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Article

Perceived neighborhood disorder, racial-ethnic discrimination and leading risk factors for chronic disease among women: California Behavioral Risk Factor Surveillance System, 2013

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ABSTRACT

Social environmental factors are theoretically identified as influential drivers of health behaviors – tobacco smoking, alcohol consumption, and physical activity – related to chronic disease disparities. Empirical studies investigating relationships involving social environmental factors have found that either greater interpersonal racial-ethnic discrimination or perceived neighborhood disorder were associated with adverse health behaviors, with potentially larger effects among women. We simultaneously tested whether measures of perceived racial-ethnic discrimination and perceived neighborhood disorder were associated with physical activity, alcohol consumption and tobacco smoking; lifestyle risk factors of major chronic disease among women. Data were from the 2013 California Behavioral Risk Factor Surveillance System. In addition to demographic and socioeconomic factors, women self-reported experiences with racial-ethnic discrimination and perception of neighborhood disorder (i.e., crime safety, traffic safety, and aesthetics/physical disorder). Survey-, and inverse probability of censoring-weighted regression models of each chronic disease risk factor were used to investigate associations involving racial-ethnic discrimination and neighborhood disorder, controlling for potential confounders. Perceiving racial-ethnic discrimination and greater neighborhood disorder were associated with a greater tobacco smoking prevalence. Experiences of racial-ethnic discrimination were associated with greater alcohol consumption among African American and Latino women, but not White women. Similarly, African American women reporting experiences with racial-ethnic discrimination report engaging in physical activity about half as much time as women reporting no racial-ethnic discrimination. Increases in perceived neighborhood disorder were associated with increases in alcohol consumption. All associations with social environmental factors were adjusted for potential confounders and each other. Neighborhood disorder and racial-ethnic discrimination may be important, independent contributors to chronic disease risk through relationships with tobacco smoking, alcohol consumption, and physical activity.

Introduction

According to the Global Burden of Disease Study 2015, 88.8% of all U.S. deaths and 89.6% of years lived with disability (YLD) were attributable to non-communicable disease; 64.7% of deaths and 15.6% of YLD resulted from cancer, cardiovascular disease, diabetes mellitus or chronic obstructive pulmonary disease (i.e., preventable chronic diseases with common risk factors) (Vos, Barber, Bell, Bertozzi-Villa, Biryukov & Bolliger, 2015; Wang, Naghavi, Allen, Barber, Bhutta &

Carter, 2016). Shared risk factors among the leading and preventable chronic diseases include tobacco use, excessive alcohol use and physical inactivity (Forouzanfar, Alexander, Anderson, Bachman, Biryukov & Brauer, 2015). Despite changing trends, 2015 estimates of risk factor prevalence among U.S. adults remained high –51.0% physically inactive, 15.1% smoked tobacco, and 23.4% reported at least one heavy alcohol consumption day (≥ 4 drinks for women, ≥ 5 drinks for men) in the previous year (Ward, Clarke, Nugent & Schiller, 2016). Identifying common and modifiable mechanisms associated with these risk

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factors could motivate public health interventions aiming at reducing chronic disease burden.

Recently, increased attention has focused on the social and physical environmental factors affecting an individual's health opportunities and decisions (Bailey, Krieger, Agnor, Graves, Linos & Bassett, 2017; Cooper, Arriola, Haardrfer & McBride, 2016; Pratt, Perez, Goenka, Brownson, Bauman & Sarmiento, 2015). Recognizing that various contexts are important to explaining patterns of population health and health behaviors is not new (Cornely, 1956). However, identifying *modifiable* social and physical environmental factors that influence health and health choices is gaining attention as progress to intervene on increasing trends of certain chronic disease risk factors has slowed and financial costs risen (Bailey, et al., 2017; Pratt, et al., 2015). In contrast to individually focused behavioral interventions such as counseling and education, efforts that focus on social and physical contexts are suggested to be more effective based on their wider reach and potential for sustainability. (Adler, Cutler, Jonathan, Galea, Glymour & Koh, 2016; Frieden, 2010; Gottlieb, Glymour, Kersten, Taing, Hagan & Vlahov, 2016).

Neighborhood disorder (physical deterioration/disorganization or lack of social control) and racial-ethnic discrimination are potentially influential social environmental factors that are linked to health behaviors and outcomes (Bécares, 2014; Chen & Yang, 2014; Ross & Mirowsky, 2001). Neighborhood disorder potentially results from institutional forms of racial-ethnic discrimination, such as housing and mortgage-lending discrimination (Powell, Slater, Chaloupka & Harper, 2006; Rugh, et al., 2015). Evidence from studies of the early 21st Century subprime lending and foreclosure crisis suggest racialized patterns of subprime lending, foreclosure, and real-estate-owned (REO) homes (Howell, 2006; Kim & Cho, 2016; Rugh, 2015; Rugh, et al., 2015). Due to these race- and ethnicity-based patterns of home mortgage lending and REO, African American and Latino families lost disproportionate amounts of wealth during the most recent economic downturn (Rugh, et al., 2015; Rugh, 2015). Evidence suggests that REO homes, which are concentrated in neighborhoods with a disproportionate percentage of African American or Latino residents due to de facto racial-ethnic residential segregation, are less well maintained than surrounding, owner-occupied homes (Dane, et al., 2013). Thus, these forms of institutional discrimination are important factors in the creation of adverse neighborhood characteristics (i.e., reduced socioeconomic resources, health-related access, and increased racial-ethnic segregation). These adverse neighborhood characteristics, in turn, influence interpersonal racial-ethnic discrimination and might also feed back into neighborhood disorder (Bécares, 2014; Osypuk, Roux, Hadley & Kandula, 2009; Sampson, et al., 1997; Sampson & Raudenbush, 2004). A nascent body of literature suggests that perceptions of neighborhood disorder systematically vary based on intrapersonal characteristics, including demographic, socioeconomic, and experiential factors (Brunton-Smith, 2011; Franzini, Caughy, Nettles & O'Campo, 2008; Hipp, 2010). Despite these systematic differences through which individuals perceived neighborhood disorder, previous research has demonstrated correlations between neighborhood disorder that is measured objectively and through perceptions.

