

ORIGINAL ARTICLE

# Social Determinants of Adherence to COVID-19 Risk Mitigation Measures Among Adults With Cardiovascular Disease

**BACKGROUND:** Social determinants of health (SDOH) may limit the practice of coronavirus disease 2019 (COVID-19) risk mitigation guidelines with health implications for individuals with underlying cardiovascular disease (CVD). Population-based evidence of the association between SDOH and practicing such mitigation strategies in adults with CVD is lacking. We used the National Opinion Research Center's COVID-19 Household Impact Survey conducted between April and June 2020 to evaluate sociodemographic disparities in adherence to COVID-19 risk mitigation measures in a sample of respondents with underlying CVD representing 18 geographic areas of the United States.

**METHODS:** CVD status was ascertained by self-reported history of receiving heart disease, heart attack, or stroke diagnosis. We built de novo, a cumulative index of SDOH burden using education, insurance, economic stability, 30-day food security, urbanicity, neighborhood quality, and integration. We described the practice of measures under the broad strategies of personal protection (mask, hand hygiene, and physical distancing), social distancing (avoiding crowds, restaurants, social activities, and high-risk contact), and work flexibility (work from home, canceling/postponing work). We reported prevalence ratios and 95% CIs for the association between SDOH burden (quartiles of cumulative indices) and practicing these measures adjusting for age, sex, race/ethnicity, comorbidity, and interview wave.

**RESULTS:** Two thousand thirty-six of 25 269 (7.0%) adults, representing 8.69 million in 18 geographic areas of the United States, reported underlying CVD. Compared with the least SDOH burden, fewer individuals with the greatest SDOH burden practiced all personal protection (75.6% versus 89.0%) and social distancing measures (41.9% versus 58.9%) and had any flexible work schedule (26.2% versus 41.4%). These associations remained statistically significant after full adjustment: personal protection (prevalence ratio, 0.83 [95% CI, 0.73–0.96];  $P=0.009$ ), social distancing (prevalence ratio, 0.69 [95% CI, 0.51–0.94];  $P=0.018$ ), and work flexibility (prevalence ratio, 0.53 [95% CI, 0.36–0.79];  $P=0.002$ ).

**CONCLUSIONS:** SDOH burden is associated with lower COVID-19 risk mitigation practices in the CVD population. Identifying and prioritizing individuals whose medical vulnerability is compounded by social adversity may optimize emerging preventive efforts, including vaccination guidelines.

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## WHAT IS KNOWN

- Social determinants of health (SDOH) pose challenges to the privilege of practicing recommended coronavirus disease 2019 (COVID-19) risk mitigation measures among individuals with unfavorable socioeconomic profile.
- Coronavirus exposure factors, rather than susceptibility from comorbidities, may have a greater mediating role in COVID-19–related disparities among those with greater SDOH burden.

## WHAT THE STUDY ADDS

- Population-based evidence of the greater SDOH burden associated with lower adherence to COVID-19 risk mitigation practices. Compared with those with the least SDOH burden, 76% (versus 89%) and 42% (versus 59%) of those with the highest SDOH burden reported practicing all personal protective measures and social distancing measures. Twenty-six percent of individuals with the greatest SDOH burden could afford flexible work schedules compared with 41% of those with the least distress.
- Our study supplements the call to identify and prioritize for vaccination and culturally competent health messaging, socially vulnerable populations whose limitation in adhering to the mitigation measures perpetuates the disparities in COVID-19.

The health burden of coronavirus disease 2019 (COVID-19)–related morbidity<sup>1</sup> and excess mortality<sup>2,3</sup> stress the need for strict adherence to risk mitigation measures, including hand hygiene, respiratory etiquette (including the wearing of face mask), physical distancing (at least 6 feet from people outside of household), and social distancing recommendations, to slow the spread of the disease.<sup>4–6</sup> However, various social and environmental conditions, defined collectively as social determinants of health (SDOH), pose challenges to practicing recommended safety measures.<sup>7,8</sup>

Current evidence suggests population and individual-level SDOH measures, such as neighborhood income, area deprivation, and health literacy, may impact adherence to risk mitigation measures.<sup>7,9–11</sup> Practicing social distancing has been described as a privilege from favorable socioeconomic status.<sup>12–14</sup> These social barriers become particularly relevant in populations clinically vulnerable to adverse COVID-19 outcomes, like individuals with cardiovascular disease (CVD).<sup>15,16</sup> To the best of our knowledge, no large-scale study has evaluated the extent to which cumulative social disadvantage for individuals impacts adherence to COVID-19 risk mitigation measures in adults with CVD.

