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# Association between the geographic accessibility of PrEP and use of PrEP among MSM in nonurban areas

**J. Danielle Sharpe, PhD, MS**[1], **Travis H. Sanchez, DVM, MPH**[1], **Aaron J. Siegler, PhD, MHS**[1], **Jodie L. Guest, PhD, MPH**[1], **Patrick S. Sullivan, DVM, PhD**[1]

[1]Department of Epidemiology, Rollins School of Public Health, Emory University, Atlanta, Georgia

## Abstract

**Purpose:** The U.S. HIV epidemic has become a public health issue that increasingly affects men who have sex with men (MSM), including those residing in nonurban areas. Increasing access to pre-exposure prophylaxis (PrEP) in nonurban areas will prevent HIV acquisition and could address the growing HIV epidemic. No studies have quantified the associations between PrEP access and PrEP use among nonurban MSM.

**Methods:** Using 2020 PrEP Locator data and American Men's Internet Survey data, we conducted multilevel log-binomial regression to examine the association between area-level geographic accessibility of PrEP-providing clinics and individual-level PrEP use among MSM residing in nonurban areas in the U.S.

**Findings:** Of 4,792 PrEP-eligible nonurban MSM, 20.1% resided in a PrEP desert (defined as more than a 30-minute drive to access PrEP), and 15.2% used PrEP in the past 12 months. In adjusted models, suburban MSM residing in PrEP deserts were less likely to use PrEP in the past year (adjusted prevalence ratio (aPR) = 0.35; 95% confidence interval (CI) = 0.15, 0.80) than suburban MSM not residing in PrEP deserts, and other nonurban MSM residing in PrEP deserts were less likely to use PrEP in the past year (aPR = 0.75; 95% CI = 0.60, 0.95) than other nonurban MSM not residing in PrEP deserts.

**Conclusions:** Structural interventions designed to decrease barriers to PrEP access that are unique to nonurban areas in the U.S. are needed to address the growing HIV epidemic in these communities.

### Keywords

accessibility; geographic; HIV pre-exposure prophylaxis; men who have sex with men; nonurban

## Introduction

The HIV epidemic in the United States (US) is a public health issue that originated and remains well established in metropolitan areas, but it is steadily becoming an epidemic

**Corresponding author:** J. Danielle Sharpe, PhD, MS, 1518 Clifton Road NE, Grace Crum Rollins Room #467, Department of Epidemiology, Rollins School of Public Health, Emory University, Atlanta, GA 30322, danielle.sharpe@emory.edu.

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affecting nonurban areas.[1–4] Epidemiologic trends in recent years reveal increasing HIV burden in nonmetropolitan areas in the US, with such areas reporting an overall HIV diagnosis rate of 5.0 per 100,000 population in 2017 and an overall HIV prevalence of 119.3 per 100,000 population in 2016, which indicate greater rates than those of several metropolitan statistical areas in the US.[2] Nonurban areas are not only being increasingly affected by HIV, but they are also largely affected by poor health care infrastructure. There is a dearth of primary care physicians, HIV specialty clinics, and adequate transportation systems to access these providers and services in rural and suburban areas across the US, hindering efforts to reduce the HIV epidemic in these less urbanized areas.[4–10] Pre-exposure prophylaxis (PrEP) is an antiretroviral medication that is efficacious for HIV prevention in HIV-negative persons at increased risk for HIV infection,[11–22] and scaling up this biomedical intervention in nonurban areas can help address the growing HIV epidemic in these areas.

Men who have sex with men (MSM) residing in nonurban areas across the US have lower usage levels of HIV prevention services, including PrEP, than MSM in urban areas,[23–26] and access to PrEP providers is a contributor to this disparity.[27–33] Similar to other HIV-related health care services, PrEP services are not always available to persons residing in nonurban localities of the US. Studies have shown that there is a scarcity of PrEP-providing clinics and PrEP-knowledgeable providers in rural and suburban communities across the US, with less urbanized areas more likely to be PrEP deserts (i.e., areas with limited geographic accessibility to PrEP providers).[27,28,30–32] Also, even when primary care physicians in rural areas are aware of or knowledgeable about PrEP, they often recommend that patients with PrEP indications seek PrEP care with infectious disease or HIV specialists in urban areas.[30–32] Rural MSM who are able to access PrEP services may travel to metropolitan localities for adequate PrEP care, often driving at least 30 minutes and up to 2.5 hours to access a PrEP-providing clinic and ancillary PrEP care services.[30,31] Moreover, aside from the lack of PrEP providers, there are also socio-contextual factors nonurban MSM experience that impede PrEP access.[30–32] For instance, accessing quality PrEP care in affirming and confidential spaces can be difficult. Some providers in nonurban areas may have biased, sex-negative, and stigmatizing views about PrEP.[30–32] Thus, the challenges populations at high risk for HIV infection, such as MSM, encounter when attempting to access PrEP medication and quality PrEP care are exacerbated in nonurban areas.

