# Effect of Social Determinants of Health on Uncontrolled Human Immunodeficiency Virus (HIV) Infection Among Persons With HIV in San Francisco, California

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***Background.*** In 2010–2014, the San Francisco Department of Public Health (SFDPH) established programs to rapidly link people with human immunodeficiency virus (PWH) to care and offer antiretroviral therapy (ART) at human immunodeficiency virus (HIV) diagnosis. Such programs reduced the number of PWH out of care or with detectable HIV viral load (ie, uncontrolled HIV infection). We investigated the role of social determinants of health (SDH) on uncontrolled HIV.

***Methods.*** Cross-sectional data from adult PWH diagnosed and reported to the SFDPH as of December 31, 2019, prescribed ART, and with confirmed San Francisco residency during 2017–2019 were analyzed in conjunction with SDH metrics derived from the American Community Survey 2015–2019. We focused on 5 census tract-level SDH metrics: percentage of residents below the federal poverty level, with less than a high school diploma, or uninsured; median household income; and Gini index. We compared uncontrolled HIV prevalence odds ratios (PORs) across quartiles of each metric independently using logistic regression models.

***Results.*** The analysis included 7486 PWH (6889 controlled HIV; 597 uncontrolled HIV). Unadjusted PORs of uncontrolled HIV rose with increasingly marginalized quartiles, compared to the least marginalized quartile for each metric. Adjusting for demographics and transmission category, the POR for uncontrolled HIV for PWH in the most marginalized quartile remained significant across metrics for poverty (POR = 2.0; confidence interval [CI] = 1.5–2.6), education (POR = 2.4; CI = 1.8–3.2), insurance (POR = 1.8; CI = 1.3–2.5), income (POR = 1.8; CI = 1.4–2.3), and income inequality (POR = 1.5; CI = 1.1–2.0).

***Conclusions.*** Beyond demographics, SDH differentially affected the ability of PWH to control HIV. Despite established care programs, PWH experiencing socioeconomic marginalization require additional support to achieve health outcome goals.

***Keywords.*** antiretroviral therapy; HIV/AIDS; social determinants of health; surveillance; viral suppression.

By the end of 2019, more than 1 million people were living with diagnosed human immunodeficiency virus (HIV) in the United States [1]. The prevalence of HIV was 319.9 per 100 000 nationally and 336.6 in the state of California [1]. In the city and county of San Francisco (SF), California, as of December 31, 2019, there were 12 550 SF residents with HIV, and the HIV prevalence was the highest of all counties in California at 1411.1 per 100 000 [2].

Several interventions to improve health outcomes for persons with HIV (PWH) in SF have been implemented. These include the San Francisco Department of Public Health's (SFDPH) recommendation in 2010 for antiretroviral therapy (ART) irrespective of CD4 lymphocyte count (CD4 count) [3], targeted and expanded coverage of HIV testing since 2011 to increase awareness of HIV status [4], and establishment of programs in 2013–2014 to rapidly link people newly diagnosed with HIV to care, offering ART on the same day of HIV diagnosis [5]. Assessing the impact local initiatives have on reducing care-related disparities over time is necessary for adapting and focusing interventions to populations in greatest need and to reach San Francisco's "Getting to Zero" (GTZ) goals of zero new HIV infections, zero HIV-related deaths, and zero HIV stigma. The GTZ initiative, a multisector consortium of local organizations [4, 6, 7], has achieved success at reducing both the number of new HIV infections [8] and the number of PWH who are either out of care or have detectable HIV viral load (uncontrolled HIV infection) [9,10]. Despite these encouraging declines, health disparities exist, and success in treatment and care retention has not been equal across all populations [9].

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To further reduce the number of PWH with uncontrolled HIV infection, it is important to consider the social determinants of health (SDH). These are the social structures and economic systems that include the social and physical environment and health services [11]. Structural and societal factors and availability, cost of health services, and access to health services form either passageways or barriers to good health.

A conceptual framework, developed by the World Health Organization's Commission on Social Determinants of Health [12] and adopted by the Centers for Disease Control and Prevention (CDC)'s National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention (NCHHSTP) [11], helps to better analyze and understand the drivers of health and health inequities in the United States, determine priorities, and target and refocus intervention efforts. Incorporating SDH measures in surveillance systems is one of the activities outlined in the NCHHSTP white paper on SDH [11].

Many US studies have investigated SDH among newly diagnosed PWH [13–23], but few have included those with previously diagnosed HIV infection [24]. Although focusing on those newly diagnosed provides insights into people with recent infection and can inform HIV prevention and testing initiatives, it does not address the much larger number of individuals who are living with HIV but were infected in years past. In SF, this group represents the majority of those needing HIV treatment services [8]. Maintaining care engagement and viral suppression among people with prevalent HIV infection is paramount to achieving the GTZ initiative goal of zero transmission, because new infections are presumed to be driven largely by locally prevalent uncontrolled infections.