While several studies have reported associations involving either greater perceived racial-ethnic discrimination or neighborhood disorder and increased prevalence of major risk factors for chronic disease (Borrell, Kiefe, Diez-Roux, Williams & Gordon-Larsen, 2013; Chavez, Ornelas, Lyles & Williams, 2015; Chen & Yang, 2014; Echeverra, Diez-Roux, Shea, Borrell & Jackson, 2008; Hunte, 2011; Osypuk, et al., 2009), none have jointly tested the relationships between racial-ethnic discrimination and neighborhood disorder on health behaviors. Given the theoretical and empirical evidence indicating a potential relationship between perceived racial-ethnic discrimination and perceived neighborhood disorder, simultaneous investigation of the associations of both factors and health is important for motivating interventions. Moreover, evidence suggests that relationships between social

environmental factors, especially those involving perceived neighborhood disorder, and health related factors or outcomes might vary by sex, necessitating sex-specific analyses (Bennett, McNeill, Wolin, Duncan, Puleo & Emmons, 2007; Boehmer, Hoehner, Deshpande, Ramirez & Brownson, 2007; Unger, Diez-Roux, Lloyd-Jones, Mujahid, Nettleton & Bertoni, 2014).

The purpose of this study was to simultaneously investigate relationships between perceived racial-ethnic discrimination, neighborhood disorder and prevalence of common and shared risk factors of several chronic diseases among women. These risk factors include: weekly aerobic physical activity duration, past month alcohol consumption and current tobacco smoking. We hypothesized that, independent of one another, increased perceived neighborhood disorder and perceived racial-ethnic discrimination would be associated with increased prevalence of each chronic disease risk factor. As relationships between racial-ethnic discrimination and health might be different by race and ethnicity (Krieger, Smith, Naishadham, Hartman & Barbeau, 2005), we also hypothesized that the associations of perceived racial-ethnic discrimination on each chronic disease risk factor would be greater among African American and Latina compared to non-Latina White women.

Materials and Methods

Data

Data were self-reported from the California 2013 Behavioral Risk Factor Surveillance System Survey (BRFSS). The California survey is part of the US BRFSS –the world's largest ongoing public health survey (Centers for Disease Control and Prevention, (CDC), 2012). The telephone-administered survey became dual framed in California in 2012 to include cell phone users in addition to landline (Ryan-Ibarra, Inundi, Zuniga & Ewing, 2013). Since 2011, US and California BRFSS were weighted using iterative proportional fitting to account for potential biases due to non-response and non-coverage and allow generalizations to the target populations (Centers for Disease Control and Prevention, (CDC), 2012; Ryan-Ibarra, et al., 2013). Iterative proportional fitting is a weighting procedure considered superior to the previously used method of post-stratification because the latter required knowledge of demographic distributions within small geographic areas while the newer procedure does not require this information (Centers for Disease Control and Prevention, (CDC), 2012). The California data was utilized for this study because the two exposure variables of interest – perceptions of racial-ethnic discrimination and perceptions of neighborhood disorder – were unique to California BRFSS. Moreover, California is a socio-demographically diverse state with a large population. The 2013 California BRFSS response rate as calculated by using standards set by the Council of American Survey Research Organizations was 42%. (Ryan-Ibarra, et al., 2013).

Weekly aerobic physical activity duration was a variable calculated by BRFSS personnel and provided within survey responses. It is derived from a series of questions about types of non-work related physical activities, and frequency and duration of those activities. Typical minutes of weekly vigorous intensity or vigorous intensity equivalents of aerobic physical activity (hereafter, "physical activity") were then calculated from each participant's responses. Aerobic physical activity duration was limited to those reporting no more than 2520 min (42 h) per a week ($n = 55, 1.7\% > 2520$ min per a week). Similarly, previous 30-day alcohol consumption was calculated from alcohol consumption type (beer, wine, liquor), frequency, and volume questions. Tobacco smoking was categorized as current versus former or never.

Age (integer years), race and ethnicity ('non-Latina White' ("White"), 'non-Latina Black or African American' ("African American"), or 'Latina/Hispanic'), marital status ('married/unmarried couple' and 'divorced, widowed, separated or never married'), educational attainment ('less than high school diploma', 'high school diploma

or equivalent', 'some college or associate degree' or 'graduate of four-year college or more'), and household income (the midpoint of categories < \$10,000, \$10,000-\$14,999, \$15,000-\$19,999, ..., \$100,000-\$125,000, ≥\$150,000) were from the BRFSS. Preferred language use (Spanish or English) – a commonly used measure of acculturation (Osypuk, et al., 2009), and potential confounder in studies of self-reported health behaviors and outcomes – (Viruell-Fuentes, Morenoff, Williams & House, 2011) was also included. Other racial-ethnic groups were omitted due to low frequencies.

Questions representing perceived neighborhood disorder were from three questions related to the outdoor physical activity environment of a respondent's neighborhood: 'Thinking about criminal activity, how safe is it to walk, run, or bike in your neighborhood or community?', 'Thinking about traffic, how safe is it to walk, run, or bike in your neighborhood or community?', 'How pleasant is it to walk, run, or bike in your neighborhood or community? For example, are there trees and proper lighting, no graffiti, or abandoned buildings?'. Possible responses to the first two safety-related questions were 'Very safe', 'Somewhat safe', 'Somewhat unsafe', or 'Very unsafe'. Possible responses to the last question were 'Very pleasant', 'Somewhat pleasant', 'Somewhat unpleasant', or 'Very unpleasant'. These three variables had acceptable internal consistency reliability (see results) and were sum scored for use as a continuous variable in subsequent analyses (range 3–12). Greater values indicated greater perceived neighborhood disorder. In addition to the three neighborhood questions, women were asked about experiences with racial-ethnic discrimination: 'Have you ever experienced discrimination because of your race or ethnicity?'(yes/no). An appreciable proportion (29.0%) of participants did not respond to either the neighborhood disorder or discrimination questions. Moreover, there was evidence that censoring by these main exposure variables was differential by age, education, and physical activity (Appendix A). As a protection against the potential for selection bias due to differential missing data, adjustments were made to all analyses (see below). The institutional review board of Rutgers University approved this study.

Statistical analyses

Sample characteristics were examined by current smoker status (yes / no), median monthly alcoholic drink consumption (0 drink / ≥ 1 drinks), and median weekly aerobic physical activity duration (< 238 min. / ≥ 238 min.). Select sample characteristics were also displayed by race and ethnicity. Means, standard errors, percentages and frequencies were calculated. A logistic regression model of current tobacco use was built to investigate associations involving perceived neighborhood disorder and racial-ethnic discrimination while controlling for the potential confounders age, race, marital status, education, income and survey language. Negative binomial regression was used to model monthly alcoholic drink consumption and weekly physical activity. Exponentiated regression estimates of the negative binomial regression coefficients yielded prevalence ratios (PR) by levels of factors. Interactions between race-ethnicity and racial-ethnic discrimination were tested in each model. For each modelled health behavior we estimated the unadjusted and adjusted relationships between the main exposures of interest – perceived neighborhood disorder and racial-ethnic discrimination – and the given health behavior as: 1) neighborhood disorder or racial-ethnic discrimination adjusted for all other factors and 2) adjustment for all other factors and mutual adjustment for the other social environmental variable of interest. Alcohol consumption sensitivity analyses were: 1) zero-inflated negative binomial models with identical sets of covariates in both the zero model and non-zero model and 2) heavy alcohol use – as defined by the National Institute on Alcohol Abuse and Alcoholism as consuming ≥ 8 drinks a week – using logistic regression.

