A New Look at Socioeconomic Determinants of Pre-exposure Prophylaxis (PrEP) Usage in Rural and Urban Counties

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One recent innovation in the fight against the HIV epidemic is that of pre-exposure prophylaxis (PrEP), a combination of tenofovir and emtricitabine that has been shown to reduce the risk of contracting HIV by 99% when taken daily. However, PrEP access is hindered across the United States due to numerous disparities. For example, looking at geography alone, only 12% of PrEP access sites nationwide are found in rural areas, compared to 88% in urban areas. Therefore, this study looks to address the rural-urban disparity by examining the socioeconomic determinants of PrEP usage in select rural areas in comparison to those in urban areas, providing crucial information for the expansion of PrEP access in rural communities. This was done through the collection of various socioeconomic data and PrEP prevalence data for rural and urban counties in Ohio, Illinois, and Indiana, using databases from the American Community Survey and AidsVu. PrEP prevalence data was then correlated with various socioeconomic variables through the formation of separate linear regressions for urban and rural communities. Comparisons between these models suggest that PrEP usage is concentrated among younger populations in urban communities, as opposed to older populations within rural communities. In addition, the effects of education and racial composition seem to be pronounced in urban areas, while they do not significantly affect PrEP prevalence in rural areas. Such information may prove vital in the development of interventions designed to target populations within rural counties, increasing PrEP access and addressing PrEP disparities across the US.

Introduction

The HIV/AIDS epidemic has been established as one of the most persistent issues facing public health in the United States. Even after 4 decades in the United States, the epidemic is responsible for 38,000 new infections every year, stemming from sexual transmission, the sharing of intravenous needles, and contact with infected bodily fluids (Centers for Disease Control and Prevention [CDC], 2019). However, public health officials now have various tools to mitigate the continuing spread of HIV, including rampant testing and the use of antiretroviral medications to treat HIV patients (Harris et al., 2019). One recent innovation is the development of pre-exposure prophylaxis (PrEP), a pill containing the antiretroviral medications tenofovir and emtricitabine that can reduce the risk of contracting HIV by 99% when taken daily (Anderson et al., 2013). In light of this progress, a national initiative was released by the White House in February 2019, titled "Ending the HIV Pandemic: A Plan for America". This plan dictates that, by 2030, at least 95% of people with HIV should have a diagnosis and be virally suppressed, meaning that they have successfully reduced the amount of virus in their body with antiretroviral therapy (Harris et al., 2019). In addition, the initiative highlights the importance of PrEP, suggesting that, in order to reduce the incidence of HIV by 90% by 2030, at least 50% of those at increased risk of infection should be taking PrEP. While progress is being made with increasing rates of HIV testing and viral suppression, PrEP rates have remained low in certain populations; for example, 42.1% of White Americans at increased risk of HIV were able to get PrEP, compared to just 10.9% for Hispanics/Latinos and 5.9% for African Americans (Harris et al., 2019). Such evidence points to wide disparities that still exist in regards to PrEP use, making the study of these disparities imperative to increase PrEP access and successfully mitigate future HIV infections in the United States.

Indeed, research suggests that various socioeconomic factors significantly contribute to inequalities in PrEP usage and PrEP access. For example, in a study that compiled a dataset with 188,546 PrEP users nationwide, the county-level PrEP prevalence rate (the number of PrEP users in a county divided by that county's total population) and PrEP-to-need ratio (the number of PrEP users in a county divided by the number of new HIV cases in that county) were correlated with demographic characteristics, such as the percentage of people uninsured, the percentage of those with a bachelor's degree, and the

percentage of those in poverty (Siegler et al., 2020). And results show that, while the percentage of those in poverty did not significantly impact PrEP prevalence in a given county, PrEP-to-need ratios would decrease by 4% for every 5% increase in the concentration of those below the poverty line. On the contrary, prevalence rates would increase by 8% for every 5% increase in the proportion of those with a bachelor's degree, and PrEP-to-need ratios would decrease by 6% for every 5% increase in the percentage of those without health insurance (Siegler et al., 2020). In other words, while race plays a significant role as a determinant of PrEP usage, so do other, critical socioeconomic characteristics, contributing to PrEP disparities and even explaining the lackluster progress in driving PrEP use across the country.