Human immunodeficiency virus surveillance provides robust, systematically collected, population-based data that can be used in conjunction with SDH metrics to measure the success of citywide care-related initiatives across diverse populations. Our objective was to undertake an exploratory analysis of the factors, particularly SDH, associated with uncontrolled HIV infection among PWH who resided in SF. The overarching goal was to identify barriers that can be removed to improve HIV-related care and reduce health disparities, especially among vulnerable populations.

## METHODS

### Study Sample and Data Collection

This was a cross-sectional study of PWH from January 1, 2017 to December 31, 2019. The study included PWH aged 18 years and older who were diagnosed with HIV and alive as of December 31, 2019, had been prescribed ART, and whose most recently reported address from January 1, 2017 to December 31, 2019 was in SF (Figure 1). We excluded PWH lacking a record of ART prescription (N = 119) because the expectation of controlled HIV (our outcome) could not be made.

Sociodemographic and HIV transmission characteristics, laboratory data, ART prescription, and vital status were collected from HIV surveillance case reports, medical records, and death registry searches as part of routine HIV surveillance on all study participants. Human immunodeficiency virus surveillance data collection is required by state law (California Health and Safety Code [HSC] 121 022 and HSC 120130); therefore, Institutional Review Board approval and consent was deemed unnecessary according to state regulations. Data used in this study are protected by state law and are not publicly available.

We used the American Community Survey (ACS) 5-Year Data (2015–2019) [25] to derive quartiles of SDH metrics based on distributions across SF census tracts, given the unique socioeconomic situation locally. We focused on 5 key metrics: (1) percentage of residents living below the federal poverty level was categorized as <6.00%, 6.00%–8.99%, 9.00%–12.99%, and ≥13.00%; (2) percentage of residents with less than a high school diploma was categorized as <4.00%, 4.00%–8.99%, 9.00%–16.99%, and ≥17.00%; (3) percentage of residents uninsured was categorized as <2.00%, 2.00%–3.99%, 4.00%–5.99%, and ≥6.00%; (4) median household income was categorized as <$84 000, $84 000–$115 999, $116 000–$151 999, and ≥$152 000; and (5) Gini index, a measure of income inequality in which 0 indicates perfect equality and 1 indicates extreme inequality [26], was categorized as <0.433, 0.433–0.465, 0.466–0.502, and ≥0.503. Participants' most recent addresses during the study period were used to link them to their census tract's corresponding SDH metric quartiles. Due to missingness of census tract data, homeless PWH could not be linked to the census tract-level ACS SDH metrics.

Uncontrolled HIV was defined based on Rojas et al [24], with slight modification, using participants' most recent viral load test and CD4 test during the study period (Supplemental Figure 1). A participant was determined to have controlled HIV if their latest viral load test result was undetectable, defined as <200 copies/mL. A participant was determined to have uncontrolled HIV if their latest viral load was ≥200 copies/mL or they had no viral load test or CD4 test reported to SFDPH during the study period (ie, out of care). Participants were excluded for having an inconclusive HIV status if they lacked a viral load test but had a CD4 test (n = 7), because this indicated some level of clinical care during the study period with no definitive value for viral suppression.

