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Brief Report

Racial Disparities Associated with Increased Burden of Sexually Transmitted Infections in North Carolina, Southeastern United States

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Abstract: Sexually transmitted infections (STIs) constitute a major public health issue in the United States. North Carolina (NC) in the southeastern U.S. ranks among the highest in STI incidence. We aimed to describe the incidence rates and identify potential risk factors of STIs in NC. The STI data reported by the NC Department of Health and Human Services for 2018 were compiled for chlamydia, gonorrhea, syphilis, and HIV infections for all 100 NC counties. Linear regression modeling was used to assess the association of STIs with predefined county-level variables. The mean STI incidence rates per 100,000 persons were highest for chlamydia (592.43 ± 30.02), followed by gonorrhea (212.06 ± 13.75), HIV (12.66 ± 0.947), and syphilis (3.33 ± 0.439). For chlamydia, higher risk was significantly associated with income (β = −0.008, SE = 0.003; $p = 0.006$), education (some college; β = 10.02, SE = 3.15, $p = 0.002$), race (Black; β = 12.17, SE = 1.57, $p < 0.0001$), and number of truck stops (β = 20.20, SE = 6.75, $p = 0.004$). The same variables, except for education, were associated with higher gonorrhea risk. Only race (being Black) was significantly associated with higher syphilis risk. Racial disparities in STI burden were significant, with race (being Black) constituting a risk factor for all four STIs. Interventions targeted to identified risk factors may help to reduce the STI burden in NC.

Keywords: chlamydia; gonorrhea; syphilis; HIV; sexually transmitted infections; risk factors; racial disparities

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1. Introduction

Sexually transmitted infections (STIs) represent a major public health issue in the United States (U.S.). The STI burden in terms of direct medical costs was nearly $16 billion in 2018 [1], and the asymptomatic nature of some STIs perpetuates transmission within racially and ethnically minoritized populations. In a recent report, the Centers for Disease Control and Prevention (CDC) estimated that 1 in every 5 individuals in the U.S. had an STI, resulting in a total of nearly 68 million prevalent infections in 2018 alone [1,2]. Of those reported cases, approximately 26 million represented new diagnoses. Due to the dramatic increase in STI incidence rates and its impact on healthcare costs, the STI National Strategic Plan was issued in December 2020 for the purpose of creating a five-year action plan to address the proper management of the STI epidemic [3]. This strategic public health plan revolves around five ambitious goals that include preventing the spread of STIs, improving the health outcomes associated with STIs, reducing health disparities in STI burden, and advancing STI research, screening technologies, and interventions [3]. Progress in STI prevention has been limited prior to the CDC's issuance of its national

strategic plan. For example, the implementation of innovative non-invasive diagnostic techniques (e.g., nucleic acid amplification tests or NAATs [4]) has facilitated the expansion of public health screenings and STI providers outside traditional STI clinics [5,6]. More epidemiological studies are needed to inform national, as well as local, interventions that will help to alter the current upward trajectory of STI cases, especially for chlamydia and gonorrhea. Our research aims to further the discussion around STI incidence rates in regard to health disparities and health inequalities that drive specific risk factors for infection.

Nationally notifiable STIs include *Chlamydia trachomatis* (chlamydia), *Neisseria gonorrhoeae* (gonorrhea), *Treponema pallidum* (syphilis), and sexually transmitted human immunodeficiency virus (HIV). The epidemiology, clinical presentations, treatment, and prevention of these STIs have been described in detail previously [7–9]. According to the most recent CDC national survey report, combined U.S. cases of chlamydia, gonorrhea, and syphilis totaled more than 2.5 million in 2021, constituting a 5.5% increase compared to in the 2020 data [10]. North Carolina ranks among the southeastern states with some of the highest rates of reported bacterial STI cases per 100,000 population. The CDC's 2021 STD Surveillance Report ranked North Carolina 7th highest in chlamydia and gonorrhea rates and 17th in rates of primary and secondary syphilis [11]. These STI statistics are concerning given the potential for serious long-term impacts on reproductive health with devastating sequelae due to the common asymptomatic nature of sexually transmitted chlamydia and gonorrhea. Health outcomes for females with untreated or inadequately treated STIs may include infertility, pelvic inflammatory disease, ectopic pregnancy, and miscarriage [12–14]. Furthermore, STIs can augment the risk of HIV transmission and acquisition [15,16]. The objective of this secondary study was to describe incidence rates and identify potential risk factors associated with the three most commonly reported bacterial STIs (chlamydia, gonorrhea, and syphilis) and sexually transmitted HIV using North Carolina county data for 2018.

