. Rev. Sociol 1998;24:1–24.
11. Cohen S, Doyle WJ, Skoner DP, et al. Social ties and susceptibility to the common cold. JAMA. 1997;277(24):1940–4. [PubMed: 9200634]
12. Kim D, Subramanian SV, Gortmaker SL, et al. US state- and county-level social capital in relation to obesity and physical inactivity: a multilevel, multivariable analysis. Soc Sci Med. 2006;63(4): 1045–59. [PubMed: 16644081]
13. Ahern MM, Hendryx MS. Social capital and risk for chronic illnesses. Chronic Illn. 2005;1(3): 183–90. [PubMed: 17152181]
14. Holtgrave DR, Crosby RA. Social capital, poverty, and income inequality as predictors of gonorrhoea, syphilis, chlamydia and AIDS case rates in the United States. Sex Transm Infect. 2003;79(1):62–4. [PubMed: 12576618]
15. Thomas JC, Torrone EA, Browning CR. Neighborhood factors affecting rates of sexually transmitted diseases in Chicago. J Urban Health. 2010;87(1):102–12. [PubMed: 19997865]
16. Rupasingha A, Goetz SJ, Freshwater D. The production of social capital in US counties. J Socio Econ. 2006 [with updates];35:83–101.
17. United States Congress Joint Economic Committee Social Capital Project. The Geographic of Social Capital in America: Report prepared by the Vice Chairman's staff. April 2018. Accessed at http://lee.senate.gov/scp/socialcapitalindex. Accessed June 12 2019.
18. 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(4):231–7. [PubMed: 28302356]
19. Marotta P Assessing Spatial Relationships between Race, Inequality, Crime, and Gonorrhea and Chlamydia in the United States. J Urban Health. 2017;94(5):683–98. [PubMed: 28831708]
20. Owusu-Edusei K, Chang BA, Aslam MV, et al. Does including violent crime rates in ecological regression models of sexually transmissible infection rates improve model quality? Insights from spatial regression analyses. Sex Health. 2019;16(2):148–57. [PubMed: 30885293]

21. Owusu-Edusei K, Chesson HW, Leichliter JS, et al. The association between racial disparity in income and reported sexually transmitted infections. Am J Public Health. 2013;103(5):910–6. [PubMed: 23488482]
22. Owusu-Edusei K, Gift TL, Leichliter JS, et al. The Spatial Association Between Federally Qualified Health Centers and County-Level Reported Sexually Transmitted Infections: A Spatial Regression Approach. Sex Transm Dis. 2018;45(2):81–6. [PubMed: 28876293]
23. Centers for Disease Control and Prevention. NCHHSTP AtlasPlus. Updated 2017. Accessed at https://www.cdc.gov/nchhstp/atlas/index.htm. Accessed December 15 2017.
24. United States Census Bureau. American FactFinder: 2012–2016 American Community Survey. 2018 Accessed at http://factfinder.census.gov/faces/nav/jsf/pages/download_center.xhtml#none. Accessed April 20 2019.
25. Mccullagh P, Nelder JA. Generalized Linear Models. 2nd ed. Boca Rotan, FL: Chapman & Hall/CRC; 1989.
26. LeSage JP. Econometric Toolbox. 2010 Accessed at www.spatial-econometrics.com. Accessed 21 January 2019.
27. Anselin L Spatial Econometrics: Methods and Models. Boston, MA: Kluwer Academic Press; 1988.
28. Clogg CC, Petkova E, Haritou A. Statistical methods for comparing regression coefficients between models. Am J Sociol. 1995;100:1261–312.
29. Afshartous D, Preston RA. Key Results of Interaction Models With Centering. J Stat Educ. 2011;19(3).
30. Belsley DA, Kuh E, Welsch RE. Regression Diagnostics New York: John Wiley & Sons; 1980.
31. 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:iii52–7. [PubMed: 21098057]
32. Glick SN, Morris M, Foxman B, et al. A Comparison of Sexual Behavior Patterns Among Men Who Have Sex With Men and Heterosexual Men and Women. J Acquir Immune Defic Syndr. 2012;60(1):83–90. [PubMed: 22522237]
33. Centers for Disease Control and Prevention. Sexually transmitted disease surveillance, 2017. Atlanta, GA: U.S. Department of Health and Human Services; 2018.
34. Centers for Disease Control and Prevention. Chlamydia Screening Percentages Reported by Commercial and Medicaid Plans by State and Year. 2014 Accessed at https://www.cdc.gov/std/chlamydia/chlamydia-screening-2014.htm. Accessed August 9 2019.

Table 1.