In this study, we aimed to describe adherence to COVID-19 risk mitigation measures among patients with CVD and evaluate the association between cumulative

SDOH burden and adherence to such measures in a representative sample of adults with CVD in the United States. We hypothesized that individuals with greater social disadvantage would be less likely to practice personal protection, social distancing, and work flexibility recommendations.

## METHODS

The data and program codes that support the findings of this study are available from the corresponding author upon request.

### Study Design and Sampling Methodology

In this cross-sectional study, we used publicly available data from the COVID-19 Household Impact Survey.<sup>17</sup> Funded by the Data Foundation and conducted by the National Opinion Research Center at the University of Chicago, this survey was designed to provide statistics about health, economic security, and social dynamics of the US adult household population nationwide and for 18 geographic areas. The geographic areas include 10 states and 8 metropolitan statistical areas. The states are California, Colorado, Florida, Louisiana, Minnesota, Missouri, Montana, New York, Oregon, and Texas, and the metropolitan statistical areas are Atlanta-Sandy Springs-Alpharetta, Georgia; Baltimore-Columbia-Towson, Maryland; Birmingham-Hoover, Alabama; Chicago-Naperville-Elgin, Illinois-Indiana-Wisconsin; Cleveland-Elyria, Ohio; Columbus, Ohio; Phoenix-Mesa-Chandler, Arizona; and Pittsburgh, Pennsylvania.

The study surveyed adults ≥18 years of age from the nationally representative AmeriSpeak sample and an address-based sample (ABS) of adults living in the 18 geographic areas. The AmeriSpeak sample—a probability-based sample—is selected from the National Opinion Research Center's AmeriSpeak panel using strata based on age, race/Hispanic ethnicity, education, and sex. For the ABS sample, the sampling frame is based on an extract of the US Postal Service delivery-sequence file. Details of sampling approaches and sampling weight derivations (with nonresponse adjustment) for both AmeriSpeak and ABS panels are provided in Methods in the [Data Supplement](#). There were 3 waves of survey interviews conducted in English and Spanish, over the web or by telephone: week 1 (April 20, 2020, to April 26, 2020), week 2 (May 4, 2020, to May 10, 2020), and week 3 (May 30, 2020, to June 8, 2020). We merged data from all 3 interview waves for both AmeriSpeak and ABS survey panels in our analyses. Survey items assessed biographical characteristics, socioeconomic well-being before and during the pandemic, comorbidity burden, COVID-19 symptoms experienced, measures taken in response to COVID-19, and social relationships before and during the pandemic. The items were adapted from established national surveys like the Current Population Survey, American Community Survey, Understanding America Study, and other online platforms, surveys, and instruments. A [Data Supplement](#) and a link to the survey questionnaire (<https://www.covid-impact.org/about-the-survey-questionnaire>) are provided. Since the National Opinion Research Center's COVID-19 Household Impact Survey data are publicly available and deidentified, no institutional review board approval was required for the study.

## Study Cohort Selection

We included all adults >18 years of age, with a positive history of CVD. Survey participants who responded “Yes” to the item “Has a doctor or other health care provider ever told you that you have any heart disease, heart attack or stroke?” were considered to have a history of CVD.

## Study Variables

### Independent Variable

We built, de novo, a cumulative index of SDOH burden using 12 factors across 6 SDOH domains from the Kaiser Family Foundation SDOH framework.<sup>18</sup> The domains are economic stability, neighborhood/physical environment, education, food, community/social context, and health care system (Figure 1).