Throughout the analysis, gender was categorized as cis-man, cis-woman, or transgender. Race/ethnicity was categorized as White, Black/African American, Latinx, Asian/Pacific Islander, or other/unknown. Age as of December 31, 2019 was categorically defined into the following groups: 18–24, 25–29, 30–39, 40–49, 50–59, 60–69, and ≥70 years old. Human immunodeficiency virus transmission category was categorized as men who have sex with men (MSM), transwomen who have sex with men (TWSM), persons who inject
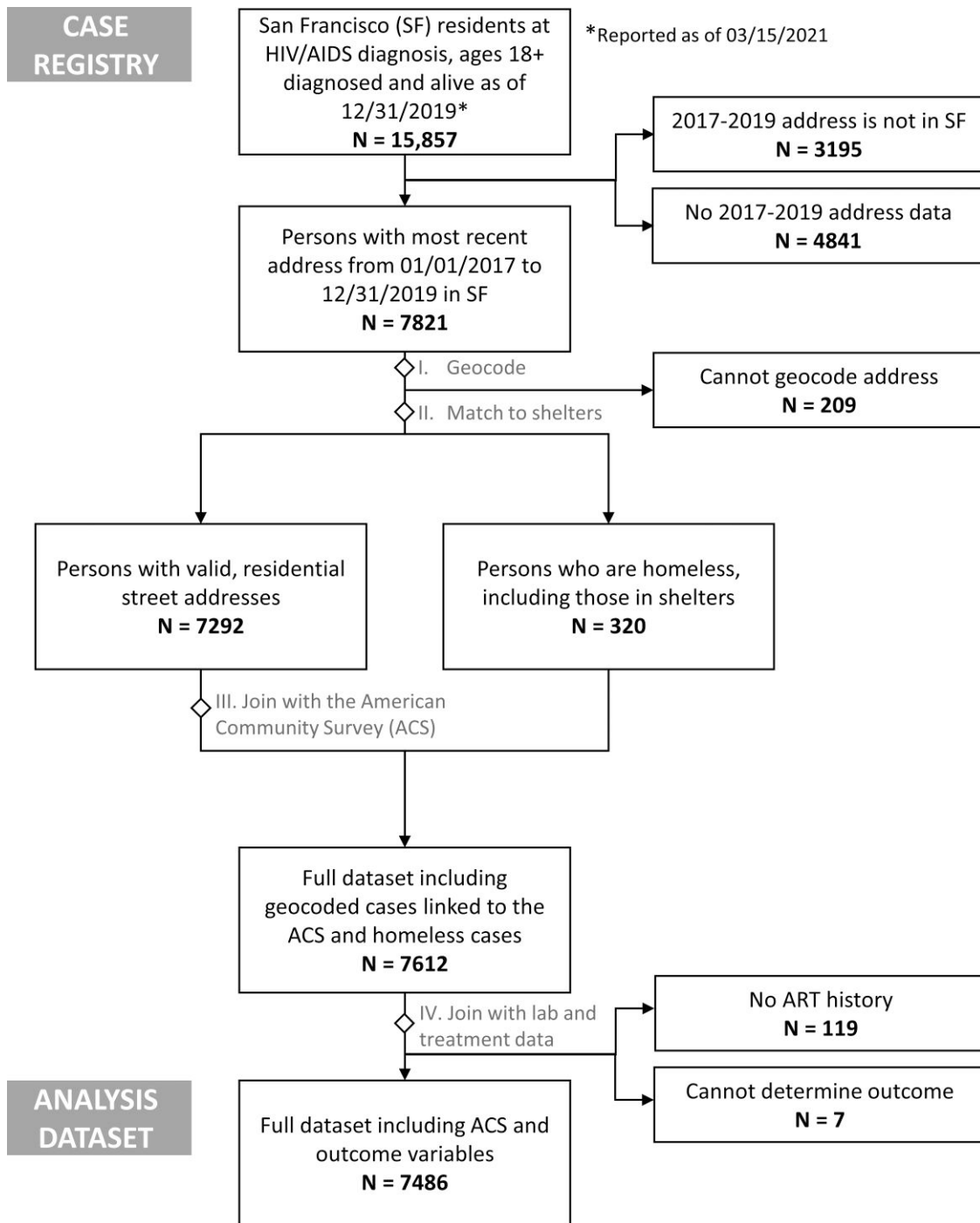
**Figure 1.** Flow chart of cases selected for analysis. AIDS, acquired immune deficiency syndrome; ART, antiretroviral therapy; HIV, human immunodeficiency virus; lab, laboratory.

drugs (PWID), men who have sex with men and who also inject drugs (MSM-PWID), transwomen who have sex with men and who also inject drugs (TWSM-PWID), heterosexual, or other/unknown. Country of birth was categorized as United States of America (USA) or USA dependency, foreign country, or unknown. Homelessness, defined as a person whose most current

address was reported as homeless or a homeless shelter, was dichotomized as yes or no.

**Statistical Analysis**

Logistic regression was used to compare the distribution of case characteristics by uncontrolled HIV, with estimated unadjusted

prevalence odds ratios (POR), 95% confidence intervals (CIs), and *P* values. *P* < .05 and 95% CIs that did not include 1.0 were considered statistically significant. Significant demographics and transmission category variables were considered for inclusion as covariates in adjusted logistic regression models in the primary analysis, as informed by causal inference models.

For the primary analysis, which included housed PWH, each SDH metric served as an independent variable with uncontrolled HIV as the dependent outcome of interest. Unadjusted and adjusted logistic regression was performed to compare differences in uncontrolled HIV prevalence among quartiles of each of the 5 SDH metrics separately, constructing 5 unadjusted and 5 adjusted logistic regression models for the binary uncontrolled HIV outcome. The least marginalized quartile served as the referent group for each metric (<6.00% below federal poverty level, <4.00% with less than a high school diploma, <2.00% uninsured, median household income ≥$152 000, Gini index <0.433). Each adjusted model included 1 SDH metric and all demographic variables identified as potential confounders.

We also assessed for interaction between SDH metrics and demographics. In comparisons of the Schwarz Criterion, we found these interaction parameters did not significantly improve the fit of our primary model. All models for which results are presented converged, lacked evidence of overdispersion, and had evidence of goodness of fit according to the Hosmer-Lemeshow test.

We also performed a sensitivity analysis in which we included homeless PWH. In these analyses, we imputed the highest poverty quartile (≥13%) and the lowest median household income quartile (<$84 000) for all homeless participants. We then constructed 2 additional unadjusted and adjusted logistic regression models, adjusting for housing status as an additional covariate in the multivariate models. We made no assumptions for education, insurance, or income inequality levels among those experiencing homelessness and thus did not model for these metrics in the sensitivity analysis. All statistical analyses were conducted with an alpha of 0.05 for significance and were performed using SAS software version 9.4.

