Social and Structural Determinants of Health and Incidence Rates of Sexually Transmitted Diseases

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A dissertation

submitted in partial fulfillment of the

requirements for the degree of

Doctor of Philosophy

University of Washington

2023

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Program Authorized to Offer Degree:

School of Nursing

University of Washington

Abstract

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Sexually Transmitted Diseases

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Background: The United States (U.S.) faces a severe sexually transmitted disease (STD) epidemic, with rates exceeding historical highs. Social determinants of health (SDOH), LHD's STD-related service delivery and local health department (LHD) resources influence STD incidence rates. Current STD prevention approaches often focus on individual-level behavior change, neglecting the crucial role of community-level factors. This dissertation addresses this research gap by exploring the links between SDOH, LHD's STD-related service delivery, and STD incidence rates at the county level.

Purpose: Building on a robust conceptual framework, the aims of this dissertation were to (1) evaluate the longitudinal associations between social determinants of health and STD incidence rates at the county-level in the U.S.; (2) investigate the impact of differences in STD-related screening service delivery on STD incidence rates; and (3) identify positive deviant (PD) counties that have exceptionally low STD rates and examine the predictors of STD outcomes in those counties.

Methods: This dissertation utilized various quantitative methods, including a panel regression model, a spatial autoregressive model, and PD analysis, to analyze data from publicly available sources.

Results: Aim 1 found that STD incidence rates, including chlamydia, gonorrhea, and P & S syphilis, more than doubled over a 20-year period. Longitudinal analyses revealed significant associations between higher social capital and lower chlamydia and gonorrhea rates. Higher eviction rates correlated with increased STD incidence across all three STDs, while higher prison incarceration rates were associated with higher gonorrhea rates. Aim 2 indicated that LHD jurisdictions relying on STD-related screening services, community-delivered and independent of LHD funding, demonstrated significantly lower STD incidence rates compared to those with STD-related screening services provided by LHDs directly and by others in the community. Aim 3 found that 19.06% of U.S. counties were classified as PD counties, exhibiting unexpectedly low STD incidence rates. Predictors of PD counties included small population sizes, and specific social vulnerability index (SVI) subcategories related to racial and ethnic subgroups, housing and transportation vulnerabilities. Counties providing STD-related treatment services provided LHD directly and through community providers were associated with PD identification.

Conclusions: The dissertation contributes to the understanding of the complex relationships between SDOH, STD-related service delivery approaches, and STD incidence rates. Our findings can inform policy makers and public health officials in developing targeted interventions and

allocating resources to reduce STD rates. The identification of PD counties provides valuable insights into potential best practices for STD prevention and control.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

First of all, I would like to thank my committee members— Drs. Betty Bekemeier, David Grembowski, Jillian Pintye, and Darryl Holman —for their guidance throughout the dissertation process. I would particularly like to express my deep appreciation and gratitude to Dr. Betty Bekemeier. Dr. Bekemeier advised me how to approach health services research and academics during my PhD journey. Dr. Bekemeier always considers improving trust, transparency, and confidentiality in her relationship with me, allowing me to make the most of my research capabilities and making research results more reliable and valid. There were times when I could have given up on my PhD program, especially as I experienced difficult situations during 3rd year of my PhD study, Dr. Bekemeier always encouraged me not to give up and gave me the confidence that I could do it. Without Dr. Bekemeier, I would not have been able to finish this dissertation. Dr. Pintye is the best mentor that could have ever met. What supported me, even more than her vast knowledge and academic curiosity in the sexually transmitted diseases, was that she has shown the friendship and support that are much needed for international students. Dr. Grembowski always shared his thoughtful insights, comments, and questions that made this dissertation much clearer and stronger.

I met many amazing people at the University of Washington, School of Nursing. I would like to thank Drs. Eunjung Kim, Doris Boutain, and Hilaire Thompson for giving me the great opportunity to be a research assistant during my PhD studies. I learned a lot from working with you and was able to grow as a nursing researcher. I am also thankful to my friends and colleagues, especially 2017 cohort: Dahee Wi, Rachel Yeji Lee, Michelle Shin, Li Juen Chen, and Jinyi Li, as well as academic advisor: Besty Mau.

I would like to express my gratitude to Dr. Jae-Uk Song, Yu Mi Ha, Hayeon Oh, Jin Hee Kim, Na Yeon Kim, Hae Sun Choi, Ye Jin Lee of the Department of Respiratory Medicine at Kangbuk Samsung Hospital. I received their great considerations and assistances while completing my dissertation and clinical experience in South Korea. I am also deeply grateful to my friends, Hohyun Seong, Dae-Seok Choi, Jong-Min Park, Junghee Kim, Seokhwon Lim, Sangjoon hong, Chuljoon Jung, Ma Eul Kang and Rebekah Maldonado Nofziger, for their unwavering support, help and friendship.

Last but not least, I would like to special thanks to my family and relatives, Jin-Yong Lim, Soonja Nam, Hae-Sun Lim and Jin-Nam Lim. I could not have been able to achieve my PhD journey, without their incredible support, help, and love.

DEDICATION

This dissertation is dedicated to the memory of my beloved father, Jin-yong Lim (1952-2019) and my mother, Soon Ja Nam.

Chapter 1. INTRODUCTION

The United States (U.S.) is currently experiencing sexually transmitted diseases (STDs) epidemic at the nation's highest recorded levels (National Academy of Public Administration, 2019). Rates of STDs in the U.S. have increased annually for the past decade accounting for over 2.5 million cases of STDs in 2021 (Centers for Disease Control and Prevention [CDC], 2023). Social determinants and the allocation of both public and private resources to communities, which in turn shape environments, are linked to numerous health outcomes and can impact an individual's risk of STD acquisition (Andreatos et al., 2017; Gallet, 2017; Owusu-Edusei et al., 2020). STDs, as a health outcome, are also directly or indirectly impacted by multiple social determinants and structural factors (Tapp & Hudson, 2020). Various factors have been identified as contributors to incidence rates of STDs within the context of social determinants. High incidence rates of STDs are often concentrated in socially and economically marginalized populations and regions as consequences of poverty, housing instability, lack of education and limited access to health care (Sharpe et al., 2010). As STD epidemics have primarily been investigated as an individual-level phenomenon, approaches to prevent STDs have largely been designed to change individual behavior, and individual interventions have been developed without an understanding of the context that directly and indirectly influences STD acquisition and prevention (DiClemente et al., 2005).

Local Health Departments (LHDs) play a key role in preventing and controlling the incidence of STDs in the jurisdictions that they serve and in addressing these community-level factors (Rodriguez et al., 2012; Rodriguez et al., 2018). Researchers can, thus, investigate STD epidemics by examining the value of adopting community-level approaches and the important role of LHDs in preventing and treating STDs within the context of social and structural determinants of health (Dean & Fenton, 2010; Owusu-Edusei et al., 2020; Tapp & Hudson, 2020). Furthermore, the specific impact of community-level factors on STD rates within local health jurisdictions has not been adequately studied. Studies are needed to explore the ecological and longitudinal relationship between social and structural determinants and the incidence of STDs, considering the population size, organizational structure, approaches, and resources within local health jurisdictions.

Social and structural determinants of health and STDs

Social determinants, classified as economic stability, education, health care access, neighborhood environment, and community context, are associated with local STD rates (CDC, 2021; Hogben & Leichliter, 2008; Tapp & Hudson, 2020). To better understand and address the STD epidemic in the U.S., one approach is to investigate county-level social determinants, with the goal of explaining the important role of social determinants of health for both preventing and protecting population health regarding STDs.

Social capital

Social capital is the concept used primarily in the fields of sociology, economics, and political science (Berkman et al., 2014). The application of social capital to public health and nursing research has surged over the past 10 years. Still, however, the association between social capital and STDs has received relatively little attention (Holtgrave & Crosby, 2003; Owusu-Edusei et al., 2020). To date, we found four studies that investigated the link between social capital and STDs. Two of them analyzed data at the state-level (Holtgrave & Crosby, 2003; Semaan et al., 2007), one of them used county-level data (Owusu-Edusei et al., 2020), and one used neighborhood data in Chicago (Thomas et al., 2010). Because longitudinal research on this association with various social determinants is lacking, longitudinal county-level associations between social capital and incidence rates of STDs are especially important to explore as a means to strengthen our understanding of these relationships.

Housing instability

Housing status is another important social determinant that is associated with physical health outcomes, mental health outcomes (e.g., stress, depressive symptoms, and anxiety), and risky health behaviors (e.g., smoking, alcohol and drug use; Niccolai et al., 2019). Housing instability (i.e., eviction rates) is also linked to risky sexual behaviors, such as multiple sexual partners and inconsistent condom use, which increases STD transmission and exposure to STDs (Lim et al., 2017). Although various studies have looked at alcohol and drug use that are linked to sexually risky behavior at the individual level, little is known about the impact of population-level housing instability for incidence rates of STDs at the county-level.

Incarceration

As a social determinant, incarceration is closely linked to STDs in marginalized communities (Thomas & Sampson, 2005). Previous studies have identified that jail and prison inmates are at high risk of STDs/HIV and are more likely than the general population to engage in sexually risky behaviors and sexual networks that accelerate their chance of contracting STDs after periods of incarceration (Dauria et al., 2015; Nowotny et al., 2020). These engagements expose individuals to risks of sex with STD-infected partners (Pflieger et al., 2013). Most research on the association between incarceration and STDs rates has been conducted as cross-sectional designs and at an individual level (Khan, Behrend, et al., 2011; Khan, Epperson, et al., 2011). Much remains unknown about the ecological relationship between incarceration at a population-level and county incidence rates of STDs.

Types of STD-related service delivery, and STDs

LHDs are central providers of STD-related services, particularly STD prevention, screening, and treatment services, and play an important role in controlling STDs (Paschal et al., 2011; Rodriguez et al., 2012). LHDs vary widely in size, organizational system, service delivery and partnerships with community organizations, all of which have effects on STD-related service delivery in relation to prevention and treatment strategies (Rodriguez et al., 2012). Previous evidence has shown that better resourced LHDs, the presence of a local board of health, and having integrated partnerships with community organizations are important predictors of performance of local public health, including STD prevention and treatment (Bhandari et al., 2010; Paschal et al., 2011). In addition, STD-related service delivery approaches and types of services provided by LHDs are known to be affected by county public health spending (Leichliter et al., 2017). According to a study of county-level public health expenditures in California, a $1 increase in public health spending per capita resulted in 0.3% decrease in gonorrhea rates and 0.6% decrease in syphilis rates, respectively (Gallet, 2017). To our knowledge, however, the association between types of LHD STD-related service delivery and local incidence rates of STDs remains unclear.

STDs in Positive deviant LHDs

Most research on positive deviance (PD) has focused primarily on individual characteristics that relate to performance beyond expectations (Hendryx et al., 2017). In the field of public health, this concept has been applied to children’s nutrition, newborn care, maternal and child health (MCH), and sexual behavior at the individual level (Berggren & Wray, 2002; Marsh et al., 2002). As a framework for identifying and learning from individuals and communities that practice beyond expectations (Klaiman, Pantazis, et al., 2016), PD can be also applied to community-level health outcomes as well as individual level health outcomes (Walker et al., 2007).

Previous studies have used system-level approaches of PD to identify LHD jurisdictions that had exceptionally high MCH outcomes compared to other LHD jurisdictions in the same state (Klaiman, Chainani, et al., 2016; Klaiman, Pantazis, et al., 2016), and counties where health outcomes (e.g., adult obesity, diabetes, colorectal cancer, and circulatory disease mortality rates) exceed expectations in Indiana (Hendryx et al., 2017). To date, no studies have been conducted on STDs using a PD framework at the county-level. Empirical findings from the PD method can provide a necessary step for examining high performing LHDs and communities to investigate the types of STD-related service delivery that leads to better STD outcomes than their peers.

Conceptual Framework

The conceptual framework below (Figure 1) describes the relationships among social determinants of health, a community's epidemiologic context, and STD rates at the county-level. The framework is largely based on a model developed by Hogben and Leichliter (2008) and the World Health Organization (World Health Organization, 2010) and explains a general organization of the relationships between social determinants of health and STD acquisition or transmission. Figure 1 provides the conceptual framework for this dissertation and additionally includes specific factors of social determinants and the epidemiologic context to illustrate how social determinants of health may be related to epidemiologic context and STD rates within counties. The social determinants (e.g., social capital, housing instability, and incarceration) and structural determinants (e.g., STD-related service delivery) are expected to influence STD rates (Kilmarx et al., 1997; Niccolai et al., 2019; Nowotny et al., 2020; Owusu-Edusei et al., 2020). The epidemiologic context includes contextual factors (e.g., sociodemographic, and geographic characteristics) and internal mechanisms (e.g., health system characteristics; Harling et al., 2013;

Pflieger et al., 2013), which may mediate the relationships between social determinants and STD rates.

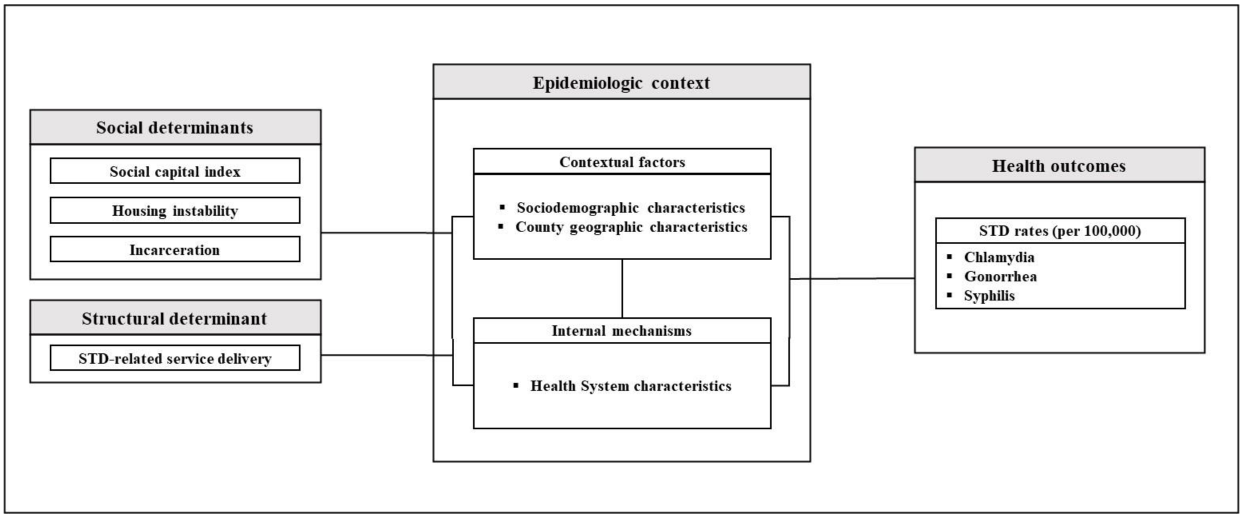

Figure 1-1. A conceptual framework of the associations among social and structural determinants, epidemiological context, and STD incidence rates in local areas

Objectives

As described above, knowledge gaps exist regarding the longitudinal and cross-sectional associations between social and structural determinants of health and STD incidence rates at the county-level. The overall objectives of this dissertation are to: (1) evaluate the longitudinal associations between social determinants of health and STD incidence rates at the county-level in the U.S.; (2) investigate the impact of differences in STD-related screening service delivery on STD incidence rates; and (3) identify PD counties that have exceptionally low STD rates and examine the predictors of STD outcomes in those counties.

