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# Association of Race and Other Social Determinants of Health with HIV Pre-Exposure Prophylaxis Use: A County-level Analysis using the PrEP-to-Need Ratio

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## Abstract

**Background:** Research is limited on the effect of racism and social determinants of health on HIV pre-exposure prophylaxis (PrEP) use.

**Methods:** This study used the PrEP-to-Need Ratio (PNR), which measures PrEP prescriptions divided by HIV diagnoses in the county, to evaluate sufficient PrEP use. AIDSVu datasets were compared to county-level social determinants of health. Standardized regression coefficients ($\beta$) were compared to identify strongest associations with PNR.

**Results:** Overall, factors including percent African American and percent uninsured had negative correlations with PNR, whereas median household income and severe housing cost burden had positive associations. Stratifying for population size, percent African American, percent uninsured, and severe housing cost burden were significant for low populations, whereas median household income, percent in poverty, percent uninsured, and percent African American were significant for large populations.

**Conclusion:** To reduce PrEP disparities, public health must develop strategies to reach those most in need, especially historically disadvantaged communities.

### Keywords

Pre-exposure prophylaxis; HIV; social determinants of health; PrEP-to-Need-Ratio

## Introduction

An estimated one million people are living with HIV in the U.S., with about 37,000 new infections diagnosed in 2019 (Centers for Disease Control and Prevention, 2019). Racism and barriers to health care engagement are large drivers of poor HIV care cascade outcomes (Arnold et al., 2014; Cahill et al., 2017). Socioeconomic factors including poverty and

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unemployment have also been correlated with greater HIV incidence (Latkin et al., 2013). Moreover, health disparities are present in the treatment of HIV. Individuals with lower socio-economic status (SES) experience delays to antiretroviral treatment (Joy et al., 2008), and individuals with lower SES experience greater mortality rates from HIV (Rubin et al., 2010). Racism has a similar role on outcomes of the HIV care cascade (Khazanchi et al., 2021; Bowleg et al., 2022). HIV prevalence is greatest among Black or African Americans, accounting for an estimated 42.1% of HIV incidence in 2019 (Centers for Disease Control and Prevention, 2021). Furthermore, research suggests that among African Americans, distrust in the healthcare system is associated with experiences of racism (Hsueh et al., 2021).

In 2012, the U.S. Food and Drug Administration approved the use of HIV pre-exposure prophylaxis (PrEP), which is highly effective in reducing HIV infection. When taken as prescribed, PrEP can reduce the risk of infection through sex by approximately 99% and via injection drug use by approximately 74% (Choopanya et al., 2013; Grant et al., 2014; Liu et al., 2016; Martin et al., 2015). PrEP is recommended to be administered to individuals who have multiple sexual partners, a partner living with HIV, inconsistent condom use, or share injection equipment (Centers for Disease Control and Prevention, 2018).

Further research is needed to identify and address health disparities in PrEP uptake and persistence. Surveys have shown that fewer Black and Latinx men who have sex with men (MSM) had discussed PrEP with a health care provider compared to White MSM (Kanny et al., 2019). Similarly, African American and Hispanic individuals are less likely than White individuals to be prescribed PrEP, even after adjusting for PrEP indications (Huang et al., 2018). Social determinants of health (SDOH), such as residential segregation, poverty, and insurance status to pay for PrEP, can impede PrEP initiation (Cao et al., 2020; Nieto et al., 2020). Moreover, PrEP discontinuation has been shown to be affected by changes in logistical barriers—such as difficulties navigating the health care system and insurance costs—and challenges relating to adherence (Siegler et al., 2018; Whitfield et al., 2018; Zarwell et al., 2021).

To improve descriptions of access needs and disparities, researchers developed the PrEP-to-Need Ratio (PNR) to define the ratio of the PrEP users since its introduction in 2012 to the number of HIV diagnoses in each respective year. Thus, PNR acts as continuous measure in comparing PrEP uptake to the number of HIV diagnoses in a county, serving as a method to analyze disparities in PrEP use. When PNR is low, it indicates an unmet need for PrEP based on local HIV prevalence. Previous research using PNR and AIDSVu national datasets have largely focused on factors such as gender, age, region, and policy implementation (Rosenberg & Marcus 2018; Siegler et al., 2020; Sullivan et al., 2020). Adding to the literature, this current analysis seeks to determine the impact of general socioeconomic and demographic characteristics on the PNR. In conjunction with research on individual mechanisms, this analysis could inform PrEP implementation programs.