## RESULTS

### Study Sample Characteristics
The study population included 7486 PWH ([Figure 1](#)), 6889 with controlled HIV and 597 with uncontrolled HIV. Most were cis-men (90%), White (54%), 50–59 or 60–69 years old (34% and 25%, respectively), MSM or MSM-PWID (70% and 15%, respectively), and USA-born (72%). Overall, only 3% of those with controlled HIV were homeless compared with 18% of those with uncontrolled HIV ([Table 1](#)). Gender, race/ethnicity, age, HIV transmission category, birth country, and housing status were all significantly associated with uncontrolled HIV in our bivariate analysis ([Table 1](#)).

### Uncontrolled Human Immunodeficiency Virus Status by Social Determinants of Health Metric
Among housed participants prescribed ART, we observed increasing prevalence of uncontrolled HIV in increasingly marginalized quartiles across all SDH metrics ([Figure 2](#)). Unadjusted odds of uncontrolled HIV rose with increasingly marginalized quartiles, compared to the least marginalized quartile for all metrics. Adjusting for demographics and transmission category, the POR for uncontrolled HIV for PWH in the most marginalized quartile remained significant across metrics for poverty (POR = 1.95; 95% CI = 1.46–2.61), education (POR = 2.37; 95% CI = 1.76–3.20), insurance (POR = 1.80; 95% CI = 1.29–2.51), median household income (POR = 1.79; 95% CI = 1.38–2.32), and income inequality (POR = 1.48; 95% CI = 1.11–1.96). Adjusted PORs comparing less marginalized quartiles to the least marginalized quartile were also significant for metrics for education, insurance, and median household income ([Table 2](#)). Race/ethnicity, age, HIV transmission category, and birth country remained significantly associated with uncontrolled HIV across all 5 multivariate models ([Supplemental Table 1](#)).

### Sensitivity Analysis Including Homeless People With Human Immunodeficiency Virus
Our sensitivity analysis, which included homeless PWH, had similar findings. Among housed and unhoused PWH prescribed ART, we observed comparable trends in increasing uncontrolled HIV prevalence and odds with increasingly marginalized quartiles across both metrics analyzed—poverty prevalence and median household income. Adjusting for demographics, transmission category, and housing status, PWH in the most marginalized quartile—to which homeless participants were all assigned—remained at significantly higher odds for uncontrolled HIV compared to PWH living in the least marginalized quartile for both poverty prevalence (POR = 1.97; 95% CI = 1.48–2.63) and median household income (POR = 1.79; 95% CI = 1.37–2.33) ([Table 3](#)). Race/ethnicity, age, HIV risk transmission category, birth county, and housing status remained significantly associated with uncontrolled HIV across both multivariate sensitivity models.

## DISCUSSION

Our study identified a significant relationship between SDH and uncontrolled HIV infection after adjusting for sociodemographic variables known to be associated with poor virologic suppression, and we found that worse SDH metrics were independently associated with increases in uncontrolled HIV among our study population. We observed similar and significant associations across all SDH metrics studied: (1) percentage

**Table 1. Demographic Characteristics of Persons With HIV in San Francisco Between 2017 and 2019, by Uncontrolled HIV Infection Status (N = 7486)**

| Characteristics | Category | Controlled HIV Infection | | Uncontrolled HIV Infection | | Bivariate Analysis | |
|---|---|---|---|---|---|---|---|
| | | N | % | N | % | Type III χ² P Value | Crude POR[a] |
| | Total | 6889 | 100% | 597 | 100% | | |
| Gender | Cis-Men | 6226 | 90% | 486 | 81% | <.0001 | – |
| | Cis-Women | 444 | 6% | 70 | 12% | | **2.02 (1.54–2.64)** |
| | Transgender | 217 | 3% | 41 | 7% | | **2.40 (1.70–3.39)** |
| Race/Ethnicity | White | 3785 | 55% | 246 | 41% | <.0001 | – |
| | Black/African American | 809 | 12% | 133 | 22% | | **2.53 (2.02–3.17)** |
| | Latinx | 1505 | 22% | 150 | 25% | | **1.53 (1.24–1.90)** |
| | Asian/Pacific Islander | 523 | 8% | 27 | 5% | | 0.79 (0.53–1.19) |
| | Other/Unknown | 267 | 4% | 41 | 7% | | **2.36 (1.66–3.36)** |
| Age Group | 18–24 | 44 | 1% | 6 | 1% | <.0001 | 1.75 (0.74–4.16) |
| | 25–29 | 145 | 2% | 22 | 4% | | **1.95 (1.21–3.12)** |
| | 30–39 | 743 | 11% | 139 | 23% | | **2.40 (1.90–3.04)** |
| | 40–49 | 1103 | 16% | 162 | 27% | | **1.88 (1.51–2.35)** |
| | 50–59 | 2386 | 35% | 186 | 31% | | – |
| | 60–69 | 1838 | 27% | 66 | 11% | | **0.46 (0.35–0.61)** |
| | 70+ | 630 | 9% | 16 | 3% | | **0.33 (0.19–0.55)** |
| Transmission Category[b] | MSM | 4981 | 72% | 267 | 45% | <.0001 | – |
| | TWSM | 134 | 2% | 17 | 3% | | **2.37 (1.41–3.98)** |
| | PWID | 387 | 6% | 82 | 14% | | **3.95 (3.02–5.17)** |
| | MSM-PWID | 924 | 13% | 165 | 28% | | **3.33 (2.71–4.10)** |
| | TWSM-PWID | 78 | 1% | 22 | 4% | | **5.26 (3.23–8.58)** |
| | Heterosexual | 294 | 4% | 33 | 6% | | **2.09 (1.43–3.06)** |
| | Other/Unknown | 91 | 1% | 11 | 2% | | **2.26 (1.19–4.27)** |
| Birth Country | United States | 4924 | 71% | 443 | 74% | .0167 | – |
| | Foreign Country | 1325 | 19% | 88 | 15% | | **0.74 (0.58–0.94)** |
| | Unknown | 640 | 9% | 66 | 11% | | 1.15 (0.87–1.50) |
| Homeless | No | 6696 | 97% | 492 | 82% | <.0001 | – |
| | Yes | 193 | 3% | 105 | 18% | | **7.40 (5.74–9.55)** |