There is limited existing research on the relationship between geographic accessibility to PrEP and usage of PrEP among populations at increased risk for HIV who reside in nonurban areas across the US because most studies on PrEP access and use have been conducted using populations sampled from urban areas.[34–39] Moreover, previous studies that have been conducted to examine PrEP accessibility among MSM in nonurban areas have largely been qualitative in nature.[30–32] Thus, research is needed to address these gaps in knowledge by quantitatively estimating the association between PrEP accessibility and the use of PrEP among MSM residing in nonurban areas. Identifying barriers to PrEP accessibility, such as drive time to PrEP providers, and understanding the effect of these barriers on PrEP use among nonurban MSM are high priority considering the US Ending the HIV Epidemic (EHE) Initiative. The EHE Initiative emphasizes improving HIV prevention efforts, including expanding PrEP access and uptake, in states with a disproportionate

number of new HIV infections in nonurban areas.[40–42] In this study, we assessed the association between area-level drive-time accessibility of PrEP-providing clinics and the usage of PrEP at the individual level among MSM residing in nonurban areas in the US. Also, because studies have reported unexpected findings regarding the distribution of PrEP deserts in suburban areas[27] and PrEP uptake in these areas,[23] we examined the effect of PrEP accessibility on PrEP use as modified by type of nonurban area (suburban area versus other nonurban area).

## Methods

### Study Population

The American Men's Internet Survey (AMIS) is a national repeated cross-sectional online survey of HIV risk behaviors and uptake of HIV prevention services among MSM in the US.[43–47] There have been eight AMIS cycles completed between 2013 and 2020, with each cycle collecting data from an estimated 10,000 MSM. For this study, AMIS participants were recruited through convenience sampling using banner advertisements (ads) on websites and social media applications frequented by MSM or through email blasts to members of MSM-frequented websites. Email recruitment was also extended to participants from previous AMIS cycles who consented to being re-contacted for future research studies.

Participants were eligible for AMIS if they identified as male, were at least 15 years of age, resided in a valid US ZIP Code, and identified as gay or bisexual or reported ever having oral or anal sex with a man. Participants who clicked on AMIS study ads, met the eligibility criteria, and provided consent were immediately directed to the online survey. AMIS data were collected and stored using a secure server administered by Alchemer (Boulder, Colorado, US). AMIS participation was not incentivized. The AMIS study was reviewed and approved by the Emory University Institutional Review Board.

The study population for the present study comprised MSM who participated in the 2020 cycle of AMIS (AMIS-2020), reported an HIV-negative or unknown serostatus, were PrEP-eligible, and resided in nonurban ZIP Codes in the contiguous US. Using an algorithm based on clinical guidelines by the Centers for Disease Control and Prevention, we determined PrEP eligibility on the basis of whether study participants met either of the following criteria: (1) had a main male sexual partner with HIV or (2) had two or more male sexual partners in the past 12 months AND either any condomless anal sex with a man in the past 12 months or a diagnosis of any sexually transmitted infection, including gonorrhea, chlamydia, and syphilis, in the past 12 months.[24,48] Using the 2013 NCHS Rural-Urban Classification Scheme, MSM resided in nonurban ZIP Codes if their respective ZIP Codes were located within large fringe metropolitan, medium metropolitan, small metropolitan, micropolitan, and non-core counties.[49]

### Study Measures

Our primary explanatory variable was drive-time accessibility of PrEP-providing clinics, a ZIP Code-level variable measured by whether a participant's ZIP Code of residence was classified as being a PrEP desert. We obtained geographic postal code boundaries for

five-digit ZIP Codes in the contiguous US for the period of March 2020 from TomTom (Amsterdam, Netherlands), a commercial vendor that creates and regularly updates US ZIP Code boundaries based on the most current and complete postal information available from the US Postal Service. We matched the geographic ZIP Code boundaries from TomTom to ZIP Codes reported by the study participants and computed the geometric centroid of each participant's ZIP Code. We obtained geolocation data for 3,875 PrEP-providing clinics present in the contiguous US in September 2020 from the PrEP Locator database, a US database of registered health care providers that prescribe PrEP.[50] PrEP Locator is a national, validated, and frequently updated database that includes vetted PrEP providers using a standardized identification and verification process conducted by HIV researchers.[50] Using the ArcGIS Network Analyst extension (Esri, Redlands, CA), we conducted a spatial network analysis to compute the drive time from the centroid of each participant's ZIP Code to the nearest PrEP-providing clinic. Based on prior research,[27] participants were categorized as living in a PrEP desert if they resided in a ZIP Code with a one-way drive time of more than 30 minutes to the nearest PrEP-providing clinic.

The outcome of interest was the report of recent PrEP use, an individual-level variable obtained from the AMIS-2020 study. In AMIS-2020, participants were asked the following: "In the past 12 months, have you taken PrEP?" Participants could respond with any of the following options: "No," "Yes," "I prefer not to answer," or "Don't know." Recent PrEP use was measured dichotomously, with recent use indicated by participants who responded "Yes" or "No" to having taken PrEP in the past 12 months.