For this analysis, we wanted to gather a wide array of socioeconomic factors to inspire future framing of public policy. Poverty rates and income were studied to determine the influence of wealth, income inequality to analyze classism, severe housing cost burden to

measure housing insecurity, unemployment rates to study the impact of employment, the percent uninsured to determine the impact of insurance, percent over 25 years old with a high school diploma to quantify educational attainment, alongside demographic data to measure structural factors regarding race. By analyzing such factors at the county-level, we can better understand the mechanism in which socioeconomic factors interact and manifest in PrEP use. Past research on an individual level have indicated high costs, housing insecurity, lack insurance, and racism have led to decreased treatment use and greater HIV risk (Aidala et al., 2016; Nieto et al., 2020; Mayer, Agwu, & Malebranche, 2020; Khanzanchi et al., 2021; Bowleg et al., 2020); as such, we hypothesized higher poverty rates, lack of insurance, income inequality, unemployment, severe housing cost burden, percent of African Americans, and percent of Hispanics would have negative correlations with PNR. However, due to increased ability to pay, understanding of health and the healthcare system, and greater resources in urban areas (Chen, Roy, Khushalani, & Puddy, 2022; Goldman & Smith, 2002); we hypothesized positive correlations of PNR with median household income, educational attainment, and population size.

## Methods

### Data Source and Retrieval

De-identified county level PNR data for 2018 was retrieved from AIDSVu.org. All HIV surveillance data was obtained by the Centers for Disease Control and Prevention's Division of HIV/AIDS Prevention's HIV Incidence and Case Surveillance Branch HIV surveillance database, which was later compiled by AIDSVu.org to calculate PNR. PrEP data was obtained from Symphony Health, Gilead Sciences, Inc., using patient-level prescription data from 54,000 pharmacies, 1,500 hospitals, and 80,000 physician practices. PrEP and HIV data was compiled into PNR by AIDSVu.org (Sullivan et al., 2020). PNR was created to model disparities based off demographics and other characteristics (Siegler et al., 2018), which was its use in this study. We retrieved data from the U.S. Census Bureau 2018 county estimates and AIDSVu.org Public Datasets for measures of social determinants of health, encompassing indicators of racial and ethnic segregation, socioeconomic inequality, and health care access. Per 45 CFR 46.101, research using de-identified publicly available data does not involve "human subjects". Therefore, this study was exempt from Institutional Review Board oversight.

After removal of 2,523 counties that had 0 new cases or < 3 individuals using PrEP, 696 counties were retained for this analysis. A county-level model was chosen because it provides a reasonable number of HIV cases and PrEP prescriptions, while allowing for more geographically precise estimates of PNR and social determinants of health than a state- or national-level model.

### Measures

Independent variables considered in this analysis were percent African American, percent Hispanic, percent living in poverty, percent of individuals over 25 years old with a high school diploma, median household income, the Gini coefficient (which measures income inequality), percent uninsured, percent unemployed, and percent living with severe housing

cost burden. Differences in PNR based on percent African American and percent Hispanic may suggest racial inequality related to PrEP prescriptions, while differences in PNR based on percent living in poverty, median household income, income inequality, percent uninsured, percent unemployed, percent with high school diploma, and percent living with severe housing costs may suggest socioeconomic inequality. Percent with severe housing cost burden is defined as the percentage of individuals spending greater than 50% of their annual household income on housing-related expenditures. All measures were controlled for population size by adding population size to the multiple linear regression to lessen the known impact of urbanicity on PrEP access, in addition to regression analysis stratified by population size.

