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Racial and ethnic differences in the association of social cohesion and social capital with HIV testing

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ABSTRACT

HIV testing rates vary by race and ethnicity. Whether social capital indicators are related to HIV testing and whether these associations differ by race or ethnicity is unknown. Multivariable analysis was used to examine whether social capital (collective engagement and civic and social participation), including social cohesion (trust in neighbors, neighbors willing to help, feelings of belongingness) were associated with testing for HIV in the past 12 months. Participants were white, Black or African American, and Hispanic/Latino adults ages 18 to 44 (N = 2823) from the general population, in Philadelphia, PA who participated in the Southeastern Pennsylvania Household Health Surveys 2010 and 2012. Overall HIV testing in this sample was 42%, and was higher among women, and Black compared to white people. Mean social capital scores were significantly highest among whites. Greater trust in neighbors was associated with lower odds of testing for HIV (adjusted Odds Ratio [aOR]:0.61, 95% CI = 0.49–0.74), and this relationship varied by race/ethnicity, with stronger inverse associations among Hispanic/Latino (aOR = 0.43, $p < 0.001$) and white adults (aOR = 0.50, $p < -0.001$) than among Black adults (aOR = 0.75, $p < 0.05$). Greater neighborhood belongingness (aOR = 1.31, 95% CI = 1.11–1.54) and working together to improve the neighborhood (aOR = 1.33, 95%CI = 1.03–1.73) were associated with higher odds of testing for HIV. Different indicators of social capital were associated with higher as well as lower odds of testing for HIV. These patterns did not vary statistically by race or ethnicity. HIV testing prevention interventions will need to address social capital in design and implementation strategies.

1. Introduction

HIV continues to be a persistent challenge in the U.S. and major health prevention challenge for racial health equity. In 2019, the highest rate of new HIV diagnosis was among Blacks/African Americans (hereafter, Black people) (45.0) followed by 21.5 for Hispanic/Latino, and 5.3 among white people (Centers for Disease Control and Prevention, 2021). Moreover, fewer Black people compared to U.S. average are linked to care within 90 days of a new infection (Centers for Disease Control and Prevention, 2021). These gaps in HIV diagnosis and care support the urgent need to better understand other HIV prevention activities such as HIV testing.

HIV testing as a preventive strategy can facilitate higher linkage to HIV care and improved HIV-related health outcomes, especially for people at increased risk of HIV (Girardi, Sabin et al. 2007; Chopel 2015; Ransome, Terzian et al. 2015). On aggregate, HIV testing rates are high among Black people (Rountree, Chen et al. 2009; Kaiser Family Foundation, 2020), driven by higher testing among Black men who have sex with men — who have the highest HIV incidence (Cooley, Oster et al. 2014; Essuon, Zhao et al. 2020). Yet, despite high rates of HIV testing among Black people, they are more than 10 times and three times likely than white and Hispanic/Latino people, respectively, to be diagnosed

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with HIV in the advanced stages of AIDS (Hess et al., 2018). Higher rates of late or delayed diagnosis among Black people are related to both structural and behavioral factors such as lower access to care as well as high HIV stigma in their communities (Levy, Wilton et al. 2014; Ransome, Kawachi et al. 2016; Ransome, Batson et al. 2017). Aside from those factors, HIV testing is important for racial equity. One study showed that HIV testing resulted in identifying a higher percentage of Black (58.5%) compared to white (17%) and Hispanic/Latino people (15%) with previous HIV not known to be in care (Essuon, Zhao et al. 2020). These statistics underscore the importance of research to understand predictors of timely HIV testing, regardless of transmission status, to inform strategies to reduce HIV inequalities in diagnosis and care (Essuon, Zhao et al. 2020).

Racism and discrimination, racial residential segregation, and poverty are all well-known social determinants that contribute to racial differences in HIV testing outcomes (Institute of Medicine, Barr, 2014, Buot, Docena et al. 2014; Dmowska & Stepinski, 2014, Randolph, Golin et al. 2020; Centers for Disease Control and Prevention, 2021). Other social determinants, such as social capital, which may be related to better or higher HIV testing, are under researched. Social capital has been associated with preventive behaviors for other chronic diseases (Dean, Subramanian et al. 2014; Dean, Subramanian et al. 2015; Hasan, Dean et al. 2020), but has been sufficiently investigated with respect to HIV preventive behaviors, such as testing, in the United States (Ransome, Thurber et al. 2018).

Social capital is an umbrella term often defined in public health as the structure of networks and collective resources within a community that people within that community can access and benefit from (Kawachi and Berkman 2014). The term often encompasses social cohesion, which are the cognitive aspects of social capital (Villalonga-Olives & Kawachi, 2015). Social capital focuses more on the structural aspects of relationships such as connectedness, institutional linages, degree of citizenship, participation in organizations, and frequency of general collective action (Harpham, 2008; Villalonga-Olives & Kawachi, 2015). Social cohesion describes the cognitive aspects of connectedness such as reciprocity, sharing, trust, sense of belonging, perceived social responsibility, willingness to help, generalized trust, and trust of one's neighbor (Kawachi and Berkman 2014). The levels of social capital and social cohesion also matter for health, and measures may fit along a quadrant of Forms and Scope that go from structural aspects (starting left) to cognitive aspects (far right) and intersecting vertically from micro level (bottom), meso (middle), and macro (top) (Grootaert & Thierry Van, 2002). In this study, we focus primarily on the bottom right quadrant where micro, meso and cognitive aspects intersect, such as trust, belongingness, and cooperation with others.