This dissertation consists of five chapters and three study aims. Chapter 1 provides background information based on previous studies, a conceptual model, and the objectives of this dissertation. In Chapter 2, **Aim 1** examines county-level longitudinal associations between social determinants (e.g., social capital indices, housing instability, and incarceration) and incidence rates of chlamydia, gonorrhea, and P & S syphilis using publicly available data sources for the years

2000 to 2019 using a panel regression model, while controlling for potential confounders (e.g., unemployment rate, federal poverty rate, median household income, and core-based statistical areas). In Chapter 3, **Aim 2** evaluates whether three types of STD-related screening service delivery approaches – screening performed by an LHD directly, provided by others in a community independent of LHD funding, and combined/both together – are related to STD rates within local county jurisdictions in the U.S. using a spatial autoregressive (SAR) model. In Chapter 4, **Aim 3** identifies counties that have exceptionally low STD incidence rates in the U.S., and investigates predictors of these positive deviant counties, focusing on a county's internal (e.g., lead executive as a clinician, local boards of health, and STD-related service delivery) and external factors (e.g., population size, social vulnerability index, and core-based statistical area). Chapter 5 provides an overall summary and implications of the dissertation's findings.

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Chapter 2. THE ASSOCIATION BETWEEN SOCIAL DETERMINANTS OF HEALTH AND INCIDENCE RATES OF SEXUALLY TRANSMITTED DISEASES AT THE COUNTY-LEVEL IN THE UNITED STATES FROM 2000-2019

Abstract

Sexually transmitted diseases (STDs), including chlamydia, gonorrhea, and syphilis, remain a serious public health concern in the United States (U.S.). STDs are not evenly distributed across the country, with significant geographical disparities highlighting the role of local social and structural factors. Social determinants of health (SDOH), such as social capital, eviction rate, and prison incarceration rate, impact health outcomes and potentially influence risk of STD acquisition and transmission. This study investigated the longitudinal associations between SDOH and STD incidence rates at the county-level in the U.S. over a 20-year period from 2000 to 2019. We compiled data on SDOH and annual STD incidence rates (chlamydia, gonorrhea, and P & S syphilis) for all U.S. counties over a 20-year period. Panel regression models were employed to examine the associations between SDOH and STD rates, controlling for confounders. We found significant links between social capital, eviction rate, prison incarceration rate and STD incidence rates. Higher social capital was associated with lower chlamydia and gonorrhea rates, while higher eviction rates were associated with higher rates of all three STDs and higher prison incarceration rates were associated with higher gonorrhea rates. This study provides valuable insights into the long-term effects of social determinants on STD disparities. These findings inform the development of effective interventions and policies to address rising STD rates and promote health equity across diverse communities.

Keywords: Sexually transmitted diseases, social determinants of health, social capital, eviction rate, incarceration rate, county-level analysis, health disparities

Introduction

Sexually transmitted diseases (STDs), including chlamydia, gonorrhea, and syphilis, remain a serious public health problem and continue to rise in the United States (U.S.; Kreisel et al., 2021; Scott-Sheldon & Chan, 2020). STDs rates in the U.S. have increased annually since 2013, accounting for over 2.5 million cases of STDs in 2021 (Centers for Disease Control and Prevention [CDC], 2023). STDs are very geographically concentrated in the U.S., with 96 out of 3,142 counties contributing approximately 50% of all reported cases of chlamydia and 76 counties constituting 50% of all reported gonorrhea cases (CDC, 2021a). In 2019, counties with the highest chlamydia (573.9 cases per 100,000) and gonorrhea (205.4 cases per 100,000) rates were concentrated in the South region, and primary and secondary (P & S) syphilis rates (16.9 cases per 100,000) were highest in the West region (CDC, 2021a). Given the county-level variations in STD rates, it is important to investigate the local social and structural factors that influence this geographical variation in STD incidence rates (Chesson et al., 2012).

Social determinants of health (SDOH) may influence geographic differences and disparities in STD incidence at the county-level (Dean & Fenton, 2010; Hogben & Leichliter, 2008). SDOH, affecting the conditions under which people live, grow, work, and interact with others (Marmot et al., 2008; World Health Organization, 2010), are generally linked to numerous health outcomes and influence an individual's risk of STD acquisition and transmission (Andreatos et al., 2017; Gallet, 2017; Owusu-Edusei et al., 2020). In particular, STDs are directly or indirectly affected by multiple social determinants (Tapp & Hudson, 2020), because social determinants interact with social norms and pathogen traits to influence the epidemiologic context, which in turn interacts with behaviors to influence the probability of acquiring or transmitting STDs (Hogben & Leichliter, 2008). Previous studies found that higher STD rates were associated with social capital (Owusu-Edusei et al., 2020; Semaan et al., 2007), housing instability (Niccolai et al., 2019), and incarceration (Nowotny et al., 2020; Thomas & Sampson, 2005).

The application of social capital to public health and nursing research has surged over the past 10 years. However, the association between social capital and STDs has received relatively little attention (Holtgrave & Crosby, 2003; Owusu-Edusei et al., 2020). There are only a few studies examining the link between social capital and STDs at the state-level (Holtgrave & Crosby, 2003; Semaan et al., 2007), county-level (Owusu-Edusei et al., 2020) and neighborhood-level (Thomas et al., 2010). Housing is another important social determinant that is associated with physical health outcomes, mental health outcomes (e.g., stress, depressive symptoms, and anxiety), and risky health behaviors (e.g., smoking, alcohol, and drug use; Niccolai et al., 2019). Housing instability (i.e., eviction rates) is linked to risky sexual behaviors, such as multiple sexual partnership and inconsistent condom use, which increases STD transmission and exposure to STDs (Lim et al., 2017). Lastly, incarceration rate is closely linked to STDs in marginalized communities (Thomas & Sampson, 2005). Previous studies have identified that a majority of jail and prison inmates are at high risk of STDs/HIV and are more likely than the general population to engage in sexual risk behaviors and sexual networks that accelerate their chance of contracting STDs after periods of incarceration (Dauria et al., 2015; Nowotny et al., 2020). These engagements expose individuals to risks of sex with STD-infected partners (Pflieger et al., 2013).

Little is known about the longitudinal impact of county-level social capital, housing instability, and prison incarceration rates on incidence rates of STDs. To strengthen our understanding of relationships regarding STD incidence and county-level SDOH, longitudinal analyses could help by providing evidence on how SDOH change over time and track with STD incidence rates. The objective of this study was to determine the longitudinal associations between

SDOH (e.g., social capital, housing instability, and prison incarceration) and incidence rates of chlamydia, gonorrhea, and syphilis at the county-level in the U.S. over a 20-year period. Specifically, we test whether the linkages between three societal-level SDOH rates and the STD rates are independent of those associated with county-level determinants of STDs.

Methods

Data

The authors compiled publicly available data for 3,213 counties from 2000 to 2019 (64,260 observations) from multiple resources and merged the data by using the Federal Information Processing Standards (FIPS) codes, a five-digit number where the first two digits designate the state, and the last three digits describe the county-equivalent. We obtained annual chlamydia, gonorrhea, and primary and secondary (P & S) syphilis incidence rates per 100,000 population for 2000-2019 in all counties from the CDC's National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention (NCHHSTP) AtlasPlus website (CDC, 2021b).

For county-level social determinants, we obtained social capital index data (1997, 2005, 2009 and 2014) from the Penn State social capital index (PSSCI) website (Penn State University College of Agricultural Science, n.d.), annual eviction rates (2000-2018) from the Eviction Lab National Database (Gromis et al., 2022), and annual incarceration rates from the Vera Institute of Justice "In Our Own Backyard" Incarceration Trends (2000-2018) dataset (Vera Institute of Justice, 2020). We obtained unemployment rate, median household income, poverty rate, and Core-Based Statistical Area (CBSA) data from various public datasets. We used the annual average unemployment rate from the local area unemployment statistics (LAUS), which was constructed using county-level unemployment rate data from the Bureau of Labor Statistics (BLS; U.S. Bureau of Labor Statistics, 2022). We obtained median household income and federal poverty rate data from the U.S. Census Bureau's SAIPE (small area income and poverty estimates) program, which produces single-year estimates of income and poverty for U.S. states and counties (U.S. Census Bureau, 2022). Core-Based Statistical Area (CBSA) data were obtained from the National Bureau of Economic Research (NBER)'s Census Core-Based Statistical Area (CBSA) to link with the Federal Information Processing Series (FIPS) County Crosswalk to identify rural and urban areas of the counties (National Bureau of Economic Research, n.d.).

Measures

Dependent variables were the annual incidence rates of STDs (chlamydia, gonorrhea, and P & S syphilis). We used the county-level incidence rates of STDs by calculating the sum of the number of cases in each county per year divided by annual population estimates for the U.S. Census Bureau's County Intercensal Estimates, which were provided by the CDC (CDC, 2021b; U.S. Census Bureau, 2020). Chlamydia was defined as a STD caused by *Chlamydia trachomatis*, gonorrhea was defined as a STD caused by *Neisseria gonorrhoeae*, and P & S syphilis was infected by *Treponema pallidum* and characterized the first and second stage of syphilis, which have symptoms of sores at the original site of infection (primary syphilis), and starts with rash on one or more areas of the body (secondary syphilis; CDC, 2021b; Kidd et al., 2018).

Independent variables included social capital index, housing instability and prison incarceration. Social capital index was defined as "a collective manifestation of behaviors, attitudes, and values of individual members of a community" (Rupasingha et al., 2006, p. 85). The Penn State social capital index (PSSCI) we included measured social capital by using U.S. county-level multiple components (e.g., ethnic homogeneity, income inequality, attachment to place, and education; Rupasingha et al., 2006). Housing instability was measured by eviction rate. As a legal process in which tenants are removed from rental property, eviction rate was defined as "the number of households that received an eviction judgement per 100 renter-occupied households in a year" (Niccolai et al., 2019, p. 64). Specifically, we used the eviction rate instead of eviction filing rate, because eviction filing rate includes several cases filed against the same address in the same year, but eviction rates only calculate a single address for which an eviction judgment was received (Gromis et al., 2022). Incarceration was defined as "the annual estimates of jail and prison admissions of county residents per 100,000 people" (Nowotny et al., 2020, p. S131). We used prison admissions for incarceration rate, which is an estimate of the number of prison admissions in each jurisdiction or county in a given year (Vera Institute of Justice, 2020).

Because socioeconomic factors may be correlated with our independent variables (e.g., social capital, eviction rates, and prison incarceration rates) and STD incidence rates, we included unemployment rate, median household income, poverty rate, and Core-Based Statistical Area (CBSA) as control variables, which were available from the public data sources from 2000 to 2019. The county-level unemployment rate was measured by the number of unemployed people in each county divided by the number of people in the labor force in each county (U.S. Bureau of Labor Statistics, 2022). Median household income was calculated from the income of the householder and all people 15 years and older in the household (Bell & Robinson, 2020). We used the median household income after adjusting for 2019 consumer price index (CPI). Poverty rate was measured by comparing total pre-tax annual family income to a table of federal poverty thresholds, which depended on the family size, number of children, and age of householder (Bell & Robinson, 2020). CBSAs were defined as geographical delineations that encompass both metropolitan and micropolitan statistical areas (Centers for Medicare & Medicaid Services, 2022). Metropolitan statistical areas have at least one urbanized area of 50,000 or more population, and micropolitan statistical areas have at least one urban cluster of at least 10,000 but less than 50,000 population (U.S. Census Bureau, 2021).

Statistical analysis

Descriptive statistics were analyzed, and trends of annual incidence rates of chlamydia, gonorrhea, and P & S syphilis were graphed. We also mapped the changes in average 5-year incidence rates of STDs between 2000-2004 and 2015-2019. Pearson correlation coefficients were computed to assess the linear relationship between variables. Before performing panel regression models, an ordinary least squares (OLS) model was estimated to examine the variance inflation factors (VIF) of the social capital, eviction, and prison incarceration rates, and multicollinearity was not detected.

Panel regression model

We examined the longitudinal associations between social determinants of health (e.g., social capital, housing instability, and incarceration) and annual incidence rates of STDs from 2000 to 2019. We included unemployment rate, median household income, poverty rate, and CBSA in the multivariate model to control for confounders that were empirically evaluated in previous studies (Holtgrave & Crosby, 2003; Tapp & Hudson, 2020). The general form of the equation for panel random-effect regression model is as follows:

$$Y_{it} = \alpha_i + \beta_1 SC_{it} + \beta_2 ER_{it} + \beta_3 PI_{it} + \beta_4 X_{it} + v_{it} + \varepsilon_{it} \qquad t = 1 \ldots\ldots, 20$$

where Y_{it} was the dependent variable, representing the three annual STD incidence rates (chlamydia, gonorrhea, and P & S syphilis) of county *i* and at time (year) *t* (from 1 to 20). *SC* was social capital, *ER* was eviction rate, and *PI* was prison incarceration rate as independent variables.

X_{it} was control variables (unemployment rate, median household income, poverty rate, and CBSA). α_i was the unknown intercept for each county and β was the coefficient. v_{it} was uncorrelated with measured variables that were included in the model, and ε_{it} was error term. We used random-effect regression model because it has the advantage of estimating both time-constant and time-varying variables (Allison, 2009). We estimated unadjusted and multivariate (adjusted) panel random-effect regression models for each STD. All analyses were conducted using STATA version 17.0 (StataCorp LLC, College Station, TX). This study did not require institutional review board (IRB) approval because the study used publicly available and de-identified secondary datasets containing county-level information.

Results

In Table 1, from 2000-2019, incidence rates per 100,000 more than doubled for all STDs: chlamydia (115.88 vs. 399.87), gonorrhea (45.17 vs. 126.63), and P&S syphilis (1.11 vs. 5.81). Social capital index increased slightly from - 0.001 in 2000 to 0.001 in 2019. Eviction rates were 0.89 in 2000 compared to 1.91 per 100 rental homes in 2019. Prison incarceration rates increased from 460.24 per 100,000 in 2001 to 511.08 per 100,000 in 2019.

While all three STDs (chlamydia, gonorrhea, and P & S syphilis) showed increases in annual incidence rates during the study period from 2000 to 2019 (Figure 1), chlamydia, incidence rates rose sharply from 2000 to 2003, and increased continuously from 2004 to 2019. For gonorrhea, incidence rates were relatively flat from 2000 to 2015, and grew sharply from 2016 to 2019. For P & S syphilis, incidence rates were relatively flat from 2000 to 2012, like gonorrhea, and increased rapidly from 2013 to 2019. Variations in incidence rates by county for chlamydia were greater than for gonorrhea and P & S syphilis (Figure 1).

For chlamydia, the counties with average annual incidence rates more than 470 cases per 100,000 increased from 197 counties in 2000-2004 to 803 counties in 2015-2019. For gonorrhea, the counties with average annual incidence rates more than 201 cases per 100,000 were 250 counties in 2000-2004 to 446 counties in 2015-2019. For P & S syphilis, the counties with average annual incidence rates more than 11 cases per 100,000 increased from 39 counties in 2000-2004 to 307 counties in 2015-2019 (Figure 2).

The overall combined correlations from 2000 to 2019 are shown in Table 2. For chlamydia, there was a negative correlation between social capital chlamydia rate (r = -.232, $p < .001$). By contrast, there were positive correlations between eviction rate (r = .354, $p < .001$), prison incarceration rate (r = .090, $p < .001$) and chlamydia rate. Similar results were found for gonorrhea, with a negative correlation between social capital (r = -.222, $p < .001$), but positive correlations between eviction rate (r = .413, p < .001), prison incarceration rate (r = .116, $p < .001$) and gonorrhea rate. For P & S syphilis, there were negative correlations between social capital (r = -.097, $p < .001$), prison incarceration rate (r = -.010, $p < .001$) and P & S syphilis rate. Whereas there were positive correlations between eviction rate (r = .222, $p < .001$) and P & S syphilis rate.

In Table 3, after controlling for covariates in Model 2, social capital was negatively associated with chlamydia rates (β = -5.16, $p < 0.05$), and eviction rates were positively associated with chlamydia rates (β = 10.35, $p < 0.001$). For gonorrhea, social capital was negatively associated with gonorrhea rates (β = -8.67, $p < 0.01$), and eviction rates (β = 7.72, $p < 0.001$) and prison incarceration rates (β = 0.001, $p < 0.05$) were positively associated with gonorrhea rates. For P & S syphilis, only one association was found: eviction rates were positively associated with P & S syphilis rates (β = 0.15, $p < 0.001$).