2. Materials and Methods

Annual newly diagnosed STI data reported by the North Carolina Department of Health and Human Services (NC DHHS; https://www.ncdhhs.gov, accessed on 21 June 2023) for 2018 were compiled for chlamydia, gonorrhea, syphilis (primary stage only), and sexually transmitted HIV infections for all 100 counties in North Carolina. We have used an ecological study design for our analyses, and therefore the unit of observation was the county for our study variables. All 100 North Carolina counties were analyzed to describe the incidence rates of STIs per county as a function of county-level sociodemographic and geographic-level characteristics. Incidence rates were reported per 100,000 population with rate denominators calculated using bridged-race population estimates for 2018 from the National Center for Health Statistics (https://www.cdc.gov/nchs/nvss/bridged_race.htm, accessed on 26 September 2023). Descriptive analyses were performed, and the results were presented as median values with minimum and maximum measures of dispersion. Linear regression modeling was used to assess the association of STI incidence rates with multiple county-level independent variables such as college education, household income, racial/ethnic minority population, female composition, primary care physician (PCP) ratio, uninsured status, number of truck stops, and distance (in miles using Google Maps) to Interstate 95 (I-95). The sources for the sociodemographic and geographic-level variables included the Economic Research Service of the U.S. Department of Agriculture (https://www.ers.usda.gov/data-products/county-level-data-sets/county-level-data-sets-download-data/, accessed on 21 June 2023), County Health Rankings Data for North Carolina (https://www.countyhealthrankings.org/explore-health-rankings/north-carolina/data-and-resources, accessed on 21 June 2023), and U.S. Census data (https://www.census.gov/quickfacts/fact/table/NC/PST045219, accessed on 21 June 2023). The distance (in miles) of the county to Interstate 95 (I-95) was estimated using Google Maps. The I-95 route in North Carolina can be found at http://i95highway.com/interstate_95_north_carolina_map/index.html, accessed on 5 July 2023.

The number of truck stops per county was obtained from the TruckMaster® database for Truck Stops In North Carolina (http://www.findfuelstops.com/truck-stop-in-NC, accessed on 5 July 2023). All statistical analyses were performed using SPSS version 26.0 (IBM Corp, Armonk, NY, USA) at $\alpha = 0.05$.

3. Results

The STI incidence rates and sociodemographic and geographic-level characteristics for all 100 NC counties are presented in Table 1. Across all 100 NC counties, the median STI incidence rates per 100,000 persons (all ages) in 2018 were highest for urogenital chlamydial infections (537.0; min–max range, 179.5–1222.3; Table 1), followed by urogenital gonococcal infections (181.6; 43.7–534.6). The median statewide incidence rate of sexually transmitted HIV per 100,000 persons (all ages) was 11.3 (min–max range, 4.8–28.0). The median incidence rate of syphilis (primary stage only) per 100,000 persons (all ages) over the same study period in North Carolina was 2.5 (min–max range, 0.6–15.5).

Table 1. STI incidence rates, sociodemographic and geographic-level characteristics of all counties in North Carolina, 2018.

Variable	Median	Minimum	Maximum
Some college education (%)	57.0	40.9	81.0
Household income ($)	46,000	33,000	76,000
Black population (%)	19.4	1.1	61.2
Female (%)	51.3	45.8	53.7
Unemployed (%)	5.3	3.8	9.2
No. truck stops	3.0	1.0	12.0
Distance to I-95 (miles)	119.3	7.3	399.1
PCP ratio	2075	533	10,213
Uninsured status (%)	13.0	10.0	21.0
Rural (%)	50.7	1.1	100.0
Chlamydia (IR per 100,000)	537.0	179.5	1222.3
Gonorrhea (IR per 100,000)	181.6	43.7	534.6
Primary syphilis (IR per 100,000)	2.5	0.6	15.5
HIV (IR per 100,000)	11.3	4.8	28.0

Abbreviations: PCP, primary care physician; IR, incidence rate; HIV, human immunodeficiency virus.