Whether aspects such as trust in individual neighbors and sense of community should be operationalized as an individual feature or attribute of the collective has long been debated (Bess, Fisher et al. 2002), however, social capital and social cohesion, in most public health research, has largely been construed as a property of the collective (Kawachi & Berkman, 2014). Thus, even when individual-level measures are sometimes used, the conceptual frame of the question focuses on the collective aspect. For instance, measures of trust ask individuals whether "neighbors" can be trusted or whether people in their "neighborhood" are willing to work to help each other (Sampson, Raudenbush, & Earls, 1997).

Social capital and social cohesion indicators may contribute in different ways to the use of HIV prevention resources (Ransome, Thurber et al. 2018), such as HIV testing. Living in socially cohesive neighborhoods can be an advantage/drawback at the same time, a phenomenon described as "Disruptive social capital," by Takahashi and Magalong (2008). For instance, individuals in socially cohesive neighborhoods characterized by high trust and feelings of belongingness may project social norms that HIV infection is the result of promiscuous behavior and may stigmatize individuals living with HIV who then may be less likely to seek HIV care and prevention resources, including HIV testing (Campbell, Skovdal et al. 2011; Cene, Akers et al. 2011). Alternatively, socially cohesive neighborhoods could cultivate a supportive environment for people to seek and use HIV testing (Cene, Akers et al. 2011). Structural aspects of social capital such as volunteering or high political participation can also impact HIV testing, both in a good or bad way. For instance, the political and community participation can be mobilized in opposition to health promoting aspects when the groups who need the help (e.g., homeless and people with HIV or those who use drugs) are stigmatized by a majority group. Othering leads to the Not in My Back Yard (NIMBY) syndrome where the social capital generated within one group is used to keep away resources that may benefit other groups (Takahashi, 1998). On a positive note, social organization and community participation has long been a common route through which marginalized groups have used to fight for equality and health resources (James, Schulz et al., 2001, pp. 165–188).

Empirical studies showed that both social capital and social cohesion aspects have been associated with lower HIV risk through HIV testing (Karim et al., 2008; Pronyk et al., 2008; Fonner, Kerrigan et al. 2014). As we have shown, the mechanisms relating to health and HIV are complex, and thus producing both positive and negative associations. As such, empirical studies are needed to build the evidence base with respect to HIV testing as an outcome. There remains a paucity of evidence in the U. S. context that links social capital with HIV testing among major race groups. Therefore, we examine whether social capital is associated with HIV testing in a large urban U.S. city and whether these associations vary by race/ethnicity.

2. Methods

2.1. Study sample

We used the 2010 and 2012 cross-sectional samples of the Southeastern Pennsylvania Household Health Survey (SPHHS) administered by the Public Health Management Corporation(Public Health Management Corporation Community, 1983). The SPHHS is a random-digit dialing comprehensive telephone and cellphone survey that assesses population responses to health, social, and behavioral items among a representative sample of residents of Southeastern Pennsylvania, age 18 years and older. Data are weighted to the census population. The characteristics of the sample across survey years are intentionally similar. Therefore, combining the data was not a threat to temporal variability. Informed consent was not required. These secondary publicly available data were not considered human subjects research and exempt from institutional IRB.

2.2. Measures

2.2.1. Social capital indicators

Social cohesion was assessed with three questions. Respondents were asked the extent to which they agreed that "Most people in my neighborhood can be trusted" and "I feel that I belong and am a part of my neighborhood." Response options were "strongly agree, agree, disagree, and strongly disagree," and were scored from 1 to 4. Response options were reverse coded so that higher scores indicated higher levels of agreement. Respondents were also asked, "Please rate how likely people in your neighborhood are willing to help their neighbors with routine activities such as picking up their trash cans or helping to shovel snow." Responses were "always, often, sometimes, rarely, and never," and were scored from 1 to 5. This variable was also reverse coded so that higher values indicated greater frequency of neighbors helping one another.

Table 1
Sample characteristics by testing for HIV in the past 12 Months.