Discussion

In this analysis of annual incidence rates of STDs from 2000 to 2019 in the U.S, we found longitudinal associations between SDOH (e.g., social capital, eviction rate, and prison incarceration rate) and STD incidence rates. Our findings indicate that, as expected, higher eviction rates were associated with higher rates of all three STDs, and higher social capital was associated with lower chlamydia and gonorrhea rates. In addition, higher prison incarceration rates were associated with higher gonorrhea rates.

Social capital is a concept used primarily in the fields of sociology, economics, and political science (Berkman et al., 2014). In this study, we confirmed that increases in social capital were significantly associated with decreases in the annual incidence rates of chlamydia, gonorrhea, and P & S syphilis at the county-level. Our findings are consistent with results from previous studies that found similar negative relationships between social capital and STDs at the individual-level and community-level (Holtgrave & Crosby, 2003; Owusu-Edusei et al., 2020; Semaan et al., 2007; Valente et al., 2020). Social capital has been linked to safer sexual behaviors, early STD detection, and better engagement of STD care at the individual-level (Valente et al., 2020). Moreover, a high level of social capital seems to improve social infrastructure to control and prevent transmission of STDs at the community-level (Holtgrave & Crosby, 2003; Owusu-Edusei et al., 2020; Semaan et al., 2007). Holtgrave and Crosby (2003) performed exploratory analysis of the state-level correlation between Putnam’s comprehensive social capital and chlamydia, gonorrhea, syphilis rates, and reported that social capital was a strong predictor of STD rates. Semaan et al. (2007) argued that social capital is important in reducing or eliminating regional and disparities in STD rates. Owusu-Edusei et al. (2020) analyzed two types of social capital indices (US Congress Social

Capital Index [USCSCI] and Penn State Social Capital Index [PSSCI]) and STD rates and reported the importance of applying social capital to STD prevention and control.

Our findings showed that high eviction rates were positively associated with the incidence rates of STDs (chlamydia, gonorrhea and P& S syphilis) at the county-level. Over the past decade, housing and rental costs in the U.S. have increased dramatically (Jahromi et al., 2023; Leifheit & Jennings, 2019). Health problems caused by housing vulnerability, thus, are likely to spread faster and more seriously (Bambra et al., 2020). In terms of STDs, housing instability is significantly related to increased risk of sexual vulnerabilities (Groves et al., 2021). Housing instability, including eviction, may increase sexual and social vulnerabilities in ways that increase STD incidence rates at the community-level (Leifheit & Jennings, 2019). In other words, frequent residential moves may lead to unstable health care and reduced STD screening and treatment, resulting in STD transmission to one's sexual partners and increasing community-level STD incidence and prevalence (Lim et al., 2017; Niccolai et al., 2019). Communities with supportive housing, such as New York City, have demonstrated the impact of supportive housing program on STDs among young adults and reported a negative association between housing stability and diagnosed STD rates (Lim et al., 2017). A study of the effects of homelessness and unstable housing on chlamydia and gonorrhea screening in San Francisco has also shown that homeless and unstably housed people living with HIV had 34% lower odds of chlamydia and gonorrhea screening (Clemenzi-Allen et al., 2019). Our findings are consistent with these previous studies and support bringing renewed attention to the importance of housing stability for preventing STDs.

In terms of incarceration, prison incarceration rates were positively associated with chlamydia rates. Consistent with previous studies, this study extended previous evidence that examined the associations between incarceration and STD rates by reporting that prison incarceration rates were longitudinally associated with gonorrhea rates in the U.S. at the county-level. Through previous studies, we found a mechanism for a positive relationship between incarceration and STD rates in the inmates' risky sexual behaviors. First, people with more frequent incarceration histories had significantly greater number of sexual partners, higher frequency of unprotected sex and higher risk sexual partnerships (e.g., multiple partnerships and concurrent partnerships) both during and after periods of incarceration, which increases STD transmission (Khan et al., 2009; Khan et al., 2011; Widman et al., 2014). Second, inmates infected with STDs often had delayed access to medical screening and treatment while incarcerated (Brinkley-Rubinstein & Turner, 2013), which suggests that improved access to medical care might reduce STD rates in incarcerated populations. In terms of the length of stay for inmates, jail is designed for short-term incarceration, meanwhile prison is designed for long-term incarceration. We only analyzed prison incarceration admission in this study, but future study should consider the length of stay of inmates.

The strengths of this study include, first, that we studied, counties the smallest geographical units in which social determinants and STD data are publicly available across the U.S., thus, providing larger sample sizes and more variability to investigate longitudinal trends, changes, and relationships of social determinants and STD rates. Although there are several cross-sectional studies on the association between social determinants and STD rates at the state-level, research on associations at the county-level is still lacking. This study, thus, provides a better understanding of the ecological link between social determinants and STD rates, and suggests future directions for further investigation and STD intervention at the county-level. Second, social determinants include various interacting indicators with several indicators of social determinants influencing STD rates. This study used multiple indicators (e.g., social capital, housing instability, and incarceration) for social determinants from publicly available data resources, while previous research examined only one indicator in each analytical model (Niccolai et al., 2019; Nowotny et al., 2020; Owusu-Edusei et al., 2020). We were, thus, able to compare the relationships of multiple indicators of social determinants on STD rates side-by-side.

Limitations

There are limitations in this study. As this was a secondary data analysis, datasets in this study were not specifically designed for these research objectives. There were also limitations to data of differential resources for monitoring and surveillance at the county-level. Although the CDC's STD surveillance data provided incidence rates of STDs for all counties in the U.S., data for some counties were missing or unknown, and the number of reported cases of STDs was also influenced by trends in diagnosis, screening, and reporting practice. Data regarding the social capital index were only available some of the years in the 2001-2019 period; index scores were interpolated for the missing years. Therefore, our results of social capital were likely to be somewhat underestimated.

Conclusions

Through a longitudinal approach, this study indicates that social capital, eviction rates and prison incarceration rates were associated with the annual chlamydia, gonorrhea, and P & S syphilis incidence rates in the U.S at the county-level. Our findings contribute to expanding better understandings of the longitudinal associations between SDOH factors and STD incidence rates. In contrast to conventional individual-level STD interventions, more community-level interventions are needed that influence SDOH factors that contribute to STD incidence and other adverse outcomes. Our findings can help policy makers develop geographically specific STD prevention policies and inform resource allocation for better preventing, screening, and treating STDs.

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Table 2-1. General characteristics (*n* = 3,213)

Variable	2000		2019		Total (2000-2019)	
	Mean	*SD*	Mean	*SD*	Mean	*SD*
STDs rates (per 100,000 people)						
Chlamydia	115.88	170.39	399.87	293.22	286.94	261.12
Gonorrhea	45.17	98.08	126.63	146.76	73.03	107.04
Primary &Secondary (P & S) Syphilis	1.11	4.94	5.81	10.14	2.12	6.55
Social Capital	-.001	1.41	.001	1.24	-0.0001	1.32
Eviction Rate (no. of evictions per 100 rental homes)	.89	1.40	1.91	2.08	1.64	1.92
Prison Incarceration Rate (per 100,000 people)	460.24	759.12	511.08	503.03	486.20	701.76
Unemployment rate (%)	4.54	2.04	4.09	1.79	6.20	3.03
Federal poverty rate (%)	12.95	5.89	14.11	6.15	15.29	6.90
Median household income ($)	35,438.35	10,597.59	54,325.60	16,713.78	42,670.93	14,316.89
Core-Based Statistical Areas (CBSA)						

Metropolitan Statistical Area	1,234	(38.41)	1,234	(38.41)	1,234	(38.41)
Micropolitan Statistical Area	646	(20.11)	646	(20.11)	646	(20.11)
Rural Areas	1,333	(41.49)	1,333	(41.49)	1,333	(41.49)

Note. SD = standard deviation; Social capital was measured by using U.S. county-level multiple components (e.g., ethnic homogeneity, income inequality, attachment to place, education); eviction rates were measured by the number of households that received an eviction judgement per 100 renter-occupied households in a year; prison incarceration was measured by the annual estimates of prison admissions of county residents per 100,000 people.

Table 2-2. Pearson correlation between STDs, social capital, eviction rates, and jail incarceration rates

Variable	Correlations					
	1	2	3	4	5	6
1. Chlamydia Rate	1.000					
2. Gonorrhea Rate	0.798***	1.000				
3. P & S Syphilis Rate	0.320***	0.338***	1.000			
4. Social Capital	-0.232***	-0.222***	-0.097***	1.000		
5. Eviction Rate	0.354***	0.413***	0.222***	-0.355***	1.000	
6. Prison Incarceration Rate	0.090***	0.116***	-0.010*	-0.151***	0.045***	1.000

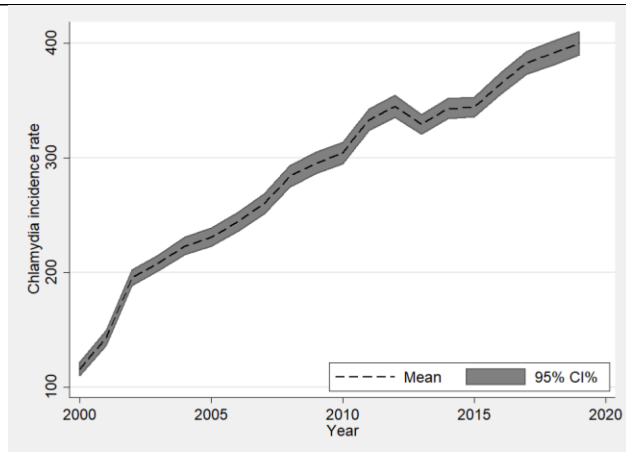
Note. *$p < .05$; **$p < .01$; ***$p < .001$.

Table 2-3. The association between social determinants and STDs (2000-2019)

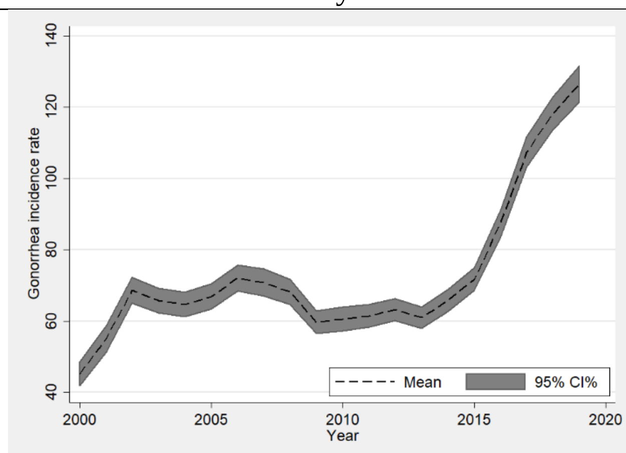
Correlates	Chlamydia Rate		Gonorrhea Rate		P & S syphilis Rate	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
Social Capital	-20.13 (2.35)***	-5.16 (2.15)*	-10.43 (0.87)***	-8.67 (0.86)***	-0.11 (0.05)*	0.05 (0.05)
Eviction Rates	11.76 (1.47)***	10.35 (1.36)***	7.75 (0.55)***	7.72 (0.55)***	0.22 (0.03)***	0.15 (0.03)***
Prison Incarceration Rates	0.002 (0.00)	0.001 (0.00)	0.002 (0.00)*	0.001 (0.00)*	0.00003 (0.00)	0.00004 (0.00)
Covariates						
Unemployment rate		7.42 (0.50)***		-1.77 (0.20)***		0.002 (0.01)
Federal poverty rate		10.16 (0.34)***		1.42 (0.14)***		0.09 (0.01)***
Median Household Income		0.007 (0.00)***		-0.00004 (0.00)		0.00005 (0.00)***
Core-Based Statistical Area						
Metropolitan Statistical Area	Reference	Reference	Reference	Reference	Reference	Reference

Micropolitan Statistical Area	-1.94 (11.63)	-18.39 (4.55)***	-1.05 (0.20)***
Rural Areas	-35.96 (9.75)***	-23.06 (3.83)	-1.02 (0.18)***

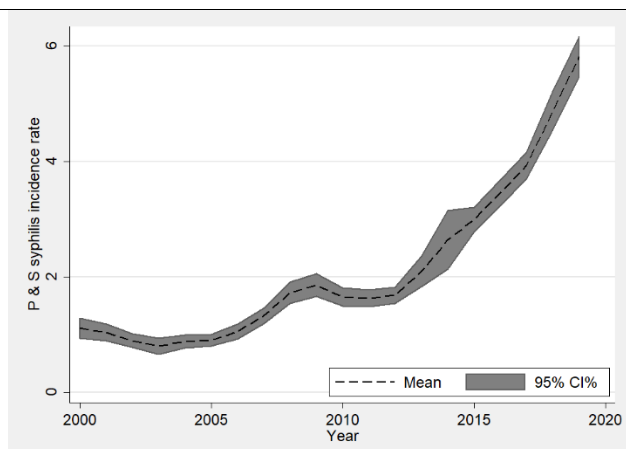
Note. Model 1 is unadjusted, and model 2 is adjusted for covariates. *p < .05; **p < .01; ***p < .001.



Chlamydia



Gonorrhea



P & S syphilis

Figure 2-1. Trends in average sexually transmitted disease incidence rates, 2000-2019

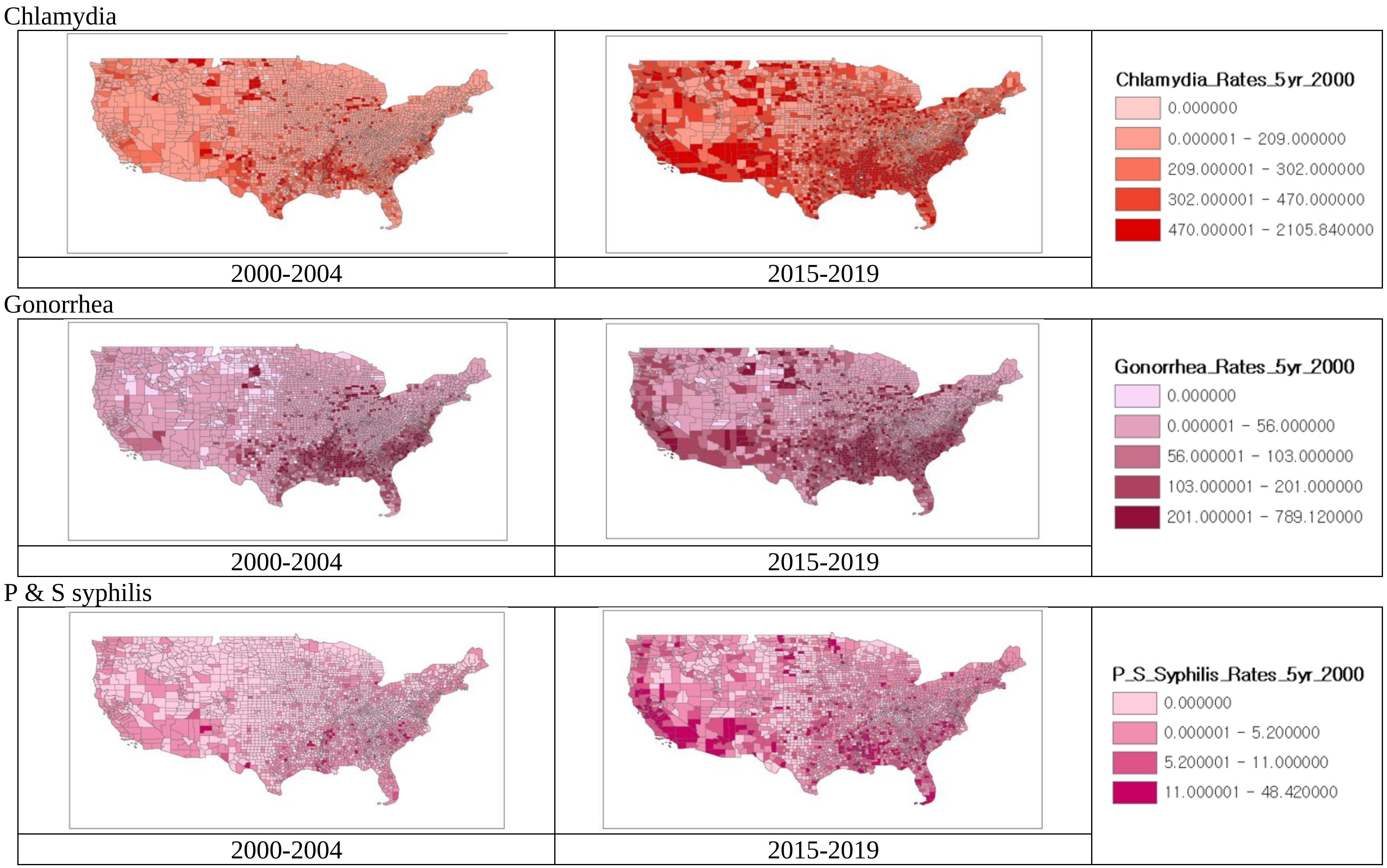


Figure 2-2. Comparison of 5-year spatial trends of incidence rates of STDs between 2000-2004 and 2015-2019