While socioeconomic factors are now widely used to explain PrEP-related disparities, there is still one critical determinant that needs more investigation: geography. Geography has been shown to play a major role in a myriad of HIV-related disparities. For example, in 2018, despite representing only 38% of the US population, the US South accounted for about 52% of new HIV diagnoses nationwide (Ahonkhai et al., 2022). Such disparities are not just observed between large regions of the United States. In a study investigating urban-rural differences across the US, results concluded that 95% of HIV care sites nationwide were located in urban centers, and the median county-level drive time to the closest HIV care site was around 45 minutes. This was in stark contrast to rural areas, where the median drive time to an HIV care site was about 90 minutes, twice that of urban settings (Masiano et al., 2019). Clearly, even within smaller geographical areas, wide discrepancies occur in HIV care and treatment between urban and rural areas, putting rural communities at a disadvantage through reduced access to care.

By extension, urban-rural disparities impact PrEP access, specifically. In a study on the location of PrEP care sites nationwide, it was found that only 12% of care sites were found in rural counties, compared to 88% in urban counties (Siegler et al., 2018). As the study further explained, when looking at the distribution of the 2,094 PrEP-providing clinics across the United States and counties across all 9 census divisions within the country, it was found that rural, noncore counties, on average, only had 33.2 PrEP clinics for every 1,000 new HIV diagnoses in these counties, while large central metro counties and medium metro counties had 52.2 PrEP clinics for every

1,000 HIV diagnoses and 56.5 PrEP clinics for every 1,000 HIV diagnoses, respectively (Siegler et al., 2018). Even as HIV incidence in rural counties may be lower than that of urban counties across the United States, when comparing differences in PrEP access relative to differences in HIV incidence, it is clear that PrEP access in many rural counties falls short when compared to access in urban counties. Evidently, PrEP access is severely hampered by rural-urban disparities, even within smaller, geographic areas. And the consequences are significant. For example, in states like South Carolina, 27% of newly diagnosed HIV cases were from rural areas in 2015 (Weissman et al., 2015). This is despite the fact that, on average, only 6.4% of men who have sex with men (MSM) live in rural areas, especially significant given that 60-70% of incident HIV infections in the United States occur in MSM (Siegler et al., 2014). In other words, even though a small proportion of those in high-risk populations (such as MSM) live in rural areas, these communities can still account for a significant proportion of HIV incidence in various areas across the United States, especially given the continuing urban-rural disparity in PrEP access. As one study investigated, 17.5% of PrEP-eligible MSM live in areas where the nearest PrEP care site is at least 30 minutes away, discouraging PrEP use for a significant proportion of those at higher risk of infection. Unsurprisingly, 42.5% of those who live in these so-called “PrEP deserts” live in rural communities, meaning that almost 62,800 MSM at high-risk of HIV infection do not have access to convenient PrEP care (Siegler et al., 2019). Therefore, it is imperative that interventions are implemented to increase PrEP access within rural areas, encouraging PrEP usage and promoting equity across the United States.

However, for interventions to prove effective in encouraging PrEP use in rural counties, socioeconomic determinants of PrEP usage need to be identified within rural communities. After all, the most effective interventions directly address the social determinants of health within a community, as well as target disadvantaged populations to mitigate health disparities (Williams et al., 2008). Despite this, the social factors influencing PrEP usage in rural areas, specifically, have not yet been identified. In fact, correlations between socioeconomic factors and PrEP-related measures have only been drawn for urban and rural counties *together*, with urban-rural comparisons only going so far as to comparing measures such as PrEP prevalence, rather than the social determinants influencing PrEP

prevalence (Siegler et al., 2020). Consequently, it becomes imperative to study the socioeconomic determinants of PrEP usage among rural counties, specifically. Therefore, the research question of this paper asks: "Regarding the impact of various socioeconomic factors on PrEP use designed to mitigate HIV risk, to what extent do differences exist between selected rural and urban communities?" Answering this question will provide key insights into the demographics of rural settings and how they play a role in PrEP participation compared to determinants within urban communities, allowing for effective, targeted measures that can improve PrEP participation, access, and even equity across the country.