Economic stability included employment (employed/retired versus previously/never employed), total household income in 2019 ( $\geq$ \$100 000 versus \$50 000 to  $<$ \$100 000 versus  $<$ \$50 000), the ability to pay an unexpected \$400 expense (pay in full using cash or its equivalent versus unable to pay in full now versus unable to pay at all), and the application or receipt of income or other forms of assistance (neither applied nor received any assistance versus applied, received, or tried to apply for assistance). For neighborhood/physical environment, education, and community/social context, respondents reported their type of developed human settlement (suburban/urban versus rural dwelling), highest education ( $\geq$ bachelor's degree versus some college versus  $\leq$ high school diploma/equivalent), neighborhood quality (trust in neighbors and communication with neighbors), and social integration through volunteering (yes/no), respectively. Health care system comprised insurance (any insurance plan versus uninsured/Indian health only). Food domain was assessed with 30-day food insecurity items (“In the last 30 days, we worried our food would run out before we got money to buy more” and “In the last 30 days, the food that we bought just did not last, and we did not have money to get more”) and a Likert scale (never true [score 0], sometimes true [score 1], and often true [score 2]). We categorized respondents as food secure, marginally food secure, or food insecure from the aggregate of the 2 items (0, 1–2,  $\geq$ 3, respectively; Table I in the [Data Supplement](#)).

Each factor was assigned a value of 0 if favorable (eg, bachelor's degree or above, any insurance plan, employed/retired, and  $\geq$ \$100 000) and 1 or 2 if unfavorable (based on the level of disadvantage; Table I in the [Data Supplement](#)). The cumulative score for an individual was calculated as the sum of the responses to the items and ranged from 0 to 15. We ranked the scores by quartiles using the following cutoff values: 4 (25th percentile), 6 (50th percentile), and 8 (75th percentile). Higher quartiles corresponded to greater SDOH burden.

### Dependent Variables

Participants responded “Yes” or “No” to the item “Which of the following measures, if any, are you taking in response to the coronavirus?” for 19 measures that applied (Table II in the [Data Supplement](#)). For our analyses, we used 9 of the measures: wear a face mask, keep 6 feet distance from those outside a respondent's household (physical distancing), wash or sanitize hands, cancel/postpone pleasure, social, or recreational activities, avoid public/crowded places, avoid restaurants, avoid high-risk contact, work from home, and cancel/postpone work activities.

We categorized the 9 measures into 3 broad mutually exclusive mitigation strategies, personal protection, social distancing, and work flexibility, in response to COVID-19. Measures under personal protection strategy included wearing a face mask, washing/sanitizing hands, and physical distancing. Social distancing comprised canceling/postponing pleasure, social, or recreational activities, avoiding public/crowded places, avoiding restaurants, and avoiding high-risk contact. Flexible work schedules comprised working from home and canceling/postponing work activities.

We categorized respondents' level of adherence according to the number of measures practiced for each strategy. Where appropriate, respondents practiced no measure, only one measure, some but not all measures, and all measures of each broad mitigation strategy.