Chapter 3. AN EXAMINATION OF LOCAL SCREENING SERVICES FOR STDS AND THE IMPACT OF APPROACHES IN SERVICE DELIVERY ON STD INCIDENCE RATES

Abstract

Sexually transmitted disease (STD) incidence rates in the United States (U.S.) continue to rise, prompting investigations into effective control strategies. Local health departments (LHDs) play a pivotal role in STD management, historically providing screening and treatment services. As LHDs increasingly collaborate with community partners and the private sector, their approaches to providing STD-related services are changing. This study examined the association between three types of LHD STD-related screening service delivery approaches and STD incidence rates in U.S. LHD jurisdictions from 2000 to 2019. We analyzed data for 1,090 LHD jurisdictions, including annual STD incidence rates (chlamydia, gonorrhea, and syphilis) and STD-related screening service delivery categories: LHD directly provided screening, screening provided by others in the community and independent funding, and screening services provided by LHDs and by community providers combined/both together. Spatial panel autoregressive models were used to evaluate associations between STD-related screening service delivery and STD rates, controlling for socioeconomic and geographic factors. We found that STD-related screening service provided in a LHD jurisdiction by community providers and independent of LHD funding had significantly lower STD incidence rates than a jurisdiction where STD screening services were performed directly by LHDs and by others in the community. Our findings suggest that community providers performing STD-related screening services might be more effective than relying solely on LHDs or combined approaches. This shift likely reflects the changing role of LHDs and increased community partnerships. While LHDs may still need to directly provide STD-related

service delivery in rural areas, strong partnerships with community partners are essential to ensure adequate access to STD screening and treatment across all LHD jurisdictions.

Keywords: sexually transmitted diseases, local health departments, community partners, STD-related screening service delivery, spatial analysis

Introduction

In the United States (U.S.), estimates by the Centers for Disease Control and Prevention (CDC) indicate that approximately 26 million people were newly infected with all types of STDs and nearly 68 million people had STDs in 2018 (CDC, 2021c). Incidence rates of sexually transmitted diseases (STDs) in 2021 remain high, with 1,644,416 cases of chlamydia, 710,151 cases of gonorrhea, and 176,713 cases of all stages of syphilis reported (CDC, 2023). STDs are implicated in short- and long-term health complications including congenital infection, infertility, and ectopic pregnancy (Barrow et al., 2020). Yet, STD-related services are often suboptimal because of low rates of screening and multiple barriers to treatment (National Academies of Sciences, 2021).

Local health departments (LHDs) are the frontline of controlling STDs and serve as an access point for STD prevention, screening, and treatment (Paschal et al., 2011; Rodriguez et al., 2012). LHDs differ widely in size, financing, organizational oversight, services provided and partnerships; all of which have effects on STD-related service delivery, including screening and treatment strategies (Rodriguez et al., 2012). Although LHDs are responsible for STD-related service delivery in their communities, the types of STD-related services vary depending on the number of local providers, funding, and resources (Paschal et al., 2011). In 2014, when most provisions of the Patient Protection and Affordable Care Act (ACA) took effect, LHDs were faced with budget cuts, changes in key public health functions, and dwindling resources (French et al., 2016; Rodriguez et al., 2018) at the same time as more third party entities were able to fill in clinical gaps in services (Hsuan & Rodriguez, 2014; Rodriguez et al., 2018). Many LHDs subsequently, thus, reduced their own direct STD service provision as these third parties provided the services (Hsuan & Rodriguez, 2014; Rodriguez et al., 2018).

Previous evidence shows that better resourced LHDs, the presence of a local board of health, and integrated partnerships with community organizations are important predictors of public health system performance, including STD prevention and treatment (Bhandari et al., 2010; Paschal et al., 2011). In addition, greater public health spending is related to greater provision of STD-related service delivery provided by LHDs (Leichliter et al., 2017; Lim et al., 2022). In the current era of Public Health 3.0 and U.S health care reform, the roles and responsibilities of LHDs have changed, expanding public health practice to more deeply and widely engage in collaborations with community partners and private agencies (DeSalvo & Kadakia, 2021; DeSalvo et al., 2017). STD-related services are now frequently provided by community organizations or private clinics rather than directly by LHDs (Hsuan & Rodriguez, 2014). However, the impact of varied organizations providing STD screening services within communities on population-level STD incidence rates remains unclear (Rodriguez et al., 2018).

Because STD surveillance and screening are critical to local communities and service provision has changed, we sought to evaluate the types of STD-related screening service arrangements and their relationships to STD incidence rates in the local context. The objective of this study was to examine the association between three types of STD-related screening service delivery approaches and incidence rates of STDs within local county jurisdictions in the U.S. The approaches we examined were screening performed by the LHD directly, provided by others in the community and independent of LHD funding, and services by LHDs and by community providers combined/both together.

Methods

Data

We compiled publicly available county-level data obtained between 2000 and 2019 from multiple sources and merged these data with the 2019 National Association of County and City Health Officials (NACCHO) Profile Survey of Local Health Departments (Profile) data by using the Federal Information Processing Standards (FIPS) county codes. NACCHO conducts the Profile survey approximately every three years to develop a comprehensive description of funding, staffing, governance, and activities of LHDs across the U.S. (NACCHO, 2020). For the 2019 Profile survey, a total of 2,459 LHDs were included in the study population, and 1,496 LHDs responded (response rate, 61%; NACCHO, 2020). We excluded 249 LHDs in the sample because of their multi-county or multi-city jurisdiction designation that was difficult to link directly to FIPS codes. An additional 157 LHDs were excluded because they did not respond to the Profile's STD-related service delivery items for screening. The study population, thus, consisted of 1,090 single county-based LHDs in the U.S. (Figure 1). STD services related specifically to screening were focused on for this study since this was the most common STD service directly provided by LHDs in 2019 (NACCHO, 2020) and because of the importance of screening for STD surveillance. Data were limited to the 2019 Profile survey since it was the most recent Profile survey with an adequate sample size for analysis and linking these data to previous Profile surveys would have greatly limited this sample and not be as generalizable to today.

Annual incidence rates of chlamydia, gonorrhea, and P & S (primary and secondary) syphilis per 100,000 population (2000-2019) were obtained from the CDC's National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention (NCHHSTP) AtlasPlus website (CDC, 2021b). We obtained the presence or absence of an LHD having a board of health from the 2019 NACCHO Profile survey (NACCHO, 2020) and the annual average unemployment rate (2000-2019) by county from the U.S. Bureau of Labor Statistics (2022). Federal poverty rate and median household income from 2000 to 2019 were obtained from the U.S. Census Bureau's SAIPE (small area income and poverty estimates) program data, which produces single-year estimates of income and poverty for U.S. states and counties (U.S. Census Bureau, 2022). Census Core-Based Statistical Area (CBSA) data were gained from the National Bureau of Economic Research (NBER)'s CBSA to the FIPS County Crosswalk (National Bureau of Economic Research, n.d.) to control for rurality.

Measures

Our independent variable was types of STD-related screening service delivery which was operationally defined by the NACCHO Profile survey item about STD-related screening service delivery (e.g., "Check whether and how your LHD and other organizations provided that activity or service in your jurisdiction during the past year"). Based on this question and its response choices, STD-related service delivery was categorized into 3 different types of screening service delivery: "1) performed by LHD directly; 2) provided by others in the community and independent of LHD funding, and 3) combined—provided directly by the LHD and by others in the community and independent of LHD funding." (NACCHO, 2020). Our dependent variables were the annual incidence rates of three STDs (chlamydia, gonorrhea, and P & S syphilis) at the county-level, compiled from the CDC's AtlasPlus website (CDC, 2021a).

Because previous studies reported that presence of LHD local boards of health and socioeconomic variables were associated with STD incidence rates at the population level (Nowotny et al., 2020; Owusu-Edusei et al., 2020; Rodriguez et al., 2012), therefore we included presence or absence of local boards of health, unemployment rate, median household income, poverty rate, and CBSA as control variables. Presence or absence of local boards of health was measured by the question, "Does your LHD have one or more local boards of health?" (NACCHO, 2020). We measured the county-level unemployment rate as the number of unemployed people in each county divided by the number of people in the workforce in each county (U.S. Bureau of Labor Statistics, 2022). We measured federal poverty rate by comparing total pre-tax annual family income to federal poverty threshold tables, which varies according to family size, number of children, and age of householder (Bell & Robinson, 2020). We used the median household income as the income of the householder and all people 15 years and older in the household after adjusting for the 2019 consumer price index (CPI; Bell & Robinson, 2020). CBSA was categorized into 3 groups: metropolitan, micropolitan, and rural areas (i.e., less than 10,000, 10,000 to 49,999, and more than 50,000; Centers for Medicare & Medicaid Services, 2022).

Statistical analysis

The unit of analysis was a county-level LHD. Descriptive statistics were computed with STD-related screening service delivery categorized into 3 groups as mentioned above. In bivariate analyses, we compared the annual STD incidence rates by type of STD-related screening service delivery to investigate whether STD incidence rates differed according to the type of STD-related service delivery for screening. As a sensitivity analysis, we compared STD incidence rates between LHD jurisdictions included and excluded from the primary analysis to assess potential bias.

Spatial autoregressive (SAR) model

We examined the associations between the three types of STD-related service delivery approaches and annual incidence rates of STDs from 2000 to 2019 using a spatial panel autoregressive model. We included the control variables in the multivariate model. As LHDs were the unit of analysis, we used an identity link function, robust standard errors, and exchangeable correlation structure. The general form of equation for spatial autoregressive (SAR) model is as follows:

$$Y_t = X\beta_1 + S_t\beta_2 + \rho WR_t + \mu + \varepsilon_t \qquad t = 1 \ldots\ldots, 20$$

where Y was a n x 1 vector of the STD rates at time (year) t (from 1 to 20). X was a n x k matrix of independent variables (i.e., types of STD-related service delivery) for n LHDs, and S_t was a n x k matrix of exogenous socioeconomic and geographic characteristics (i.e., local boards of health, unemployment rate, median household income, poverty rate, and CBSA) of the LHD that are constant across time. W was the n x n spatial weight matrix, μ was a vector of parameters, and ε was error vectors. B_1 was the coefficient of interest for testing the relationships between service delivery arrangements and STD rates; ρ was the SAR lag coefficient. We estimated unadjusted and multivariate spatial regression models for each STD. Spatial contiguity weight matrices and all analyses were conducted in STATA version 17.0 (StataCorp LLC, College Station, TX). This study was determined to not require institutional review board approval given its use of publicly available, unidentifiable secondary datasets.

Results

Overall, 1,090 LHD jurisdictions were included in this study (44.3% of all LHD jurisdictions nationally and 72.9% of LHDs with NACCHO data available). Table 1 indicates that during 2000-2019, the average annual incidence rates of chlamydia, gonorrhea, and P & S syphilis per 100,000 increased dramatically (121.18 in 2000 vs. 420.46 in 2019 for chlamydia, 50.30 vs. 137.33 for gonorrhea, and 1.31 vs. 6.25 for syphilis). STD rates were similar between LHD jurisdictions included and excluded from the primary analysis. Unemployment rates decreased from 4.37 in 2000 to 1.49 in 2019 and federal poverty rates decreased from 12.47 in 2000 to 5.32. Median household income increased from $55,902 to $56,800 after adjusting for 2019 consumer price index (CPI). Of the 1,090 LHDs, 766 (70.28%) had local boards of health. STD-related screening service delivery was classified into three categories: (1) performed by LHD directly (185 LHDs, 16.97%), (2) provided by others in community and independent of LHD funding (206 LHDs, 18.90%), and (3) combined/both together (699 LHDs, 64.13%).

Table 2 display details of STD-related screening service delivery types by the local population size and geographic area. The combination of services both performed by LHD directly and provided by others in the community had the most counties engaged in this type of STD-related service delivery for screening (64.13%) and was most common in county population sizes of 500,000 or more (88.89%). Solo STD-related service delivery by LHDs was most common in populations of 50,000 or less (19.47%). Geographically, STD-related service delivery provided by others in the community was most common in the upper mid-west, and combined services by both the LHD directly and by others in the community was spread across the country.

In total, STD-related screening services provided by others in the community and independent of LHD funding showed the lowest average STD incidence rates per 100,000 (192.23 for chlamydia, 31.54 for gonorrhea, and 1.10 for P & S syphilis, respectively; Table 3). Among LHD jurisdictions with populations of 50,000 or less, LHDs that performed STD-related screening services directly and without other independent community providers delivering screening services had the highest incidence rates for each STD examined (323.27 for chlamydia, 90.91 for gonorrhea, and 1.83 for P & S syphilis, respectively). Among counties of 500,000 or more residents, jurisdictions in which LHDs and other independent providers in the community both provided screening services had the highest incidence rates of the three STDs (424.43 for chlamydia, 142.95 for gonorrhea, and 6.15 for P & S syphilis).

When geographical patterns were considered in spatial panel regression models with combined population sizes, jurisdictions that provided STD-related screening services through service delivery by others in the community and independent of LHD funding had significantly lower STD incidence rates per 100,000 than jurisdictions with both LHDs directly and community providers directly delivering the services, after adjusting for control variables (-65.25 for chlamydia, -43.27 for gonorrhea, and -0.66 for P & S syphilis, Table 4). In subgroup analyses, jurisdictions that provided screening through others in the community and independent of LHD funding consistently had significantly lower STD incidence rates per 100,000 in all population size groups for chlamydia (-50.73 for populations < 50,000, -46.19 for 50,000-499,999, and -209.01 for populations > 500,000), for gonorrhea (-33.97 for populations < 50,000, -35.52 for 50,000-499,999, and -122.60 for populations > 500,000), and populations of 500,000+ for P & S syphilis (-4.04; Table 5).

Discussion

In this large study of annual STD incidence rates by type of STD-related screening service delivery in 2000 - 2019, we found that STD screening services provided in a county by community providers and independent of LHD funding had significantly lower STD incidence rates than counties where STD screening services were performed directly by LHDs and by others in the community.