AMIS-2020 study participants reported data on covariates, including age, race/ethnicity, educational attainment, annual household income, health insurance coverage, health care stigma, and geography. Age was categorized as 15–24 years, 25–29 years, 30–39 years, and 40 years and older. Race/ethnicity was categorized as non-Hispanic White, non-Hispanic Black, Hispanic, and other or multiple races. Educational attainment was dichotomized as having a high school diploma or less or having at least some college education. Annual household income was categorized as $0–$19,999, $20,000–$39,999, $40,000–$74,999, and $75,000 or more. Health insurance coverage was categorized as private health insurance only, public health insurance only, other or multiple forms of health insurance, or no form of health insurance. Participants reported anticipated health care stigma, which was measured by asking participants if they felt afraid to go to or avoided health care services because of fear someone may learn they had sex with men.[51] Participants also reported enacted health care stigma, which was measured by asking participants whether they heard health care providers gossiping about them or had not been treated well by health care providers because they had sex with men.[51] Anticipated and enacted health care stigma were both dichotomized as ever or never experiencing the specific type of health care stigma. Participants reported state of residence, from which region of residence was defined using US Census Bureau designations (Northeast, Midwest, South, and West). For our study, we further categorized nonurban ZIP Codes as suburban (large fringe metropolitan) or other nonurban (medium metropolitan, small metropolitan, micropolitan, and non-core) based on existing literature.[23,24] These covariates were selected as confounders *a priori* based on previous research[23–25,27,28,51–53] and using a directed acyclic graph.

### Statistical Analysis

We computed descriptive statistics among the study population for age, race/ethnicity, educational attainment, annual household income, health insurance coverage, anticipated and enacted health care stigma, US Census region, nonurban ZIP Code type, and PrEP desert status of participants' ZIP Codes by use of PrEP in the past 12 months. We conducted bivariate multilevel regression analyses using log-binominal generalized estimating equations (GEEs) with an exchangeable working correlation structure to examine the unadjusted associations between demographic, socioeconomic, and geographic characteristics and PrEP use in the past year. Then, we conducted a series of multivariable multilevel regression analyses using log-binominal GEEs with an exchangeable working correlation structure to examine the adjusted association between PrEP desert status of participants' ZIP Codes and PrEP use in the past year. Model 1 adjusted for demographic and socioeconomic factors (age, race/ethnicity, educational attainment, annual household income, health insurance coverage, and anticipated and enacted health care stigma). Model 2 additionally adjusted for geographic factors (US Census region and nonurban ZIP Code type), and Model 3 additionally included an interaction term between PrEP desert status and nonurban ZIP Code type. Unadjusted prevalence ratios (PR) with 95% confidence intervals (CIs) were calculated from the bivariate multilevel log-binomial regression models, and adjusted prevalence ratios (aPR) with 95% CIs were calculated from the multivariable multilevel log-binomial regression models. Since one's sexual behavior, and consequently PrEP eligibility, can vary over time, we also conducted sensitivity analyses to include AMIS-2020 study participants with a negative or unknown HIV status who were not eligible for PrEP at the time of the survey (see Appendix). We used ArcGIS Pro version 2.3.3 for the spatial network analysis and SAS version 9.4 (SAS Institute Inc., Cary, NC) for all statistical analyses.

## Results

Overall, 4,792 MSM participating in AMIS-2020 reported an HIV-negative or unknown serostatus, were PrEP-eligible, and resided in nonurban ZIP Codes in the contiguous US (Table 1). Of all MSM, 20.1% resided in a PrEP desert, and 15.2% of MSM used PrEP in the past 12 months. Nearly half were aged 15–24 years, and about a third earned $75,000 or more in annual household income. Approximately one-third of MSM represented racial/ethnic minority groups, including 9.6% non-Hispanic Black, 18.0% Hispanic, and 6.9% other or multiple races. Most MSM completed at least some college education and had private health insurance coverage. Nearly one in four (23.9%) MSM reported experiencing anticipated health care stigma, and 8.7% reported experiencing enacted health care stigma. Four in ten (43.7%) MSM resided in a ZIP Code located in the South, and one in three (33.4%) MSM resided in a ZIP Code in a suburban area.

In the unadjusted regression model, area-level drive-time accessibility of PrEP-providing clinics was associated with individual-level PrEP use in the past 12 months among PrEP-eligible AMIS-2020 MSM participants in nonurban areas (Table 2). Compared with MSM who did not reside in PrEP deserts, MSM residing in PrEP deserts were less likely to use PrEP in the past 12 months (PR = 0.62; 95% CI = 0.51, 0.77). In adjusted models,

this association between area-level PrEP accessibility and individual-level PrEP use in the past 12 months remained (Table 3). After adjusting for age, race/ethnicity, educational attainment, annual household income, health insurance coverage, and experiences of anticipated and enacted health care stigma, MSM residing in PrEP deserts were less likely to report PrEP use in the past 12 months (aPR = 0.66; 95% CI = 0.53, 0.82) compared with those who did not reside in PrEP deserts. After additionally adjusting for US Census region and nonurban ZIP Code type, MSM who resided in PrEP deserts were less likely to use PrEP in the past year compared with MSM not residing in PrEP deserts (aPR = 0.70; 95% CI = 0.56, 0.87).

