

A County-Level Examination of the Relationship Between HIV and Social Determinants of Health: 40 States, 2006-2008

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Abstract: *Background:* Social determinants of health (SDH) are the social and physical factors that can influence unhealthy or risky behavior. Social determinants of health can affect the chances of acquiring an infectious disease – such as HIV – through behavioral influences and limited preventative and healthcare access. We analyzed the relationship between social determinants of health and HIV diagnosis rates to better understand the disparity in rates between different populations in the United States.

Methods: Using National HIV Surveillance data and American Community Survey data at the county level, we examined the relationships between social determinants of health variables (e.g., proportion of whites, income inequality) and HIV diagnosis rates (averaged for 2006-2008) among adults and adolescents from 40 states with mature name-based HIV surveillance.

Results: Analysis of data from 1,560 counties showed a significant, positive correlation between HIV diagnosis rates and income inequality (Pearson correlation coefficient $\rho = 0.40$) and proportion unmarried – ages >15 ($\rho = 0.52$). There was a significant, negative correlation between proportion of whites and rates ($\rho = -0.67$). Correlations were low between race-specific social determinants of health indicators and rates.

Conclusions/Implications: Overall, HIV diagnosis rates increased as income inequality and the proportion unmarried increased, and rates decreased as proportion of whites increased. The data reflect the higher HIV prevalence among non-whites. Although statistical correlations were moderate, identifying and understanding these social determinants of health variables can help target prevention efforts to aid in reducing HIV diagnosis rates. Future analyses need to determine whether the higher proportion of singles reflects higher populations of gay and bisexual men.

Keywords: HIV, social determinants of health, income inequality, proportion unmarried, non-whites, county level.

INTRODUCTION

The effects of the human immunodeficiency virus (HIV) continue to disproportionately plague certain communities across the United States. For instance, racial and ethnic minority populations have been greatly affected by HIV and acquired immunodeficiency syndrome (AIDS) [1]. A major focus has been placed on individuals and their sexual behaviors as explanations for differences in HIV rates. While individual risk behavior can be seen as a major contributor of HIV exposure, relatively little attention has been placed on the social determinants that may play an important role in sexual health. The community environment and resources (or lack of resources) associated with it can influence sexual behavior, which in turn may contribute to disparate rates of HIV transmission and may also help explain the potential differences among racial/ethnic groups [1-4].

In the United States, risk-reduction strategies have been a major means for encouraging changes in sexual behaviors that may put individuals at risk for HIV infection [5]. When

observing the person-time-place triad and the host-agent-environment triad, not enough attention is focused on place and environment [2, 6]. The individual-level approach tends to ignore the impact that social and community context have in choosing whether to engage in risky behaviors; whereas the spatial location where an individual resides provides the social and sexual context that can effect HIV risk within that area [7-10]. Prior research has shown that patterns in the 'structure of relationships' defined at multiple levels rather than just the differences in individual risky behavior can help in understanding patterns of HIV transmission [7, 11, 12]. Changing individual-level behaviors can result in some overall change; however the individual-level change may be insufficient in impacting large-scale community indicators (e.g., percent of people living with HIV infection) [13]. Therefore, examining population factors may provide insight into the disparate rates of HIV transmission.

Understanding the influences that community-level factors have in facilitating and/or inhibiting personal risk behaviors is a recent focus of conceptual, methodological, and analytical inquiry at the Centers for Disease Control and Prevention (CDC). The National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention (NCHHSTP) at the CDC is shifting from the major focus being individual-level health and moving toward examining population health

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strategies – in particular social determinants of health (SDH) [1]. NCHHSTP has adopted the World Health Organization's (WHO) conceptual framework of social determinants of health as the driving force for the reduction of health disparities and promotion of health equity. This framework relates structural determinants (e.g., socio-economic status (SES), poverty) to intermediary determinants (e.g., psychosocial, behavior, and biological factors), which may affect individual health status [1, 14]. With the use of this framework, we analyzed the relationship between social determinants of health and HIV in hopes of better understanding the inequity in HIV diagnosis rates across different groups within the United States.

Social determinants of health are the social and physical environment and health services that make a person less or more likely to engage in unhealthy behavior [1, 14-18]. Social determinants of health can affect an individual's chances of acquiring a chronic or infectious disease – such as HIV – through influences on behavior, limited access to preventive measures and limited access to healthcare providers or testing sites [19-21]. Research shows that the social environment in which an individual lives has a large impact on HIV infection [6, 7]. There are a number of social and structural determinants that increase a person's risk of becoming infected with HIV, including cultural context, social networks, neighborhood effects, structural violence and discrimination, and demographic change [7, 22]. In addition, SES and poverty status greatly impact rates of sexually transmitted infections (STIs) including HIV infection, and these determinants are compounded when examined by race and ethnicity [2, 3, 23-26].