Abbreviations: HIV, human immunodeficiency virus; MSM, men who have sex with men; POR, prevalence odds ratio; PWID, persons who inject drugs; TWSM, transwomen who have sex with men.

[a]Prevalence odds ratio significant at alpha = 0.05 are in bold.

[b]Transmission category is defined as MSM, TWSM, PWID, combinations of these, heterosexual, or other/unknown. Other/unknown includes transfusion/hemophilia transmission.

of residents living below the federal poverty level; (2) percentage of residents with less than a high school diploma; (3) percentage of residents uninsured; (4) median household income; and (5) Gini index. Our sensitivity analysis demonstrated relevant SDH metrics were similarly associated when homeless PWH were included in our models and categorized to hypothesized SDH quartiles.

The association between HIV incidence and the various demographic variables, including community-level SDH metrics, are well documented in the literature [13–20, 23]. Studies using CDC HIV surveillance data have identified disparities and higher incidence rates of HIV diagnosis associated with the following primary predictive factors: gender, race, ethnicity/nativity, geography, and transmission category [13–20, 23]. National-level research suggests that SDH and health outcomes are linked by underlying conditions such as residential segregation, access to medical treatment, and psychological stress [23].

However, although some studies have explored how various demographic factors impact HIV outcomes and treatment adherence among PWH [24, 27, 28], fewer have focused on how SDH factors contribute to the successful control of chronic HIV infection [24, 28]. Ecological research previously used principal component analysis to identify communities with lower combined economic stability, education levels, and access to health insurance to have higher rates of uncontrolled HIV [24]. Our study found similar results in a case-based analysis that modeled each community-level SDH metric on its own. Although we recognize that the SDH of HIV intersect in complex ways [29], using separate models for these metrics allowed us to draw conclusions on each community-level factor independently, supporting further research and general recommendations related to all 5. Each of these SDH metrics was significantly associated with uncontrolled HIV infection, suggesting a broad spectrum of related barriers that must be removed.
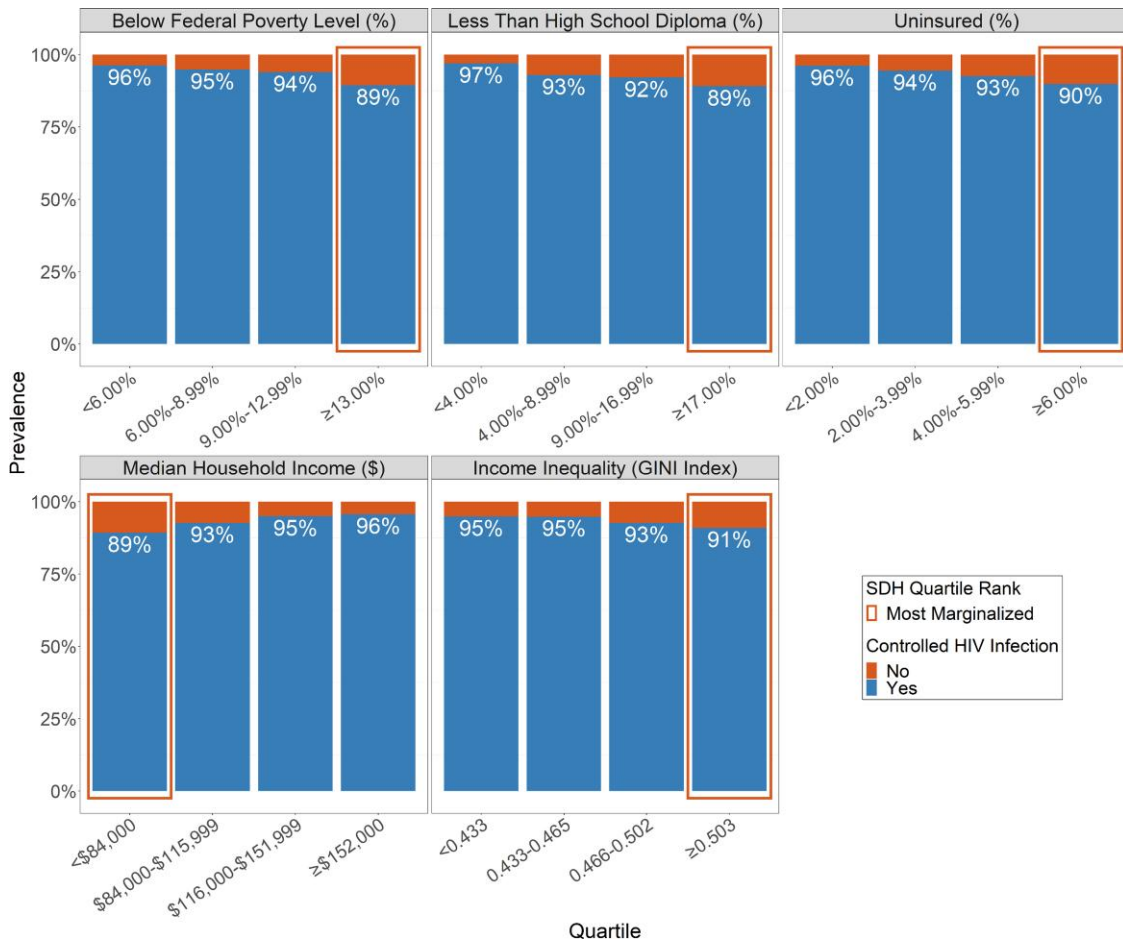
**Figure 2.** Proportions of controlled human immunodeficiency virus (HIV) infection by social determinants of health (SDH) quartiles, among housed persons with HIV in San Francisco between 2017 and 2019 (N = 7188).