Variable	Tested for HIV n = 1178 (41.73%)		Did Not Test for HIV n = 1645 (58.27%)		Total n = 2823		p-value
Social Cohesion							
Neighbors can be trusted[a], mean (SD) ("Trust")	2.39	(0.5)	2.63	(0.5)	2.52	(0.5)	**0.000*****
Neighbors willing to help each other[b], mean (SD) ("Neighbor")	3.31	(0.8)	3.43	(0.8)	3.38	(0.8)	**0.000*****
I feel I belong in my neighborhood[c], mean (SD) ("Belong")	2.97	(0.7)	3.00	(0.7)	2.99	(0.7)	0.45
Social Capital							
Neighbors work together to improve neighborhood[d], n (%) ("Improve")							
Yes	838	(70.3)	1175	(68.2)	2013	(69.1)	0.36
No	340	(29.7)	470	(31.8)	810	(30.9)	
# Neighborhood groups in which I participate[e], mean (SD) ("Participate")	0.67	(0.8)	0.79	(0.9)	0.73	(0.9)	**0.01***
Individual Covariates, n(%)							
white	258	(22.8)	849	(50.2)	1107	(38.0)	**0.000*****
Black	709	(54.8)	605	(32.6)	1314	(42.4)	
Hispanic/Latino	211	(22.5)	191	(17.2)	402	(19.5)	
Age, mean (SD)	32.30	(7.3)	34.69	(7.9)	33.63	(7.7)	**0.000*****
Female, n (%)	802	(57.4)	1060	(50.4)	1862	(53.5)	**0.004****
Male	376	(42.6)	585	(49.6)	961	(46.5)	
Heterosexual, n (%)	1095	(92.3)	1565	(95.2)	2660	(93.9)	**0.040***
Homosexual, bisexual or other	61	(5.7)	59	(3.3)	120	(4.4)	
Missing	22	(2.0)	21	(1.5)	43	(1.7)	
Married, n (%)	391	(33.2)	815	(51.0)	1206	(43.1)	**0.000*****
Unmarried, divorced	784	(66.7)	823	(48.5)	1607	(56.6)	
Missing	3	(0.2)	7	(0.5)	10	(0.4)	
Below 200% poverty level, n (%)	596	(51.9)	510	(35.6)	1106	(42.8)	**0.000*****
At or above 200% poverty level	581	(48.1)	1135	(64.5)	1716	(57.2)	
Missing	1	(0.1)	0	0.00	1	(0.0)	
Education, n (%)							
Less than high school grad	133	(13.1)	124	(10.8)	257	(11.8)	**0.000*****
High school grad or vocational	641	(51.9)	693	(40.8)	1334	(45.8)	
Some college	227	(18.3)	388	(21.3)	615	(20.0)	
College and higher	173	(16.5)	435	(26.6)	608	(22.1)	
Missing	4	(0.3)	5	(0.4)	9	(0.4)	
Employed, n (%)	712	(58.6)	1152	(69.1)	1864	(64.4)	**0.000*****
Unemployed, retired, else	461	(40.9)	486	(30.5)	947	(35.14)	
Missing	5	(0.5)	7	(0.4)	12	(0.5)	
Owns home, n (%)	522	(39.6)	997	(50.5)	1519	(45.7)	**0.000*****
Rent, other	649	(59.8)	636	(48.7)	1285	(53.6)	
Missing	7	(0.6)	12	(0.8)	19	(0.7)	
Insured, n (%)	983	(78.1)	1393	(79.3)	2376	(78.8)	0.588
Non-insured	195	(21.9)	252	(20.7)	447	(21.2)	

(*continued on next page*)

Table 1 (*continued*)

Variable	Tested for HIV n = 1178 (41.73%)		Did Not Test for HIV n = 1645 (58.27%)		Total n = 2823		p-value
Smoker, n (%)	334	(28.9)	398	(25.4)	732	(26.9)	0.134
Non-smoker	838	(70.4)	1243	(74.4)	2081	(72.6)	
Missing	6	(0.7)	4	(0.3)	10	(0.5)	
Has regular source of care, n (%)	1037	(84.8)	1412	(79.7)	2449	(82.0)	**0.029***
No regular source of care	136	(14.9)	231	(19.9)	367	(17.7)	
Missing	5	(0.3)	2	(0.3)	7	(0.3)	
Year, n (%)							
2010	685	(48.3)	959	(52.2)	1644	(50.4)	0.105
2011	493	(51.8)	686	(47.8)	1179	(49.6)	

p-value is for Pearson's χ^2 F statistic (categorical variables) and *t*-test (continuous variables). Boldface indicates statistical significance (*p < 0.05, **p < 0.01, ***p < 0.001).

[a] Strength of agreement that "most people in my neighborhood can be trusted" (higher indicates more strongly agrees).

[b] Frequency with which "most people in my neighborhood are willing to help their neighbor" (higher indicates greater frequency of helping).

[c] Strength of agreement that "I feel that I belong and am part of my neighborhood" (higher indicates more strongly agrees).

[d] Indicator of whether "people in your neighborhood ever worked together to improve the neighborhood" (higher indicates yes).

[e] "Number of local groups or organizations in your neighborhood you currently participate in" (higher indicates more participation).

Table 2
Social Cohesion and Social Capital and Testing for HIV in the Past 12 Months by race and ethnicity.

Variable	Race/ethnicity						p-values		
	Black n = 1314 (42.4%)		Hispanic/ Latino n = 402 (19.5%)		white n = 1107 (38%)		Black vs. Hispanic/ Latino	Black vs. white	Hispanic/Latino vs. white
Social Cohesion									
Neighbors can be trusted[a], mean (SD) ("Trust")	2.39	(0.55)	2.43	(0.43)	2.70	(0.49)	0.284	**0.000*****	**0.000*****
Neighbors willing to help each other[b], mean (SD) ("Neighbor")	3.36	(0.86)	3.15	(0.69)	3.51	(0.76)	**0.000*****	**0.000*****	**0.000*****
I feel I belong in my neighborhood[c], mean (SD) ("Belong")	2.95	(0.75)	2.92	(0.57)	3.07	(0.64)	0.588	**0.004****	**0.001****
Social Capital									
Neighbors work together to improve neighborhood[d], n (%) ("Improve")									
Yes	929	(72.5)	227	(56.1)	768	(70.6)	**0.000*****	0.436	**0.000*****
No	332	(27.5)	161	(43.9)	295	(29.4)			
# Neighborhood groups in which I participate[e], mean (SD) ("Participate")	0.67	(0.86)	0.59	(0.63)	0.88	(0.94)	0.196	**0.000*****	**0.000*****
Tested for HIV in the past 12 months									
Yes	709	(57.4)	211	(51.1)	258	(26.6)	0.078	**0.000*****	**0.000*****
No	605	(42.7)	191	(48.9)	849	(73.4)			

p-value is for Pearson's χ2 F statistic (categorical variables) and *t*-test (continuous variables). Boldface indicates statistical significance (*p < 0.05, **p < 0.01, ***p < 0.001).

[a] Strength of agreement that "most people in my neighborhood can be trusted" (higher indicates more strongly agrees).

[b] Frequency with which "most people in my neighborhood are willing to help their neighbor" (higher indicates greater frequency of helping).

[c] Strength of agreement that "I feel that I belong and am part of my neighborhood" (higher indicates more strongly agrees).