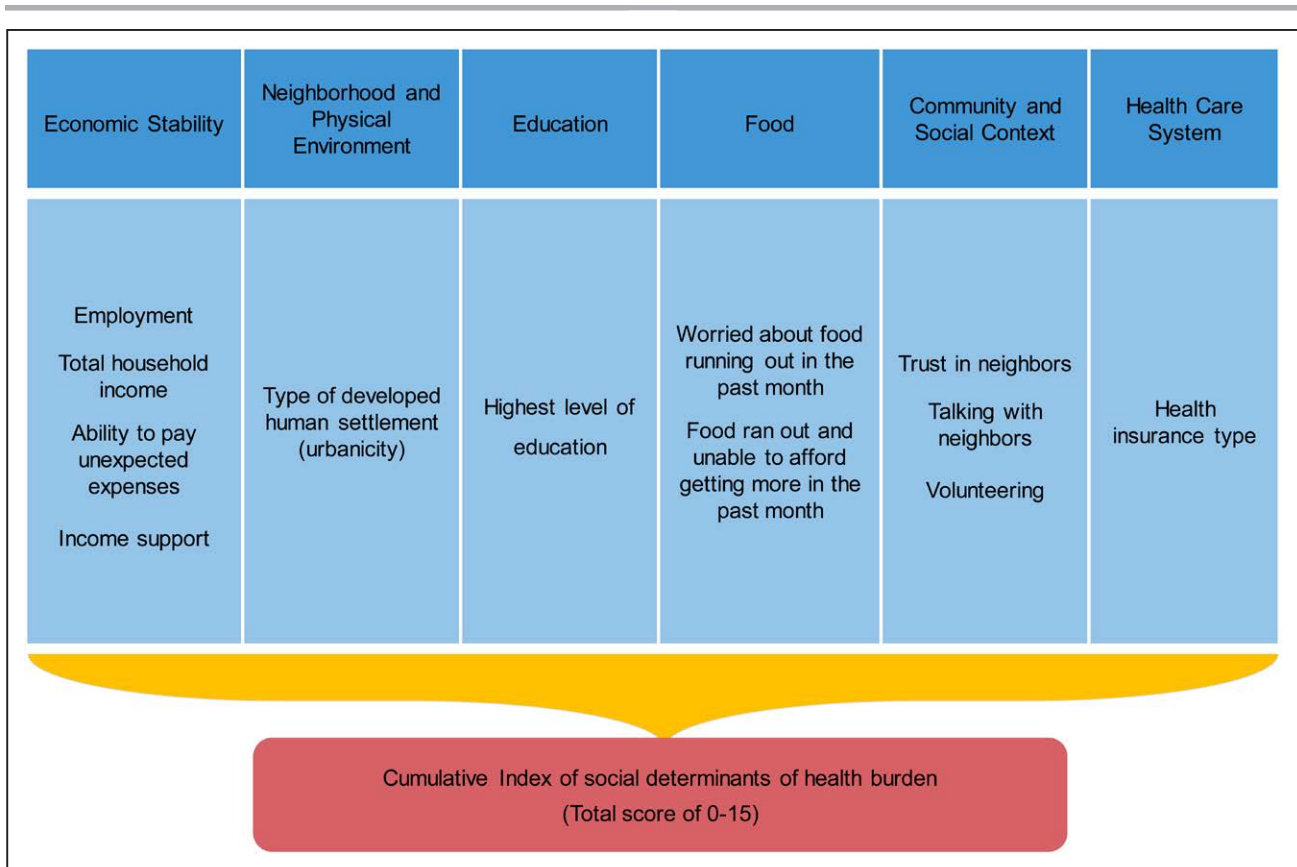
### Covariates and Other Variables

Age (18–44, 45–59, and  $\geq$ 60 years), sex (male/female), race/ethnicity (Hispanic, non-Hispanic White, non-Hispanic Black, non-Hispanic Asian, and non-Hispanic other), and comorbidity score were used as covariates. Participants responded “Yes” or “No” to a personal history of the following medical conditions: diabetes, high blood pressure or hypertension, asthma, chronic lung disease and chronic obstructive pulmonary disease, bronchitis and emphysema, allergies, a mental health condition, cystic fibrosis, liver disease or end-stage liver disease, cancer, a compromised immune system, and overweight or obesity. Consequently, we categorized participants as having 0, 1 to 2, or  $\geq$ 3 comorbidities.<sup>19</sup> A participant's history of COVID-19 was ascertained through a “Yes” or “No” response to the item, “Has a doctor or other health care provider ever told you that you have COVID-19?”.

## Statistical Analysis

To provide representative estimates, prederived sampling weights, adjusted for nonresponse, were utilized in our analyses.<sup>17</sup> We described sociodemographic and clinical characteristics of and the distribution of SDOH burden index by CVD status in the analytic sample using appropriate summary statistics. We described and compared with  $\chi^2$  tests the proportion of individuals with CVD adhering to the individual mitigation measures across quartiles of the cumulative index of the SDOH burden. Further, we described the proportions of adults with CVD practicing none, one, some, and all measures of each COVID-19 mitigation strategy. In the [Data Supplement](#), we described further the distribution of adherence to the COVID-19 risk mitigation measures by age, sex, and race/ethnicity origins in adults with CVD.

We fit separate Poisson regression models to evaluate the association between cumulative SDOH burden and adherence to (1) personal protection guidelines, (2) social distancing strategy, and (3) opportunities for flexible work schedules, using prevalence ratios with robustly estimated 95% CIs.<sup>20,21</sup> For these models, respondents were categorized as practicing all measures (versus less than all measures) of personal protection guidelines and social distancing strategy. For the practical reason of many jobs usually able to offer one of the two flexible work schedules, we categorized work flexibility as affording at least one flexible schedule as against no flexible schedule. Multivariable models adjusted for the potentially confounding variables: age, sex, race/ethnicity, comorbidity



**Figure 1.** Social determinants of health and the cumulative Social Determinants of Health Index.

burden, and interview wave.<sup>22-25</sup> For each outcome, we evaluated a linear dose-response relationship between cumulative SDOH index and the practice of the preventive strategies by treating the SDOH index as a continuous variable. The item for ascertaining CVD status—“Has a doctor or other health care provider ever told you that you have any heart disease, heart attack or stroke?”—likely restricts a positive response to respondents who would have access to a physician or provider since access to care varies by SDOH burden. Thus, we performed a post hoc analysis to determine whether our regression estimates were robust across health insurance status (uninsured and any insurance plan).