Linear regression modeling indicated that a higher risk of chlamydia was significantly associated with such sociodemographic and geographic-level variables as household income ($\beta = -0.008$, SE = 0.003; $p = 0.006$), educational attainment (some college; $\beta = 10.02$, SE = 3.15, $p = 0.002$), race (Black; $\beta = 12.17$, SE = 1.57, $p < 0.001$), and the number of truck stops ($\beta = 20.20$, SE = 6.75, $p = 0.004$) (Table 2). Other examined variables like female gender, distance to I-95, PCP ratio, and uninsured status did not attain statistical significance in our regression models. Except for education, the same sociodemographic variables observed for chlamydial infections were also significantly associated with higher gonorrhea risk: household income ($\beta = -0.004$, SE = 0.002, $p = 0.023$), race (Black; $\beta = 5.21$, SE = 0.89, $p < 0.001$) and number of truck stops ($\beta = 9.60$, SE = 3.81, $p = 0.014$). Only race (being Black) was significantly associated with a higher risk of primary syphilis ($\beta = 0.22$, SE = 0.06, $p = 0.001$) (Table 2). Notably, gender and uninsured status were not associated with higher bacterial STI incidence rate in our study. Gender (female; $\beta = 1.16$, SE = 0.56, $p = 0.042$), distance to I-95 ($\beta = 0.03$, SE = 0.01, $p = 0.01$), and race (Black; $\beta = 0.40$, SE = 0.07, $p < 0.001$) were associated with higher risk of reported HIV infection (Table 2).

Table 2. Linear regression estimates for STIs in all counties in North Carolina, 2018.

Variable	Chlamydia			Gonorrhea			Syphilis (Primary)			HIV		
	β	SE	*p*	β	SE	*p*	β	SE	*p*	β	SE	*p*
Some college education	10.02	3.15	0.002	2.34	1.77	0.191	0.12	0.09	0.200	0.15	0.13	0.259
Household income	−0.008	0.003	0.006	−0.004	0.002	0.023	0.00004	0.00	0.573	0.00006	0.00	0.623
Black population	12.17	1.57	<0.001	5.21	0.89	<0.001	0.22	0.06	0.001	0.40	0.07	<0.001
Female population	−20.49	13.05	0.12	3.01	7.36	0.684	−0.72	0.42	0.094	1.16	0.56	0.042
No. truck stops	20.20	6.75	0.004	9.60	3.81	0.014	−0.09	0.18	0.632	0.49	0.28	0.079
Distance to I-95	−0.20	0.27	0.468	0.10	0.15	0.513	0.01	0.008	0.084	0.03	0.01	0.01
PCP ratio	−0.01	0.01	0.280	−0.01	0.007	0.332	0.00	0.00	0.416	0.00	0.001	0.463
Uninsured status	−1.65	10.66	0.078	−0.83	6.01	0.890	0.56	0.32	0.086	0.30	0.45	0.507

Abbreviations: STIs, sexually transmitted infections; β, beta coefficient; SE, standard error of the estimate; PCP, primary care physician; HIV, human immunodeficiency virus. Boldface indicates a statistically significant *p*-value ($p < 0.05$).

4. Discussion

In this study, a major finding was that the epidemiology of the STI epidemic in North Carolina continues to be characterized by dramatic racial disparities. Being Black constituted a significant risk factor for all four STIs examined in this analysis of the 2018 NC DHHS data. Previous national surveillance data have demonstrated higher incidence rates of STIs among some racial and ethnic minority populations compared to White populations [17]. Although non-Hispanic Black persons comprise only about 12% of the total U.S. population, 31% of bacterial STI cases of chlamydia, gonorrhea, and syphilis (both primary and secondary) were diagnosed among Black people in 2021 [17]. Recently, a retrospective, cross-sectional study using Medicaid administrative claims data in South Carolina found that medical claims filed for chlamydia, gonorrhea, and HIV were significantly associated with non-Hispanic Black or other minority race/ethnicity individuals compared to White individuals [18]. Additionally, Giannouchos et al. [18] found that residents of rural counties were more likely to have a Medicaid claim related to a diagnosis of chlamydia or gonorrhea compared to urban residents. While rurality was not specifically investigated as a variable in regression analyses in this study, North Carolina has a substantial rural population, with a median percentage of rural counties of 50.7 in 2018. Rural versus urban disparities in STI incidence warrant closer examination given the prevalence of rural communities in the southeastern U.S.