[d] Indicator of whether "people in your neighborhood ever worked together to improve the neighborhood" (higher indicates yes).

[e] "Number of local groups or organizations in your neighborhood you currently participate in" (higher indicates more participation).

Table 3
Regression Results for the Odds of testing for HIV in the Past 12 Months.

Models	(1)		(2)		(3)	
	Bivariate		Unadjusted Model of Social Cohesion and Social Capital		Covariate Adjusted Model of Social Cohesion and Social Capital	
	OR	95% CI	AOR	95% CI	AOR	95% CI
Social Cohesion						
Trust	**0.50*****	[0.42,0.59]	**0.43*****	[0.35,0.53]	**0.61*****	[0.49,0.74]
Neighbor	**0.87****	[0.79,0.96]	0.92	[0.81,1.04]	0.9	[0.79,1.03]
Belong	0.95	[0.85,1.08]	**1.33*****	[1.13,1.56]	**1.31****	[1.11,1.54]
Social Capital						
Improve	1.1	[0.90,1.36]	**1.34***	[1.05,1.70]	**1.33***	[1.03,1.73]
Participation	**0.88****	[0.79,0.97]	0.91	[0.82,1.01]	0.99	[0.89,1.10]
Race/ethnicity (ref = white)						
Black	**3.71*****	[2.98,4.62]			**2.86*****	[2.25,3.65]
Hispanic/Latino	**2.88*****	[2.14,3.88]			**2.30*****	[1.68,3.16]
Age	**0.97*****	[0.96,0.98]			**0.97*****	[0.96,0.98]
SES (poverty, employ, educ, own)	**0.71*****	[0.65,0.77]			**0.85****	[0.76,0.94]
Unmarried (ref = married)	**2.11*****	[1.74,2.57]			**1.50*****	[1.21,1.86]
Missing	0.65	[0.13,3.30]			0.5	[0.079,3.17]
Insured	0.93	[0.73,1.20]			1.22	[0.91,1.65]
Male	**0.75****	[0.62,0.91]			0.87	[0.70,1.08]
Homosexual, bisex (ref = heterosexual).	**1.80***	[1.14,2.83]			**2.21****	[1.35,3.62]
Missing	1.41	[0.64,3.11]			1.57	[0.66,3.77]
Has source of care	**1.43***	[1.08,1.88]			**1.69****	[1.22,2.35]
Missing	1.18	[0.21,6.54]			1.22	[0.20,7.59]
2011 (ref = 2010)	1.17	[0.97,1.41]			1.13	[0.92,1.39]
N	2823		2823		2823	
p			**0.000*****		**0.000*****	

Boldface indicates statistical significance (*p < 0.05, **p < 0.01, ***p < 0.001).
Notes. (Model 1) Bivariate results are each variable's association with HIV testing with no covariates.
(Model 2) Unadjusted model is social cohesion and social capital association with HIV testing, and no covariates.
(Model 3) Adjusted model is the Model 2 + race/ethnicity and covariates.

Table 4
Race-stratified multivariable regression models for the adjusted odds of testing for HIV in the past 12 Months.

	Race and ethnicity					
	white		Black		Hispanic/Latino	
	AOR	95% CI	AOR	95% CI	AOR	95% CI
Social Cohesion						
Trust	**0.50*****	[0.35,0.72]	**0.75***	[0.57,0.99]	**0.43*****	[0.26,0.69]
Neighbor	0.8	[0.62,1.05]	1.02	[0.85,1.22]	0.78	[0.58,1.05]
Belong	**1.74*****	[1.26,2.41]	1.1	[0.90,1.36]	1.46	[0.95,2.25]
Social Capital						
Improve	**1.73***	[1.10,2.72]	1.09	[0.75,1.60]	1.4	[0.74,2.65]
Participation	0.9	[0.75,1.08]	1.05	[0.90,1.22]	0.95	[0.70,1.30]
Race/ethnicity (ref = white)						
Black						
Hispanic/Latino						
Age	**0.97****	[0.95,0.99]	**0.97****	[0.96,0.99]	**0.96****	[0.93,0.99]
SES (poverty, employ, educ, own)	**0.77****	[0.64,0.93]	**0.87***	[0.75,1.00]	0.92	[0.71,1.18]
Unmarried (ref = married)	**1.53***	[1.04,2.24]	1.24	[0.92,1.67]	**1.98***	[1.16,3.36]
Missing	1	[1,1]	**15.8***	[1.51,165.1]	1	[1,1]
Insured	0.85	[0.47,1.54]	1.32	[0.89,1.96]	1.36	[0.74,2.51]
Male	0.91	[0.64,1.32]	1.01	[0.74,1.38]	0.67	[0.38,1.15]
Homosexual, bisex (ref = heterosexual).	1.72	[0.84,3.51]	**3.53***	[1.34,9.28]	2.18	[0.60,7.93]
Missing	1.06	[0.21,5.28]	0.43	[0.093,1.97]	**8.36****	[2.29,30.4]
Has source of care	1.57	[0.89,2.78]	**1.68***	[1.06,2.69]	2.01	[0.97,4.16]
Missing	1.03	[0.04,24.1]	1	[1,1]	0.64	[0.02,17.4]
2011 (ref = 2010)	1.09	[0.76,1.56]	1.03	[0.77,1.37]	1.57	[0.95,2.60]
N	1102		1311		401	
p	**0.000*****		**0.000*****		**0.000*****	

All race-stratified models are adjusted for covariates and show the relationship between social cohesion and social capital with testing for HIV in the past 12 months.