We determined whether the type of nonurban ZIP Code where MSM resided modified the association between area-level PrEP accessibility and individual-level PrEP use (Table 3). Suburban MSM residing in PrEP deserts were less likely to use PrEP in the past 12 months (aPR = 0.35; 95% CI = 0.15, 0.80) compared with those not residing in PrEP deserts. Other nonurban MSM residing in PrEP deserts were also less likely to have used PrEP in the past year than those not residing in PrEP deserts (aPR = 0.75; 95% CI = 0.60, 0.95). Generally, similar associations between area-level PrEP accessibility and individual-level PrEP use in the past year were reported when including all AMIS-2020 participants with an HIV-negative or unknown serostatus who resided in nonurban ZIP Codes regardless of PrEP eligibility status (see Appendix).

## Discussion

With the HIV epidemic growing in rural and suburban communities across the US, increasing the use of effective HIV prevention strategies, such as PrEP, is key for reducing new HIV infections among populations disproportionately affected by HIV, such as MSM, in these areas. Determining the structural barriers to improving and expanding PrEP use among MSM populations can help inform structural interventions, policies, and other efforts that are developed and implemented to support the US EHE Initiative in nonurban areas.[40,41,54] Thus, we sought to quantify the relationship between area-level geographic accessibility of PrEP-providing clinics and individual-level PrEP use among nonurban MSM. In this novel multilevel epidemiologic study using a large, online database of nonurban MSM, we found that residing in a PrEP desert (more than 30 minutes one-way drive time from the nearest PrEP-providing clinic) was negatively associated with the usage of PrEP in the past year among MSM in nonurban areas.

Specifically, we found that, overall, MSM who resided in PrEP deserts were 30% less likely to use PrEP in the past 12 months compared with those not residing in PrEP deserts when adjusting for demographic, socioeconomic, and geographic characteristics. These findings reflect the disparities in PrEP accessibility among populations in nonurban areas in the US. For instance, we previously reported that 94% of nearly 109,000 PrEP-eligible MSM who lived in PrEP deserts resided in nonurban communities, including an estimated 25,127 PrEP-eligible MSM residing in suburban communities and 77,005 PrEP-eligible MSM residing in other nonurban communities.[27] Research has also found that the density of PrEP-providing clinics per new HIV diagnoses was lowest among suburban and rural areas compared with urban areas.[28] Our study's findings also reflect research that has highlighted disparities

in the uptake of PrEP among nonurban populations. One study reported that urban areas had higher PrEP use than nonurban areas, but this phenomenon was indicative of higher HIV burden and, thus, need in urban areas.[55] We previously found that PrEP-eligible MSM in nonurban areas reported less PrEP use than those in urban areas between 2013–2017, with PrEP-eligible MSM residing in suburban areas, small/medium metropolitan areas, and rural areas being 38%, 42%, and 55% less likely than PrEP-eligible MSM in urban areas to use PrEP, respectively.[24] We also found similar findings of PrEP-eligible MSM residing in suburban and rural areas consistently reporting lower levels of ever using PrEP than those in urban areas.[23] Ultimately, our study's results reflect findings from existing literature, but we also build upon such literature by demonstrating that drive time to a PrEP-providing clinic affects PrEP use regardless of nonurban dichotomies (suburban, other nonurban, rural, etc.). Future work may be needed to further investigate the determinants of the disparities in the relationship between PrEP access and PrEP usage in suburban and rural areas, especially considering the importance of expanding access to and use of PrEP among disproportionately affected populations in nonurban areas as in accordance with the US EHE Initiative.

Our study identified heterogeneity in the association between residing in a PrEP desert and using PrEP in the past 12 months when considering the type of nonurban ZIP Code where MSM resided. Particularly, suburban MSM residing in PrEP deserts were 65% less likely to use PrEP in the past year compared with suburban MSM not residing in PrEP deserts, and other nonurban MSM residing in PrEP deserts were 25% less likely to use PrEP in the past year than other nonurban MSM not residing in PrEP deserts. The finding of a more extreme association between residing in a PrEP desert and recent use of PrEP among MSM living in suburban ZIP Codes as opposed to in other types of nonurban ZIP Codes reflects the challenging barriers to health care access that are unique to suburban communities in the US. One barrier is that suburban communities are disproportionately affected by PrEP deserts. Suburban areas have more estimated PrEP-eligible MSM residing more than 30 minutes from a PrEP-providing clinic than any other urbanicity type.[27] Relatedly, another barrier is the suboptimal distribution of PrEP-providing clinics in relation to populations in need in suburban communities. We have reported that suburban areas have fewer PrEP-providing clinics per PrEP-eligible MSM (1.9 clinics per 1000 MSM) than any other urbanicity type, including rural areas (2.5 clinics per 1000 MSM).[28] Lastly, over time, persons in suburban areas have been increasingly affected by rising levels of poverty and other socioeconomic inequities that have made accessing health care services in these areas challenging.[56] Considering these barriers, suburban communities in the US may need targeted interventions to establish more PrEP-providing clinics, including clinics with financial navigation services and services for uninsured populations, to serve MSM at high risk for HIV infection residing in such communities.