Results

Gender

Correlations between the percentages of males and females and PrEP prevalence in urban counties (Figures 1 and 2, respectively) prove to be statistically insignificant, with a shared p-value ($p = 0.192$) that is well above 0.05, the significance threshold for p-values. Similarly insignificant correlations are found between the percentages of males and females and PrEP prevalence in rural environments (Figures 3 and 4, respectively), with a shared p-value ($p = 0.266$) that is, also, well above 0.05.

Age

In urban settings, it is found that there is no significant correlation between the percentage of those under 25 years old and PrEP prevalence (Figure 5), as suggested by the p-value of 0.183, well above the threshold of 0.05. However, in rural counties, a statistically significant correlation ($p < 0.001$) is found between the percentage of those under 25 years old and PrEP prevalence (Figure 6), with this correlation modeled by the equation $y = -1.5383x + 78.617$. The value of the coefficient (-1.5383) suggests that the PrEP prevalence rate decreases by 1.5383 persons/100,000 individuals for a percent increase in the proportion of under-25 year olds. It should be noted, however, that this correlation is linked to an r-value of 0.311, which suggests that this correlation, although present, may be weak in nature.

Meanwhile, correlations between the percentages of 25-34 year olds and PrEP prevalence rates among both urban and rural

counties (Figures 7 and 8, respectively) prove to be statistically significant, with both p-values under 0.05 (<0.001 and 0.021, respectively). In urban counties, this correlation is modeled by the equation y = 9.7684x - 76.019, suggesting that PrEP prevalence increases by 9.7684 persons/100,000 individuals for every percent increase in the proportion of 25-34 year olds (this is despite the lower r-value of 0.523, attributable to outliers at [11.4, 95.8], [18.2, 156.5], and [16.3, 236.9]). However, rural counties exhibit an opposite correlation, modeled by the equation y = -3.2444x + 67.702, suggesting that PrEP prevalence decreases by 3.2444 persons/100,000 individuals for every percent increase in the proportion of 25-34 year olds. However, this correlation may be weaker in nature given an r-value of 0.200 attributable to greater variability within the data.

However, unlike correlations with the proportions of 25-34 year olds, correlations with the proportions of 35-44 year olds in *both* urban and rural settings (Figures 9 and 10, respectively) are statistically insignificant, with a p-value of 0.181 in urban counties and a p-value of 0.414 in rural counties.

Similarly, a statistically insignificant correlation is found between the percentage of 45-54 year olds and PrEP prevalence in urban counties (Figure 11, p = 0.186). That being said, a significant correlation is found between the percentage of 45-54 year olds and PrEP prevalence in rural counties (Figure 12, p = 0.007), signified by the equation y = 3.8706x - 19.509. Indeed, the coefficient within the equation (3.8706) suggests that PrEP prevalence increases by 3.8706 persons/100,000 individuals for every percent increase in the proportion of 45-54 year olds. However, this correlation is weak with wide variation within the data, as indicated by an r-value of 0.232.

As for correlations with the proportions of 55 year olds and older, the p-values for urban and rural counties (Figures 13 and 14, respectively) are well under the threshold of 0.05 (0.001 and <0.001, respectively), suggesting that the correlations for both urban and rural counties are statistically significant. The correlation between the proportion of ≥55 year olds and PrEP prevalence in urban counties is indicated by the equation y = -2.006x + 103.82, suggesting that the PrEP prevalence rate decreases by -2.006 persons/100,000 individuals for every percent increase in the proportion of ≥55 year olds. And this trend is relatively strong, as shown with the close alignment of the data with the line of best fit. In fact, the low r-value of 0.293 is mainly due to outliers at (24.3, 115.7), (37.3, 95.8), (23.1, 156.5), and

(26.6, 236.9). However, contrary to urban counties, the correlation between the proportion of ≥55 year olds and PrEP prevalence in rural counties is modeled by the equation y = 1.5323x - 20.102, suggesting that PrEP prevalence increases by 1.5323 persons/100,000 individuals for every percent increase in the proportion of ≥55 year olds. That being said, this is a relatively weak correlation with an r-value of 0.324, unsurprising given the weaker alignment of the data with the line of best fit.