The three variables were treated as continuous since the differences between response categories were not necessarily meaningful. Civic and social participation was a count variable corresponding to the question, "How many local groups or organizations in your neighborhood do you currently participate in such as social, political, religion, school-related, or athletic organization?" Collective engagement was assessed by asking respondents, "Have people in your neighborhood ever worked together to improve the neighborhood?" Responses were "yes or no."

2.2.2. HIV testing

The primary outcome was HIV testing in the past 12 months assessed through the question, "About how long has it been since you last had a test for HIV/AIDS?" Responses were coded 1 for one year or less, and 0 for never or more than one year.

2.2.3. Race/ethnicity

Self-reported race/ethnicity was defined as a categorical variable (white was the reference), with Black/African American and Hispanic/Latino as comparison groups.

2.2.4. Covariates

Covariates were selected based on prior research on neighborhood social cohesion and on social determinants of HIV-related behaviors (Grover, Grosso et al. 2016; Ransome, Kawachi et al. 2017). These included continuously coded age, categorical distributions of sex, marital status, and sexual orientation. Socioeconomic status was a principal component index containing education level, employment status, home ownership, and whether respondents' income was below or above 200% of the poverty level. Higher scores indicated higher socioeconomic status. Health insurance was a binary variable indicating if the person had a regular source of care. A year variable was included to account for possible time-period effects since two waves of survey data from 2010 to 2012 were analyzed.

2.3. Statistical analysis

The analytic sample was comprised of white, Black, and Hispanic/Latino adults, ages 18–49 years, who reported whether they had taken an HIV test in the past 12 months from Philadelphia, PA. This analysis builds on previous research on social capital and HIV in this area(Ransome, Dean et al. 2017; Ransome, Kawachi et al. 2017). Survey weights were used for all analyses. All analysis was conducted using Stata: Release 14(StataCorp, 2015).

Missing data were handled in two ways. For covariates, missing data were coded as a separate response category for categorical variables or was replaced by the variable mean for continuous variables. For the social capital variables, separate multivariable models were used to estimate predicted values for each of these variables. These predicted values then replaced any missing data. Predictors in these multivariable models included HIV testing in the past 12 months and study covariates that had significant bivariate associations with the social capital variable being modeled. We later conducted sensitivity analysis by testing whether study results were robust to different methods of handling missing data, including multiple imputation and complete case control. We generated descriptive statistics that compared the characteristics of respondents who did and did not report taking an HIV test in the past 12 months. Differences between the two groups were assessed using T-tests for characteristics coded as continuous variables, and Pearson's $\chi 2$ F statistic for categorical variables. We also examined descriptive differences in the levels of social capital and HIV testing among white, Black, and Hispanic/Latino respondents. T-tests and Pearson's $\chi 2$ F statistics were used to make pairwise comparisons between the three groups. We examined Spearman correlations between study variables to inform model specification. Social capital variables were examined for multicollinearity, but results determined this was not a problem.

For the main analysis, we first assessed the bivariate associations between HIV testing and each of the study variables. Covariates with non-significant associations with HIV testing were excluded from the multivariable models. The baseline multivariable model included only social capital indicators as predictors of HIV testing, while the full model added covariates. We used the full model to estimate the association between social capital and HIV testing for the full sample, and separately for white, Black, and Hispanic/Latino respondents. To formally test for differences across these groups, we estimated models with interaction terms between race/ethnicity and each of the social capital variables. The significance of these interactions was assessed using the Wald Chi-Square test.

3. Results

Sample characteristics are summarized in Table 1. Out of 2823 total respondents from Philadelphia, PA 1178 (41.7%) reported testing for HIV test in the past 12 months. Study participants were Black (42.4%), Hispanic/Latino (19.5%), and white (38%). The average age was 32.3 years, and 42.8% lived below 200% of the poverty line. Average levels of social capital were equivalent or lower among those who reported testing for HIV in the past 12 months compared to those who did not test for HIV.

Results of social capital indicators by race/ethnicity are shown in Table 2. Compared with white people, Black and Hispanic/Latino people less strongly agreed that neighbors can be trusted, that neighbors are willing to help each other, and that they feel they belong to their neighborhood. Latinos less strongly agreed that neighbors are willing to help each other compared with Blacks. A higher percentage of Black and white people reported that neighbors work together to improve the neighborhood compared with Hispanics/Latinos. White people participated in a greater number of neighborhood groups compared to Blacks and Hispanics/Latinos. A significantly lower percentage of white people reported HIV testing in the past 12 months (26.6%) compared with Black (57.4%) and Hispanic/Latino (51.5%) people.

Regression results for the main associations between the social cohesion and social capital variables with testing for HIV in the past 12 months are shown in Table 3. For social cohesion, more strongly agreeing that people in their neighborhood can be trusted ("trust") (AOR = 0.61, 95% CI: 0.49,0.74) and more strongly agreeing that one belongs and is part of their neighborhood ("belong") (AOR = 1.31, 95% CI: 1.11,1.54) were associated with higher odds of testing for HIV in the past 12 months in the unadjusted and adjusted models with all covariates.

When considering social capital, individuals who reported that

people in their neighborhood had ever worked together to improve the neighborhood ("improve") had 33% higher odds of testing for HIV in the past 12 months, in the unadjusted and adjusted model (AOR = 1.33, 95% CI: 1.03,1.73).

In the fully adjusted models, Black race and Hispanic/Latino ethnicity, being unmarried, identifying as homosexual, and having a usual source of care were associated with higher odds of testing for HIV in the past 12 months. Increasing age and higher socioeconomic status were significantly associated with lower odds of testing for HIV in the past 12 months (Table 3).