Reducing the spread of the HIV epidemic in nonurban communities in the US necessitates expanding both the accessibility of PrEP and usage of PrEP, especially in disproportionately affected MSM communities. Accordingly, the US EHE Initiative established one of its four major strategies for reducing the US HIV epidemic to "prevent new HIV transmission by using proven interventions, including pre-exposure prophylaxis…," focusing on enhancing HIV prevention efforts and improving PrEP access and uptake in states with

a disproportionate number of new HIV cases in nonurban areas.[40,41] To achieve the prevention strategy of the EHE Initiative, our findings suggest there could be a benefit to decreasing transportation barriers to PrEP access, and this could be accomplished in a number of ways. This may require improved spatial allocation of PrEP-providing clinics and more PrEP providers that are available to serve disproportionately affected populations in suburban and rural communities across the US. Achieving increased PrEP access and uptake may also require partnerships between state and local health departments and various health care providers in diverse settings. Currently, the Centers for Disease Control and Prevention funds state and local health departments to address the growing HIV epidemic in suburban and rural communities; however, there may be opportunities to innovate PrEP health care delivery by decentralizing the current PrEP delivery model from traditional clinical settings and partnering with other health care providers, such as pharmacists and nurses, to overcome present barriers to PrEP uptake and contribute to PrEP usage expansion efforts.[29,33,57–63] The EHE Initiative's prevention strategy may also be attained by incorporating alternative PrEP delivery models, primarily telehealth-based or home-based PrEP programs, in nonurban areas. The use of telemedicine, mobile phone applications, and home-based PrEP service delivery models may better contribute to the increase of PrEP use among MSM populations in rural and suburban areas by providing convenient, confidential, and safe spaces for PrEP health care provision where anti-HIV, anti-MSM, and PrEP stigma can be minimized.[29,33,57,64–72] Interventions designed to decrease barriers to PrEP access, such as establishing additional PrEP-providing clinics in diverse settings and innovative home-based and technology-based PrEP service provision programs, are needed to address the growing HIV epidemic in nonurban US communities, and such interventions should be affordable, accommodating and acceptable to clients, and culturally competent to reduce HIV transmission in disproportionately affected MSM populations.[30,73–77]

## Limitations

There are several limitations of our study. First, the AMIS-2020 participants included in our study may not be representative of the MSM population in the US because AMIS-2020 was overrepresented by MSM who were non-Hispanic White, were highly educated, and reported high annual household incomes. While the sociodemographic distribution of the AMIS-2020 participants is generally comparable to US adults, it does not fully reflect MSM in the US with disproportionate risk for HIV infection, particularly with regard to race/ethnicity and socioeconomic status.[78,79] Because of this, our findings may be conservative since we do not necessarily capture MSM who may be more affected by social vulnerabilities and who may be more likely to reside in PrEP deserts and less likely to use PrEP. Also, AMIS-2020 participants were recruited using convenience sampling. This may have led to the enrollment of MSM who may have been more interested in sexual health concerns significant to MSM communities. While the AMIS-2020 dataset likely suffers from some level of selection bias, the nature of the sampling used in AMIS prevents the determination of the direction or magnitude of the effect of selection bias. Moreover, there is no unbiased sampling method for this disproportionately affected population.

Second, we defined our exposure variable (drive-time accessibility of PrEP-providing clinics, or whether a participant's ZIP Code of residence was a PrEP desert) using a

30-minute threshold. Longer thresholds (e.g., 60-minute or 120-minute PrEP deserts) may be appropriate for nonurban areas where expectations for drive time to health care services are likely greater; however, the 30-minute threshold has historically been and continues to be considered the standard for accessing non-emergency and primary health care services, including PrEP-providing clinics.[27,80,81] Also, studies using focus group methodology found that MSM in nonurban areas reported drive times of at least 30 minutes to access PrEP providers, justifying the use of a 30-minute PrEP desert threshold in our novel study on the effect of area-level PrEP accessibility on individual-level PrEP use.[30,31] Additional studies should replicate our study using other drive-time thresholds or, even, determine the most optimal threshold by computing one-way drive times to the nearest PrEP-providing clinic continuously (in minutes) to redefine the most appropriate drive-time threshold for a specified area of interest.