Race/ethnicity

Correlations between the percentages of African Americans and PrEP prevalence rates prove to be statistically significant for both urban and rural counties, as seen in Figures 15 and 16 (with p-values of <0.001 and 0.039, respectively). The correlation between the percentage of African Americans and PrEP prevalence in urban counties is modeled by the equation y = 1.777x + 30.442, where PrEP prevalence rates increase by 1.777 persons/100,000 individuals for every percent increase in the proportion of African Americans. And this is a relatively strong trend, with the low r-value of 0.477 attributable mainly to outliers at (22.6, 156.5) and (23.4, 236.9). In addition, the 95% confidence interval for this coefficient ranges from 1.173 persons/100,000 individuals to 2.381 persons/100,000 individuals. Meanwhile, the correlation between the percentage of African Americans and PrEP prevalence in rural counties is modeled by the equation y = 0.8066x + 28.767, where PrEP prevalence rates increase by 0.8066 persons/100,000 individuals for every percent increase in the proportion of African Americans, with this coefficient also having a 95% confidence interval ranging from 0.040 persons/100,000 individuals to 1.573 persons/100,000 individuals, linked to a weaker correlation with a low r-value of 0.179.

Similar to the association with the proportion of African Americans, it is found that, for every percent increase in the proportion of Latin Americans, PrEP prevalence increases by 1.7011 persons/100,000 individuals within urban counties (Figure 17), with this relationship modeled by the equation y = 1.7011x + 33.626, however skewed with the presence of outliers at (1.3, 95.8), (10.4, 115.7), (5.5, 156.5), and (25.3, 236.9). However, there is no significant correlation between the percentage of Latin Americans and PrEP prevalence in rural counties (Figure 18), with a p-value of 0.631, well above the significance threshold of 0.05.

Poverty, Education, and Health Insurance

In regards to the impact of poverty on PrEP prevalence, p-values of 0.070 and 0.066 for urban and rural counties (Figures 19 and 20), respectively, suggest that there are no significant relationships between the percentage of the population below the poverty line and PrEP prevalence rates in urban or rural counties.

Within urban counties, a p-value of 0.001 suggests that there is a significant relationship between the percentage of those with a bachelor's degree and PrEP prevalence (Figure 21), modeled by the equation $y = 1.3967x + 17.94$, suggesting that prevalence rates increase by 1.3967 persons/100,000 individuals for every percent increase in the proportion of the population with a bachelor's degree. And this is with close alignment of the data with the line of best fit, despite outliers at (8.5, 95.8), (19.7, 115.7), (25.8, 156.5), and (26.1, 236.9). However, the same cannot be said for rural counties, where a p-value of 0.981 suggests that there is no statistically significant relationship between the percentage of those with a bachelor's degree and PrEP prevalence (Figure 22).

Lastly, in regards to the percentage of those without health insurance, p-values of 0.193 and 0.127 for urban and rural counties (Figures 23 and 24), respectively, suggest that statistically significant relationships do not exist between the proportions of those without health insurance and PrEP prevalence in both urban and rural counties.

Methods

The first step in data collection was to determine the geographic scope of county-level data. This was especially critical because the scope had to be large enough, including enough urban/rural counties, to create viable correlations, but several, conflicting factors made widening the geographic scale of the data challenging. For example, the time constraints of this project simply didn't allow for data to be collected from every state in the United States; in addition, the effects of differences in state policy had to be minimized if data was taken from multiple states (Siegler et al., 2020). To address this issue, an approach was modeled from past studies examining HIV statistics relative to location, in which states were grouped through official United States census divisions to minimize state policy differences and reduce the volume of data collected (Siegler et al., 2020). One

division that is often been included in studies is the East North Central Division, containing the states of Ohio, Wisconsin, Michigan, Indiana, and Illinois. Within this division, the three states with the most counties are Ohio (88), Indiana (92), and Illinois (102), having a total of 282 counties. Therefore, this study will specifically examine the counties of Ohio, Indiana, and Illinois to acquire enough data for correlational analysis and maintain feasibility.