All analyses accounted for the BRFSS weights and the potential for differential missing of the main exposure variables according to the following methods. The original BRFSS weights were constructed based

on the complex survey design as well as the probability of participant non-response and survey non-coverage. The final BRFSS weights used in these analyses were calculated following inverse probability of censoring weighting (IPCW) methods (Robins, et al., 1994; Tan, 2011). The unscaled final BRFSS weight was calculated as the product of the original BRFSS weight and the inverse probability of exposure censoring. Unscaled weights were re-scaled so that standard error estimates were not underestimated due to weight inflation from the IPCW procedure. Final, scaled BRFSS weights were calculated by multiplying each unscaled weight by the ratio of the sum of original weights of non-missing values to the sum of unscaled weights. All analyses were conducted separately by chronic disease risk factor, including separate IPCW analyses. Results of non-IPCW analyses utilizing complete case analyses are displayed in Appendices B, C, and D.

Post-hoc sensitivity analyses were conducted to determine if conclusions change when modeling perceived neighborhood disorder items separately as opposed to a sum score. Despite one of the three items not statistically significantly improving the fit of each modelled health behavior, no patterns emerged. As such and for parsimony, only sum scores of perceived neighborhood disorder are shown. SAS 9.4 was used in all analyses.

Results

Analyses were restricted to respondents with non-missing covariate and outcome data: $n_{\text{Tobacco}} = 2405$ (67.7%), $n_{\text{Alcohol}} = 2410$ (67.8%), $n_{\text{Physical Activity}} = 2349$ (67.5%). Although large percentages of missing were due to refusal to answer either the discrimination or neighborhood perception questions, large percentages were also missing due to refusal to answer the tobacco smoking (16.8%) or alcohol consumption (18.9%) questions. However, those missing either the discrimination or neighborhood perception questions were also highly likely to be missing the tobacco smoking or alcohol consumption questions. Among those not missing either the discrimination or neighborhood perception questions, percentages of those missing tobacco smoking or those missing alcohol consumption both reduced to 0.2%. Internal consistency reliability of each perceived neighborhood disorder measure by chronic disease risk factor was acceptable; $\alpha_{\text{Tobacco}} = 0.77$, $\alpha_{\text{Alcohol}} = 0.77$, $\alpha_{\text{Physical Activity}} = 0.78$. Overall, the neighborhood disorder score had a mean of 4.7 and standard deviation of 1.8 (results not shown).

Perception of ever experiencing racial-ethnic discrimination, perceived neighborhood disorder, current tobacco smoking, monthly alcoholic drink consumption, weekly aerobic physical activity duration, and refusal to provide an informative response to either the perception of ever experiencing racial-ethnic discrimination or perceived neighborhood disorder questions all varied by race-ethnicity (Table 1). Approximately 62% of African American women, 22% of Latinas, and 10% of White women report ever experiencing racial-ethnic discrimination. Average perceived neighborhood disorder was 5.5, 5.2, and 4.3 among Latinas, African American and White women, respectively. However, a greater percentage of African American (26.5%) and Latina women (26.8%) refused to answer either the discrimination or disorder questions compared to White women (19.3%). Latinas reported the lowest prevalence of tobacco smoking (5.5%), lowest average monthly alcoholic drink consumption (4.2), and lowest average weekly physical activity duration (325.6 min), and White women reported the highest tobacco smoking (10.0%), alcohol consumption (10.6 drinks), and physical activity (414.6 min).

Current tobacco smoking

Approximately 9% of women were current tobacco smokers (Table 2). Women more likely to be current tobacco smokers were White or African American, separated, divorced, widowed, or never married, with a high school diploma or less, of lower income, administered the survey in English, and reported higher perceived

Table 1
Select sample characteristics by race-ethnicity, California Behavioral Risk Factor Surveillance System, 2013¹.

	White n/mean (%/SE)	Latino/ Hispanic n/mean (%/SE)	African American n/mean (%/SE)
Overall	1806 (60.4)	874 (32.5)	149 (7.1)
Racial-ethnic discrimination			
No	1422 (89.9)	563 (77.7)	46 (38.4)
Yes	150 (10.1)	141 (22.3)	83 (61.6)
Neighborhood disorder score (3–12)	4.3 (0.04)	5.5 (0.9)	5.2 (0.2)
Current tobacco smoker			
No	1399 (90.0)	654 (93.4)	112 (89.7)
Yes	173 (10.0)	50 (6.6)	17 (10.3)
Monthly alcohol consumption (serving)	10.6 (0.6)	4.2 (0.6)	6.1 (1.5)
Weekly aerobic physical activity (min.)	414.6 (16.4)	325.6 (30.5)	327.3 (72.2)
Missing discrimination or perceived neighborhood disorder score ²			
No	1577 (80.7)	706 (73.2)	130 (73.5)
Yes	355 (19.3)	261 (26.8)	39 (26.5)

¹ All factors shown significantly vary by race, $p < 0.05$ for chi-square test of difference

² Analyses weighted using original BRFSS weights.

neighborhood disorder. Among all participants, current tobacco smoking was higher among women who perceived experiences of racial-ethnic discrimination. After adjusting for potential confounders but not perceived neighborhood disorder, women who experienced racial-ethnic discrimination had 1.55 (95% CI: 1.06 – 2.23) greater odds of current tobacco smoking than those not experiencing discrimination (Table 3). Similarly, the odds of tobacco smoking increased by 14% (95% CI: 5–23%) for each increase in perceived neighborhood disorder score. The relationships between tobacco smoking and experiences of racial-ethnic discrimination or perceived neighborhood disorder remained largely the same when mutually adjusting for each other; OR Discrimination = 1.44 (95% CI: 0.99–2.11), OR Perceived neighborhood disorder = 1.13 (95% CI: 1.04 – 1.22). Race-ethnicity did not interact with racial-ethnic discrimination in models of current tobacco smoking (results not shown).

Table 2
Sample characteristics by chronic disease-related risk factors, California Behavioral Risk Factor Surveillance System, 2013.