No interactions between any of the social cohesion or social capital variables and race/ethnicity were statistically significant. However, despite the lack of statistical significance, we present stratified results in Table 4 for two reasons. First, statistical significance of interactions cannot detect other potential qualitative reasons why there may still be differences by race. Second, in our previous work, we have identified several reasons why race differences in social capital may exist (Gilbert, Ransome et al. 2022; Villalonga-Olives, Majercak et al. 2022), and so therefore provide the readers with data to inform better health equity programming.

Race-stratified models show that more strongly agreeing that people in their neighborhood can be trusted ("trust") was significantly associated with lower odds of testing for all groups. However, the negative odds appeared stronger for Blacks (AOR = 0.75, 95% CI: 0.57, 0.99) compared to white (AOR = 0.50, 95% CI: 0.35,0.72), and Hispanic/Latino (AOR = 0.43, 95% CI: 0.26,0.69) and the point estimates for the coefficient for Blacks were outside of the confidence intervals for whites and Hispanics. Only white people who reported that people in their neighborhood had ever worked together to improve the neighborhood ("improve") had a significant and higher odds of testing for HIV in the past 12 months (AOR = 1.73, 95% CI: 1.10,2.72), but not Blacks or Hispanics/Latinos.

Multivariate results were mostly robust to different methods for handling missing data for the social capital indicators, including using multiple imputation, replacing missing with mean values, and complete case analysis.

4. Discussion

This is the first study to examine the associations between social capital and social cohesion indicators and HIV testing among individuals in the U.S. and determine if these associations vary by race/ethnicity. Social capital indicators were associated both with lower odds of testing for HIV in the past 12 months (trust in neighbors or "trust") and higher odds of testing for HIV in the past 12 months (feelings of belongingness or "belong"). The size of associations (i.e., odds ratio) between higher ratings of trust in neighbors and lower odds of testing for HIV was largest among Black people, although race/ethnic differences were not statistically significant. This finding among Black people appears paradoxical. HIV prevalence is highest in predominantly Black communities. The high HIV prevalence in Black communities is due to multiple structural conditions such as segregation and poverty that creates a milieu of barriers to determinants of health and inequitable opportunities to reduce health risk (Ransome, Kawachi et al. 2016; Boutrin & Williams, 2021). A high HIV prevalence may be correlated with a higher perceived HIV risk among Black people (Blackstock, Frew et al. 2015), and, in theory should be related to higher testing. Alternately, people reporting high trust among neighbors may expect that others are looking out for them/protecting them, and thus may be less likely to get tested under that assumption.

It was surprising that higher trust in one's neighbor to be associated with lower odds of testing for HIV. Yet, in other studies social cohesion ("trust") has been linked to increased reported HIV testing or had no association with HIV testing (Grover, Grosso et al. 2016; Lippman, Leslie et al. 2018; Edi Putra & Januraga, 2020, Lyu, Zhou et al. 2021). Potential explanations for these mixed or null findings is that the data in this study represent individual-level, not group-level, metrics of social capital and social cohesion, and are disaggregated by race and ethnicity. Another potential explanation is that associations found in prior studies are from larger heterogeneous regions (e.g., the entire U.S. state or U.S. counties)(Ransome, Batson et al. 2017). Some of those studies were primarily ecological (i.e., not among individuals)(Ransome, Thurber et al. 2018) or from international contexts, such as Swaziland (Grover, Grosso et al. 2016)

These findings could also be different if neighborhood-level social cohesion was examined, which is another step for future work. For instance, Grover, Grosso, and Ketende et al. found that residents that live in a sub-Saharan African area with high social cohesion were more likely to test for HIV in the past 12 months(Grover, Grosso et al. 2016)

Collective engagement (working together to improve the neighborhood or "improve") was associated with higher odds of testing for HIV in the past year. This association appeared to be driven among whites despite interactions by race/ethnicity. The association was not significant for Blacks or Hispanics/Latinos. Qualitative inquiry will be necessary to understand why this pattern appears in whites only. The positive associations of collective engagement ("improve") and social cohesion ("belong") with HIV testing among whites only reflect whites having larger, more diverse social networks that are characterized by high levels of social integration and different network role composition (Busette et al., 2020; Gilbert, Ransome et al. 2022). Whites participated in more neighborhood groups compared to Blacks and Hispanic/Latinos in this study.

4.1. Limitations and strengths

There are limitations in this study. We had specific social capital indicators, which although popular, are not the universe of measures and often reflect narrow definitions of the construct (i.e., mostly based on Robert Putnam's work) (Szreter & Woolcock, 2004, Ransome, Thurber et al. 2018). Other social capital and related aspects that measure things like "assistance", "altruism," or "solidarity" may be more relevant for HIV testing (Friedman, Pouget et al. 2015; Villalonga-Olives, Kawachi et al. 2021), which should be tested in future work. Nevertheless, these measures are valid based on face, convergent, and nomological validity criteria set forth by Lee and Kim (Lee & Kim, 2013) and were reliable over the two survey periods. Next, the retrospective, cross-sectional nature of the data in this study limits causal inference. It is possible (although highly unlikely) that HIV testing could have driven some aspects of social capital, such as trust among neighbors. This study was not designed to identify mediators or mechanisms between social

capital indicators and HIV testing. Therefore, multiple individual and contextual level factors could either be explaining or confounding our associations (especially those in directions opposite of what theory would suggest). Although we adjusted for several structural factors that influence HIV testing (e.g., SES and health care use), unmeasured confounding is possible. We did not have other covariates such as risky sexual behavior and other sexual health covariates like condom use. Other research has also documented potential issues with interpreting results from studies that cannot examine multiple spatial scales, termed spatial misclassification (Duncan, Regan et al. 2018). For instance, the presence and strength of social capital at the census tract level will likely be stronger than at the zip-code level, but weaker than if a smaller radius or buffer zones around a person's residence was used (Balsa-Barreiro, Menendez et al. 2022).