Previous studies of demographic, housing, and transmission factors have recommended enhanced outreach and support for specific communities based on their observed associations [4, 7, 13, 30]. These remain important considerations, because most associations between demographics and uncontrolled HIV were not explained away by the SDH metrics in our models. However, HIV care programs should similarly aim to support PWH from communities of high poverty, low income, low education, low health insurance access, and high-income inequality. Working with and involving community partners in settings with these marginalized SDH attributes is key to effective HIV care and achieving controlled HIV among PWH in these communities. Ultimately, however, the systematic barriers that create disparities in income, education, and insurance access must themselves be addressed to achieve equity in HIV care.

The city of SF represents a unique research venue, given its large and established community of PWH, similarly expansive HIV surveillance system, and its nature as a densely populated, urban center experiencing notable disparities in HIV incidence

and housing with governmental action to address each [4, 6–9, 30]. The nationally derived ACS quartiles were not able to distinguish important differences; therefore, we used locally derived quartiles to establish our SDH metric cutoffs. This allowed for an analysis tailored for identifying recommendations for SF and mitigated the possibility of unintended confounding that could arise from using SDH inputs derived from a different underlying population [31]. Other urban centers should consider this approach rather than relying on the national metrics to analyze SDH in their local communities.

Furthermore, SF is unique for interventions given that it already has relatively well established HIV care programs [3, 5, 10], and we concluded that this contributed to the much lower prevalence of uncontrolled HIV among PWH in our study compared to a comparable study in another major US urban center (8% vs 41%) [24]. Still, disparities exist in local communities of PWH because success in controlling HIV infection has not been equal across populations [9]. This study observed PWH residing in census tracts with worse SDH metric measures and those experiencing homelessness are

**Table 2. Counts, Proportions, and PORs for Uncontrolled HIV Infection by SDH Quartiles Among Housed PWH in San Francisco Between 2017 and 2019 (N = 7188)**