	Current tobacco smoker N/Mean (%/SE)		Monthly alcohol use (med.) N/Mean (%/SE)		Weekly Physical Activity (med.) N/Mean (%/SE)	
	No	Yes	0 drinks	≥ 1 drink	< 238 min	≥ 238 min
Overall	2156 (91.1)	238 (8.9)	1201 (48.6)	1197 (51.4)	1291 (49.8)	1058 (50.2)
Age (year)	51.6 (0.4)	49.4 (1.2)	51.7 (0.6)	52.0 (0.5)	49.0 (0.6)	53.0 (0.6)
Race-ethnicity						
Latino/Hispanic	652 (93.7)	48 (6.3)	459 (64.4)	241 (35.6)	322 (57.0)	191 (43.0)
African American	112 (89.7)	17 (10.3)	72 (55.1)	58 (44.9)	62 (56.3)	35 (43.7)
White	1392 (89.9)	173 (10.1)	670 (40.0)	898 (60.0)	635 (46.0)	608 (54.0)
Marital status						
Separated/divorced/ widowed/ never married	1127 (88.3)	161 (11.7)	667 (50.7)	623 (49.3)	524 (49.8)	448 (50.2)
Married/unmarried couple	1029 (93.4)	77 (6.6)	534 (46.9)	574 (53.1)	495 (50.0)	386 (50.0)
Education						
< High school	407 (87.2)	65 (12.8)	267 (84.3)	56 (15.7)	129 (52.5)	79 (47.5)
High school diploma or equivalent	613 (87.1)	98 (12.9)	293 (61.8)	180 (38.2)	184 (48.6)	144 (51.4)
Some college or associate's degree	842 (94.6)	46 (5.4)	347 (48.3)	366 (51.7)	317 (51.5)	247 (48.5)
≥ 4-year college	2156 (91.1)	238 (8.9)	294 (32.0)	595 (68.0)	389 (48.3)	364 (51.7)
Income	\$63,543 (\$1,252)	\$45,447 (\$3,167)	\$43,857 (\$1,506)	\$77,057 (\$4,599)	\$66,565 (\$1,838)	\$56,447 (\$1,575)
Survey language						
English	1837 (90.3)	223 (9.7)	922 (42.9)	1142 (57.1)	865 (48.3)	758 (51.7)
Spanish	319 (96.0)	15 (4.0)	279 (81.2)	55 (18.8)	154 (62.6)	76 (37.4)
Perceived neighborhood disorder score (3–12)	4.7 (0.04)	5.2 (0.17)	5.1 (0.06)	4.5 (0.06)	4.8 (0.06)	4.6 (0.07)
Racial-ethnic discrimination						
No	1828 (91.7)	192 (8.3)	1011 (48.4)	1011 (51.6)	863 (49.9)	709 (50.1)
Yes	328 (88.4)	46 (11.6)	190 (49.6)	186 (50.4)	156 (49.9)	125 (50.1)

Table 3
Model estimates of current tobacco use by levels of neighborhood disorder and racial-ethnic discrimination, California Behavioral Risk Factor Surveillance System, 2013^a.

	OR (95% CI)	OR (95% CI)	OR (95% CI)
Neighborhood disorder score (per 1 point)	1.14 (1.05–1.23)		1.13 (1.04–1.22)
Racial-ethnic discrimination			
No		1.00	1.00
Yes		1.54 (1.06–2.24)	1.44 (0.99–2.11)

^a Adjusted for age, marital status, race-ethnicity, education, income, survey language

Table 4
Model estimates of average monthly alcohol use and weekly aerobic physical activity duration by perceived neighborhood disorder and racial-ethnic discrimination, California Behavioral Risk Factor Surveillance System, 2013^{a,b}.

	PR (95% CI)	PR (95% CI)	PR (95% CI)
Perceived neighborhood disorder ^b	See Fig. 1a		See Fig. 1b
Racial-ethnic discrimination x Race-ethnicity			
Among White			
Racial-ethnic discrimination			
No	1.00		1.00
Yes	0.89 (0.62–1.27)		0.89 (0.62–1.27)
Among Latino/Hispanic			
Racial-ethnic discrimination			
No	1.00		1.00
Yes	1.76 (1.19–2.61)		1.62 (1.09–2.40)
Among African American			
Racial-ethnic discrimination			
No	1.00		1.00
Yes	2.27 (1.15–4.48)		2.10 (1.06–4.16)
	Aerobic Physical Activity Duration		
	PR (95% CI)	PR (95% CI)	PR (95% CI)
Perceived neighborhood disorder score (per 1 point)	1.01 (0.97–1.05)		1.01 (0.97–1.05)
Racial-ethnic discrimination x Race-ethnicity			
Among White			
Racial-ethnic discrimination			
No	1.00		1.00
Yes	1.19 (0.91–1.58)		1.19 (0.91–1.58)
Among Latino/Hispanic			
Racial-ethnic discrimination			
No	1.00		1.00
Yes	1.29 (0.94–1.77)		1.28 (0.93–1.75)
Among African American			
Racial-ethnic discrimination			
No	1.00		1.00
Yes	0.55 (0.33–0.93)		0.54 (0.32–0.91)

^a Adjusted for age, marital status, race-ethnicity, education, income, survey language

^b PR = Prevalence ratio

Alcohol use

About half of women reported no alcohol consumption at all. Women more likely to report any alcohol use were White or African American, of higher educational attainment and income, administered the survey in English, and reported lower neighborhood disorder. Any alcohol use did not vary by women’s perception of racial-ethnic discrimination overall (Table 2). However, the relationship between racial-ethnic discrimination and monthly alcohol consumption varied by race-ethnicity (Table 4, Appendix E). After adjustment for potential

confounders, perception of racial-ethnic discrimination was associated with 1.76 (95% CI: 1.19–2.61) and 2.27 (95% CI: 1.15–4.48) times the number of alcoholic drinks consumed monthly among African American and Latina women, respectively.

After adjusting for potential confounders, a second-order relationship (U-shaped) existed between perceived neighborhood disorder and monthly alcoholic drink consumption (Table 4 and Fig. 1). Monthly alcoholic drink consumption decreased as perceived neighborhood disorder increased by one unit from the least disordered score to the next lowest. There were no significant changes in monthly alcohol consumption corresponding to increases in perceived neighborhood disorder between low-mid disorder scores (Fig. 1, non-stippled region). However, increases in perceived neighborhood disorder among higher disorder values was associated with statistically significant increases in monthly alcohol consumption (Fig. 1, stippled region). The relationships between monthly alcoholic drink consumption, perceived neighborhood disorder, and the interaction involving racial-ethnic discrimination and race-ethnicity changed little with mutual adjustment for each social environmental factor. Both the second-order perceived neighborhood disorder term and the interactions between race-ethnicity and racial-ethnic discrimination were robust to alcohol use categorization (heavy vs not) and model specification (zero-inflated negative binomial) (results not shown).