Third, we constructed our exposure variable at the ZIP Code level; however, ZIP Codes are not an optimal geographic unit for geospatial analysis because they are representations of US mail delivery routes, not established geographic boundaries.[82,83] Additionally, ZIP Codes are added, discontinued, and altered by the US Postal Service with high frequency.[82,83] To account for these limitations, we used the most recent database of ZIP Code geographic boundaries that was available at the time of our study. Fourth and furthermore, the geometric centroids of participants' ZIP Codes, not actual residential addresses, were used to model geographic access to PrEP-providing clinics. However, ZIP Codes are relatively accurate representations of communities and may be useful for community-level interventions, despite not having residential addresses of AMIS-2020 participants. Moreover, because ZIP Codes were classified based on the nonurban designation of the county in which they were located, some ZIP Codes may have been misclassified because many large counties contain both suburban and more rural ZIP Codes, but we were not able to assign nonurban designations at a sub-county level.

Finally, the AMIS-2020 data were collected during the coronavirus disease 2019 (COVID-19) pandemic; thus, the findings reported in our study may be transitory. However, while recent studies have reported some interruptions to the accessibility and use of PrEP due to COVID-19, MSM in the US have largely been able to continue receiving prescriptions for PrEP and accessing their PrEP medications during the pandemic.[84–87] These studies were conducted during the early phases of the COVID-19 pandemic; therefore, the level of disruption the pandemic had on the accessibility of PrEP health care infrastructure and, thus, the availability of PrEP may have fluctuated by varying degrees over time. Future studies should continue to evaluate the relationship between area-level PrEP accessibility and individual-level PrEP use under non-pandemic conditions.

## Conclusions

Scaling up PrEP, an antiretroviral medication effective for preventing HIV transmission, can help address the growing HIV epidemic among MSM in nonurban areas. Our findings suggest that, overall, MSM who resided in PrEP deserts were 30% less likely to use PrEP in the previous 12 months compared with those not residing in PrEP deserts. We also found that suburban MSM residing in PrEP deserts were 65% less likely to use PrEP in the past

year than suburban MSM not residing in PrEP deserts, and other nonurban MSM residing in PrEP deserts were 25% less likely to use PrEP in the past year than other nonurban MSM not residing in PrEP deserts. Structural interventions designed to decrease barriers to PrEP access that are unique to nonurban areas in the US are needed to address the growing HIV epidemic in these communities.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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**Table 1.**

Characteristics of PrEP-eligible nonurban MSM participants in the American Men's Internet Survey 2020 cycle, overall and by status of PrEP use in the past 12 months – United States.

| | Overall Study Population N (%) | Recent PrEP Use[b] N (%) | No Recent PrEP Use[b] N (%) |
|---|---|---|---|
| Total | 4,792 (100%) | 726 (15.2%) | 4,066 (84.9%) |
| PrEP desert status | | | |
| Not residing in a PrEP desert[a] | 3,827 (79.9%) | 627 (16.4%) | 3,200 (83.6%) |
| Residing in a PrEP desert[a] | 965 (20.1%) | 99 (10.3%) | 866 (89.7%) |
| Age (years) | | | |
| 15–24 | 2,349 (49.0%) | 236 (10.1%) | 2,113 (90.0%) |
| 25–29 | 1,147 (23.9%) | 225 (19.6%) | 922 (80.4%) |
| 30–39 | 404 (8.4%) | 116 (28.7%) | 288 (71.3%) |
| 40 and older | 892 (18.6%) | 149 (16.7%) | 743 (83.3%) |
| Race/ethnicity | | | |
| Non-Hispanic White | 3,084 (65.5%) | 468 (15.2%) | 2,616 (84.8%) |
| Non-Hispanic Black | 450 (9.6%) | 67 (14.9%) | 383 (85.1%) |
| Hispanic | 848 (18.0%) | 132 (15.6%) | 716 (84.4%) |
| Other or multiple races | 326 (6.9%) | 50 (15.3%) | 276 (84.7%) |
| Educational attainment | | | |
| High school or less | 1,202 (25.1%) | 97 (8.1%) | 1,105 (91.9%) |
| At least some college | 3,590 (74.9%) | 629 (17.5%) | 2,961 (82.5%) |
| Annual household income | | | |
| $0 – $19,999 | 695 (16.3%) | 96 (13.8%) | 599 (86.2%) |
| $20,000 – $39,999 | 1,011 (23.7%) | 131 (13.0%) | 880 (87.0%) |
| $40,000 – $74,999 | 1,118 (26.2%) | 208 (18.6%) | 910 (81.4%) |
| $75,000 or more | 1,447 (33.9%) | 243 (16.8%) | 1,204 (83.2%) |
| Health insurance coverage | | | |
| Private only | 3,105 (67.7%) | 507 (16.3%) | 2,598 (83.7%) |
| Public only | 674 (14.7%) | 121 (18.0%) | 553 (82.1%) |
| Other/Multiple | 256 (5.6%) | 37 (14.5%) | 219 (85.6%) |
| None | 555 (12.1%) | 54 (9.7%) | 501 (90.3%) |
| Anticipated healthcare stigma | | | |
| Never | 3,648 (76.1%) | 558 (15.3%) | 3,090 (84.7%) |
| Ever | 1,144 (23.9%) | 168 (14.7%) | 976 (85.3%) |
| Enacted healthcare stigma | | | |
| Never | 4,373 (91.3%) | 618 (14.1%) | 3,755 (85.9%) |
| Ever | 419 (8.7%) | 108 (25.8%) | 311 (74.2%) |
| Region | | | |
| Northeast | 780 (16.3%) | 140 (18.0%) | 640 (82.1%) |
| Midwest | 1,115 (23.3%) | 146 (13.1%) | 969 (86.9%) |