Thereafter, the counties from Ohio, Indiana, and Illinois had to be divided into urban and rural counties, allowing for socioeconomic variables to be correlated within urban and rural areas separately. This was done using the official rural-urban classification from the National Center of Health Statistics, which explains that rural counties are those located outside metropolitan statistical areas (MSAs), while urban counties are those located within metropolitan statistical areas (Masiano et al., 2019). In order to use this classification, official maps of 2020 MSAs for Ohio, Indiana, and Illinois were collected from the United States Census Bureau, and the counties being studied were accordingly divided into rural and urban groups.

With the scope and volume of data determined, the next step was to collect socioeconomic data for each county. This data would be correlated with PrEP statistics across urban/rural counties to determine the impact of various socioeconomic factors on PrEP usage, and so it was imperative that socioeconomic data came from an official, reliable source. The source for this study was the 2019 American Community Survey, which contained 5-year estimates on housing demographics and determinants of health insurance coverage by sex and age (Siegler et al., 2020; Siegler et al., 2018; Gant et al., 2014; U.S. Census Bureau, 2020). From these sources of information, the specific socioeconomic variables extracted for each county were the percentage of men, percentage of women, percentage of people at specific age intervals (less than 25 years, 25 to 34 years, 35 to 44 years, 45 to 54 years, 55 years and older), percentage of African Americans, percentage of Latin Americans, percentage of those below the poverty line, percentage of those without health insurance, and percentage of those with a bachelor's degree or higher. These socioeconomic variables have been commonly used in past studies in correlation with HIV-related/PrEP-related statistics, and they were specifically taken from 2019 data to avoid the potential, extraneous effects of the COVID pandemic, which has been linked to reduced

capacity for non-COVID related conditions and the use of telehealth services, which seem to favor higher-income households and White families in terms of usage (Russo et al., 2021). Therefore, analyzing PrEP usage from 2019 will provide information from more "normal" circumstances.

And, of course, data on PrEP usage had to be collected for each county, as well. This data came from AIDSVu, an online database compiled from the CDC's National HIV Surveillance Program containing a plethora of spreadsheets filled with data on HIV diagnoses, HIV testing, and, of course, PrEP usage (Siegler et al., 2018; Young et al., 2018). The specific spreadsheet used for this study was titled "2019 County PrEP", displaying county-level information on the number of PrEP users within the given area. This allowed for the collection of county-level PrEP prevalence, calculated for each county by dividing the number of PrEP users by the total population and multiplying the quotient by 100,000, displaying the number of PrEP users in a county per 100,000 persons. By measuring the frequency of PrEP users within a given county, PrEP prevalence acts as an effective measure of PrEP usage in a given county; in addition, it is much more feasible to collect because other measures of PrEP usage (e.g. the PrEP-to-need ratio, or PnR) require information such as the number of HIV diagnoses in a given area, data that is frequently blocked from public access due to data suppression laws. These laws are designed to protect individuals who live in counties with small populations and few HIV cases, blocking the publication of data from these counties as it could pose a threat of identification to the few people with HIV. Less frequently, these laws are also used to protect PrEP users, blocking data on PrEP usage from certain counties; therefore, from the 282 counties selected for study, data was recorded from a total of 235 counties (118 urban counties and 135 rural counties).

The final step of this study's methodology involves analyzing socioeconomic and PrEP-related data for each county, specifically through linear regressions. This regression analysis was done using the Excel add-in RegressIt, which created scatterplots correlating PrEP prevalence rates (plotted along the y-axis) with individual socioeconomic factors (plotted along the x-axis) in rural and urban counties, deriving linear functions based on the data. These functions are critical for data analysis, especially because the slope for each function (namely, the coefficient of x) describes the change in PrEP

prevalence for an incremental change in a socioeconomic measure (Siegler et al., 2020). For example, if this methodology was used to plot the PrEP prevalence rate in urban counties as a function of the percentage of African Americans in a county, the slope of the derived function would show the change in PrEP prevalence for every percent increase in the concentration of African Americans. Clearly, the use of calculated, linear functions represents an effective procedure in determining the effect of various socioeconomic factors on the county-level PrEP prevalence rate, and so these functions were calculated for each socioeconomic variable in correlation with PrEP prevalence within rural and urban counties, separately (Siegler et al., 2020).