The underlying drivers of racial disparities in sexual health outcomes are likely due to a complex interaction between multiple socioeconomic and structural factors and not to individual sexual behavior alone. As a critical social determinant of sexual health, socioeconomic status plays an impactful role in STI transmission and acquisition [19]. In our analysis of NC STI data, household income was significantly associated with a higher risk for chlamydial and gonorrheal infections, while some college education was significantly associated with risk of chlamydia only. Social contextual factors such as poverty, unemployment or underemployment, and lower educational attainment can influence sexual behavior and have been associated with higher STI rates among populations disproportionately impacted by such factors [19,20]. As a southern state with high prevalence of STIs, North Carolina should be a focus of public health prevention and intervention measures, policies, and community-level programs aimed at reducing STI incidence rates and improving health outcomes for minoritized populations. The efficacy of any public health policy actions will likely need to address the socioeconomic and structural inequalities underlying racial disparities in STI risk [19].

A new finding of this study was the significant association between the number of truck stops and a higher risk of chlamydial and gonorrheal infections, suggesting that travel or migration influences the epidemiology of STIs in North Carolina. Similarly, our analysis indicated that distance to I-95, the main north–south Interstate Highway on the U.S. East Coast, was significantly associated with a higher risk of sexually transmitted HIV infection but not bacterial STIs. The I-95 corridor is a major conduit for interstate and intrastate

travel and intersects eight counties (Robeson, Cumberland, Harnett, Johnston, Wilson, Nash, Halifax, and Northampton) in eastern North Carolina. In a previous study using ordered spatial logistic regression analyses, North Carolina had at least 10 hot spot counties for two bacterial STIs, and these counties were clustered in and around the I-95 corridor [21], suggesting a possible geographical correlation between interstate travel access and certain STI incidence. The availability of numerous geolocation-based hookup/dating apps likely facilitates casual sexual encounters while traveling, thus promoting risky sexual behavior. A recent study found that past STI history, number of sexual partners, and substance use were associated with an increased risk of interstate sexual encounters, suggesting a need for "interjurisdictional" approaches to STI prevention and control [22]. More research is needed to ascertain the direct and indirect effects of such geographic-level variables on STI incidence in North Carolina. Increasing access to appropriate sexual education, including the potential health risks of using geolocation-based hookup apps, and offering affordable barrier contraceptives at truck stops and interstate rest areas may help to improve public sexual health in North Carolina.

This study has a number of important limitations inherent in its ecological design. Most notably, the study variables were collected and analyzed on a county (i.e., aggregate) level rather than on an individual level. Hence, our study is subject to the ecological fallacy, whereby our group-level findings may not necessarily apply at the individual level. This fallacy may be due to bias resulting from systematic differences between the counties in the measurement of our explanatory variables, differences in STI diagnosis, or differences in the completeness of STI reporting between counties. As a result, caution in interpretation is needed when applying our county-level results to individuals. Furthermore, because this is a secondary analysis, we do not have control over the quality and accuracy of the data used in the assessment of our study variables; consequently, the bias in the data collection process may not be visible. Despite these limitations, our study has some noteworthy strengths. First, we have provided updated information on statewide STI frequency using carefully collected data from the NC DHHS website. Second, we have used the most parsimonious set of variables in our regression models to examine four STIs of public health significance in North Carolina. Third, our regression models have shown variables that are significantly associated with each STI, providing opportunities to target public health interventions. Lastly, our findings are consistent with previous literature on racial disparities in STI incidence but also add to the literature by identifying geographic-level variables associated with the frequency of certain STIs in North Carolina. Overall, this work has generated significant associations between county-level factors and STI incidence that can serve as hypotheses for further in-depth exploration.

5. Conclusions

Bacterial and viral STIs continue to impose substantial health and economic impacts in the U.S. This study provided updated epidemiological evidence on racial disparities in the burden of chlamydia, gonorrhea, primary syphilis, and HIV infections in North Carolina, demonstrating that incidence rates for all four STIs continue to be significantly higher for non-Hispanic Black people. We also identified other predictors such as gender, household income, educational attainment, number of truck stops, and distance to I-95 that were significantly associated with one or more of the STIs analyzed. A comprehensive public health interventional approach aimed at these factors may help to reduce STI burden and improve sexual health in North Carolina.

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