| | Overall Study Population N (%) | Recent PrEP Use[b] N (%) | No Recent PrEP Use[b] N (%) |
|---|---|---|---|
| South | 2,092 (43.7%) | 302 (14.4%) | 1,790 (85.6%) |
| West | 805 (16.8%) | 138 (17.1%) | 667 (82.9%) |
| Nonurban type | | | |
| Suburban[c] | 1,598 (33.4%) | 279 (17.5%) | 1,319 (82.5%) |
| Other nonurban[c] | 3,193 (66.7%) | 447 (14.0%) | 2,746 (86.0%) |
| Medium metro | 1,640 (34.2%) | 267 (16.3%) | 1,373 (83.7%) |
| Small metro | 721 (15.1%) | 102 (14.2%) | 619 (85.9%) |
| Micropolitan | 566 (11.8%) | 63 (11.1%) | 503 (88.9%) |
| Non-core | 266 (5.6%) | 15 (5.6%) | 251 (94.4%) |

Notes: MSM: men who have sex with men; PrEP: pre-exposure prophylaxis

[a] PrEP desert refers to ZIP Codes with a one-way drive time of more than 30 minutes to the nearest PrEP-providing clinic.

[b] Recent PrEP use refers to PrEP use in the past 12 months.

[c] Surbuban ZIP Codes are located within large fringe metropolitan counties, and other nonurban ZIP Codes are located within medium metropolitan, small metropolitan, micropolitan, and non-core counties.

**Table 2.**

Unadjusted associations with PrEP use in the past 12 months among PrEP-eligible nonurban MSM participants in the American Men's Internet Survey 2020 cycle – United States.

| | Unadjusted Prevalence Ratio (95% CI) |
|---|---|
| PrEP desert status | |
| Not residing in a PrEP desert[a] | Referent |
| Residing in a PrEP desert[a] | **0.62 (0.51–0.77)** |
| Age (years) | |
| 15–24 | Referent |
| 25–29 | **1.96 (1.65–2.32)** |
| 30–39 | **2.90 (2.39–3.52)** |
| 40 and older | **1.67 (1.38–2.03)** |
| Race/ethnicity | |
| Non-Hispanic White | Referent |
| Non-Hispanic Black | 0.98 (0.77–1.25) |
| Hispanic | 1.02 (0.85–1.22) |
| Other or multiple races | 1.01 (0.77–1.32) |
| Educational attainment | |
| High school or less | Referent |
| At least some college | **2.18 (1.78–2.67)** |
| Annual household income | |
| $0 – $19,999 | 0.82 (0.66–1.02) |
| $20,000–$39,999 | **0.77 (0.63–0.94)** |
| $40,000 – $74,999 | 1.11 (0.93–1.31) |
| $75,000 or more | Referent |
| Health insurance coverage | |
| Private only | Referent |
| Public only | 1.10 (0.92–1.32) |
| Other/Multiple | 0.88 (0.64–1.21) |
| None | **0.60 (0.46–0.78)** |
| Anticipated healthcare stigma | |
| Never | Referent |
| Ever | 0.96 (0.82–1.13) |
| Enacted healthcare stigma | |
| Never | Referent |
| Ever | **1.83 (1.52–2.19)** |
| Region | |
| Northeast | Referent |
| Midwest | **0.72 (0.58–0.90)** |
| South | **0.80 (0.67–0.96)** |
| West | 0.96 (0.77–1.18) |

| | Unadjusted Prevalence Ratio (95% CI) |
|---|---|
| Nonurban type | |
| Suburban[b] | Referent |
| Other nonurban[b] | **0.80 (0.69–0.92)** |

Notes: CI, confidence interval; MSM, men who have sex with men; PrEP, pre-exposure prophylaxis

Bold values indicate statistical significance at $P < .05$.

[a]PrEP desert refers to ZIP Codes with a one-way drive time of more than 30 minutes to the nearest PrEP-providing clinic.

[b]Surbuban ZIP Codes are located within large fringe metropolitan counties, and other nonurban ZIP Codes are located within medium metropolitan, small metropolitan, micropolitan, and non-core counties.