This analysis explores the relationship between social determinants of health and HIV diagnosis rates at the county level using data from the U.S. Census Bureau's American Community Survey (ACS) and the National HIV Surveillance database. We chose county as the population/community level of interest because it provides more variability for examining the various social determinants of health characteristics. A better understanding of the patterns of social determinants of health and HIV diagnosis rates may provide direction for further investigation and intervention activities.

METHODS

Data were obtained from two sources: the National HIV Surveillance System and the American Community Survey (ACS). HIV diagnosis data included HIV diagnoses by county, transmission category, race/ethnicity, age, and sex for the combined years 2006-2008 for adults and adolescents (≥ 13 years of age) from 40 states with long-standing confidential, name-based HIV infection reporting (Alabama, Alaska, Arizona, Arkansas, Colorado, Connecticut, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, New Jersey, New Mexico, New York, Nevada, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin, Wyoming). These data were reported to the National HIV Surveillance system through June 2010. We determined the average annual HIV diagnosis rates (cases per 100,000 population) for the counties using the 2006-2008 population

count estimates obtained from the U.S. Census Bureau [27]. HIV diagnosis data were statistically adjusted for reporting delays and missing risk-factor information, but not for incomplete reporting.

Social determinants of health data were obtained from the American Community Survey, which is an ongoing survey that collects data annually [28]. American Community Survey gives more in-depth information of the community population than the Decennial Census, including significant social determinants of health characteristics. We used the 3-year American Community Survey data from 2006-2008 which encompassed geographic areas with populations of 20,000 or greater; these data are more reliable than the 1-year estimates [28]. The social determinants of health variables that we examined at the county level were the following: Income inequality – measurement of disparity of household income within a county (represented by the Gini coefficient, 0 = total equality, 1 = total inequality), the proportion with less than high school education (ages ≥ 18), the proportion of the labor force unemployed (ages ≥ 16), the proportion of whites (ages ≥ 15), the proportion below poverty level (ages ≥ 15 : overall population and for race and ethnicity), the proportion not currently married (% unmarried ages ≥ 15 : overall population and for race and ethnicity), and the proportion of females to males (sex ratio ages ≥ 15 : overall population and for race and ethnicity). Different age groups were obtained for these social determinants of health variables based on the age categories provided from the American Community Survey.

We merged the HIV rate data with the American Community Survey social determinants of health variables at the county level. For this, we merged the data by the Federal Information Processing Standard (FIPS) code in the 40 states. County FIPS are unique identifiers for counties and county equivalents in the United States [29].

Statistical Analysis Software (SAS) version 9.2 [30] was used to analyze the correlation between HIV diagnosis rates and social determinants of health variables using the approach proposed by Song *et al.*, [31]. The closer the correlation value is to ± 1 , the stronger the relationship; however, the closer the correlation value is to 0, the weaker the relationship. Since correlation measures linear relationships, we transformed the rate variable using the square root transformation so that it approximately followed the normal distribution and was more linearly related to the other variables. Also, correlations between HIV diagnosis rates and social determinants of health variables could be caused by, or confounded with, other demographic or social determinants of health variables. To control the effects of other variables, we estimated partial correlations - the correlation between two variables, with an adjustment for a third variable.

RESULTS

From the national HIV data, there were 2,235 counties within the 40 states with long-standing confidential name-based HIV infection reporting. From the American Community Survey data, there were 1,887 counties in the 50 states and Puerto Rico with populations of 20,000 or greater. After merging the HIV and American Community Survey

data together, there were a total of 1,560 counties within the 40 states with social determinants of health data. American Community Survey information was not available for 327 counties, and they were not included in the analysis. From the 1,560 counties over the 3 years, there were a total of

121,462 estimated diagnoses of HIV and an average annual rate of 22.0 per 100,000 adults and adolescents. By age, the highest percentage of cases were between the ages of 40-49 (27.0%), followed closely by cases between the ages of 30-39 (26.6%) and 20-29 (25.9%) (Table 1). For race/ethnicity,

Table 1. Diagnoses of HIV Infection Among Adults and Adolescents for Selected Characteristics from 2006-2008 in the 1560 Counties with Social Determinants of Health Data in the 40 State