Weekly aerobic physical activity duration

Reporting a shorter duration of physical activity was more likely among women characterized as African American or Latina, attaining less than a high school diploma, higher income, administering the survey in Spanish, and reporting higher perceived neighborhood disorder. Physical activity duration did not vary by women’s perception of racial-ethnic discrimination overall (Table 2). However, the relationship between racial-ethnic discrimination and physical activity varied by race-ethnicity such that physical activity duration was halved (OR = 0.55, 95% CI: 0.33–0.93) if African American women perceived racial-ethnic discrimination (Table 4, Appendix F). There were no discernable relationships between perception of racial-ethnic discrimination and physical activity duration among Latina or White women. Adjustment for perceived neighborhood disorder had little to no influence on the relationship between physical activity and perception of racial-ethnic discrimination by race-ethnicity. There was no association between perceived neighborhood disorder and physical activity duration after adjusting for potential confounders and racial-ethnic discrimination (Table 4).

Discussion

This investigation of the relationships between two potentially salient social environmental factors influencing health disparities – perceived racial-ethnic discrimination and perceived neighborhood disorder – and leading risk factors of chronic diseases suggests that these social factors might operate independently of one another. Independent of perceived racial-ethnic discrimination and other potential confounders, greater perceived neighborhood disorder was associated with a higher prevalence of tobacco smoking and alcohol consumption but not physical activity. The relationship between perceived neighborhood disorder and monthly alcohol drink consumption was ‘u-shaped’: a slight increase in perceived neighborhood disorder from the least disordered score (‘very safe/pleasant’ on all 3 items to ‘somewhat safe/pleasant’ on 1/3) was associated with a decrease in alcohol consumption, while increases in perceived neighborhood disorder from moderate-high disorder neighborhoods was associated with increases in alcohol consumption. Perception of racial-ethnic discrimination was associated with greater tobacco smoking regardless of race-ethnicity, perceived neighborhood disorder or other potential confounders. The relationship between racial-ethnic discrimination and

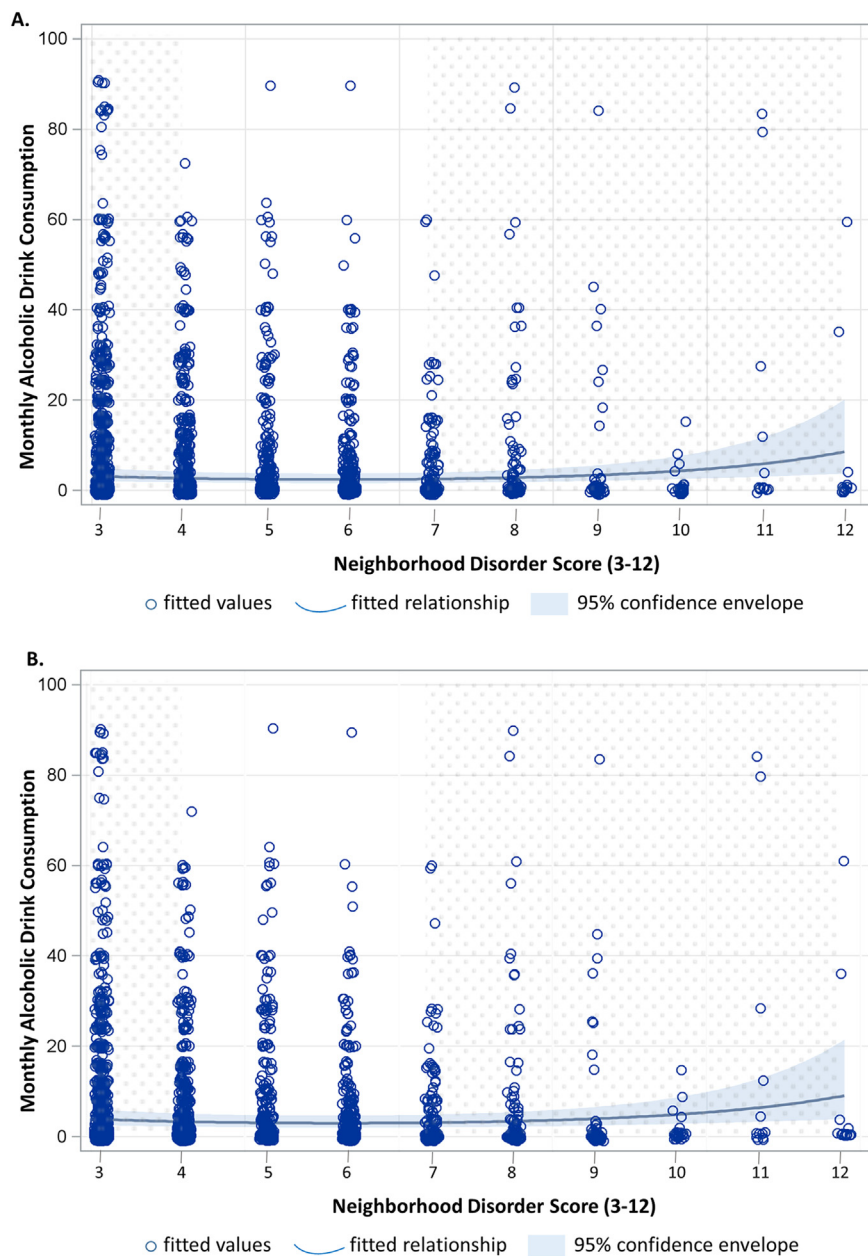


Fig. 1. Estimated alcohol use by perceived neighborhood disorder score, California Behavioral Risk Factor Surveillance System, 2013: a) adjusted for all factors except racial-ethnic discrimination x race-ethnicity interaction, and b) adjusted for all factors^{1,2,3,4}. ¹ Adjusted for age, marital status, race-ethnicity, education, income, survey language, racial-ethnic discrimination, and race-ethnicity x racial-ethnic discrimination. ² Stippled regions denote $P < 0.05$ for Chi-square test of $\beta = 0$, where β is the change in monthly alcohol consumption associated with an increase of 1 neighborhood disorder score, tested at each observable score (3–12). ³ Fitted values are randomly jittered to show frequency. ⁴ Y-axis limited to 100 alcoholic drinks ($n = 11$, 0.50% observations between 101–225 drinks).

alcohol use or physical activity was dependent on respondent’s race or ethnicity: among African American women having experienced racial-ethnic discrimination was associated with greater alcohol consumption and lower physical activity duration. Similarly, Latina experiencing racial-ethnic discrimination had nearly double the consumption of alcoholic drinks. There were no discernable differences in alcohol consumption or physical activity duration by perception of racial-ethnic discrimination among White women.