We conducted all analyses using STATA (v.16; STAT Corp, Austin, TX) and used a 2-tailed  $\alpha$ -level of 0.05 for statistical significance. Variables with missingness  $\geq 25\%$  were excluded from all analyses. We developed our models using complete case analysis. Eighty-one percent of observations had complete data, and missingness in race/ethnicity (11%; the highest of the variables of interest) was weakly correlated with the study outcomes. Therefore, we did not impute any missing data.

## RESULTS

The pooled sample of 25269 adults comprised 6475 respondents from the AmeriSpeak panel and 18794 respondents from the ABS panel and represented  $\approx 127.37$  million adults from the 18 geographic regions of the United States. Overall, individuals who reported a CVD diagnosis (7%, representing 8.69

million adults from 18 geographic areas) tended to be  $\geq 60$  years of age (68%), men (54%), non-Hispanic White (67%), and insured (96%; Table 1). Thirty-five percent of adults with CVD had the most SDOH burden. More than half of those with CVD reported earning  $< \$50,000$  in total household income in 2019. About 57% had at least 3 comorbidities, and hypertension was the most prevalent comorbidity (72%). The proportion of adults with CVD who reported ever receiving a COVID-19 diagnosis within the study period was 1.4%. Comparison of baseline characteristics between adults with CVD and those without CVD is shown in Table III in the [Data Supplement](#).

Figure 2 shows the distribution of the cumulative SDOH index in adults with a CVD diagnosis and those without CVD diagnosis. The median SDOH cumulative index for adults with CVD was 6 (interquartile range, 5–8) compared with a median of 6 (interquartile range, 4–8) for those without CVD. In Figures I through III in the [Data Supplement](#), we illustrate the distributions of SDOH burden across age, sex, and race/ethnicity among adults with CVD.

Among adults with CVD, adherence to individual measures under personal protection strategy ranged between 89% to 95% and 66% to 79% for social distancing measures (Table 2). Overall, the proportion of individuals adhering to individual mitigation measures

**Table 1. Sample Characteristics of Adults Who Reported a History of CVD Diagnosis From the COVID-19 Household Impact Survey**