Diagnoses of HIV Infection (2006-2008)				
Selected Characteristics	No.	Estimated		
		No.	%	Rate
Age at Diagnosis				
13-19	5,112	5,476	4.5	8.3
20-29	29,322	31,407	25.9	33.4
30-39	30,147	32,265	26.6	36.1
40-49	30,603	32,739	27.0	33.1
50-59	13,895	14,867	12.2	17.1
60+	4,401	4,708	3.9	4.1
Race/Ethnicity				
American Indian/Alaska Native	462	494	0.4	13.0
Asian	1,172	1,277	1.1	7.7
Black/African American	56,982	61,160	50.4	83.4
Hispanic/Latino ^a	20,099	21,503	17.7	33.2
Native Hawaiian/Other Pacific Islander	112	118	0.1	34.8
White	33,021	35,156	28.9	9.1
Multiple races	1,632	1,754	1.4	34.5
Sex				
Male	84,224	90,207	74.3	33.6
Female	29,255	31,254	25.7	11.1
Transmission Category				
Male Adult or Adolescent				
Male-to-male sexual contact	47,407	64,433	71.4	--
Injection drug use	4,793	8,373	9.3	--
Male-to-male sexual contact and injection drug use	2,580	3,752	4.2	--
Heterosexual contact ^b	8,365	13,430	14.9	--
Other ^c	21,079	219	0.2	--
Female Adult or Adolescent				
Injection drug use	2,678	5,222	16.7	--
Heterosexual contact ^b	13,600	25,876	82.8	--
Other ^c	12,977	156	0.5	--
Total^d	113,480	121,462	100.0	22.0

Data include persons with a diagnosis of HIV infection regardless of stage of disease at diagnosis.

Numbers resulted from statistical adjustment that accounted for reporting delays and missing risk-factor information, but not for incomplete reporting. Rates are per 100,000 population. Rates are not calculated by transmission category because of the lack of denominator data.

^aHispanics/Latinos can be of any race.

^bHeterosexual contact with a person known to have, or to be at high risk for, HIV infection.

^cIncludes hemophilia, blood transfusion, perinatal exposure, and risk factor not reported.

^dIncludes 1 person of unknown sex.

Because column totals for estimated numbers were calculated independently of the values for the subpopulations, the values in each column may not sum to the column total.

the majority of cases were black/African American (50.4%). The highest percentage of cases was male (74.3%). For males, the highest percentage of cases was attributed to male-to-male sexual contact (71.4%); whereas for females, the highest percentage of cases was attributed to heterosexual contact (82.8%).

When examining the social determinants of health variables, income inequality had an average GINI index of 0.43 (range: 0.33 to 0.60) (Table 2). The average proportion of individuals among counties with less than high school education was 0.17 (range: 0.03 to 0.48). Due to sampling and lack of particular racial/ethnic populations within certain counties, there were 1,558 counties with data available for the proportion of whites, and the average proportion was 0.80 (range: 0.05 to 0.99). Only 1,541 counties had data available for proportion unemployed and 1,559 counties had data available for proportion below poverty, and the average proportions were 0.04 (range: 0.01 to 0.12) and 0.13 (range: 0.02 to 0.37), respectively. For proportion unmarried and the female to male sex ratio, the averages were 0.45 (range: 0.31 to 0.71) and 1.05 (range: 0.60 to 1.33), respectively. We also examined the proportion unmarried, proportion below poverty, and sex ratio for whites, blacks/African Americans, and Hispanics /Latinos.

Of the correlations computed, the strongest relationships between social determinants of health variables and average HIV diagnosis rates were proportion of whites ($\rho = -0.67$), proportion unmarried ($\rho = 0.52$), and income inequality ($\rho = 0.40$) (Table 3). As the proportion of whites increase within counties, there was a statistically significant decrease in HIV diagnosis rates ($p < 0.001$). As the proportion unmarried increased and as income inequality increased

within counties, there was a statistically significant increase in HIV diagnosis rates ($p < 0.001$ and $p < 0.001$, respectively). We did not observe a strong relationship between HIV diagnosis rates and other social determinants of health variables. Also, correlations were low between race-specific social determinants of health indicators and HIV diagnosis rates.