County-level summary statistics of social capital indices, temporally smoothed chlamydia, gonorrhea and P&S syphilis rates (2012–2016), and control variables (five-year estimates [2012–2016]) used in the state-specific fixed-effects spatial regression analysis

Variable	N	Mean	SD	Median	IQR	Minimum	Maximum
Social capital indices (SCIs)							
PSSCI[a]	3,073	−0.00587	1.186	−0.225	−0.751 – 0.469	−3.183	9.149
USCSCI	2,937	0.00212	1.000	−0.00279	−0.654 – 0.660	−4.315	2.971
Sexually transmitted infections (STIs) [#/100,000]							
Chlamydia	3,073	343.7	229.5	283.1	194.5 – 427.7	0	2,420
Gonorrhea	3,073	69.98	83.22	38.87	17.88 – 93.71	0	1,047
P&S syphilis	3,073	2.379	5.904	1.190	0 – 2.905	0	248.9
Sociodemographic and economic factors							
% Black (non-Hispanic)	3,073	9.069	14.53	2.267	0.628 – 10.35	0	86.18
% Hispanic/Latino	3,073	8.952	13.64	3.800	1.927 – 9.066	0	98.96
% Asian	3,073	1.184	2.186	0.560	0.254 – 1.194	0	34.38
% AIAN	3,073	1.553	6.024	0.338	0.158 – 0.759	0	83.89
% NHOPI	3,073	0.0662	0.174	0.0108	0 – 0.0594	0	3.542
Income inequality (Gini coefficient)	3,073	0.445	0.0348	0.442	0.421 – 0.465	0.321	0.627
Median household income (2016 US $)	3,073	47,700	12,367	46,212	39,593 – 53,502	18,972	125,672
% commuting > 1 hour	3,073	0.0766	0.0462	0.0651	0.0433 – 0.0966	0	0.334
Sex ratio (# males/100 females)	3,073	100.7	11.81	98.30	95.58 – 102.1	70.94	364.8
Birth rate (# births/1000)	3,073	56.35	21.36	54	44 – 66	0	240
Population density (# residents/sq. mile)	3,073	218.5	990.0	45.06	17.43 – 114.41	0.114	34,128
% aged 15–24 years	3,073	12.94	3.422	12.40	11.30 – 13.60	3	47
% aged 25–29 years	3,073	5.762	1.333	5.600	5.00 – 6.400	0	15.20

N, number of observations; SD, standard deviation; IQR, interquartile range

PSSCI, Penn State social capital index; USCSCI, United States Congress social capital index

AIAN, American Indian and Alaska Native; NHOPI, Native Hawaiian and other Pacific Islander

[a] We dropped an outlier county (Edgefield, South Carolina) that had a value of 21.8.

Table 2.

Summary regression results of the estimated county-level association between the two social capital indices (Penn State social capital index [PSSCI] and the United States Congress social capital index [USCSCI]) and the commonly reported three bacterial sexually transmitted infections in the United States

		Unadjusted	Adjusted			
STI	**SCI**	**Univariate GLM β (95% CI)**	**Multivariate GLM β (95% CI)**	**Spatial Lag Model β (95% CI)**	**Spatial Error Model β (95% CI)**	**SARMAM β (95% CI)**
Chlamydia	PSSCI (n=3073)[b]	−0.21 (−0.23,−0.19)	−0.10 (−0.12,−0.08)	−0.09 (−0.12,−0.08)	−0.10 (−0.11,−0.08)	−0.09 (−0.11,−0.08)
	PSSCI (n=2,937)[bc]	−0.20 (−0.22,−0.18)	−0.10 (−0.12,−0.09)	−0.10 (−0.12,0.08)	−0.10 (−0.12,−0.08)	−0.09 (−0.11,−0.08)
	USCSCI (n=2,937)	−0.40 (−0.42,−0.39)	−0.30 (−0.32,0.27)	−0.30 (−0.32,0.28)	−0.30 (−0.32,−0.27)	−0.30 (−0.32,−0.27)
Gonorrhea	PSSCI (n=3073)[b]	−0.40 (−0.44,−0.36)	−0.19 (−0.22,−0.12)	−0.18 (−0.21,0.15)	−0.19 (−0.22,−0.16)	−0.18 (−0.21,−0.15)
	PSSCI (n=2,937)[bc]	−0.40 (−0.44,−0.36)	−0.22 (−0.26,−0.19)	−0.21 (−0.24,−0.17)	−0.22 (−0.25,−0.19)	−0.21 (−0.24,−0.17)
	USCSCI (n=2,937)	−0.76 (−0.79,−0.73)	−0.56 (−0.61,−0.51)	−0.57 (−0.62,−0.52)	−0.56 (−0.61,−0.51)	−0.57 (−0.62,−0.52)
P&S Syphilis	PSSCI (n=3073)[b]	−0.37 (−0.44,−0.31)	−0.09 (−0.15,−0.03)	−0.15 (−0.24,−0.05)	−0.16 (−0.26,−0.07)	−0.15 (−0.24,−0.05)
	PSSCI (n=2,937)[bc]	−0.38 (−0.44,−0.32)	−0.10 (−0.14,−0.05)	−0.19 (−0.28,−0.11)	−0.21 (−0.30,−0.12)	−0.20 (−0.28,−0.11)
	USCSCI (n=2,937)	−0.66 (−0.71,−0.61)	−0.43 (−0.57,−0.30)	−0.43 (−0.56,−0.29)	−0.43 (−0.56,−0.29)	−0.43 (−0.56,−0.29)

All the coefficients were significant at 1%.

β = coefficient; CI, confidence interval; SCI, social capital index; STI, sexually transmitted infection; GLM, generalized linear model; SARMAM, spatial auto-regressive moving average model; P&S, primary and secondary

[b] All the Penn State social capital index coefficients were significantly different ($p<0.01$) from the corresponding United States Congress social capital index coefficients for each model.

[c] Repeated with data on the same counties that were used for the USCSCI analyses (n=2,937).