Our study also has some strengths. Our study is novel because it is the first study to test these associations by race/ethnicity in the U.S. Thus, our results contribute to advancing the scholarship on this issue. Better, more strategic, and optimal testing of HIV (e.g., early, or soon after a risky sexual event) is critical for reducing racial inequalities in new and late HIV diagnosis. This study assessed one established metric of HIV testing (in the past 12 months) that informs the HIV care cascade (MacCarthy, Hoffmann et al. 2015). These results provide important baseline information for future work that can assess other measures of HIV testing. This study also showed the value of assessing cognitive aspects of social capital, such as trust in neighbors.

From a prevention perspective, health practitioners when screening individuals at HIV or other health care appointments may find it useful to identify the patients relationship with their neighbors and then probe to identify whether those relationships are a source of stress or support. Similarly, if these results hold in other larger scale studies with different populations, health practitioners may find it useful to ask their patients about their level of belongingness to their neighborhood as well as whether they work together with others to improve their neighborhood. Social prescribing has become increasingly popular in health care practices, especially post the COVID-19 pandemic (Younan, Junghans, Harris, Majeed, & Gnani, 2020). This work contributes to a body of evidence that may inform social connectedness and social prescribing approaches to HIV prevention. Last, the sample sizes were sizeable and the effect sizes and coefficients we reported can be used to inform power calculations for future studies seeking to detect racial and ethnic differences in social capital and HIV testing.

5. Conclusions

Several social capital indicators were associated with both higher as well as lower odds of testing for HIV in the past 12 months. These directions did not statistically vary by race or ethnicity. HIV testing prevention interventions will need to address social capital in design and implementation strategies. The results lay a foundation for future studies to examine how social capital at the neighborhood level is associated with HIV testing above and beyond individual measures and covariates.

Behavioral interventions will need to address how trust among neighbors may impact HIV testing and design strategies to improve trust among people. From a structural perspective, there is a clarion call to improve opportunities for people to develop social cohesion, including trust(Holt-Lunstad, 2022). The Citizens Planning Institute in Philadelphia is one example of structural level support to address social cohesion and capital building activities in this city(Philadelphia City Planning Commission, 2021). Evaluating whether these activities contribute to HIV testing and care is a possible step for further research. Given that social capital is also a multilevel construct, future work should assess neighborhood and other aggregate level social capital with respect to HIV testing in the past 12 months.

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Table A.1
Spearman correlation coefficients among study variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Trust[a]	1													
2 Neighbor[b]	**0.43*****	1												
3 Belong[c]	**0.47*****	**0.5*****	1											
4 Improve[d]	**0.19*****	**0.42*****	**0.29*****	1										
5 Participate[e]	**0.23*****	**0.2*****	**0.24*****	**0.2*****	1									
6 HIV test past 12 months.[f]	**−0.2*****	**−0.08*****	−0.02	0	**−0.08*****	1								
7 Age	**0.16*****	**0.12*****	**0.14*****	**0.07*****	**0.11*****	**−0.16*****	1							
8 Socioeconomic status[g]	**0.28*****	**0.16*****	**0.11*****	**0.11*****	**0.22*****	**−0.23*****	**0.09*****	1						
9 Unmarried	**−0.19*****	**−0.12*****	**−0.11*****	−0.03	**−0.17*****	**0.16*****	**−0.09*****	**−0.26*****	1					
10 Insured	**0.12*****	**0.12*****	**0.06****	**0.08*****	**0.11*****	−0.02	**0.09*****	**0.26*****	**−0.1*****	1				
11 Male	**0.05***	**−0.09*****	**0.05****	0.01	−0.02	**−0.04***	−0.04	0.01	**−0.06****	**−0.09*****	1			
12 Sexual orientation	**−0.04***	−0.01	**−0.04***	0.02	**−0.05***	**0.05***	0.01	−0.03	**0.05****	−0.03	0.01	1		
13 Has source of care	0.03	**0.09*****	**0.05****	0.04	**0.07*****	**0.04***	**0.14*****	**0.07*****	**−0.05****	**0.28*****	**−0.14*****	−0.01	1	
14 Year	**−0.17*****	**−0.09*****	−0.02	**−0.06****	−0.03	0	0	**0.08*****	**0.04***	**−0.04***	**0.07*****	0.03	0.02	1

Boldface indicates statistical significance (*p < 0.05, **p < 0.01, ***p < 0.001).
[a-c]Social cohesion variables.
[a]Strength of agreement that "most people in my neighborhood can be trusted" (higher indicates more strongly agrees).
[b]Frequency with which "most people in my neighborhood are willing to help their neighbor" (higher indicates greater frequency of helping).
[c]Strength of agreement that "I feel that I belong and am part of my neighborhood" (higher indicates more strongly agrees).
[d,e]Social capital variables.
[d]Indicator of whether "people in your neighborhood ever worked together to improve the neighborhood" (higher indicates yes).
[e]"Number of local groups or organizations in your neighborhood you currently participate in" (higher indicates more participation).
[f]Self-reported HIV testing in the past 12 months.
[g]Composite variable including education level (higher is greater), employed, at or above 200% of the poverty line, and home ownership.