This is the first known study to simultaneously assess the relationships between the social environmental factors perceived racial-ethnic discrimination and perceived neighborhood disorder and physical activity, tobacco smoking or alcohol use. Despite a conceptual grounding for a connection between racial-ethnic discrimination, neighborhood disorder and health behaviors, our results indicate that the two social constructs share minimal overlapping variability with each other yet

are independently associated with tobacco smoking, physical activity and alcohol consumption to varying degrees. Previous studies have investigated the effects of either perceived racial-ethnic discrimination or perceived neighborhood disorder on various chronic disease risk factors. Our results concerning perceived neighborhood disorder are supported by previous literature demonstrating either null or small and proportional relationships with either physical inactivity, tobacco smoking or alcohol use among U.S. adults (Echeverria, Diez-Roux, Shea, Borrell & Jackson, 2008; Osypuk, et al., 2009; Ross and Mirowsky, 2001; Wilbur, Chandler, Dancy & Lee, 2003; Wilcox, Bopp, Oberrecht, Kammermann & McElmurray, 2003). While a majority of studies reporting significant associations with either risk factor measured more dimensions of neighborhood disorder than crime and traffic safety or pleasantness (Echeverria, et al., 2008; Osypuk, et al., 2009; Ross and Mirowsky, 2001), some studies did report statistically significant

associations between perceived neighborhood disorder, as measured by these three dimensions, and chronic disease risk factors (Wilbur, et al., 2003). Several studies found that adjustment for census-based, area-level socioeconomic status (SES) resulted in null relationships between neighborhood disorder and a chronic disease risk factor (Echeverria, et al., 2008; Osypuk, et al., 2009), a finding similar to ours in that adjustment for individual-level income and education resulted in null associations between perceived neighborhood disorder and physical activity. Longitudinal data will be required to determine whether SES, individual or neighborhood, is operating as a confounder or mediator in this relationship.

Our results involving a significant second-order relationship between perceived neighborhood disorder and alcohol use warrants further discussion. It is possible that these results are an anomaly driven by the few participants' reporting greater perceived neighborhood disorder and greater alcoholic drink consumption, necessitating replication. Notably, 366 participants (17.6%) reported neighborhood perceptions of disorder that resulted in a score of 7 or greater – a small but non-negligible percentage of survey respondents. There could be an activation of perceived neighborhood disorder such that, on average, only among women with at least a 'moderate' perception of disorder do increases in perceived neighborhood disorder result in increases in alcohol consumption. Being cross-sectional data that is limited in bias adjustment to the factors measured in the BRFSS survey, these results could also be due to unmeasured confounders or incomplete control for confounding. This is especially true of the relatively slight decrease in alcohol consumption estimated for increases from the lowest possible score of perceived neighborhood disorder to the next lowest. Despite these relationships being adjusted for potential confounders including individual-level income or education, the large categorizations of these variables could allow for residual confounding.

Our results corroborate previous work that consistently demonstrates greater alcohol and tobacco use associated with more frequent reports of racial-ethnic discrimination (Borrell, et al., 2013; Chavez, et al., 2015; Chen & Yang, 2014; Krieger, et al., 2005). Moreover, we found that relationships between perceived discrimination and both alcohol consumption and physical activity was dependent on race-ethnicity, such that health-adverse behaviors were greater comparing those perceiving racial-ethnic discrimination to those not perceiving discrimination only among Latina and African American women and not among White women. These results replicate findings from a recent study (Chavez, et al., 2015), and exemplify the chronic disease risk of racial-ethnic discrimination due to higher tobacco smoking and alcohol use. Less clear are the mixed results of studies investigating relationships between racial-ethnic discrimination and physical activity (Borrell, et al., 2013; Chen & Yang, 2014; Dawson, Walker, Campbell & Egede, 2016; Edwards & Cunningham, 2013; Hunte, 2011; Shelton, Puleo, Bennett, McNeill, Goldman & Emmons, 2009; Womack, Ning, Lewis, Loucks, Puterman & Reis, 2014), the majority of which report no association between racial-ethnic discrimination and physical activity. (Dawson, et al., 2016; Edwards & Cunningham, 2013; Hunte, 2011; Shelton, et al., 2009; Womack, et al., 2014) The only other known study to report that perceptions of racial-ethnic discrimination were associated with lower physical activity was also the only known study to include corrections for missing data (Chen & Yang, 2014). It is possible that missingness of reporting racial-ethnic discrimination or physical activity resulted in estimated relationships between discrimination and physical activity that were biased towards the null (Robins, et al., 1994; Tan, 2011). The presence of this potential bias is supported in our data when comparing estimates restricted to non-missing data without adjustment for missingness through IPCW (Appendix C) to estimates restricted to non-missing data with adjustment for missingness through IPCW (Table 4); the interaction term between race-ethnicity and racial-

ethnic discrimination is not statistically significant in the former, but is in the latter case with IPCW weighting.

These race-ethnicity based interactions combined with varying prevalence of racial-ethnic discrimination by race-ethnicity underscore the salience of discrimination as a social factor that influences population health of racial-ethnic minorities. That is not to say that perceptions of racial-ethnic discrimination among individuals self-identifying as White should be dismissed, but that the overwhelmingly greater frequency and prevalence of experiencing racial-ethnic discrimination among racial-ethnic minority women is what might contribute to patterns of adverse health, partially through alcohol consumption and physical activity. As others have noted, the coping strategies employed by some individuals in response to social stressors such as discrimination might be negative (i.e., tobacco smoking or alcohol consumption) or positive (i.e., physical activity) (Borrell, et al., 2013; Hunte & Williams, 2009; Jackson, et al., 2010). The degree to which detectable associations between these stressors and specific risk factors arise might be dependent on other individual, cultural and environmental factors such as past socialization to expectations of discrimination, social capital, or resource availability that promotes healthy coping (i.e., physical activity resources, health food availability) (Hunte & Williams, 2009; Williams, et al., 2003).

This study is limited by the cross-sectional design, limited geographic extent, convenience use of discrimination and neighborhood disorder measures, and self-reported health information. The cross-sectional design prevents any causal interpretation of relationships as direction of associations cannot be guaranteed. For example, it is expected that individuals with these risk factors have a higher prevalence of chronic diseases which could lead to lower income due to lost productivity, and in turn, residential movement to lower income and higher disorder neighborhoods. Respondents were asked about 'ever' having experienced racial-ethnic discrimination as opposed to the frequency of discrimination occurring within a defined time frame. Racial-ethnic discrimination occurring many years in the past is expected to have less of an effect on health behaviors and outcomes than discrimination occurring more recently and frequently (Brody, Chen, Murry, Ge, Simons & Gibbons, 2006; Brown, Williams, Jackson, Neighbors, Torres & Sellers, 2000).