Discussion

Implications

Gender

Given the high p-values for correlations between the proportions of males and females and PrEP prevalence rates in urban and rural settings, it is clear that the percentages of males and females don't significantly impact PrEP prevalence in urban or rural counties.

Age

Despite the presence of some weaker correlations, results suggest that there is still a significant difference in the impacts of age on PrEP prevalence rates between urban and rural environments. This is exemplified by the fact that, while the correlation between the percentage of under-25 year olds and PrEP prevalence was deemed statistically insignificant, there was a positive, increasing correlation between the percentage of 25-34 year olds and PrEP prevalence in urban counties, with prevalence rates increasing by 9.7684 persons/100,000 individuals for every percent increase in the proportion of 25-34 year olds. However, within rural counties, as the proportion of ≤35 year olds increased, PrEP prevalence significantly decreased, specifically by a coefficient of 1.5383 persons/100,000 individuals for <25 year olds and a coefficient of 3.2444 persons/100,000 individuals for 25-34 year olds. Instead, PrEP prevalence increased among rural counties as the proportion of ≥45 year olds increased, specifically by 3.8706 persons/100,000 individuals for every percent increase in the proportion of 45-54 year

olds and by 1.5323 persons/100,000 for every percent increase in the proportion of ≥55 year olds. And while the correlation between the proportion of 45-54 year olds and PrEP prevalence in urban counties was deemed statistically insignificant, as the proportion of ≥55 year olds went up by one percent, PrEP prevalence decreased by -2.006 individuals/100,000 individuals. These opposing correlations suggest that, in urban counties, PrEP usage is concentrated within younger populations, while PrEP usage is concentrated within older populations in rural counties, revealing a wide difference in relationships between age and PrEP use. This is especially interesting, suggesting that younger populations may need to be targeted within interventions designed to significantly increase PrEP usage in rural settings (Williams et al., 2008).

Race/ethnicity

Overall, the effects of racial composition (specifically, the proportions of African Americans and Latin Americans) on PrEP prevalence may be less prominent in rural counties than in urban counties. For example, it was found that PrEP prevalence rates in rural counties increased by only 0.8066 persons/100,000 individuals for every percent increase in the percentage of African Americans; however, prevalence rates in urban counties increased by 1.777 persons/100,000 individuals for every percent increase in the percentage of African Americans, more than double the coefficient found in rural counties. However, this difference may be statistically insignificant and inconclusive, given that the aforementioned confidence intervals for these coefficients overlap. Nonetheless, this contributes to past literature, which suggests that PrEP prevalence increases by an average of 4% in US counties for every 5% increase in the proportion of African Americans (Siegler et al., 2020), and while a positive trend is found in both rural and urban counties, it may be more pronounced in urban counties. In addition, a significant correlation was not present between the percentage of Latin Americans and PrEP prevalence in rural counties. On the contrary, PrEP prevalence rates in urban counties increased by 1.7011 persons/100,000 individuals for every percent increase in the proportion of Latin Americans, explaining why, on average, PrEP prevalence still increases by 2% for every 5% increase in the proportion of Latin Americans in a community, despite the insignificant impact in rural communities (Siegler et al., 2020).

Therefore, the percentages of minority groups, specifically African Americans and Latin Americans, within a community may impact PrEP usage in urban counties to a much greater extent than in rural counties. This, of course, is critical in the design of interventions, indicating that racial minorities shouldn't be the focus of actions taken to increase PrEP usage within rural communities.