Only 185 LHDs (16.97%) of the 1,090 LHDs in our sample indicated that they were the only direct providers of STD-related screening services in the jurisdictions, while the other jurisdictions had these services provided by community partners or shared them between the LHD and other providers. Most of these 185 LHDs served rural jurisdictions. Historically, STD cases were typically identified and reported by LHD clinics (Barrow et al., 2020). Due, in part, to reduced public health budgets, however, the broad array of STD-related services (e.g., screening, partner services, evaluation of STD-related conditions, and laboratory services) delivered historically by LHDs and the number of LHD STD clinics themselves declined dramatically during the 2008-2009 economic recession, often depending on the existence of community partners to carry out these clinical function (National Coalition of STD Directors, 2009). Subsequently, most LHDs increasingly focused on broad public health functions of community-level assessment, policy development, and assurance, and away from the direct provision of clinical services for STDs, including screening (Mays et al., 2010; Rodriguez et al., 2018). In Massachusetts, for example, after 2007, most STD cases were reported from non-STD-specific clinics such as primary care clinics, family planning clinics, and emergency departments (Drainoni et al., 2014). Our study provides insights on the consequences of these shifts and our findings suggest an observed impact on lower STD incidence in counties that utilized other screening delivery approaches in the community to address STD screening in their jurisdiction.

Our findings suggest that the direct provision of STD screening by community providers may be particularly effective in managing and controlling new STD infections compared to jurisdictions where only the LHD or where both the LHD and private sector agencies are providing STD screening services. Cuffe et al. (2016) reported that young adults aged 15-25 are most often screened for STDs during nonspecific health visits, and women are often screened through regular gynecological examinations not associated with LHDs (LeFevre, 2014). As most LHDs are limited in providing STD screening and seldom provide STD treatment, they often referred individuals to STD services via family planning clinics, community clinics, and other STD clinics in their communities (Leichliter et al., 2020). Some patients also appear to prefer STD clinics in their communities or private agencies where these STD clinics provide them with expanded specialized

STD care and provide a relative ease of making an appointment for screening and treatment (Pearson et al., 2021). STD clinics in the private sector have also been found to be more likely to provide more specialized STD-related services than LHDs or other public clinics (Leichliter et al., 2017). In addition, because of budget cuts, LHDs have reduced STD partners' services, resulting in less STD screening for both or all sexual partners (Gift et al., 2018).

It may still be necessary for LHDs to maintain provision of STD-related screening services in rural areas, where services for community and private agency STD services and screening may be scarce. Meyerson et al. (2019) reported the type, number and distribution of STD clinics in the U.S. in 2017, and found rural communities were underserved by STD and related services. Paschal et al. (2011) also reported that LHDs in rural communities faced significant barriers to providing STD-related services and performing STD surveillance. Considering that LHDs are the primary organizations responsible to assure community prevention and treatment of STDs (Luo et al., 2015), the direct provision of STD safety-net services by LHDs may be crucial in some circumstances to assure that populations in rural communities have access to sexual health care and local surveillance (Leichliter et al., 2020; Pearson et al., 2021). Leichliter et al. (2020) surveyed the national availability of STD safety-net services and found that 64.4% of 326 LHDs reported no safety-net STD services in their community. In these jurisdictions where direct provision of STD-related services is lacking entirely, the LHD's role in assuring the local provision of STD screening and treatment may mean direct provision of the service as well as robust contact tracing and STD case management, if collaboration with community clinical providers does not exist. This, however, is difficult for LHDs which are already poorly funded and serving areas already generally underserved. As such, greater support from state and federal agencies and from health care systems are needed to bring additional STD-related resources to these communities.

Limitations

This study has limitations. First, the STD-related screening service delivery was measured using a single question from the 2019 NACCHO Profile survey. Therefore, although various STD-related services may be provided, depending on the local and geographical environment, financial resources, and STD incidence rates in a jurisdiction, STD-related screening services had to be classified into the three screening categories examined. Screening services, however, were those clinical STD services that LHDs were most often directly providing (Hsuan & Rodriguez, 2014). Second, the results of this study may suffer from surveillance bias (Haut & Pronovost, 2011), resulting in higher STD incidence rates in more closely screened groups (Rodriguez et al., 2012). Finally, since this study only analyzed provision of STD-related screening service delivery and from only 2019, further studies are needed to develop a comprehensive taxonomy of STD-related service delivery and how it changes over time in communities as a means to examine the nature, variation, and impact of a broader array of STD services and by varied institutions.

Conclusions

The provision of STD-related screening service within LHD jurisdictions is essential to reducing STD incidence rates and controlling the spread of STDs in the U.S. This study found that STD screening services provided by others in the community and independent of LHD funding had significantly lower STD incidence rates than LHD jurisdictions where both the only LHD and private sectors agencies are providing STD screening services. Our findings indicate that LHDs which are the sole direct provider of STD-related screening services should ideally establish structured partnerships with local clinics and private agencies, when present in local jurisdictions, to maintain safety-net STD services and assure the availability of STD-related services and surveillance in underserved jurisdictions.

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Table 3-1. General Characteristics of County Jurisdictions in Sample (*n* = 1,090)

Variables	2000		2019		Overall (2000 – 2019)	
	Mean	(*SD*)	Mean	(*SD*)	Mean	(*SD*)
STD incidence rates						
Chlamydia	121.18	(152.91)	420.46	(243.77)	294.21	222.37
Gonorrhea	50.30	(97.91)	137.33	(129.64)	77.27	99.18
P&S Syphilis	1.31	(6.05)	6.25	(9.18)	2.09	4.88
Local boards of health						
Yes	766	(70.28)	766	(70.28)	766	(70.28)
No	324	(29.72)	324	(29.72)	324	(29.72)
Unemployment rate (%)	4.37	(1.60)	3.96	1.49	6.10	2.68
Federal poverty rate (%)	12.47	(5.03)	14.00	5.32	15.16	6.08
Median household income ($)	55,901.88	(14,204.40)	56,799.58	(15,162.37)	(53,238.05)	(14,108.45)

Core-Based Statistical Areas (CBSA)						
Metropolitan Statistical Area	474	(43.49)	474	(43.49)	474	(43.49)
Micropolitan Statistical Area	215	(19.72)	215	(19.72)	215	(19.72)
Rural Areas	401	(36.79)	401	(36.79)	401	(36.79)

Note. *SD* = Standard Deviation; Median household income was adjusted for consumer price index (CPI) in 2019.

Table 3-2. Types of STD-related screening service delivery in 2019, by local population size (*n* = 1,090 jurisdictions)

Categories	Local population size: Number of populations < 50,000 (n = 606 jurisdictions)		Number of populations 50,000 – 499,999 (n = 412 jurisdictions)		Number of populations ≧ 500,000 (n = 72 jurisdictions)		Overall	
	n	(%)	N	(%)	n	(%)	n	(%)
1. Performed by LHD directly	118	(19.47)	60	(14.56)	7	(9.72)	185	(16.97)
2. Provided by others in community independent of LHD funding	142	(23.43)	63	(15.29)	1	(1.39)	206	(18.90)
3. Performed by LHD directly + Provided by others in community independent of LHD funding	346	(57.10)	289	(70.15)	64	(88.89)	699	(64.13)

Note. LHD = Local Health Department.

Table 3-3. Chlamydia, gonorrhea, and P& S syphilis incidence rates by types of STD-related service delivery for screening and local population size

Categories	STD incidence per 100,000							
	Local population size						Overall	
	< 50,000 (n = 606 jurisdictions)		50,000 – 499,999 (n = 412 jurisdictions)		≧ 500,000 (n = 72 jurisdictions)			
	Mean	(*SE*)	Mean	(*SE*)	Mean	(*SE*)	Mean	(*SE*)
Chlamydia incidence rates per 100,000								
1. Performed by LHD directly	323.27	(5.15)	365.19	(7.28)	283.05	(11.91)	335.34	(4.09)
2. Provided by others in community independent of LHD funding	163.68	(2.12)	256.51	(4.18)	257.48	(9.88)	192.23	(2.05)
3. Performed by LHD directly + Provided by others in community independent of LHD funding	274.16	(2.12)	335.27	(2.78)	424.43	(6.41)	313.21	(1.92)
Gonorrhea incidence rates per 100,000								
1. Performed by LHD directly	90.91	(2.31)	122.02	(3.57)	82.73	(4.62)	100.69	(1.90)
2. Provided by others in community independent of LHD funding	22.66	(0.64)	51.63	(1.70)	45.04	(6.14)	31.54	(0.71)
3. Performed by LHD directly + Provided by others in community independent of LHD funding	65.60	(1.19)	94.08	(1.27)	142.95	(3.16)	84.47	(0.86)
P & S syphilis incidence rates per 100,000								
1. Performed by LHD directly	1.83	(0.11)	2.95	(0.14)	5.00	(0.34)	2.31	(0.08)
2. Provided by others in community independent of LHD funding	0.84	(0.07)	1.68	(0.09)	2.28	(0.46)	1.10	(0.05)
3. Performed by LHD directly + Provided by others in community independent of LHD funding	1.53	(0.06)	2.41	(0.06)	6.15	(0.21)	2.32	(0.04)

Table 3-4. The association between types of STD-related screening service delivery and incidence rates of

Correlates	Chlamydia		Gonorrhea		P & S syphilis	
	Coefficient (*SE*)	*P* - value	Coefficient (*SE*)	*P* - value	Coefficient (*SE*)	*P* - value
STD-related screening service delivery						
Performed by LHD directly	8.62 (16.29)	0.597	17.50 (7.81)	0.025	0.02 (0.19)	0.920
Provided by others in community and independent of LHD funding	-65.25 (10.20)	0.000	-43.27 (4.44)	0.000	-0.66 (0.15)	0.000
Performed by LHD directly + Provided by others in community independent of LHD funding	Reference		Reference		Reference	
Covariates						
Local boards of health						
Yes	-49.18 (12.56)	0.000	-32.23 (6.30)	0.000	-0.95 (0.20)	0.000
No	Reference		Reference		Reference	
Unemployment rate	-0.02 (0.61)	0.973	-4.97 (0.27)	0.000	-0.21 (0.02)	0.000
Federal poverty rate	10.15 (0.55)	0.000	1.46 (0.23)	0.000	0.15 (0.01)	0.000
Median Household Income	0.002 (0.00)	0.000	0.0006 (0.00)	0.000	0.00004 (0.00)	0.002
Core-Based Statistical Area (CBSA)						
Metropolitan Statistical Area	95.23 (13.41)	0.000	29.44 (5.90)	0.000	1.40 (0.17)	0.000
Micropolitan Statistical Area	67.32 (13.98)	0.000	17.69 (6.54)	0.007	0.49 (0.16)	0.003
Rural Areas	Reference		Reference		Reference	

Note. *LHD* = Local Health Department; Independent variable is STD-related screening service delivery. All spatial autoregressive regression models are adjusted for covatiates (Local boards of health, unemployment rate, federal poverty rate, median house income, and CBSA).

Table 3-5. Subgroup analysis of the association between types of STD-related service delivery for the screening and incidence rates of STDs by local population size

5a. Chlamydia

Correlates	Chlamydia					
	< 50,000 (n = 606 jurisdictions)		50,000 – 499,999 (n = 412 jurisdictions)		≧ 500,000 (n = 72 jurisdictions)	
	Coefficient (SE)	*P* - value	Coefficient (SE)	*P* - value	Coefficient (SE)	*P* - value
STD-related screening service delivery						
Performed by LHD directly	41.61 (19.61)	0.034	17.81 (27.29)	0.514	-141.41 (44.67)	0.002
Provided by others in community independent of LHD funding	-50.73 (11.99)	0.000	-46.19 (18.13)	0.011	-209.01 (28.35)	0.000
Performed by LHD directly + Provided by others in community independent of LHD funding	Reference		Reference		Reference	
Covariates						
Local boards of health						
Yes	-94.99 (17.37)	0.000	-0.48 (18.55)	0.980	19.93 (41.65)	0.632
No	Reference		Reference		Reference	
Unemployment rate	1.78 (0.86)	0.040	-2.52 (0.88)	0.004	0.53 (2.31)	0.819
Federal poverty rate	9.67 (0.70)	0.000	15.41 (0.99)	0.000	17.57 (3.50)	0.000
Median Household Income	0.003 (0.00)	0.000	0.001 (0.00)	0.035	0.002 (0.00)	0.143
Core-Based Statistical Area (CBSA)						
Metropolitan Statistical Area	-9.72 (15.61)	0.931	179.27 (27.58)	0.000	109.70 (62.48)	0.079
Micropolitan Statistical Area	72.15 (18.19)	0.000	103.51 (27.37)	0.000	165.06 (63.70)	0.010
Rural Areas	Reference		Reference		Reference	

Note. *LHD* = Local Health Department.

5b. Gonorrhea

Correlates	Gonorrhea					
	< 50,000 (n = 606 jurisdictions)		50,000 – 499,999 (n = 412 jurisdictions)		≧ 500,000 (n = 72 jurisdictions)	
	Coefficient (SE)	*P* - value	Coefficient (SE)	*P* - value	Coefficient (SE)	*P* - value
STD-related screening service delivery						
Performed by LHD directly	25.09 (9.07)	0.006	29.72 (15.12)	0.049	-78.56 (23.72)	0.001
Provided by others in community independent of LHD funding	-33.97 (5.21)	0.000	-35.52 (8.37)	0.000	-122.60 (16.96)	0.000
Performed by LHD directly + Provided by others in community independent of LHD funding	Reference		Reference		Reference	
Covariates						
Local boards of health						
Yes	-51.53 (8.44)	0.000	-9.40 (9.69)	0.332	-7.67 (26.72)	0.774
No	Reference		Reference		Reference	
Unemployment rate	-4.60 (0.36)	0.000	-6.15 (0.44)	0.000	-4.96 (1.02)	0.000
Federal poverty rate	1.28 (0.28)	0.000	2.06 (0.44)	0.000	1.94 (0.90)	0.031
Median Household Income	0.0008 (0.00)	0.001	0.0004 (0.00)	0.131	0.001 (0.00)	0.052
Core-Based Statistical Area (CBSA)						
Metropolitan Statistical Area	-9.18 (7.18)	0.201	54.62 (10.94)	0.000	-57.92 (32.04)	0.071
Micropolitan Statistical Area	15.62 (8.44)	0.064	33.92 (12.05)	0.005	27.66 (33.07)	0.403
Rural Areas	Reference		Reference		Reference	

Note. *LHD* = Local Health Department.

5c. P & S syphilis

Correlates	P & S syphilis					
	< 50,000 (n = 606 jurisdictions)		50,000 – 499,999 (n = 412 jurisdictions)		≧ 500,000 (n = 72 jurisdictions)	
	Coefficient (SE)	*P*- value	Coefficient (SE)	*P*- value	Coefficient (SE)	*P*- value
STD-related screening service delivery						
Performed by LHD directly	0.16 (0.21)	0.451	0.43 (0.32)	0.181	-1.29 (1.12)	0.248
Provided by others in community independent of LHD funding	-0.23 (0.14)	0.097	-0.38 (0.26)	0.142	-4.04 (0.77)	0.000
Performed by LHD directly + Provided by others in community independent of LHD funding	Reference		Reference		Reference	
Covariates						
Local boards of health						
Yes	-1.11 (0.23)	0.000	-0.67 (0.24)	0.006	-0.53 (1.44)	0.712
No	Reference		Reference		Reference	
Unemployment rate	-0.16 (0.03)	0.000	-0.26 (0.03)	0.000	-0.54 (0.08)	0.000
Federal poverty rate	0.13 (0.02)	0.000	0.20 (0.03)	0.000	0.46 (0.13)	0.000
Median Household Income	0.00004 (0.00)	0.000	0.00003 (0.00)	0.005	0.00009 (0.00)	0.108
Core-Based Statistical Area (CBSA)						
Metropolitan Statistical Area	0.31 (0.19)	0.105	1.47 (0.32)	0.000	8.58 (1.79)	0.000
Micropolitan Statistical Area	0.47 (0.21)	0.023	0.68 (0.33)	0.040	4.96 (1.55)	0.001
Rural Areas	Reference		Reference		Reference	

Note. LHD = Local Health Department.