### Data Analysis

Descriptive statistics were reported using frequency measures. Pearson's correlation was used to assess bivariate associations between all SDOH predictors and the outcome of PNR. We then used multiple linear regression with standardized beta coefficients to test for differences in PNR by SDOH indicators. We examined variance inflation factors (VIFs) to detect multicollinearity given moderate-to-strong correlations between some predictors. As all VIFs were less than 10 and the mean was 2.65, multicollinearity was not a concern. An additional multiple regression model (Model 2) was run using backward selection, removing the variables with the lowest standardized beta values. For both models, we report standardized beta coefficients. Lastly, an additional regression model was run stratified by population size. Counties with low population were defined as those in the bottom 25$^{th}$ percentile of population size, whereas counties with large populations were defined as those in the top 75$^{th}$ percentile. All analyses were conducted using STATA SE version 16 (StataCorp, College Station, TX).

## Results

Descriptive statistics and results of bivariate analyses are reported in Table 1. We found percent African American, percent living in poverty, and percent uninsured had moderately sized negative correlations with PNR. Percent unemployed and income inequality had small, negative correlations with PNR. Percent over 25 years old and median household income had moderate, positive correlations with PNR. Lastly, percent Hispanic and percent living with severe housing cost burden had no significant association with PNR

As shown in Table 2, percent in poverty, household income, income inequality, unemployment rate, lack of insurance, educational attainment, and percent African American were all significantly correlated with PNR. Educational attainment and household income had a positive correlation, whereas all other SDOH had a negative association. All variables besides population size had a significant positive correlation with percent African American (besides PNR which had a negative association). Severe housing cost burden, unemployment, lack of insurance, lower educational attainment, lower percentages of African Americans, and larger population size had significant correlations with percent Hispanic. In Table 2, median household income and percent over 25 years old with a high school diploma are reverse coded so all socioeconomic variables are expressed as

risk factors. All 21 pairwise correlations (20 of which are significant) between these socioeconomic factors are positive, ranging from .02 to .82. Specifically, there are very strong correlations between percent in poverty and median household income, as well as median household income and educational attainment.

Results of our regression model are presented in Table 3. Percent African American, median household income, percent uninsured, and percent with severe housing cost burden were all significantly associated with PNR with the largest effect sizes. The PNR significantly decreased as the proportion of African American residents increased; however, we found no significant difference in PNR based on the percentage of Hispanic residents. PNRs significantly increased as counties' median household income increased in our model, and PNRs decreased as the rate of uninsured individuals increased in our county-level data. A more parsimonious model in which backward selection was used to systematically remove predictors not significantly associated with PNR (Model 2) showed the same pattern of associations, with no change in significant predictors of PNR.

When stratifying the regression by population size (Table 4), counties with low population sizes saw a positive standardized beta for percent with severe housing cost burden and a negative standardized beta with percent African American and percent uninsured. On the other hand, counties with large populations saw positive standardized beta coefficients with median household income and percent in poverty but negative correlations with percent uninsured and percent African American.

## Discussion

Results from this study demonstrate that US counties with a higher percentage of African American residents and a higher percentage of uninsured residents had lower PNRs, while counties with higher median household incomes and a higher percentage of residents experiencing severe housing cost burden had higher PNRs. As hypothesized, many county-level SDOH indicators were associated with PNR, demonstrating county-level factors can lead to disparate PrEP uptake, providing important groundwork for PrEP implementation and further studies using PNR.

The percent of African American residents in a county had a relatively strong negative association with PNR. Given that neighborhood racial segregation is rooted in structural racism, this finding suggests that racism may impede adequate PrEP access (Doshi, Bowleg, Blakenship, 2021). It has previously been shown that stigma, within the context of racism, can impede HIV treatment adherence and awareness of PrEP due to medical mistrust and fear of HIV stigma (Arnold et al., 2014; Cahill et al., 2017). Additionally, priority groups such as Black MSM have indicated substantial barriers to PrEP uptake because of perceived and experienced discrimination in health care settings (Quinn, Bowleg, & Dickinson-Gomez, 2019; Quinn et al., 2019). Though our model accounts for lack of insurance—one factor limiting access to care—discrimination experienced by African Americans seeking HIV care may create additional barriers, with both perceived and experienced discrimination limiting access to care (Levy et al., 2014; Maulsby et al., 2014; Mays, Cochran, & Zamudio, 2004; Millett et al., 2012; Peterson & Jones, 2009). While

these structural barriers are relatively understudied in a larger context, such barriers could result in limited PrEP outreach in primarily Black communities or, on a county-level, a lower number of PrEP providers present within counties with high percentages of African Americans.