| SDH | Quartile[b] | Controlled HIV Infection N | Controlled HIV Infection % | Uncontrolled HIV Infection N | Uncontrolled HIV Infection % | Bivariate Analysis Type III $\chi^2$ P Value | Bivariate Analysis Crude POR[c] | Multivariate Analysis[a] Type III $\chi^2$ P Value | Multivariate Analysis[a] Adjusted POR[c] |
|---|---|---|---|---|---|---|---|---|---|
| | Total | 6696 | 100% | 492 | 100% | | | | |
| Below Federal Poverty Level (%) | <6.00% | 1758 | 26% | 69 | 14% | <.0001 | – | <.0001 | – |
| | 6.00%–8.99% | 1232 | 18% | 67 | 14% | | 1.39 (0.98–1.95) | | 1.17 (0.82–1.66) |
| | 9.00%–12.99% | 1555 | 23% | 100 | 20% | | **1.64 (1.20–2.24)** | | 1.31 (0.95–1.82) |
| | ≥13.00% | 2151 | 32% | 256 | 52% | | **3.03 (2.31–3.99)** | | **1.95 (1.46–2.61)** |
| Less Than High School Diploma (%) | <4.00% | 2054 | 31% | 64 | 13% | <.0001 | – | <.0001 | – |
| | 4.00%–8.99% | 1963 | 29% | 149 | 30% | | **2.44 (1.81–3.29)** | | **1.94 (1.45–2.60)** |
| | 9.00%–16.99% | 1350 | 20% | 116 | 24% | | **2.76 (2.02–3.77)** | | **2.02 (1.49–2.74)** |
| | ≥17.00% | 1329 | 20% | 163 | 33% | | **3.94 (2.92–5.30)** | | **2.37 (1.76–3.20)** |
| Uninsured (%) | <2.00% | 1160 | 17% | 47 | 10% | <.0001 | – | .0011 | – |
| | 2.00%–3.99% | 2400 | 36% | 141 | 29% | | **1.45 (1.04–2.03)** | | 1.26 (0.90–1.76) |
| | 4.00%–5.99% | 1527 | 23% | 122 | 25% | | **1.97 (1.40–2.78)** | | **1.51 (1.07–2.14)** |
| | ≥6.00% | 1609 | 24% | 182 | 37% | | **2.79 (2.01–3.88)** | | **1.80 (1.29–2.51)** |
| Median Household Income ($)[d] | <$84 000 | 1783 | 27% | 214 | 43% | <.0001 | **2.65 (2.06–3.41)** | <.0001 | **1.79 (1.38–2.32)** |
| | $84 000–$115 999 | 1245 | 19% | 98 | 20% | | **1.74 (1.30–2.33)** | | **1.46 (1.09–1.95)** |
| | $116 000–$151 999 | 1654 | 25% | 88 | 18% | | 1.18 (0.87–1.59) | | 1.17 (0.87–1.56) |
| | ≥$152 000 | 2009 | 30% | 91 | 18% | | – | | – |
| Income Inequality (Gini Index) | <0.433 | 1354 | 20% | 73 | 15% | <.0001 | – | .0230 | – |
| | 0.433–0.465 | 1611 | 24% | 88 | 18% | | 1.01 (0.74–1.39) | | 1.09 (0.80–1.48) |
| | 0.466–0.502 | 1973 | 29% | 156 | 32% | | **1.47 (1.10–1.95)** | | 1.25 (0.94–1.67) |
| | ≥0.503 | 1758 | 26% | 175 | 36% | | **1.85 (1.39–2.45)** | | **1.48 (1.11–1.96)** |

Abbreviations: HIV, human immunodeficiency virus; POR, prevalence odds ratio; PWH, persons with HIV; SDH, social determinants of health.

[a]Multivariate models adjust for gender, race/ethnicity, age group, transmission category, and birth country.

[b]Highlighted quartiles indicate the most marginalized SDH category.

[c]PORs significant at alpha = 0.05 are in bold.

[d]Median household income is missing for PWH in some smaller census tracts (n = 6).

especially vulnerable. Innovative programs to engage PWH living in these marginalized neighborhoods and people experiencing homelessness are needed [32].

As a city with established, successful HIV interventions, SF stakeholders can use our study's findings to inform enhanced, comprehensive HIV care programming. Previous SF research recommended that outreach be provided to individuals who miss care visits to improve ART adherence [30]. We further recommend that an individual's socioeconomic status, the SDH metrics tied to their residence, and housing status are considered in how much re-engagement support a patient needs. Locally established services and pilot programs recognize this and have made strides in addressing related barriers [6, 8, 10, 33, 34].

One major service that benefits marginalized populations is SFDPH's Linkage Integration Navigation Comprehensive Services (LINCS), which actively engages with PWH identified as not in care, whether they be newly diagnosed or chronic cases [6, 8, 10, 33]. As a care re-engagement service, LINCS is key to maintaining high levels of controlled HIV among PWH and addresses much of what we recommend [6, 8, 10, 33]. Although

SDH factors such as income and education level are not explicitly part of linkage eligibility criteria, LINCS prioritizes their outreach work in neighborhoods with the largest populations of persons vulnerable to uncontrolled HIV [6,10], which our study suggests are the very same neighborhoods experiencing socioeconomic marginalization. Therefore, LINCS contributes to mitigating SDH disparities among PWH by considering geography in their outreach strategy.

San Francisco also recently piloted a text message-based HIV care navigation program (Health eNav), aiming to overcome structural barriers to care engagement [34]. Evaluation found Health eNav improved engagement overall but that participants experiencing homelessness and poverty desired longer term outreach compared to other participants [34], supporting our conclusion that marginalized PWH may need additional support.

We encourage LINCs, Health eNav, and comparable programs to continue their efforts, recommend further allocation of resources to PWH in neighborhoods facing hardships in the SDH categories studied, and support funding innovative approaches to address SDH as an obstacle toward ending the