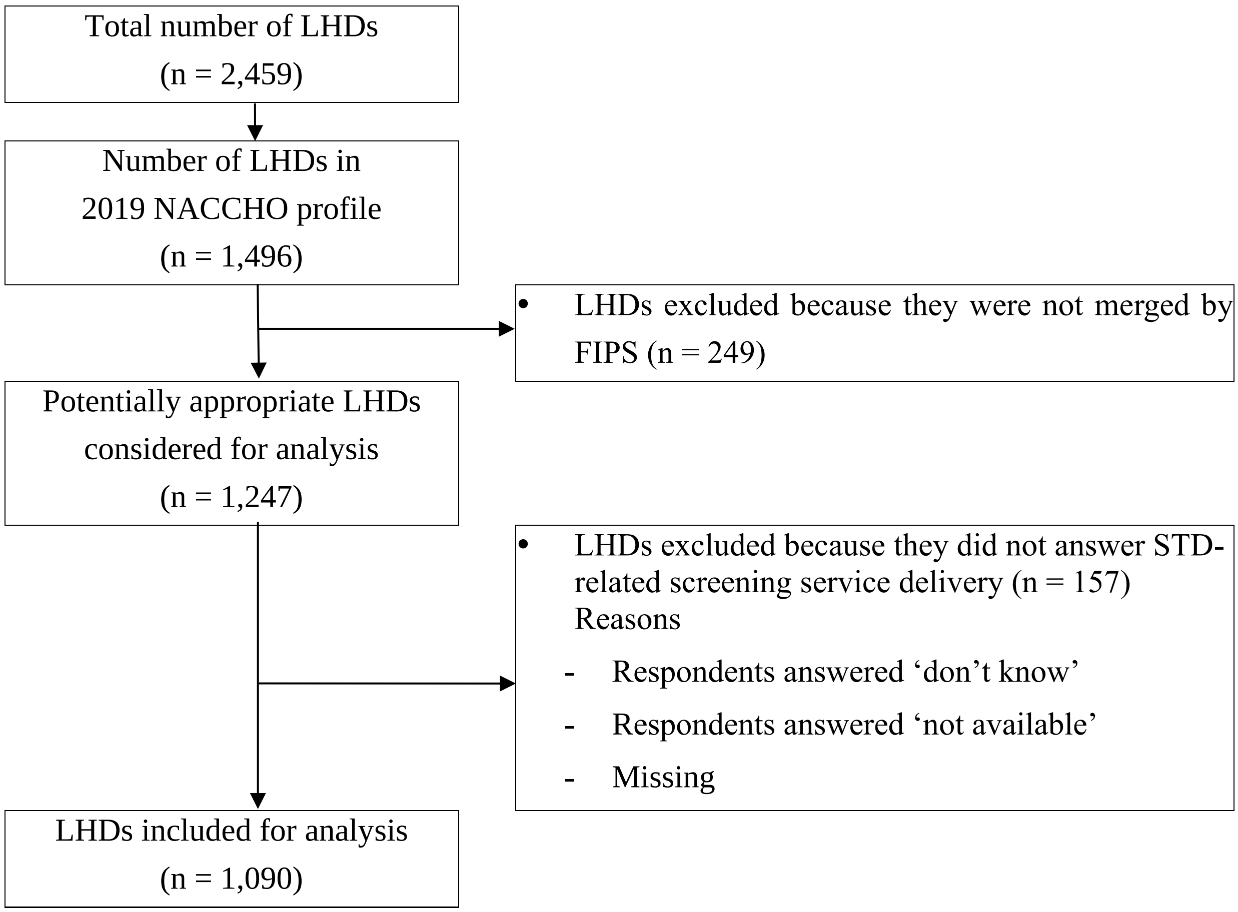

Figure 3-1. Flow diagram of sample selection process

Chapter 4. IDENTIFYING PREDICTORS FOR COUNTIES THAT HAVE EXCEPTIONALLY LOW STD RATES IN THE UNITED STATES: A POSITIVE DEVIANT MODEL

Abstract

The United States (U.S.) is experiencing an unprecedented sexually transmitted disease (STD) epidemic, with rising incidence rates for chlamydia, gonorrhea, and syphilis. Local health departments (LHDs) play a crucial role in preventing and treating STDs, but some LHDs are demonstrably more effective than others. This study utilizes a positive deviance (PD) approach to identify and analyze U.S. counties with unexpectedly low STD rates. We used a cross-sectional study design, analyzing data from 981 counties across the U.S. using multivariate regression models. We identified PD counties, considering internal and external factors and investigated predictors that affect the identification of these PD counties. We identified 187 (19.06%) PD counties. These counties were more likely to have smaller populations, high social vulnerability in specific subcategories (racial and ethnic subgroup, housing and transportation), and LHDs that provided STD-related treatment services directly and through community partnerships. Our findings demonstrate the potential of the PD approach for identifying and learning from high-performing LHDs. The identification of PD counties provides a foundation for future research to explore the nuanced interventions contributing to their success, ultimately informing targeted public health strategies and resource allocation.

Keywords: positive deviant, sexually transmitted diseases, public health, local health departments, social vulnerability, STD-related service delivery

Introduction

The United States (U.S.) is currently experiencing the highest sexually transmitted disease (STD) epidemic ever recorded, and data released by the Centers for Disease Control and Prevention (CDC) shows that incidence rates of STDs have continued to rise since 2013 (CDC, 2023d). Despite the efforts of STD prevention and treatment providers, a total of 1,644,416 cases of chlamydia (495.5 cases per 100,000), 710,151 cases of gonorrhea (214.0 cases per 100,000) and 176,713 cases of syphilis (all stage and congenital; 53.2 cases per 100,000) were reported in 2021 in the U.S., with an increase of 3.9%, 4.6% and 28.6% compared with the rates in 2020, respectively (CDC, 2023b, 2023e). While COVID-19 had a significant impact on STD-related screening services and incidence trends of STDs, which may have led to underreported STD infections early in the pandemic (CDC, 2023a; Tanne, 2022), surveillance and case numbers increased again by the end of that year (CDC, 2022) and have continued to rise (CDC, 2023d).

Local Health Departments (LHDs) play a pivotal role in preventing and treating STDs and are responsible for providing effective population-level STD surveillance in the communities they serve and assuring the delivery of STD services (Paschal et al., 2011; Rodriguez et al., 2012). LHDs, especially in rural areas, often serve as central providers of STD treatment services, including provision of medications and injections (Paschal et al., 2011). Nevertheless, some LHDs may be more effective in their STD-related prevention activities than other LHDs, but little is known about how to quantitatively identify and predict what counties might have exceptionally low STD incidence rates and what we can learn from them.

The positive deviance (PD) approach has achieved prominence in identifying and understanding individual- and community- outperformance in complex health situations (Han et al., 2022; Klaiman, Pantazis, et al., 2016; Walker et al., 2007). Most research on positive deviance has focused primarily on individual characteristics that support something performing beyond expectations (Hendryx et al., 2017). In the field of public health, this concept has been applied to children's nutrition, newborn care, maternal and child health (MCH), and sexual behavior at the individual level (Berggren & Wray, 2002; Marsh et al., 2002). As a framework for identifying and learning from individuals and communities that practice beyond expectations (Klaiman, Pantazis, et al., 2016), PD can be also applied to community-level health outcomes as well as individual-level health outcomes (Walker et al., 2007). Previous studies at the community-level have used system-level approaches of positive deviance to identify LHD jurisdictions that had exceptionally good MCH outcomes compared to other jurisdictions in the same state (Klaiman, Chainani, et al., 2016; Klaiman, Pantazis, et al., 2016), and counties where health outcomes (e.g., low rates of adult obesity, diabetes, colorectal cancer, and circulatory disease mortality rates) exceeded expectations in Indiana (Hendryx et al., 2017).

To date, no known studies have been conducted regarding STDs using a PD approach at the community- or county-level. Empirical methods using a PD framework can provide an important step toward investigating internal (e.g., LHD leadership, local boards of health oversight, types of STD-related service delivery) and external (e.g., population size, social vulnerability, and rurality) factors associated with STD outcomes that may contribute to high-performing counties and communities with better STD outcomes than their peer communities. Therefore, the aims of this study were 1) to identify "PD counties" that have exceptionally low STD incidence rates in the U.S., and 2) to investigate predictors that affect the identification of these PD counties among a county's internal and external factors.

Methods

Data

In this cross-sectional study, we compiled publicly available data from various resources and merged data from the 2019 National Association of County and City Health Officials (NACCHO) Profile Survey as well as the CDC/Agency for Toxic Substances and Disease Registry (ATSDR)'s 2018 Social Vulnerability Index (SVI) by using the Federal Information Processing Standards (FIPS) codes. NACCHO conducts the Profile Survey approximately every three years to collect information on the infrastructure and practices of LHDs across the U.S. (NACCHO 2020). CDC/ATSDR reports on its SVI every two years, providing longitudinal data for public health officials and emergency response planners to identify the communities most in need of assistance before, during, and after a hazardous event (Agency for Toxic Substances and Disease Registry, 2023).

Figure 1 presents a flow diagram that documents the inclusion and exclusion of counties to create the study's database. The most recent year of NACCHO Profile Survey data available at the time of this study was for 2019. For the 2019 NACCHO Profile Survey, 1,496 LHDs responded from a total of 2,459 LHDs in the study population (response rate 61%). We excluded 249 LHDs from the national sample due to their multi-county or multi-city jurisdiction designation that could not be connected directly to a county FIPS code. An additional 266 LHDs were excluded because their counties were missing SVI data or their NACCHO Profile Survey was missing the necessary LHD-level internal factors (e.g., executive clinician, local board of health, and STD-related service delivery data). The final study sample included 981 single county-based LHDs in the U.S.

Measures

As part of the PD approach, we sought to explain the variation in STD incidence rates (y) as a function of external factors (z) and internal factors (x). A summary of the variables included in the analyses is presented in Appendix Table 1.

STD incidence rate (y)

We used 2019 county-level incidence rates of chlamydia, gonorrhea, and P & S (primary & secondary) syphilis from the CDC's National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention (NCHHSTP) AtlasPlus website (CDC, 2023c). Chlamydia, gonorrhea, and P & S syphilis were defined as an STD caused by *Chlamydia trachomatis, Neisseria gonorrhoeae*, and *Treponema pallidum*, respectively (CDC, 2023c; Kidd et al., 2018).

External factors that LHDs have less control over (Z)

We included the following external factors that LHDs have arguably less control over: population size, four subcategories of SVI, and core based statistical area (CBSA). Population size was divided into 7 categories (e.g., < 25,000, 25,000 – 49,999, 50,000 – 99,999, 100,000 – 249,999, 250,000 – 499,999, 500,000 – 999,999, and 1 million +). SVI is a single composite score comprised of 4 subcategories--socioeconomic status, household characteristics, racial and ethnic subgroup, and housing type and transportation--ranging from 0 (lowest vulnerability) to 1 (highest vulnerability). The ATSDR considers 'vulnerability' based on socio-economic factors known to be associated with the degree to which a community exhibits certain adverse or hazardous social conditions (Agency for Toxic Substances and Disease Registry, 2022). In this study, four subcategories scores were chosen. Among the 4 subcategories, socioeconomic status was measured by the percent of those in a county who are below 150% poverty, unemployed, have a high housing cost burden, have no high school diploma, and have no health insurance (Agency for Toxic Substances and Disease Registry, 2022). Household characteristics were measured by the percent of those in a county who were aged 65 and older, aged 17 and younger, were civilians with a disability, living in single-parent households, and had limited English language proficiency (Agency for Toxic Substances and Disease Registry, 2022). Racial and ethnic subgroup included percentage of those identifying themselves in subgroup populations used by the ATSDR (e.g., Hispanic or Latino, African American, Asian, and Native American; Agency for Toxic Substances and Disease Registry, 2022). Housing type and transportation consisted of multi-unit structures, mobile homes, crowding, no vehicle, and group quarters (Agency for Toxic Substances and Disease Registry, 2022). CBSA was categorized into metropolitan, micropolitan, and rural areas.

Internal factors that LHDs can control (x)

As internal LHD factors that have been shown to be related to LHD service provision and health outcomes, we included LHD lead executive being a clinician, having oversight by a local board of health, and STD-related treatment service delivery (Klaiman, Pantazis, et al., 2016; Rodriguez et al., 2012; Rodriguez et al., 2018). Executive clinician was defined as whether an LHD's lead executive is a clinician (e.g., physican, registered nurse) or not. Local boards of health were defined as whether an LHD has a local board of health or not. STD-related treatment service delivery was categorized into 3 types of STD-related service delivery: 1) performed by the LHD directly; 2) provided by others in the community and independent of LHD funding, and 3) combined—provided directly by the LHD and by others in the community and independent of LHD funding. While LHDs vary in the type of STD services they deliver (e.g., surveillance, screening, and/or treatment), we focused on treatment here because STDs can continue to be transmitted and reinfected through unseen pathways, if untreated, ultimately leading to a variety of complications (e.g., infertility, ectopic pregnancy, and stillbirths; Gottlieb et al., 2014).

Statistical analysis

We conducted descriptive statistics to examine the general characteristics of counties in this study. We identified PD counties using two steps: 1) we analyzed a multivariate regression model ($Y = \alpha + \beta_1 (z) + e$) to assess for potential PD counties in relation to STD outcomes considering external factors (z), and 2) we added internal factors (x) in the multivariable regression model ($Y = \alpha + \beta_1 (z) + \beta_2 (x) + e$) to assess how well the model fits when including LHDs' internal variables. We identified PD counties as those with standardized residuals less than -1 in any of the three STDs in step 2 (Hendryx et al., 2017; Klaiman, Pantazis, et al., 2016). After defining PD or non-PD counties, multivariate logistic regression modelling was used to examine the predictors of PD counties of STD outcomes. All analyses were conducted in STATA version 17.0 (StataCorp LLC, College Station, TX).

Results

Table 1 presents the general characteristics of the 981 counties included in the study. The incidence rate of chlamydia, gonorrhea, and P & S syphilis in 2019 was 422.66, 139.80, and 6.46 per 100,000, respectively. Most counties in the sample were less than 25,000 in population size (37.82%), were in metropolitan areas (44.85%), had an LHD led by an executive clinician (89.81%), had an LHD with no local board of health (69.93%) and had STD-related treatment services provided by both the LHD and by a community provider (i.e., LHD directly, and others in community and independent of LHD funding; 64.12%). The county averages for the four SVI subcategories were socioeconomic status (0.494, *SD* = 0.285), household characteristics (0.490, *SD* = 0.288), racial & ethnic subgroup (0.502, *SD* = 0.281), and housing type and transportation (0.520, *SD* = 0.274).

To identify PD or non-PD counties, Table 2 shows the associations between external factors/internal factors and STD outcomes in the multivariate regression analyses. The chlamydia model showed the highest model fit (R^2 = 0.42), whereas the P & S syphilis model showed the lowest model fit (R^2 = 0.18). All the external factors were associated with the three STD rates. For the internal factors, only STD-related treatment delivery was associated with the STD rates.

We identified a PD county if the county had any (-1) studentized residuals for the three STD outcomes (i.e., chlamydia, gonorrhea, and P & S syphilis; Figure 2). We found a total of 187 counties out of 981 counties (19.06%) across the U.S. as PD counties. Table 3 indicates the number of PD counties in each of the U.S. Health and Human Services (HHS) regions. Regions 2, 9, and 10 had the highest percent of PD counties from among those in the sample - 18 out of 40 counties (45.00%) in Region 10, 16 out of 40 (40.00%) counties in Region 9, and 8 out of 22 counties (36.36%) in Region 2 performed better than expected in the STD outcomes.

The factors predicting PD counties in the logistic regression model are presented in Table 4. Counties having a population less than 25,000 were significantly associated with higher odds of being identified as a PD county (Odds Ratio [OR] = 6.47, [95% CI: 1.22 - 34.421]). In the SVI subcategories, having a high proportion of residents in a 'high vulnerability' racial and ethnic subgroup and having a high proportion of residents with a 'high vulnerability' housing type and transportation were significantly associated with higher odds of being identified as a PD county (OR = 3.29, [95% CI: 1.50 - 7.20], and OR = 11.94, [95% CI: 4.91 - 29.06], respectively). Counties that provided STD-related treatment services directly by the LHD (OR = 2.47, [95% CI: 1.21 - 5.00]) as well as through a community provider (OR = 2.22, [95% CI: 1.20 - 4.09]) were significantly associated with higher odds of being identified as a PD county than counties that provided STD services only through others in the community and independent of LHD funding.