Characteristics	Total	SDOH quartile 1	SDOH quartile 2	SDOH quartile 3	SDOH quartile 4	P value
Sample	2036	543	581	468	444	
Weighted sample	8693672 (7.0)	1358816 (15.6)	1934690 (22.3)	2372160 (27.3)	3028006 (34.8)	
Age strata, y						<0.001
18–44	130 (11.5)	21 (12.8)	18 (3.5)	25 (8.6)	66 (18.5)	
45–59	312 (20.2)	57 (14.6)	63 (14.4)	67 (14.5)	125 (30.9)	
≥60	1594 (68.3)	465 (72.6)	500 (82.1)	376 (77.0)	253 (50.7)	
Sex						<0.001
Male	1156 (54.5)	381 (70.0)	364 (61.6)	248 (57.2)	163 (41.0)	
Female	880 (45.5)	162 (30.0)	217 (38.4)	220 (42.8)	281 (59.0)	
Race/ethnicity						<0.001
Non-Hispanic White	1420 (67.2)	420 (76.9)	427 (80.5)	316 (66.8)	257 (55.0)	
Non-Hispanic Black	177 (12.4)	13 (3.5)	31 (8.2)	53 (13.6)	80 (18.1)	
Non-Hispanic Asian	26 (2.7)	11 (7.6)	7 (2.3)	6 (2.5)	2 (1.0)	
Non-Hispanic other	87 (4.7)	13 (5.4)	19 (3.9)	23 (4.7)	32 (4.9)	
Hispanic	95 (12.9)	13 (6.6)	16 (5.1)	28 (12.4)	38 (21.0)	
Education						<0.001
No high school diploma	81 (10.8)	0	4 (2.4)	25 (7.2)	52 (23.9)	
High school graduate or equivalent	322 (33.7)	4 (6.5)	44 (24.2)	99 (39.7)	175 (47.3)	
Some college	741 (33.3)	73 (21.8)	237 (39.9)	253 (43.9)	178 (25.9)	
BA or above	888 (22.1)	463 (71.8)	296 (33.5)	90 (9.2)	39 (2.9)	
Current employment status						<0.001
Employed or retired	1742 (85.0)	518 (95.8)	531 (94.0)	392 (88.7)	301 (70.9)	
Never or previously employed	235 (15.0)	18 (4.2)	38 (6.0)	58 (11.3)	121 (29.1)	
Total household income in 2019						<0.001
<\$50000	978 (58.2)	28 (3.7)	203 (30.6)	337 (64.3)	410 (93.3)	
\$50000 to <\$100000	623 (27.6)	205 (35.4)	279 (50.0)	111 (32.9)	28 (6.7)	
≥\$100000	371 (14.2)	274 (60.9)	82 (19.4)	11 (2.8)	4 (0.0)	
Developed human settlement type						0.693
Rural	143 (4.8)	9 (4.2)	27 (2.8)	51 (5.8)	56 (5.7)	
Suburban	386 (19.2)	80 (13.5)	126 (19.9)	93 (19.9)	87 (20.7)	
Urban	1507 (76.0)	454 (82.3)	428 (77.3)	324 (74.3)	301 (73.6)	
Health insurance						<0.001
Uninsured	51 (3.8)	1 (0.6)	1 (0.0)	11 (1.5)	38 (9.3)	
Any private	591 (25.6)	222 (49.8)	193 (31.3)	118 (27.3)	58 (9.9)	
Public only	608 (34.2)	73 (9.4)	153 (29.0)	149 (27.2)	233 (54.0)	
Other	766 (36.4)	242 (40.2)	227 (39.7)	184 (44.0)	113 (26.8)	
Comorbidities						
Overweight or obesity	915 (44.3)	221 (36.7)	259 (43.0)	212 (42.5)	223 (50.0)	0.231
Hypertension	1466 (72.4)	361 (60.5)	406 (71.0)	349 (75.1)	350 (76.6)	0.071
Diabetes	661 (36.9)	120 (17.9)	192 (37.8)	173 (35.9)	176 (45.6)	<0.001
Bronchitis and emphysema	384 (23.1)	66 (11.8)	88 (12.7)	112 (29.1)	118 (30.3)	<0.001
No. of comorbidities*						0.003
0	108 (5.0)	29 (5.2)	47 (7.2)	22 (6.9)	10 (1.9)	
1–2	759 (38.1)	267 (55.6)	226 (37.9)	150 (33.9)	116 (33.9)	
≥3	1169 (56.9)	247 (39.2)	308 (54.9)	296 (59.2)	318 (64.2)	
30-d food security						
Worried food will run out in the last 30 d						<0.001

(Continued)

**Table 1. Continued**

Characteristics	Total	SDOH quartile 1	SDOH quartile 2	SDOH quartile 3	SDOH quartile 4	P value
Never	1624 (69.4)	538 (99.6)	546 (96.6)	376 (76.6)	164 (33.2)	
Sometimes	290 (21.4)	3 (0.4)	28 (3.2)	79 (20.0)	180 (43.3)	
Often	113 (9.2)	0	2 (0.2)	11 (3.4)	100 (23.5)	
Food ran out in the last 30 d						<0.001
Never	1732 (76.0)	540 (100.0)	562 (98.9)	416 (85.1)	214 (43.6)	
Sometimes	201 (15.8)	0	13 (1.1)	36 (11.9)	152 (35.3)	
Often	88 (8.2)	0	1 (0.0)	11 (3.0)	76 (21.1)	
Community and social context						
Trust in neighbors						0.351
All or most	1058 (57.4)	347 (65.0)	299 (57.1)	227 (58.5)	185 (53.1)	
Some or none	967 (42.6)	195 (35.0)	279 (42.9)	237 (41.5)	256 (46.9)	
Talking to neighbors						<0.001
Daily or few times a week	1115 (54.5)	380 (74.0)	326 (64.1)	225 (44.5)	184 (47.3)	
Less than daily or few times a week	885 (45.5)	152 (26.0)	250 (35.9)	230 (55.5)	253 (52.7)	
Volunteering	640 (25.5)	306 (51.2)	168 (28.8)	96 (22.7)	70 (14.1)	<0.001

Number (weighted column percentage) shown. Missing data (%): CVD (3.2), sex (0.1), race/ethnicity (11.7), education (0.2), employment (2.3), total household income in 2019 (2.2), developed human settlement type (0.0), insurance (1.4), overweight/obesity (2.2), CVD (3.2), high blood pressure/hypertension (2.9), diabetes (2.8), bronchitis/emphysema (2.3), chronic lung disease/COPD (2.4), worried food will run out (0.4), food ran out in the last 30 d (0.5), trust neighbors (0.3), talking to neighbors (0.3), and volunteering (0.4). BA indicates bachelor's; COVID-19, coronavirus disease 2019; CVD, cardiovascular disease; and SDOH, social determinants of health.