The convenience use of these neighborhood perception items as representative of perceived neighborhood disorder is a limitation. Other research using similar items have conceptualized the constructs of perceived neighborhood safety, aesthetics, and disorder separately from one another (Boehmer, et al., 2007; Osypuk, et al., 2009; Unger, et al., 2014). However, it should be noted that perception of neighborhood safety, aesthetics, and physical disorder also significantly correlate (Cerin, Saelens, Sallis & Frank, 2006; Kramer, Maas, Wingen & Kunst, 2013), and well-known, validated measures of perceived neighborhood disorder, walkability, and safety have items that conceptually, if not explicitly, overlap (Cerin, et al., 2006; Ross & Mirowsky, 2001; Wallace, et al., 2018). Another limitation involves the unknown length of time survey respondents have perceived these neighborhoods conditions, leading to exposure misclassification. However, the high test-retest reliability of perceived neighborhood disorder indicates that respondents' perception of disorder within the same neighborhood is stable over time (Brownson, Chang, Eyler, Ainsworth, Kirtland & Saelens, 2004; Brunton-Smith, 2011), reducing the possibility that the relationship between concurrently measured perceived neighborhood disorder and an outcome will be drastically different than if perceived neighborhood disorder is measured shortly before (weeks-months) the outcome. Though racially and ethnically diverse, these results might not apply beyond women who reside in California.

Despite this study's limitations it has contributed to a better understanding of the relationships between racial-ethnic discrimination,

neighborhood disorder, and common risk factors for major chronic diseases in a diverse and population-based sample of women. The high-quality, BRFSS dataset enabled investigation of these relationships while controlling for important demographic, socioeconomic, and acculturation confounders, and adjusting for non-response and coverage biases. Use of IPCW methods minimized the potential for selection bias due to non-differential missingness of the main exposure measures. Though unvalidated, the neighborhood disorder questions queried respondents on perceptions of specific and actual sources of disorder (e.g., crime, traffic, ‘pleasantness’); a property of disorder measures preferred to general and hypothetical sources of disorder (Foster & Giles-Corti, 2008).

Conclusion

The observed significant relationships involving perceived neighborhood disorder and racial-ethnic discrimination on tobacco smoking, monthly alcohol consumption, and physical activity appear to be largely independent of one another, suggesting that they represent unique pathways to these chronic disease risk factors. Future studies investigating perceived environmental factors that might lead to less healthy behaviors or health conditions should simultaneously measure both perceived and observed versions of social and physical disorder, discrimination (institutional and interpersonal), and social capital using validated instruments when available (Cerin, et al., 2006; Krieger, et al., 2005; Mooney, Bader, Lovasi, Neckerman, Teitler & Rundle,

2014; O’Brien, et al., 2015; Ross & Mirowsky, 2001; Sampson, et al., 1997). Emerging work indicates that despite correlations between these constructs (Bjornstrom, et al., 2013; Cerin, et al., 2006; Chen & Yang, 2014; Dawson, et al., 2016; Kramer, et al., 2013; Wallace, et al., 2018) as well as within perceived and observed versions of the same construct (Brunton-Smith, 2011; Franzini, et al., 2008; Hipp, 2010), disentangling the differences remains critical. Knowledge of the unique or interdependent influences of these factors is necessary to understand how, and to what degree, modifiable social and physical environmental factors might contribute to population health.

Declarations of interest

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Ethics statement

The institutional review board of Rutgers University approved this study.

Appendix A

See Table A1.

Table A1
Models of exposure censoring by tobacco use, alcohol consumption and physical activity.^a

	Odds of exposure censoring in tobacco use models (n = 2829, p(y = 1) = 0.19)	Odds of exposure censoring in alcohol consumption models (n = 2763, p(y = 1) = 0.16)	Odds of exposure censoring in physical activity models (n = 2598, p(y = 1) = 0.11)
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age (year)	0.99 (0.98–0.99)	0.99 (0.98–0.99)	0.99 (0.98–1.00)
Race-ethnicity			
White	1.00	1.00	1.00
Latino/Hispanic	1.04 (0.74–1.47)	1.14 (0.79–1.63)	1.33 (0.87–2.04)
African American	0.98 (0.56–1.69)	1.06 (0.6–1.88)	1.07 (0.52–2.21)
Marital status			
Separated/divorced/widowed/ never married	1.00	1.00	1.00
Married/unmarried couple	1.01 (0.77–1.34)	1.09 (0.82–1.45)	1.02 (0.74–1.41)
Education			
≥ 4-year college	1.00	1.00	1.00
Some college or associate's degree	1.12 (0.78–1.59)	1.1 (0.76–1.58)	0.87 (0.54–1.41)
High school diploma or equivalent	1.63 (1.1–2.42)	1.41 (0.94–2.12)	1.50 (0.95–2.38)
< High school	1.5 (0.9–2.5)	1.24 (0.72–2.14)	1.41 (0.77–2.58)
Income (\$10,000)	0.99 (0.95–1.03)	0.99 (0.95–1.03)	1.00 (0.95–1.04)
Survey language			
Spanish	1.00	1.00	1.00
English	0.94 (0.6–1.47)	1.05 (0.65–1.7)	1.00 (0.60–1.67)
Current tobacco smoker			
No	1.00		
Yes	1.02 (0.7–1.48)		
Monthly alcohol consumption (serving)		1 (0.99–1.01)	
Weekly aerobic physical activity (100 min.)			0.96 (0.91–1.00)

^a Exposure censoring is due to participant non-response to questions related to neighborhood disorder or racial-ethnic discrimination

Appendix B

See [Table B1](#).

Table B1

Model estimates of current tobacco use by levels of perceived neighborhood disorder and racial-ethnic discrimination without accounting for missing data through IPCW, California Behavioral Risk Factor Surveillance System, 2013.^a

	Current tobacco smoker OR (95% CI)
Perceived neighborhood disorder score (per 1 point)	1.14 (1.06–1.22)
Racial-ethnic discrimination	
No	1.00
Yes	1.52 (1.05–2.18)

^a Adjusted for age, marital status, race-ethnicity, education, income, survey language, neighborhood disorder and racial-ethnic discrimination

Appendix C

See [Table C1](#).

Table C1

Model estimates of average monthly alcohol use and weekly aerobic physical activity duration by perceived neighborhood disorder and racial-ethnic discrimination without accounting for missing data through IPCW, California Behavioral Risk Factor Surveillance System, 2013.^{a,b}

	<u>Monthly Alcoholic Drink Consumption</u> PR (95% CI)
Perceived neighborhood disorder score ^b	See Figure Appendix D
Racial-ethnic discrimination x Race-ethnicity	
Among White	
Racial-ethnic discrimination	
No	1.00
Yes	0.92 (0.64–1.32)
Among Latino/Hispanic	
Racial-ethnic discrimination	
No	1.00
Yes	1.66 (1.17–2.35)
Among African American	
Racial-ethnic discrimination	
No	1.00
Yes	1.98 (1.03–3.82)
	<u>Weekly Physical Activity Duration</u> PR (95% CI)
Perceived neighborhood disorder score	1.01(0.97–1.05)
Racial-ethnic discrimination x Race-ethnicity	
Among White	
Racial-ethnic discrimination	
No	1.00
Yes	1.14 (0.83–1.55)
Among Latino/Hispanic	
Racial-ethnic discrimination	
No	1.00
Yes	1.23 (0.93–1.63)
Among African American	
Racial-ethnic discrimination	
No	1.00
Yes	0.72 (0.42–1.23)

^a Adjusted for age, marital status, race-ethnicity, education, income, survey language

^b PR = Prevalence ratio

Appendix D

See Fig. D1.