Household income had a relatively strong positive association with PNR, indicating that economic security might impact PrEP use. The high costs of PrEP and ongoing maintenance care (e.g., HIV and sexually transmitted infection testing) may be a substantial barrier to PrEP at the individual level. Ability to pay for PrEP has been previously studied as a barrier to initiating PrEP use (Mayer, Agwu, & Malebranche, 2020; Nieto et al., 2020) and to continuing PrEP over time (Siegler et al., 2018; Whitfield et al., 2018; Zarwell et al., 2021). Additionally, lower income at the county level may make it more difficult to access clinics providing PrEP. Communities with higher levels of poverty have been shown to have fewer PrEP clinics (Siegler et al., 2020). Structural-level interventions are needed to increase access and reduce the cost of PrEP care to reduce inequities in PrEP uptake in areas with greater HIV incidence. Structural interventions, such as creating additional PrEP clinics or lowering the market price of PrEP, could limit the barriers that cost and inaccessible clinics generate to PrEP uptake.

Counties with a higher percentage of uninsured individuals also had lower PNRs. If individuals do not have access to insurance, they may not be able to cover the market cost of PrEP use, as suggested by previous cross-sectional survey research (Nieto et al., 2020). Additionally, uninsured individuals are less likely to visit primary care providers (often a pathway to PrEP), which can widen existing disparities (Card, Dobkin, & Maestas, 2008; Lichtenberg, 2002; McWilliams et al., 2007). At the county level, lack of insurance may be associated with broader issues such as an overtaxed medical system that needs to prioritize more pressing issues (including late-stage cancer and death), which may arise due to avoidance of primary care (Halpern et al., 2008; McWilliams et al., 2004; Ward et al., 2008).

One surprising result was the positive association between severe housing cost burden and PNR. Previous literature has continuously shown that home insecurity can lead to individuals avoiding medical care and using the costs in place for rent (Aidala et al, 2016). However, it is important to note, after our stratified analysis, this correlation occurred chiefly in counties with lower populations. In rural counties, due to fewer renters compared to urban counties, housing cost burden may not as accurately reflect housing insecurity; there is increased stability for homeowners, so housing related costs may not accurately reflect housing insecurity. Therefore, this positive association with PNR may be due to costs from homeowners in rural counties. It is still important to note the burden on rural renters. Data from American Community Survey (ACS) estimates indicate high housing cost burden rates in rural counties; 41% of rural renters spend 30% or more of their income on housing (Joint Center for Housing Studies of Harvard University, 2016). Still, future research is needed to better understand the relationship between housing cost burden and PNR.

The stratified analysis, as shown in Table 4, indicated that the mechanisms of PrEP disparities may differ in rural and urban counties. Firstly, in counties with low population

rates, severe housing cost burden had a positive association with PNR, whereas percent uninsured and percent African American had negative associations, and percent African American had the greatest associations with PNR. However, in high-population counties percent living in poverty and median household income had positive associations and percent uninsured and percent African American had negative associations. Such results provide insightful knowledge to direct future public health campaigns. Across all counties, however, percent African American and insurance status remained the most prevalent factors; therefore, to improve PrEP uptake across the country, public health should look to address factors related to structural racism and lack of insurance.

Another interesting result included positive standardized beta coefficients for both median household income and percent in poverty for those in large population counties. Together, these results could be due to individuals qualifying for Medicaid. Individuals on Medicaid have lower out-of-pocket costs compared to other insurance options (Furukawa et al., 2020). Estimates indicate that PrEP costs for individuals with private insurance are around $200 per month, and costs approximately $8,000 a month with no insurance or prescription benefit programs (Kay et al., 2020). Past literature has shown that Medicaid expansion has led to an increase in PrEP uptake (Fayaz Farkhad, Holtgrave, & Albarracín, 2021). This relationship may only occur in communities with greater populations, as they have access to greater healthcare resources to use their insurance or purchase PrEP (Chen, Roy, Khushalani, & Puddy, 2022).