Discussion

This study used a quantitative PD approach to identify PD counties across the U.S. in relation to their STD outcomes and investigated predictors of PD counties among internal and external factors. In the total study sample, 19.06% of counties were classified as PD counties. Small population sizes and SVI subcategories pertaining to racial and ethnic subgroup and housing type and transportation were positively associated with PD identification, and STD-related treatment services provided directly by the county's LHD and through a community provider were found to be positively associated with predictors of PD identification.

In terms of internal factors predicting PD counties with favorable STD outcomes, the delivery of STD-related services both performed directly by LHDs and by other providers in the community demonstrated a particularly strong association with the identification of PD counties. Thus, it seems a shared LHD- and community-provided STD service may have been protective and playing a significant role in controlling STD incidence in these counties (Ortayli et al., 2014), and integrated STD service delivery has beneficial effects on improving access to STD-related services (Church & Mayhew, 2009). Other internal factors, such as whether or not the LHD leader was a clinician executive, were not associated with the identification of PD counties. Because clinician LHD leaders are very often nurses who are more often found leading smaller LHDs (Bekemeier & Jones, 2010), it could be that this clinician executive factor was captured by the significant findings for county population size.

In terms of external predictors of STD outcomes, population size and SVI were significantly associated with identifying PD counties. Compared with counties of over 1 million people, counties with less than 25,000 residents had 6.47 times higher odds of being identified as a PD county. As many of these small population-sized counties were likely rural, they can be expected to have the known disadvantages experienced by rural communities in terms of high rates of poor health and inadequate access to public health services (Harris et al., 2016). Previous findings from a PD study showed that some rural counties in Indiana achieved better health outcomes (e.g., percent of adult obesity, percent of low birth weight, and percent of diabetes etc.), even with low scores on poverty, education, and labor force participation (Hendryx et al., 2017).

They emphasized the need for follow-up research to generalize effective practices to other rural areas (Hendryx et al., 2017).

We found high social vulnerability in some counties, but with what appears to nonetheless be well-controlled STD incidence rates. In terms of the SVI, we identified the factors related to racial and ethnic subgroups and of housing type and transportation to be significant predictors of identification of PD counties with high odds ratios. This suggests that there are unusual circumstances or resilience-building activities that might improve STD prevention in these counties that have unexpectedly well-controlled STDs. Certain subgroups within communities may have widely adopted risk reduction behaviors or prevention messages or certain prevention strategies may have achieved particularly effective spread (Chin et al., 2012). As an individual-level study, Ober et al. (2018) found particularly protective behaviors among some high-risk HIV negative black men who have sex with men (MSM), using a PD framework. Findings showed that they were engaging in intentional risk reduction strategies during sexual activities, such as increased condom use to prevent STD infection.

As a community- and organizational-level study, there are few examples of applying PD approaches to STD outcomes. Some studies focusing on primary care and using a PD approach showed that having strong partnerships between LHDs and other health care providers created a comprehensive health care environment and enabled exceptional health outcomes at the community-level (Bradley et al., 2012; McAllister et al., 2013; O'Malley et al., 2022). This may suggest that better STD outcomes can be achieved at the community-level through close partnerships between LHDs and private sectors regarding STD screening and treatment, as might appear to be the case in our study.

This is the first known study to have quantitively examined PD counties for STD outcomes. Previous PD studies have used quantitative or qualitative methods in identifying PDs in terms of population health outcomes (e.g., adult obesity rate, circulatory disease mortality, and colorectal cancer incidence rate; Hendryx et al., 2017) and MCH outcomes (e.g., infant mortality rate and low birth weight rate; Klaiman, Chainani, et al., 2016). We found that including external factors in the initial regression model and then adding internal factors into the model slightly strengthened the model's fit in terms of finding PD counties. This would seem an important approach to identify PD counties that can further be examined for the circumstances and prevention activities that might be creating a healthier environment. Through using a quantitative PD approach here we, thus, facilitate identification of a broad national sample of PD counties with well-controlled STD incidence rates.

Limitations

As this is a cross-sectional study, a causal relationship between the independent variables and dependent variables cannot be determined. In addition, we only included 39.89% of U.S. counties due to our sampling frame and related missing data. Thus, when identifying PD counties using multivariate regression models, the results may be underestimated given data for some counties are missing or unknown. In addition, it was difficult to distinguish between underreported/missing data of the NACCHO Profile Survey and low adverse STD outcomes. A PD county could, thus, be an artifact of data quality concerns. We, therefore, attempted to improve data quality by utilizing official STD surveillance data and SVI data released by the CDC.

Conclusions

Through the PD approach, our study identified U.S. counties that had unexpectedly outperformed other counties in terms of their STD outcomes, and we examined predictors that affect the identification of PD counties for STD outcomes. The PD approach appears to be an important means to identify and further explore counties with unexpectedly well-controlled STDs. Counties with well-controlled STD outcomes, despite high social vulnerability, perhaps have service delivery factors that would seem to play an important role in controlling STDs in otherwise seemingly marginalized communities. Further in-depth studies of representative PD counties are needed to increase our understanding of the reasons behind their low STD rates.

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Table 4-1. General Characteristics (*n* = 981)

Variables	Mean or frequency	*SD or %*
Annual STD incidence rate per 100,000 in 2019		
Chlamydia	422.66	(234.32)
Gonorrhea	139.80	(124.15)
P & S Syphilis	6.46	(9.44)
Population size		
< 25,000	371	(37.82)
25,000 – 49,999	202	(20.59)
50,000 – 99,999	144	(14.68)
100,000 – 249,999	139	(14.17)
250,000 – 499,999	62	(6.32)
500,000 – 999,999	47	(4.79)
1 million +	16	(1.63)
Social Vulnerability Index (SVI)		
Socioeconomic Status	0.494	(0.285)
Household Characteristics	0.490	(0.288)
Racial & Ethnic subgroup	0.502	(0.281)
Housing Type & Transportation	0.520	(0.274)

Core Based Statistical Area (CBSA)		
Metropolitan Area	347	(35.37)
Micropolitan Area	194	(19.78)
Rural Area	440	(44.85)
Executive clinician		
Yes	881	(89.81)
No	100	(10.19)
Local boards of health		
Yes	295	(30.07)
No	686	(69.93)
STD-related treatment service delivery		
Performed by LHD directly	148	(15.09)
Provided by others in community and independent of LHD funding	204	(20.80)
Performed by LHD directly + Provided by others in community and independent of LHD funding	629	(64.12)

Note. *SD* = Standard Deviation; LHD = Local Health Department; SVI ranged from 0 to 1. A high score means high vulnerability.

Table 4-2. Results of multivariate regression models to identify positive deviant counties

2a. Results of step 1 multivariate regression models (external factors)

Variables	Model I					
	Chlamydia		Gonorrhea		P & S syphilis	
	Coefficient *(SE)*	*p*-value	Coefficient *(SE)*	*p*-value	Coefficient *(SE)*	*p*-value
External factors LHDs cannot control						
Population size						
25,000 – 49,999	-8.64 (17.25)	0.617	2.45 (9.64)	0.800	-0.23 (0.83)	0.786
50,000 – 99,999	-2.30 (21.03)	0.913	7.91 (11.75)	0.501	-1.39 (1.01)	0.170
100,000 – 249,999	92.68 (23.61)	0.000	48.80 (13.19)	0.000	0.11 (1.13)	0.920
250,000 – 499,999	118.77 (30.49)	0.000	73.24 (17.03)	0.000	3.77 (1.46)	0.010
500,000 – 999,999	85.35 (33.59)	0.011	71.46 (18.77)	0.000	6.22 (1.61)	0.000
1 million +	83.17 (50.28)	0.098	72.94 (28.09)	0.010	7.60 (2.41)	0.002
< 25,000	Reference		Reference		Reference	

Social Vulnerability Index (SVI)						
Socioeconomic Status	155.73 (33.22)	0.000	119.36 (18.56)	0.000	4.75 (1.60)	0.003
Household Characteristics	93.02 (29.01)	0.001	81.19 (16.21)	0.000	0.10 (1.39)	0.945
Racial & Ethnic subgroup	213.44 (25.90)	0.000	56.97 (14.47)	0.000	3.15 (1.24)	0.012
Housing Type & Transportation	220.26 (27.53)	0.000	75.37 (15.38)	0.000	6.03 (1.32)	0.000
Core Based Statistical Area (CBSA)						
Metropolitan Area	56.14 (18.38)	0.002	37.04 (10.27)	0.000	2.08 (0.88)	0.018
Micropolitan Area	47.86 (18.70)	0.011	16.39 (10.45)	0.117	1.03 (0.90)	0.250
Rural Area	Reference		Reference		Reference	
Model R^2	0.39		0.33		0.15	

2b. Results of step 2 multivariate regression models (both internal and external factors)

Variables	Model II					
	Chlamydia		Gonorrhea		P & S syphilis	
	Coefficient *(SE)*	*p*-value	Coefficient *(SE)*	*p*-value	Coefficient *(SE)*	*p*-value
External factors LHDs cannot control						
Population size						
25,000 – 49,999	-10.74 (17.26)	0.534	1.16 (9.65)	0.905	-0.20 (0.83)	0.814
50,000 – 99,999	-6.43 (21.16)	0.761	5.51 (11.82)	0.642	-1.31 (1.02)	0.198
100,000 – 249,999	86.98 (23.83)	0.000	45.95 (13.32)	0.001	0.08 (1.15)	0.943
250,000 – 499,999	110.22 (30.98)	0.000	69.29 (17.31)	0.000	3.63 (1.49)	0.015
500,000 – 999,999	76.64 (34.17)	0.025	67.54 (19.09)	0.000	6.08 (1.64)	0.000
1 million +	72.13 (50.67)	0.155	67.83 (28.32)	0.017	7.37 (2.44)	0.003
< 25,000	Reference		Reference		Reference	
Social Vulnerability Index (SVI)						

Socioeconomic Status	133.20 (35.41)	0.000	109.25 (19.79)	0.000	3.88 (1.70)	0.023
Household Characteristics	90.93 (29.10)	0.002	79.40 (16.26)	0.000	0.21 (1.40)	0.880
Racial & Ethnic subgroup	215.15 (26.21)	0.000	58.81 (14.65)	0.000	2.81 (1.26)	0.026
Housing Type & Transportation	226.80 (27.68)	0.000	78.37 (15.47)	0.000	6.25 (1.33)	0.000
Core Based Statistical Area (CBSA)						
Metropolitan Area	53.60 (18.41)	0.004	35.88 (10.29)	0.001	1.97 (0.89)	0.027
Micropolitan Area	46.80 (18.71)	0.013	16.00 (10.46)	0.126	1.00 (0.90	0.265
Rural Area	Reference		Reference		Reference	
Internal factors LHDs can control						
Executive clinician						
Yes	4.14 (19.57)	0.833	-0.45 (10.94)	0.967	0.71 (0.94)	0.450
No	Reference		Reference		Reference	
Local boards of health						

Yes	3.73 (13.32)	0.780	4.86 (7.44)	0.514	-1.03 (0.64)	0.109
No	Reference		Reference		Reference	
STD-related treatment service delivery						
Performed by LHD directly	52.75 (20.60)	0.011	28.97 (11.51)	0.012	0.85 (0.99)	0.388
Performed by LHD directly + Provided by others in community and independent of LHD funding	31.97 (15.92)	0.045	16.53 (8.90)	0.064	0.28 (0.77)	0.714
Provided by others in community and independent of LHD funding	Reference		Reference		Reference	
Model R^2	0.42		0.36		0.18	

Table 4-3. Number of positive deviant counties by U.S. Health and Human Services (HHS) regional map

Regions	States	Number of PD counties/ Overall number of counties in sample	% of PD counties
Region 1	CT, ME, MA, NH, RI, and VT	0/17	0.00
Region 2	NJ, and NY	8/22	36.36
Region 3	DE, DC, MD, PA, VA, WV	11/46	23.91
Region 4	AL, FL, GA, KY, MS, NC, SC, and TN	64/285	22.46
Region 5	IL, IN, MI, MN, OH, and WI	16/234	6.84
Region 6	AR, LA, NM, OK, and TX	33/113	29.20
Region 7	IA, KS, MO, and NE	15/132	11.36
Region 8	CO, MT, ND, SD, and UT	6/52	11.54
Region 9	AZ, CA, HI, and NV	16/40	40.00
Region 10	AK, ID, OR, and WA	18/40	45.00
Total		187/981	19.06

Table 4-4. Logistic regression model of factors in predicting positive deviant counties

Variables	OR	95% CI	*p*-value
External factors LHDs cannot control			
Population size			
< 25,000	6.47	[1.22, 34.42]	0.028
25,000 – 49,999	5.06	[0.95, 26.92]	0.057
50,000 – 99,999	1.88	[0.36, 9.91]	0.458
100,000 – 249,999	2.61	[0.52, 12.98]	0.241
250,000 – 499,999	3.09	[0.59, 16.03]	0.180
500,000 – 999,999	2.38	[0.44, 12.97]	0.315
1 million +		Reference	
Social Vulnerability Index (SVI)			
Socioeconomic Status	2.04	[0.68, 6.07]	0.202
Household Characteristics	2.31	[0.99, 5.38]	0.053
Racial & Ethnic subgroup	3.29	[1.50, 7.20]	0.003
Housing Type & Transportation	11.94	[4.91, 29.06]	0.000
Core Based Statistical Area (CBSA)			
Rural Area	1.81	[1.04, 3.16]	0.036
Micropolitan Area	1.07	[0.60, 1.89]	0.826

Metropolitan Area	Reference		
Internal factors LHDs can control			
Executive clinician			
Yes	1.62	[0.92, 2.85]	0.095
No	Reference		
Local boards of health			
Yes	0.87	[0.59, 1.27]	0.457
No	Reference		
STD-related treatment service delivery			
Performed by LHD directly	2.47	[1.21, 5.00]	0.012
Performed by LHD directly + Provided by others in community and independent of LHD funding	2.22	[1.20, 4.09]	0.011
Provided by others in community and independent of LHD funding	Reference		

Note. *OR* = Odds Ratio.