\*Comorbid conditions include diabetes, asthma, bronchitis or emphysema, other chronic lung disease, allergies, mental health condition, cystic fibrosis, liver disease, and a compromised immune system.

decreased with greater SDOH burden; this negative trend was statistically significant for canceling/postponing pleasure, social, or recreational activities ( $P=0.032$ ) and working from home ( $P=0.001$ ; Table 2). Report of working from home due to coronavirus among respondents with the most favorable SDOH profile (first quartile) was >2-fold that of those with the greatest burden (32% versus 12%; Table 2). The highest SDOH burden (fourth quartile) compared with the first quartile was associated with fewer individuals practicing all personal protection measures (75.6% versus 89.0%), all social distancing measures (41.9% versus 58.9%), and affording at least 1 flexible work schedule (26.2% versus 41.4%; Figure 3). We showed the trends in the practice of the broad mitigation strategies across the interview waves in Figure IV in the [Data Supplement](#). Table IV in the [Data Supplement](#) and Figures V through XIII in the [Data Supplement](#) further detail the levels of adherence to individual mitigation measures and broad mitigation strategies across age, sex, and race/ethnicity categories by SDOH profile, respectively.

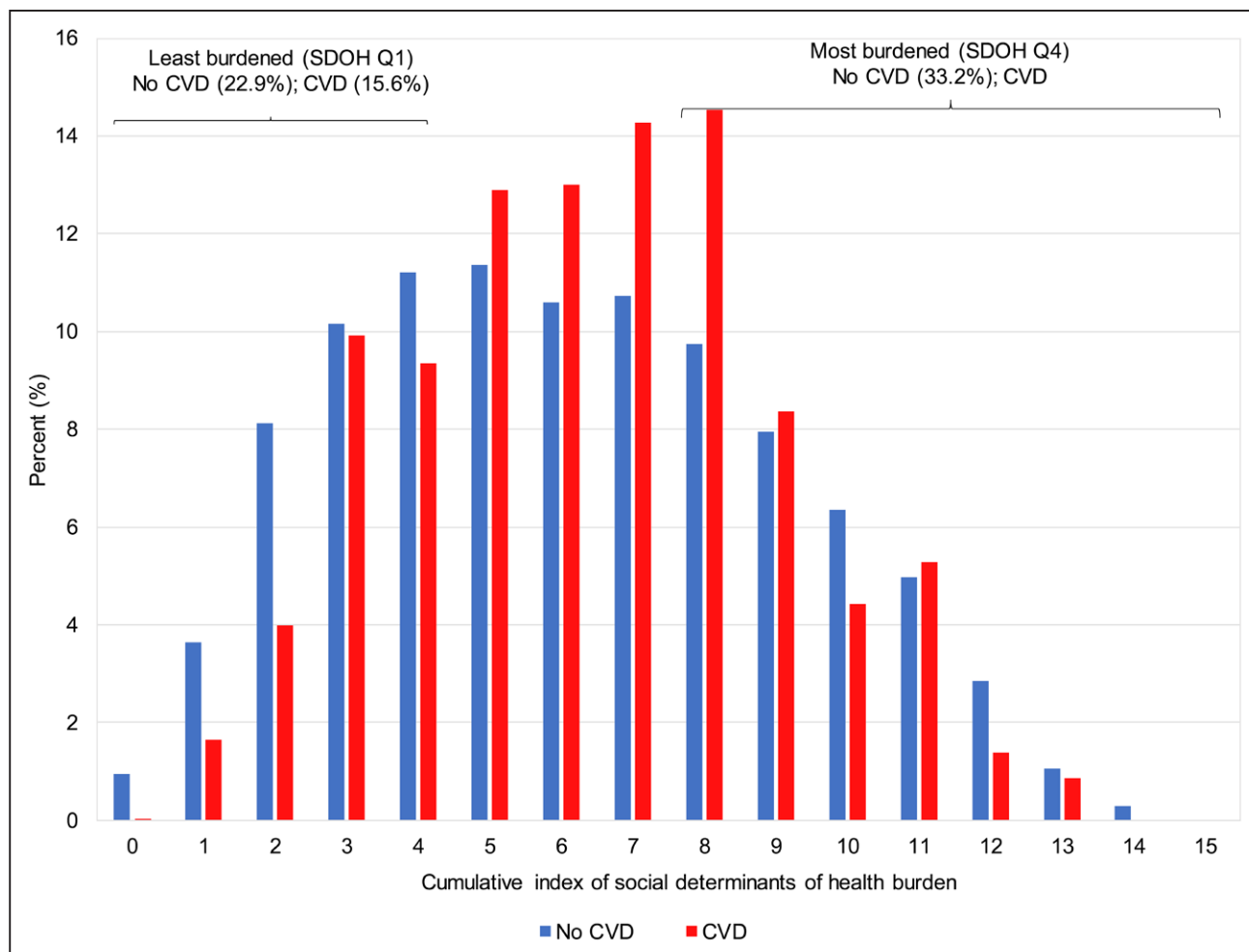
In fully adjusted models, a higher SDOH burden was associated with a lower likelihood of adhering to all measures of each broad mitigation strategy (Figure 4). Compared with the most favorable quartile, the highest SDOH burden (fourth quartile) was associated with lower likelihood of reporting adherence to all measures of personal protection (prevalence ratio, 0.83 [95% CI, 0.73–0.96];  $P=0.009$ ), lower likelihood of adhering to all social distancing measures (prevalence ratio, 0.69 [95% CI,