### Limitations

Our research is not without limitations. First, we relied on publicly available data for analysis, which resulted in incomplete data due to data suppression. Second, we used county-level indicators to measure larger constructs, such as using percent African American to measure the larger societal impact of racism. County-level indicators, while having less variance than state-wide analyses, may have large variations that are obscured in this analysis. Additionally, this analysis is unable to stratify who is using PrEP in each county; for example, certain counties may have many individuals on PrEP, but not those in the most need. Lastly, the current analysis does not allow us to understand the mechanisms of these PNR associations. However, this analysis still provides valuable information on the context of PrEP on the county level, setting the foundation for further analysis of underlying structural factors.

## Conclusion

Our study documents associations between SDOHs and PNR in the U.S. in 2018. We found percent African American, income, insurance status, and housing cost burden were related to PNR at the county level. However, the mechanisms of disparate PrEP uptake vary between urban and rural counties. To reduce PrEP disparities, public health must develop further strategies to reach those most in need, especially communities historically disadvantaged and marginalized. Future research is needed to determine the structural mechanisms which drive the associations in this study, specifically those that operate on a county level. It may also be useful to study which parts of the PrEP care cascade are most influential in counties'

disparate PrEP-to-Need described in this study, including further study of PrEP awareness, initiation, and adherence.

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## Table 1

Demographics, social determinants of health, and county characteristics and their bivariate associations with PrEP-to-Need ratio (n = 696)

| | | | PrEP-to-Need Ratio |
|---|---|---|---|
| **Continuous Variables (Range)** | ***M*** | ***SD*** | ***Pearson's r*** |
| PrEP-to-Need Ratio (0.43 – 25.7) | 4.88 | 3.97 | — |
| Percent Living in Poverty (2.6 – 37.1) | 14.5 | 5.82 | −0.50*** |
| Median Household Income (in units of $10k; 2.92 – 14.0) | 6.00 | 1.75 | 0.56*** |
| Income Inequality (Gini Coefficient; 0.34 – 0.66) | 0.46 | 0.04 | −.17*** |
| Percent with Severe Housing Cost Burden (6.9 – 31.7) | 13.9 | 3.53 | −0.01 |
| Percent Unemployed (2 – 18.9) | 4.12 | 1.31 | −0.23*** |
| Percent Uninsured (2.4 – 32.1) | 11.0 | 4.83 | −0.51*** |
| Percent Over 25 with a High School Diploma (64.5 – 98) | 87.5 | 5.44 | 0.44*** |
| Percent African American (0.55 – 80.6) | 16.9 | 15.8 | −0.46*** |
| Percent Hispanic (1.03 – 95.4) | 13.4 | 14.6 | 0.00 |
| Population Size (in units of 10k; 1.49 – 1,007) | 36.9 | 63.7 | 0.16*** |

Notes:

* $p \leq 0.05$;

** $p \leq 0.01$;

*** $p \leq 0.001$

## Table 2

Pearson R correlation matrix of indicator variables and PrEP-to-Need Ratio.

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. PrEP-to-Need Ratio | 1.00 | | | | | | | | | | |
| 2. Percent living in Poverty | **−0.50** | 1.00 | | | | | | | | | |
| 3. Median Household Income | **−0.56** | **0.82** | 1.00 | | | | | | | | |
| 4. Income Inequality | **−0.17** | **0.38** | **0.26** | 1.00 | | | | | | | |
| 5. Percent with Severe Housing Cost Burden | −.01 | **0.34** | **0.08** | **0.33** | 1.00 | | | | | | |
| 6. Percent Unemployed | **−0.23** | **0.53** | **0.44** | **0.18** | **0.22** | 1.00 | | | | | |
| 7. Percent Uninsured | **−0.51** | **0.41** | **0.45** | **0.20** | 0.02 | **0.10** | 1.00 | | | | |
| 8. Percent over 25 with a High School Diploma | **−0.44** | **0.66** | **0.55** | **0.26** | **0.17** | **0.55** | **0.57** | 1.00 | | | |
| 9. Percent African American | **−0.46** | **0.56** | **0.39** | **0.31** | **0.28** | **0.26** | **0.23** | **.30** | 1.00 | | |
| 10. Percent Hispanic | 0.00 | 0.05 | −0.07 | 0.04 | **0.29** | **0.25** | **0.35** | **0.47** | **−0.27** | 1.00 | |
| 11. Population Size | **0.16** | **−0.15** | **−0.26** | 0.02 | **0.33** | **−0.08** | −0.06 | −.01 | −0.06 | **0.31** | 1.00 |