**Table 3.** Counts, Proportions, and PORs for Uncontrolled HIV Infection by Select Social Determinants of Health Quartiles Among Housed and Homeless PWH in San Francisco Between 2017 and 2019 (N = 7486)

| SDH | Quartile[b] | Controlled HIV Infection N | Controlled HIV Infection % | Uncontrolled HIV Infection N | Uncontrolled HIV Infection % | Bivariate Analysis Type III χ² P Value | Bivariate Analysis Crude POR[c] | Multivariate Analysis[a] Type III χ² P Value | Multivariate Analysis[a] Adjusted POR[c] |
|---|---|---|---|---|---|---|---|---|---|
| | Total | 6889 | 100% | 597 | 100% | | | | |
| Below Federal Poverty Level (%) | <6.00% | 1758 | 26% | 69 | 12% | <.0001 | – | <.0001 | – |
| | 6.00%–8.99% | 1232 | 18% | 67 | 11% | | 1.39 (0.98–1.95) | | 1.17 (0.83–1.67) |
| | 9.00%–12.99% | 1555 | 23% | 100 | 17% | | **1.64 (1.20–2.24)** | | 1.32 (0.95–1.82) |
| | ≥13.00% | 2344 | 34% | 361 | 60% | | **3.92 (3.01–5.11)** | | **1.97 (1.48–2.63)** |
| Median Household Income ($)[d] | <$84 000 | 1976 | 29% | 319 | 53% | <.0001 | **3.56 (2.80–4.54)** | <.0001 | **1.79 (1.37–2.33)** |
| | $84 000–$115 999 | 1245 | 18% | 98 | 16% | | **1.74 (1.30–2.33)** | | **1.44 (1.07–1.95)** |
| | $116 000–$151 999 | 1654 | 24% | 88 | 15% | | 1.18 (0.87–1.59) | | 1.15 (0.84–1.55) |
| | ≥$152 000 | 2009 | 29% | 91 | 15% | | – | | – |

Abbreviations: HIV, human immunodeficiency virus; POR, prevalence odds ratio; PWH, persons with HIV; SDH, social determinants of health.

[a]Multivariate models adjust for gender, race/ethnicity, age group, transmission category, birth country, and housing status.

[b]Highlighted quartiles indicate the most marginalized SDH category.

[c]PORs significant at alpha = 0.05 are in bold.

[d]Median household income is missing for PWH in some smaller census tracts (n = 6).

HIV epidemic. Meanwhile, newer ART options such as long-acting injectables continue to evolve [35,36]. These options should be offered to individuals struggling with ART adherence, making controlled HIV easier to achieve alongside programs to remove barriers to care.

Finally, we recognize that although new HIV care programs can be made increasingly holistic, alleviating SDH disparities themselves is largely beyond their scope. We must work with policymakers to address unmet community needs and the political structures that create SDH disparities and consequent barriers to HIV care in SF [37].

**Strengths and Limitations**

Limitations in our study include the inherent inability of cross-sectional surveillance data to allow for causal inference between SDH metrics and our outcome variable, uncontrolled HIV infection. Temporality was even harder to establish given the 3-year window from which most recent addresses and laboratory reports were collected. This was warranted given the nature of surveillance data collection, wherein residential and laboratory data are made available and entered as they are reported to SFDPH. Restricting to a narrower time window would have resulted in a severely reduced sample size.

In addition, our SDH metrics are measured at the census tract level, not the individual level, and a neighborhood's metric may not be entirely reflective of an individual's socioeconomic status. Furthermore, because our SDH metrics were categorized as quartiles with cutoffs specific to SF, this limits the generalizability of our findings to other settings. We were also unable to categorize all individuals in

the case registry as having controlled or uncontrolled HIV due to inconclusive laboratory records. However, given the small number of cases meeting the inconclusive-status criteria, the effect on our results was likely negligible.

Finally, we recognize that mental health and substance use are associated with poorer HIV health outcomes, likely interrelate with SDH [1, 19, 22], and have been considered in tandem in past surveillance reports and studies [1, 19, 22, 33]. Although our analysis lacked information on such factors, we were able to include history of injection drug use at diagnosis as a covariate; however, this was not entirely reflective of current substance use.

We must also consider the strengths of this study. This HIV surveillance dataset, although cross-sectional, is derived from a case registry for which data are collected continuously using standardized methods. Although our study is SF-specific, these standardized data collection methods allow for a degree of reproducibility in other jurisdictions contributing to CDC HIV surveillance. It is also population-based and routinely evaluated for completeness, timeliness, and accuracy and has been found to be 98% complete [8]. Other strengths of this study include the diversity in SDH factors assessed and our use of census tract to derive SDH metrics, which is more specific than zip code, the linkage used in previous comparable research [24]. In addition, because uncontrolled HIV infection was observed to be a rare outcome among SF PWH who were prescribed ART (<10% prevalence in the overall study population and in the least marginalized [ie, the effective "unexposed"] quartiles for all 5 models), we can conclude that our measured PORs provided a reasonable approximation for the prevalence risk ratio for these strata of the analysis [38].

## CONCLUSIONS

We observed that, after adjusting for demographic variables, worse SDH metrics were associated with uncontrolled HIV among persons previously diagnosed with HIV infection in SF. In addition to established care programs, PWH experiencing socioeconomic marginalization require support and innovative interventions to achieve health outcome goals. By focusing on the health needs of vulnerable subpopulations, coupled with tailored programs and policies, we can create pathways to good health, reduce health inequities, and progress toward zero new HIV infections and ending the HIV epidemic.

### Supplementary Data

Supplementary materials are available at *Open Forum Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

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