Using partial correlations we adjusted for one of these seven variables at a time: income inequality, proportion less than high school education, proportion unemployed, proportion unmarried, proportion below poverty, sex ratio, and proportion white (Table 4). When we adjusted for income inequality, there was a shift in the direction of the correlation between the proportion below poverty and HIV diagnosis rates (ρ shifted from 0.22 to -0.01) and the correlation between the sex ratio and HIV diagnosis rates (ρ shifted from 0.09 to -0.01). That is, when controlling for income inequality, the proportion below poverty and the sex ratio were almost unrelated to HIV diagnosis rates. When adjusting for proportion unmarried, there was a shift in the direction of the correlation between the proportion below poverty and HIV diagnosis rates (ρ shifted from 0.22 to -0.05) and the relationship was statistically significant ($p = 0.03$). That is, as the proportion below poverty increased, HIV diagnosis rates decreased when controlling for proportion unmarried. There was also a shift in the direction of the correlation between the proportion less than high school (ρ shifted from 0.22 to -0.06) and HIV rates and the correlation between proportion below poverty and HIV diagnosis rates (ρ shifted from 0.22 to -0.06) when we controlled for proportion of whites. That is, as the proportion less than high school and the proportion below poverty increased, HIV diagnosis rates decreased when controlling

Table 2. American Community Survey Data for County Social Determinants of Health Characteristics Among Adults and Adolescents from 2006-2008, in the 1560 Counties in the 40 States

Social Determinants of Health	No. of Counties	Mean Proportion	Min Proportion	Max Proportion
Income Inequality (GINI Index)	1,560	0.43	0.33	0.60
Proportion less HS Education	1,560	0.17	0.03	0.48
Proportion Unemployed	1,541	0.04	0.01	0.12
Proportion White	1,558	0.80	0.05	0.99
Proportion Below Poverty	1,559	0.13	0.02	0.37
White	1,543	0.09	0.02	0.31
Black/African American	559	0.19	0.03	0.45
Hispanic/Latino ^a	395	0.14	0.02	0.36
Proportion Unmarried	1,560	0.45	0.31	0.71
White	1,560	0.44	0.24	0.71
Black/African American	932	0.68	0.37	0.95
Hispanic/Latino ^a	700	0.52	0.32	0.81
Sex Ratio (Female to Male)	1,560	1.05	0.60	1.33
White	1,560	1.05	0.07	2.37
Black/African American	932	1.06	0.20	1.61
Hispanic/Latino ^a	700	0.86	0.71	1.36

^aHispanics/Latinos can be of any race.

for proportion of whites. Both relationships were statistically significant ($p = 0.01$ and $p = 0.01$, respectively).

Table 3. Correlation Coefficients Between HIV Diagnosis Rates and Social Determinants of Health Variables from 2006-2008, in the 1560 Counties in the 40 States

Social Determinants of Health	Correlation Coefficient	p-Value
Income Inequality	0.40	<0.0001
Proportion Less HS Education	0.22	<0.0001
Proportion Unemployed	0.22	<0.0001
Proportion White	-0.67	<0.0001
Proportion Below Poverty	0.22	<0.0001
White	-0.04	0.09
Black/African American	-0.03	0.51
Hispanic/Latino ^a	0.08	0.11
Proportion Unmarried	0.52	<0.0001
White	0.26	<0.0001
Black/African American	0.15	<0.0001
Hispanic/Latino ^a	0.09	0.02
Sex Ratio (Female to Male)	0.09	0.0005
White	-0.04	0.15
Black/African American	0.16	<0.0001
Hispanic/Latino ^a	-0.07	0.08

^aHispanics/Latinos can be of any race.

DISCUSSION

In our analysis, HIV diagnosis rates increased as income inequality and the proportion unmarried increased, and rates decreased as proportion of whites increased. For certain individuals within a county, income inequality can play a role in increased economic strain and limited material availability [32]. One explanation in the observed relationship between income inequality and increased HIV diagnosis rates may be the social hierarchy established

within a community’s social and income stratifications, which leads to psychosocial harm due to perceived positioning in society, material availability, limited opportunity, and a truncated sense of control [32, 33]. This, in turn, contributes to certain coping mechanisms that may be detrimental to good health, such as limited future life chances, more impulsivity, and more risky behavior [32, 33]. This established infrastructure brings about disparities across different groups, leading to decreased medical care and decreased HIV testing among the population negatively impacted [34]. Decreased testing leads to persons unaware of their infection status, and those who are unaware have higher transmission rates than those who are aware of their status [35].

The data show a statistically significant positive correlation between proportion unmarried and HIV diagnosis rates. The proportion unmarried within an area may have some impact on HIV diagnosis rates as it relates to the structure of sexual networks within an area. This relationship could be expected based on the nature of the interactions among married versus unmarried individuals. That is, the research shows persons unmarried tend to have multiple sexual partners, and be indirectly or directly linked to a sexual network which can influence the transmission of HIV [3, 36, 37]. The effects of sexual networks could be compounded by social context, which influences transmission of HIV [3, 38]. Also, these sexual networks could differ based on sexual orientation, and with same-sex marriage not recognized or accepted in most states, this could possibly have a confounding effect [3, 39]. Future analyses need to determine whether the higher proportion unmarried reflects higher populations of gay and bisexual men.