Table A.2
Multivariable Regression Models for Adjusted Odds of Testing for HIV in Past 12 Months, with Interactions Between Social Cohesion (Trust, Belong), Social Capital (Improve) and Race/Ethnicity

	(1)		(2)		(3)		(4)		(5)		(6)	
	Trust		Belong		Improve		Trust		Belong		Improve	
	AOR	95% CI	AOR	95% CI	AOR	95% CI	AOR	95% CI	AOR	95% CI	AOR	95% CI
Social Cohesion												
Trust	**0.44*****	[0.32,0.60]	**0.52*****	[0.42,0.64]	**0.52*****	[0.42,0.64]	**0.53*****	[0.39,0.72]	**0.60*****	[0.49,0.74]	**0.60*****	[0.49,0.74]
Neighbor	0.94	[0.82,1.06]	0.93	[0.82,1.06]	0.93	[0.82,1.06]	0.9	[0.79,1.03]	0.9	[0.79,1.03]	0.9	[0.79,1.03]
Belong	**1.28****	[1.09,1.50]	**1.42****	[1.10,1.85]	**1.28****	[1.09,1.50]	**1.31*****	[1.12,1.54]	**1.48****	[1.14,1.92]	**1.31****	[1.11,1.54]
Social Capital												
Improve	1.28	[1.00,1.65]	**1.29***	[1.00,1.65]	1.46	[0.98,2.17]	**1.32***	[1.02,1.72]	**1.33***	[1.02,1.72]	**1.56***	[1.03,2.34]
Participation	0.95	[0.85,1.06]	0.94	[0.85,1.05]	0.95	[0.85,1.05]	1	[0.89,1.11]	0.99	[0.89,1.10]	0.99	[0.89,1.10]
Race/ethnicity (base = white)												
Black	1.23	[0.45,3.34]	**5.02*****	[1.98,12.8]	**3.59*****	[2.31,5.56]	1.18	[0.44,3.16]	**4.54****	[1.75,11.8]	**3.34*****	[2.10,5.31]
Hispanic/Latino	3.01	[0.74,12.2]	**3.71***	[1.07,12.9]	**2.88*****	[1.73,4.79]	**3.76***	[1.03,13.8]	**4.21***	[1.22,14.6]	**2.74*****	[1.62,4.63]
Age							**0.97*****	[0.96,0.98]	**0.97*****	[0.96,0.98]	**0.97*****	[0.96,0.98]
SES PCA (poverty, employ, educ, own home)							**0.85****	[0.76,0.94]	**0.85****	[0.76,0.94]	**0.85****	[0.76,0.94]
Unmarried							**1.50*****	[1.21,1.86]	**1.51*****	[1.21,1.87]	**1.51*****	[1.22,1.87]
Missing							0.5	[0.082,2.99]	0.5	[0.078,3.14]	0.5	[0.077,3.19]
Insured							1.22	[0.90,1.64]	1.22	[0.91,1.64]	1.23	[0.91,1.66]
Male							0.87	[0.70,1.08]	0.87	[0.70,1.07]	0.87	[0.70,1.08]
Sexual Orientation (base = heterosexual)												
Homosexual/Bisex.							**2.25****	[1.37,3.70]	**2.20****	[1.35,3.61]	**2.19****	[1.34,3.58]
Missing							1.57	[0.66,3.69]	1.58	[0.66,3.78]	1.56	[0.66,3.70]
Has source of care							**1.73****	[1.24,2.40]	**1.68****	[1.21,2.33]	**1.69****	[1.22,2.35]
Missing							1.15	[0.17,7.74]	1.12	[0.17,7.30]	1.27	[0.20,7.84]
2011 (base = 2010)							1.14	[0.92,1.40]	1.13	[0.92,1.39]	1.13	[0.92,1.39]
Trust x Black	1.45	[1.00,2.12]					1.43	[0.98,2.07]				
Trust x Hispanic/Latino	0.92	[0.54,1.59]					0.81	[0.49,1.34]				
Belong x Black			0.86	[0.64,1.15]					0.86	[0.63,1.16]		

(*continued on next page*)

Table A.2 (*continued*)

	(1)		(2)		(3)		(4)		(5)		(6)	
	Trust		Belong		Improve		Trust		Belong		Improve	
	AOR	95% CI	AOR	95% CI	AOR	95% CI	AOR	95% CI	AOR	95% CI	AOR	95% CI
Belong x Hispanic/Latino			0.88	[0.59,1.33]					0.82	[0.55,1.22]		
Improve x Black					0.83	[0.50,1.38]					0.81	[0.48,1.37]
Improve x Hispanic/Latino					0.84	[0.45,1.58]					0.77	[0.41,1.47]
N	2823		2823		2823		2823		2823		2823	
p	**0.000*****		**0.000*****		**0.000*****		**0.000*****		**0.000*****		**0.000*****	

Boldface indicates statistical significance (*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$) from Wald Chi-Square test of interactions.
Models 1 through 3 are the reduced model + race/ethnicity interaction with no covariates.
Models 4 through 6 are the interaction models with race/ethnicity* social cohesion and social capital and covariates in association with HIV testing adjusted for covariates.

Ethical statement

The secondary publicly available data used in this study was not considered human subjects research and exempt from institutional IRB at Yale University School of Public Health.

CRediT authorship contribution statement

Yusuf Ransome: Conceptualization, Methodology, Project administration, Investigation, Validation, Data curation, Visualization, Supervision, Funding acquisition, Writing – original draft, Writing – review & editing. **Kamden Hayashi:** Formal analysis, Visualization, Writing – original draft. **Joyonna C. Gamble-George:** Writing – original draft, Writing – review & editing. **Lorraine T. Dean:** Investigation, Writing – review & editing. **Ester Villalonga-Olives:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no conflict of interest.

Data availability

The authors do not have permission to share data.

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