Poverty, Education, and Health Insurance

Surprisingly, there are no significant relationships between the percentages of those below the poverty line or without health insurance and PrEP prevalence rates in urban and rural counties. In addition, a p-value of 0.981 suggests that there is not a statistically significant relationship between the proportion of those with a bachelor's degree and PrEP prevalence in rural areas. However, education does play a role in PrEP usage in urban counties--in fact, regression models suggest that PrEP prevalence rates increase by 1.3967 persons/100,000 individuals for every percent increase in the proportion of those with a bachelor's degree, clearly contributing to the 8% increase seen in PrEP prevalence with a 5% in the percentage of those with a bachelor's degree (Siegler et al., 2020). Thus, as education is associated with PrEP usage solely in urban settings, interventions aiming to increase PrEP utilization in rural areas should not focus on the uneducated, instead focusing on a broader population.

Limitations

Despite these conclusions, it is imperative to note that this study has its limitations. For example, the socioeconomic/PrEP-related data collected dates back to 2019, allowing for correlations that specifically apply to 2019, before the onset of the COVID-19 pandemic. While this was done to eliminate confounding factors potentially introduced by the COVID pandemic, it is important to acknowledge that current correlations between socioeconomic factors and PrEP usage may be shifted from those of 2019 due to the ramifications of the pandemic (Russo et al., 2021), an effect that isn't clearly studied by this paper.

In addition, because data was collected on counties from various states (i.e. Ohio, Indiana, Illinois), this data is subject to effects from differences in state policies, which can affect reporting, public access to data, and, most importantly, the availability of PrEP services to various populations, both rural and urban (Siegler et al., 2020).

Therefore, these differences can influence PrEP usage in various counties outside of the scope of socioeconomic factors, and, because of the difficulty in measuring/quantifying differences in state policy, this paper doesn't clearly account for such outside effects, potentially skewing correlations between socioeconomic factors and PrEP prevalence rates in urban and rural counties. By extension, it must be stated that correlations found between socioeconomic factors and PrEP prevalence may not be applicable to all counties across the United States, simply because of differences in state policy across the country and the fact that correlations in this paper were drawn among counties from just three states.

The final limitation that must be addressed in this paper is that correlation is not causation. This paper only provides evidence for *associations* between socioeconomic factors and PrEP prevalence in rural and urban counties; it does not suggest, however, that certain socioeconomic factors directly cause PrEP usage in urban/rural counties. This, in part, is because of the potential for confounding, or the idea that certain socioeconomic variables are impacted by other socioeconomic variables, including those that are examined in this study. Consequently, future investigations can qualify this study by examining the relationships between different socioeconomic variables, such as the proportion of people below the poverty line and the proportion of people without health insurance, in both rural and urban areas, allowing for the quantification of the relationship between PrEP usage and socioeconomic determinants while controlling for the effect of other factors.

Future Studies

Of course, it is imperative that further research take place to address the limitations found in this paper. For example, because the data used in this study was from 2019, the impact of the COVID-19 pandemic was left out. To understand the impact of the COVID-19 pandemic on associations between socioeconomic factors and PrEP prevalence, correlations between the socioeconomic variables used in this investigation and PrEP prevalence rates can be compared between 2019, before the pandemic, 2020, at the height of the pandemic, or even 2022, when much of American society was returning to normalcy.

In addition, the impact of policy differences between states can be investigated by expanding this very project and incorporating data

from additional counties, across additional states, allowing for associations between socioeconomic factors and PrEP prevalence rates in urban and rural environments that can be more accurately applied across America. Of course, these correlations could be further grouped by state, allowing for state-by-state comparisons that would specifically identify the impacts of differences in state policies across the country.

Finally, the methodology used in this paper can be expanded by correlating PrEP prevalence rates with humanistic factors that may impact PrEP usage. This is especially pertinent given the fact that those in rural and urban areas may share different values. For example, those in rural areas may prioritize privacy and restraint in addressing certain health issues, while those in urban areas may prioritize health consciousness and openness about health-related issues. Such differences might play a role in how different socioeconomic determinants impact PrEP usage; therefore, investigations centering around the differences in health-related values between urban and rural communities are critical for future study.

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