Notes: Pearson r values that are bolded indicate a p-value < .05 (p < .05). Items 3 and 8 are reverse coded so that all correlations with the outcome variable PNR are in the same direction (negative), and most correlations between independent variables are positive.

## Table 3

Results of multiple linear regression models predicting PrEP-to-Need ratio (n = 696)

| | Model 1 | | Model 2 | |
|---|---|---|---|---|
| | ***B (SE)*** | ***β*** | ***B (SE)*** | ***β*** |
| Percent Living in Poverty | 0.08 (0.05) | 0.11 | — | — |
| Median Household Income (in units of $10k) | 0.85 (0.13) | 0.37*** | 0.71(.07) | 0.31*** |
| Income Inequality | 3.45 (3.46) | 0.03 | — | — |
| Percent with Severe Housing Cost Burden | 0.09 (0.04) | 0.08* | 0.12(.03) | .11*** |
| Percent Unemployed | 0.06 (0.12) | 0.02 | — | — |
| Percent Uninsured | −.22 (.03) | −0.27*** | −0.25(.03) | −.31*** |
| Percent over 25 with a High School Diploma | .06 (0.04) | 0.08 | — | — |
| Percent African American | −.08 (0.01) | −0.34*** | −0.08(.01) | −.030*** |
| Percent Hispanic | −0.01 (0.01) | −0.02 | — | — |
| Population Size (in units of 10k) | 0.00(0.00) | .02 | — | — |
| **Model Statistics** | | | | |
| *F*-test (*df*) | 62.21(10, 685)*** | | | |
| Adj-$R^2$ | 0.47 | | | |

Notes:

* $p \leq 0.05$;

** $p \leq 0.01$;

*** $p \leq 0.001$;

**Table 4**

Results of linear regression model stratified for total population size predicting PrEP-to-Need ratio on social determinants of health (n = 174)

| | < 25% Percentile | | > 75% Percentile | |
|---|---|---|---|---|
| | ***B (SE)*** | ***β*** | ***B (SE)*** | ***β*** |
| Percent Living in Poverty | −0.05 (0.03) | −0.24 | 0.47 (0.12) | 0.52*** |
| Median Household Income | 0.17 (0.19) | 0.12 | 1.18 (0.24) | 0.52*** |
| Income Inequality | 0.77 (2.38) | 0.02 | 9.44 (6.96) | 0.08 |
| Percent with Severe Housing Cost Burden | 0.08 (0.03) | 0.21* | 0.11 (0.09) | 0.10 |
| Percent Unemployed | 0.15 (0.10) | 0.13 | −0.52 (0.34) | −0.13 |
| Percent Uninsured | −0.06 (0.02) | −0.18** | −0.24 (0.08) | −0.28** |
| Percent over 25 with a High School Diploma | −0.02 (0.03) | −0.07 | 0.14 (0.11) | 0.18 |
| Percent African American | −0.03 (0.01) | −0.48*** | −0.15 (0.03) | −0.46*** |
| Percent Hispanic | 0.00 (0.01) | −0.03 | −0.04 (0.03) | −0.17 |
| **Model Statistics** | | | | |
| *F*-test (*df*) | 10.31(9, 164)*** | | 19.95(9, 164) | |
| Adj-$R^2$ | 0.33 | | 0.50 | |

Notes:

* $p \leq 0.05$;

** $p \leq 0.01$;

*** $p \leq 0.001$;