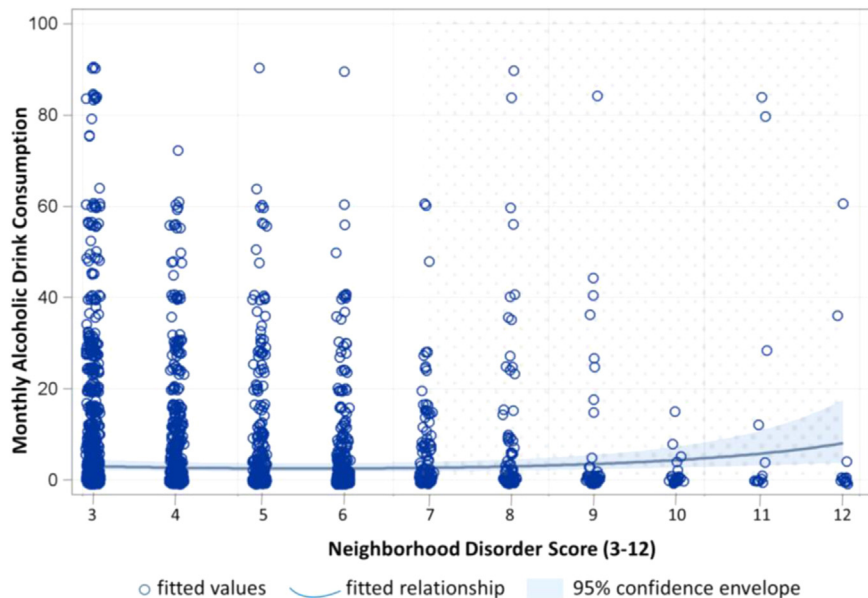


Fig. D1. Estimated alcohol use by perceived neighborhood disorder score, California Behavioral Risk Factor Surveillance System, 2013. Adjusted for age, marital status, race-ethnicity, education, income, survey language, racial-ethnic discrimination, and race-ethnicity x racial-ethnic discrimination. Stippled regions denote $P < 0.05$ for Chi-square test of $\beta = 0$, where β is the change in monthly alcohol consumption associated with an increase of 1 perceived neighborhood disorder score, tested at each observable score (3–12). Fitted values are randomly jittered to show frequency.

Appendix E

See Fig. E1.

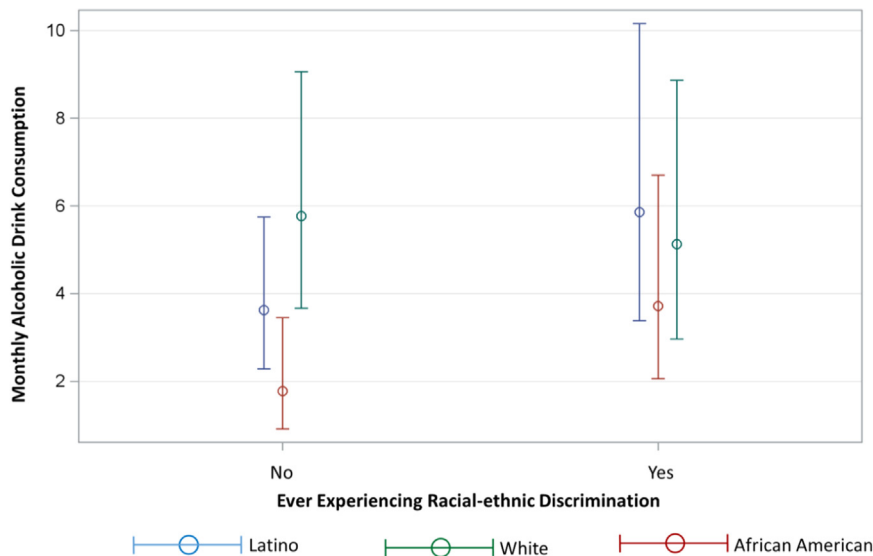


Fig. E1. Estimated monthly alcohol consumption (drinks) by race or ethnicity and racial-ethnic discrimination, California Behavioral Risk Factor Surveillance System, 2013. Estimated at: age = 40, marital status = 'Widowed, divorced, separate, never married', education = 'less than a high school diploma', annual household income = \$77,500, survey language = English, perceived neighborhood disorder score = 4.7.

Appendix F

See Fig. F1.

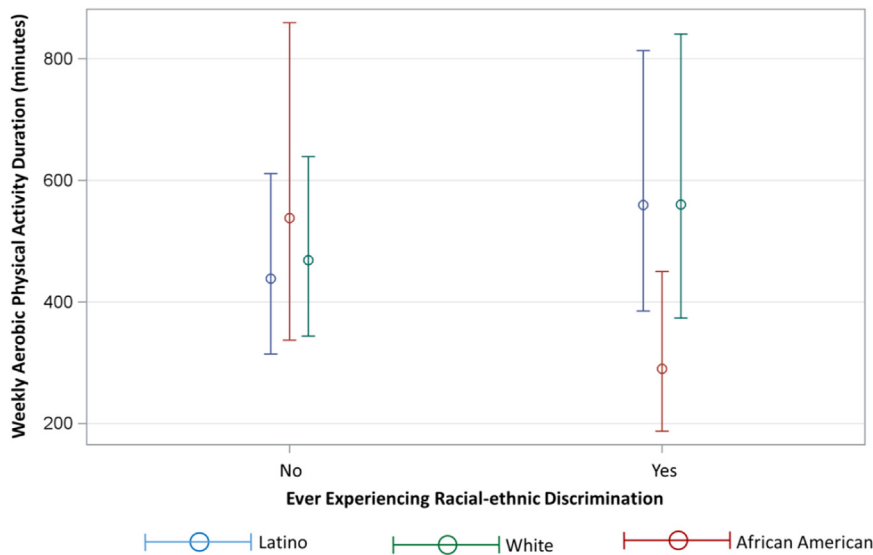


Fig. F1. Estimated aerobic physical activity duration by race or ethnicity and racial-ethnic discrimination, California Behavioral Risk Factor Surveillance System, 2013. Estimated at: age = 40, marital status = 'Widowed, divorced, separate, never married', education = 'less than a high school diploma', annual household income = \$77,500, survey language = English, perceived neighborhood disorder score = 4.7.

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