The data reflect the higher HIV prevalence among non-whites. Racial segregation and composition at the county level could affect HIV through differential distribution of resources [22]. Certain communities disproportionately impacted may have fewer resources, restricted medical access and reduced awareness of existing health programs; thereby, increasing the possibility of more risky behavior [22, 40]. Lack of resources may also have an effect on the social and sexual networks within the communities [22, 40]. Farley makes the case that race may be a marker for social and environmental factors (e.g., alcohol and drug marketing,

Table 4. Partial Correlation Coefficients of HIV Diagnosis Rates and Social Determinants of Health Variables from 2006-2008, in the 1560 Counties in the 40 States

	Controlling Variables						
	Income Inequality	Prop Less HS Education	Prop Unemployed	Prop Unmarried	Prop Poverty	Sex Ratio	Prop White
Income Inequality	--	0.37*	0.38*	0.18*	0.34*	0.39*	0.19*
Prop Less HS Education	0.13*	--	0.16*	0.19*	0.10*	0.21*	-0.06*
Prop Unemployed	0.18*	0.17*	--	0.05*	0.15*	0.21*	0.06*
Prop Unmarried	0.40*	0.51*	0.49*	--	0.48*	0.52*	0.28*
Prop Poverty	-0.01	0.12*	0.15*	-0.05*	--	0.21*	-0.06*
Sex Ratio	-0.01	0.10*	0.07*	0.06*	0.06*	--	0.02
Prop White	-0.60*	-0.65*	-0.65*	-0.55*	-0.65*	-0.66*	--

*Significantly different from zero at 5% significance level.

social capital, poor education, male incarceration, and chronic joblessness) that are related to an increase in HIV transmission [7]. Further, the data suggest that the proportion of whites within a county plays a role in the linear relationship between other social determinants of health and HIV diagnosis rates. That is, other social determinants of health variables controlled for in the partial correlation models did not contribute to the explanation of the relationship between proportion white and HIV diagnosis rates. This can partly be explained by the high prevalence of HIV among African Americans and Hispanics/Latinos, which provides greater chances for infection because of the partner pool within those racial/ethnic groups and contributes to the disparity in HIV diagnosis rates between racial/ethnic groups [41-43]. Further work is needed to understand the community environment and its contribution to any social and sexual network disparities between the different racial/ethnic groups.

We did not observe a relationship between race-specific social determinants of health variables and HIV diagnosis rates. From the American Community Survey data, there were a number of counties with missing data for blacks/African Americans and Hispanics/Latinos. Because of the lack of sampling of these populations in the American Community Survey, there were counties which contain no blacks/African Americans and Hispanics/Latinos persons. Therefore, there may not be enough power to detect an association.

There are limitations to this study. One limitation is that our analyses are based on residence at the time of diagnosis of HIV infection, which does not necessarily represent incidence or location of HIV infection. Also, the data are based on known diagnoses – it does not include those infected but undiagnosed (which is estimated at 21% nationally) [44]. Data for this analysis were adjusted for reporting delays, but not for incomplete reporting. This may result in an underestimate of the true number of cases within the given time period. Also, social determinants of health information for each individual person diagnosed with HIV are unknown. We use counties as a surrogate for the conditions of persons diagnosed with HIV. In addition, American Community Survey only surveys two-thirds of counties for its sampling population, which may have potential reliability concerns in the results. Use of county as the unit of measurement may be problematic as it may not accurately represent people's socio-economic status, which may be more closely tied to smaller areas such as neighborhoods that may reflect the connection of social networks and physical spatial locations [22, 45]. However, certain area characteristics such as income inequality and residential segregation are potentially relevant to health, and they are more meaningfully defined at larger levels or aggregations. As these larger areas may not fully explain the heterogeneity within them, it will be important to also look at smaller areas such as neighborhoods in future analyses.

This is one of the first studies to examine the relationship between social determinants of health and HIV diagnosis rates at the county level using national data. Overall, our results build on earlier works that have examined social determinants of health and HIV/AIDS infection [13, 31]. Although statistical correlations for some social determinants

of health variables were moderate, these analyses provide a first step to a better identification and understanding of social determinants of health factors in relation to the HIV burden. Future analyses may provide additional insight to help target prevention efforts and provide information on societal factors influencing disparate HIV diagnosis rates.

DISCLAIMER

The findings and conclusions in this paper are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

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CONFLICT OF INTEREST

None declared.

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