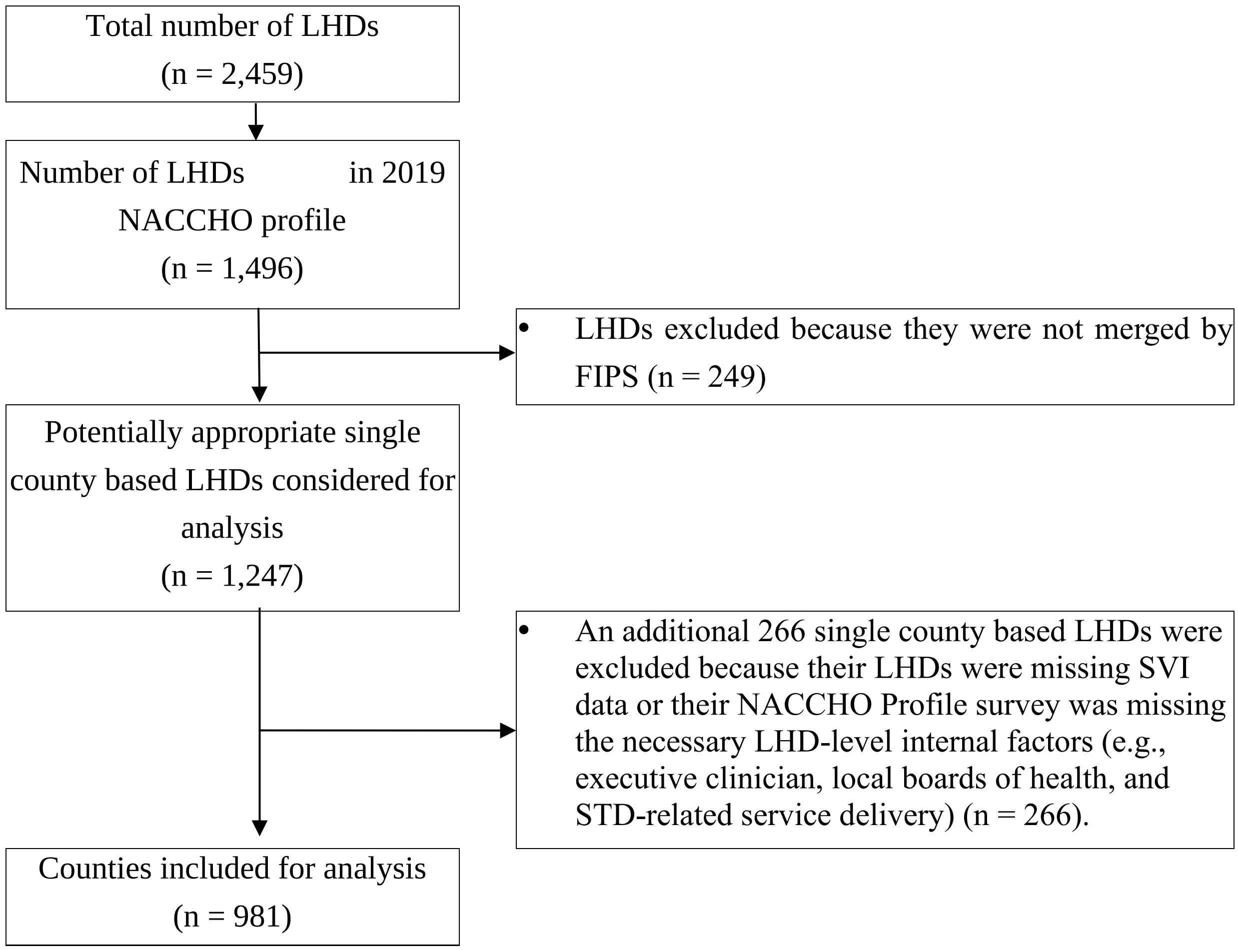
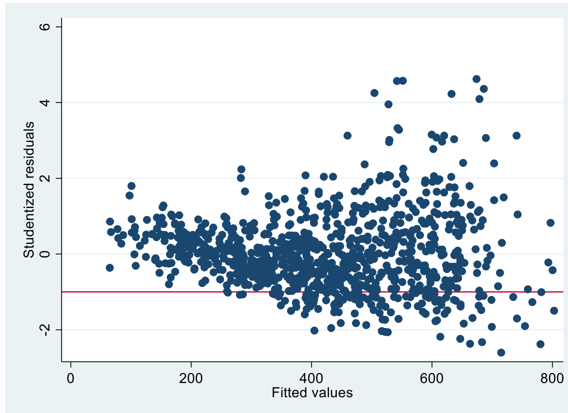
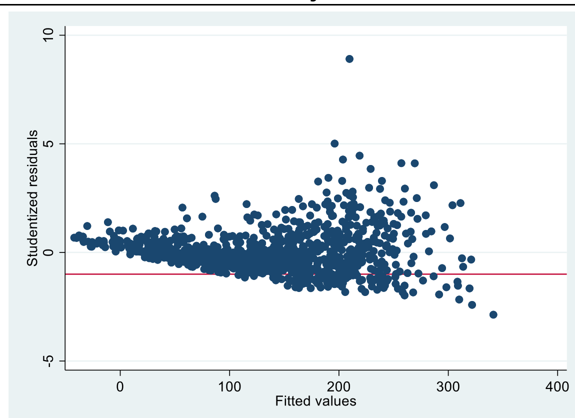


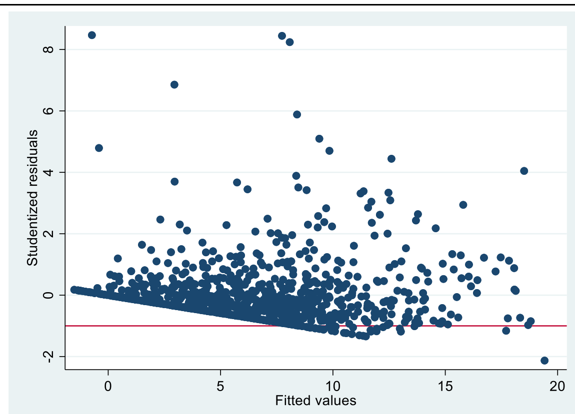
Figure 4-1. Flow diagram of sample screening process



Chlamydia



Gonorrhea



P & S syphilis

Figure 4-2. Scatter plot between studentized residuals and fitted values

Note. Standardized residuals less than -1 means PD counties. There are 125 PD counties for chlamydia, 108 PD counties for gonorrhea, and 39 PD counties for P & S syphilis.

Appendix Table 4-1. Variables included in the multivariate regression models

Variables	Measures
External factors LHDs have less control over	
Population size	7 categories (< 25,000, 25,000 – 49,999, 50,000 – 99,999, 100,000 – 249,999, 250,000 – 499,999, 500,000 – 999,999, and 1 million +)
Social Vulnerability Index (SVI)	
Socioeconomic Status	Below 150% poverty, unemployed, housing cost burden, no high school diploma, and no health insurance
Household Characteristics	Aged 65 & older, aged 17 & younger, civilian with a disability, single-parent households, and English language proficiency
Racial & Ethnic Minority Status	Hispanic or Latino (of any race); black and African American, not Hispanic or Latino; American Indian and Alaska native, not Hispanic or Latino; Asian, not Hispanic or Latino; native Hawaiian and other pacific islander, not Hispanic or Latino; two or more races, not Hispanic or Latino; other races, not Hispanic or Latino
Housing Type & Transportation	Multi-unit structures, mobile homes, crowding, no vehicle, group quarters
Core Based Statistical Area (CBSA)	Metropolitan, micropolitan, and rural area
Internal factors LHDs can control	
Executive clinician	LHD's lead executive has a clinical degree (MD, DNP, and RN) or not
Local boards of health	LHD has one or more local boards of health
STD-related treatment service delivery	3 different types of service delivery for screening: 1) performed by LHD directly; 2) provided by others in the community and independent of LHD funding, and 3) combined—provided directly by the LHD and by others in the community and independent of LHD funding.
STD outcomes	
Chlamydia incidence rate	The sum of the number of chlamydia cases in each LHD jurisdiction divided by annual population estimates in 2019

Gonorrhea incidence rate	The sum of the number of gonorrhea cases in each LHD jurisdiction divided by annual population estimates in 2019
P & S syphilis rate	The sum of the number of P & S syphilis cases in each LHD jurisdiction divided by annual population estimates in 2019

Chapter 5. CONCLUSION

In the U.S., STDs are widespread, affecting all population groups (Centers for Disease Control and Prevention [CDC], 2023a). Despite the efforts of STD prevention and treatment providers, recent data from the CDC show that STD rates have continued to rise since 2013 (CDC, 2023b; Kreisel et al., 2021). Little is known regarding development and implementation of the STD prevention while understanding the context of social and structural determinants that directly and indirectly influence STD acquisition (Hogben & Leichliter, 2008; Tapp & Hudson, 2020). The purpose of this dissertation was to: (1) determine the longitudinal relationships between SDOH (e.g., social capital, eviction rate, and prison incarceration rate) and STD incidence rates at the county-level in the U.S. over a 20-year period; (2) examine the association between types of STD-related screening service delivery approaches and STD incidence rates within local county jurisdictions in the U.S.; and (3) identify PD counties that have exceptionally low STD incidence rates in the U.S and investigate predictors that affect the identification of these PD counties among a county's internal and external factors. This conclusion chapter summarizes the main findings of each study, highlights implications and contributions to existing knowledge, and discusses recommendations for future research.

Summary of findings

The association between social determinants of health and STD incidence rates at the county level

The purpose of this study was to examine the longitudinal associations between SDOH (e.g., social capital, eviction rate, and prison incarceration) and three STD (chlamydia, gonorrhea, and P & S syphilis) incidence rates at the county-level in the U.S. In this analysis of annual incidence rates of STDs from 2000 to 2019 in the U.S., we found that incidence rate rates per 100,000 more than doubled for chlamydia (155.88 vs. 399.87), gonorrhea (45.17 vs 126.63), and

P & S syphilis (1.11 vs. 5.81). Through panel regression models, our findings suggest that higher social capital was significantly associated with lower chlamydia and gonorrhea rates, and higher eviction rates were significantly associated with higher rates of all three STDs (chlamydia, gonorrhea, and P & S syphilis). In addition, higher prison incarceration rates were significantly associated with gonorrhea rates. Our findings suggest that county-level initiatives are needed that will affect these SDOH that appear to contribute to increases in STD incidence rates.

The impact of differences in STD-related screening service delivery on STD incidence rates

The purpose of this study was to examine the spatial association between three types of STD-related screening service delivery approaches and STD incidence rates within county jurisdictions in the U.S. In this analysis, 1,090 LHD jurisdictions were included (44.3% of LHD jurisdictions and 72.9% of LHDs with NACCHO data). STD-related screening service delivery was classified into three categories: (1) performed by an LHD directly (185 LHDs, 16.97%), (2) provided by others in the community and independent LHD funding (206 LHD jurisdictions, 18.90%), and (3) combined/both (LHD directly and others in the community) together (699 LHD jurisdictions, 64.13%). In spatial panel regression models, our findings suggest that jurisdictions that had STD-related screening services provided through services delivered by others in the community and independent of LHD funding had significantly lower STD incidence rates per 100,000 than jurisdictions where STD screening services were performed directly by LHDs and by others in the community (-65.25 for chlamydia, -43.27 for gonorrhea, and -0.66 for P & S syphilis).

The investigation of predictors that affect the identification of PD counties that have exceptionally low STD incidence rates

The purpose of this study was to identify PD and non-PD counties with regard to STD incidence rates across the U.S. and to investigate predictors that influence the identification of these PD counties among a county's internal (e.g., LHD leadership, local boards of health, types of STD-related service delivery) and external factors (e.g., population size, social vulnerability, and rurality). We identified a PD county if the county had any (-1) studentized residuals for the chlamydia, gonorrhea, and P & S syphilis, and found a total of 187 (19.06%) counties out of 981 counties across the U.S. as PD counties. Our findings suggest that the factors predicting PD counties were small population sizes and SVI subcategories related to racial and ethnic subgroup and housing type and transportation, and STD-related treatment services provided directly by the county's LHD and through a community provider were positively associated with the identification of PD counties.

Implications and contributions to existing knowledge

In Aim 1, our findings contribute to expanding better understandings of the longitudinal associations between SDOH factors and STD incidence rates. Our findings can help policy makers develop geographically specific STD prevention policies and inform resource allocation for better preventing, screening, and treating STDs. In Aim 2, the provision of STD-related screening service within LHD jurisdictions is essential to reducing STD incidence rates and controlling the spread of STDs in the U.S. Our findings indicate that LHD's who are the sole direct provider of STD-related screening services should ideally establish structured partnerships with local clinics and private agencies to maintain safety-net STD services and assure the availability of STD-related services and surveillance in underserved jurisdictions. In Aim 3, The PD approach appears to be an important means to identify and further explore counties with unexpectedly well-controlled

STDs and to further examine these counties for the circumstances and prevention activities that might be supporting or promoting healthy environments.

Counties are the smallest geographical units in which social determinants and STD data are publicly available across the U.S., providing large sample sizes and sufficient variability to investigate longitudinal trends, changes, and relationships between social determinants and STD rates. Although there are several cross-sectional studies on the association between social determinants and STD rates at the state-level (Semaan et al., 2007), research on associations at the county-level is still lacking. The Aim 1 study provides a better understanding of the ecological link between social determinants and STD rates and suggests future directions for investigation and STD intervention at the county-level. Second, social determinants include various interacting indicators with several indicators of social determinants influencing STD rates. This study used multiple indicators (e.g., social capital, housing instability, and incarceration) for depicting social determinants from publicly available data resources, while previous research examined only one indicator in each analytical model (Niccolai et al., 2019; Nowotny et al., 2020; Owusu-Edusei et al., 2020). As such, we were able to compare the relationships of multiple indicators of social determinants on STD rates side-by-side. In terms of STD-related screening service delivery (Aim 2), in these jurisdictions where direct provision of STD-related services is lacking entirely, the LHD's role in assuring the local provision of STD screening and treatment may require direct provision of the service as well as robust contact tracing and STD case management, if collaboration with community clinical providers does not exist. As such, greater support from state and federal agencies and from health care systems is needed to bring additional STD-related resources to these communities. The Aim 3 is the first known study to have quantitively examined PD counties for STD outcomes across the U.S. Through using a quantitative PD approach, we facilitate identification of a broad national sample of PD counties with well-controlled STD incidence rates, as a means to further investigate the circumstances and prevention activities that might be creating a healthier environment.

Recommendations for future research

The three studies presented here comprehensively provide distinct evidence of how the social and structural factors influence incidence rates of STDs. Because secondary data analyses were used in this study, the data set in this study was not specifically designed for these research purposes. In the future, primary data on the relationship between social factors and STD incidence rates should be collected to produce more robust results. The STD-related screening service delivery examined was measured using a single question from the 2019 NACCHO Profile survey. Therefore, although various STD-related services may be provided, depending on the local and geographical environment, financial resources, and STD incidence rates in a jurisdiction, STD-related screening services had to be classified into the three screening categories examined. In future research, accurate information on STD-related service delivery among LHDs should be obtained through more specific and detailed questions. When identifying PD counties using multivariate regression models, a causal relationship cannot be determined, and the results may be underestimated given data for some counties were missing or unknown. Thus, it is necessary to investigate causal relationships with PD predictors through long-term longitudinal data collection.

This dissertation demonstrates that addressing key social determinants in communities could contribute to a reduction in STDs and that both LHDs and their local community partners have important roles to play in reducing STDs. It also demonstrates that the study of STD rates and the connection of these rates to local environments and types of service delivery is a critical area for further research, given the growing rates of new STD infections and the clear links demonstrated here between these factors.

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VITA

1. Biography

Sungwon Lim was born in Seoul, South Korea in 1983, and received bachelor's degree (2010) in nursing at the Kyung Hee University, and master's in public health (2013) at the Korea University. After experiences as a registered nurse at Kyung Hee University Hospital at Kangdong, Seoul, South Korea and as a researcher at the National Evidence-based Healthcare Collaborating Agency (NECA), Seoul, South Korea, he acquired PhD in Nursing Science at the University of Washington School of Nursing in 2023. His research interests include community and public health nursing, particularly the links between social determinants of health and infectious diseases through geographical factor and spatial analysis.

2. Curriculum Vitae

2A. Publication

Park, S., Meischke, H., & **Lim, S**. (In Press). Effect of mandatory and voluntary overtime hours on stress among 9-1-1 telecommunicators. *Workplace Health & Safety*. https://doi.org/10.1177/21650799231202794

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2B. Presentations at academic conferences

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2C. Honors and awards

Research Grant, Sigma Theta Tau International, Psi-at-Large Chapter
06/2022 - 09/2023

Statira Biggs Scholarship, University of Washington, Seattle, WA
03/2022

REID Scholarship, School of Nursing, University of Washington, Seattle, WA
09/2021 - 06/2022

Fraser Scholarship, School of Nursing, University of Washington, Seattle, WA
09/2020 - 06/2021

Sigma Theta Tau, International Honor Society of Nursing
05/2019

Conference Travel Award, School of Nursing, University of Washington, Seattle, WA
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Sharma Fellowship, School of Nursing, University of Washington, Seattle, WA
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Cole Scholarship, School of Nursing, University of Washington, Seattle, WA
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Research Assistant Scholarships (Full funding), Korea University, Republic of Korea
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Last Updated: December 15, 2023