**Table 3.**

Adjusted associations with PrEP use in the past 12 months among PrEP-eligible nonurban MSM participants in the American Men's Internet Survey 2020 cycle – United States.

| | Model 1 aPR (95% CI) | Model 2 aPR (95% CI) | Model 3 aPR (95% CI) |
|---|---|---|---|
| PrEP desert status | | | |
| Not residing in a PrEP desert[a] | Referent | Referent | - |
| Residing in a PrEP desert[a] | **0.66 (0.53–0.82)** | **0.70 (0.56–0.87)** | - |
| PrEP desert status by Nonurban type | | | |
| *Suburban area* | | | |
| Not residing in a PrEP desert[a] in suburban areas[b] | - | - | Referent |
| Residing in a PrEP desert[a] in suburban areas[b] | - | - | **0.35 (0.15–0.80)** |
| *Other nonurban area* | | | |
| Not residing in a PrEP desert[a] in other nonurban areas[b] | | | Referent |
| Residing in a PrEP desert[a] in other nonurban areas[b] | - | - | **0.75 (0.60–0.95)** |
| Age (years) | | | |
| 15–24 | Referent | Referent | Referent |
| 25–29 | **1.62 (1.35–1.95)** | **1.62 (1.35–1.95)** | **1.62 (1.35–1.95)** |
| 30–39 | **2.32 (1.89–2.86)** | **2.35 (1.91–2.88)** | **2.34 (1.90–2.87)** |
| 40 and older | **1.35 (1.09–1.68)** | **1.36 (1.10–1.68)** | **1.35 (1.09–1.68)** |
| Race/ethnicity | | | |
| Non-Hispanic White | Referent | Referent | Referent |
| Non-Hispanic Black | 1.00 (0.78–1.28) | 1.00 (0.78–1.29) | 1.00 (0.78–1.29) |
| Hispanic | 1.16 (0.97–1.40) | 1.11 (0.92–1.34) | 1.10 (0.91–1.33) |
| Other or multiple races | 1.05 (0.80–1.39) | 1.04 (0.79–1.37) | 1.04 (0.79–1.37) |
| Educational attainment | | | |
| High school or less | Referent | Referent | Referent |
| At least some college | **1.79 (1.41–2.28)** | **1.81 (1.42–2.30)** | **1.81 (1.42–2.30)** |
| Annual household income | | | |
| $0 – $19,999 | 1.04 (0.83–1.30) | 1.07 (0.86–1.34) | 1.07 (0.86–1.34) |
| $20,000–$39,999 | 0.87 (0.71–1.06) | 0.89 (0.73–1.09) | 0.89 (0.73–1.09) |
| $40,000 – $74,999 | 1.06 (0.89–1.25) | 1.08 (0.92–1.28) | 1.09 (0.92–1.28) |
| $75,000 or more | Referent | Referent | Referent |
| Health insurance coverage | | | |
| Private only | Referent | Referent | Referent |
| Public only | 1.10 (0.90–1.35) | 1.10 (0.91–1.34) | 1.10 (0.91–1.34) |
| Other/multiple | 0.85 (0.61–1.17) | 0.84 (0.61–1.17) | 0.84 (0.61–1.17) |
| None | **0.61 (0.46–0.81)** | **0.62 (0.47–0.81)** | **0.62 (0.47–0.82)** |
| Anticipated healthcare stigma | | | |
| Never | Referent | Referent | Referent |

| | Model 1 aPR (95% CI) | Model 2 aPR (95% CI) | Model 3 aPR (95% CI) |
|---|---|---|---|
| Ever | 0.89 (0.75–1.05) | 0.90 (0.76–1.06) | 0.90 (0.76–1.06) |
| Enacted healthcare stigma | | | |
| Never | Referent | Referent | Referent |
| Ever | **1.71 (1.42–2.07)** | **1.71 (1.42–2.06)** | **1.70 (1.41–2.05)** |
| Region | | | |
| Northeast | - | Referent | Referent |
| Midwest | - | 0.82 (0.66–1.02) | 0.82 (0.66–1.02) |
| South | - | 0.87 (0.72–1.06) | 0.88 (0.72–1.06) |
| West | - | 1.07 (0.86–1.34) | 1.09 (0.87–1.35) |
| Nonurban type | | | |
| Suburban[b] | - | Referent | - |
| Other nonurban[b] | - | **0.86 (0.75–0.99)** | - |

Notes: aPR, adjusted prevalence ratio; CI, confidence interval; MSM, men who have sex with men; PrEP, pre-exposure prophylaxis

Bold values indicate statistical significance at $P < .05$.

[a]PrEP desert refers to ZIP Codes with a one-way drive time of more than 30 minutes to the nearest PrEP-providing clinic.

[b]Surbuban ZIP Codes are located within large fringe metropolitan counties, and other nonurban ZIP Codes are located within medium metropolitan, small metropolitan, micropolitan, and non-core counties.