0.51–0.94];  $P=0.018$ ), and lower likelihood of affording any flexible work schedule (prevalence ratio, 0.53 [95% CI, 0.36–0.79];  $P=0.002$ ). We observed a statistically significant linear dose-response relationship between SDOH index and work flexibility ( $P=0.003$ ). Conversely, the  $P$  for linear trend was not statistically significant for personal protection ( $P=0.060$ ) and for social distancing ( $P=0.067$ ). Limited sample size (only 2 uninsured respondents in the first 2 quartiles of SDOH scores) precluded the posthoc analysis by insurance status.

## DISCUSSION

In this study of a representative sample of US adults with CVD, a higher SDOH burden was associated with a lower likelihood of adherence to COVID-19 risk mitigation strategies including personal protection, social distancing, and flexible work schedules. Our study is the first to analyze practices related to COVID-19 risk mitigation using a cross-sectional cumulative SDOH burden approach and to do so in a representative sample with CVD, a comorbidity with implications for COVID-19 severity.<sup>16,26,27</sup> We add to growing evidence that socially disadvantaged populations face multiple barriers to healthy living, including limited capacity to optimally engage in COVID-19 risk mitigation approaches.<sup>8,14</sup>

Newer patient-centered care models, aimed at improving quality of care and ameliorating health-related disparities, encourage collection and application of SDOH information.<sup>18,28</sup> To date, most quantitative



**Figure 2.** Distribution of the Social Determinants of Health (SDOH) Index among respondents of Coronavirus Disease 2019 (COVID-19) Impact Survey by cardiovascular disease (CVD) status.

The index was developed by aggregating the following SDOH factors: employment, total household income in 2019, ability to pay unexpected \$400 expense, application/receipt of a form of income assistance, type of developed human settlement, highest education attained, health insurance, neighborhood quality, volunteering, and 30-d food security. Proportions of individuals with and without CVD with the least (<25th percentile: first quartile) and the greatest ( $\geq$ 75th percentile: fourth quartile) SDOH burden are shown. SDOH Q indicates quartile of social determinants of health cumulative index.

studies have utilized either population-level measures of SDOH risk or singular individual-level determinants in characterizing the association between SDOH and COVID-19 risk and outcomes.<sup>29–32</sup> For example, 1 study used county-level data on area deprivation in neighborhoods in Louisiana to report a positive association between neighborhood disadvantage and COVID-19 infection risk.<sup>9</sup> Aggregate scores that capture the cumulative social disadvantage at both the individual and population levels have recently been developed in evaluating the association between social risks and CVD risk and outcomes.<sup>33–35</sup> In the context of COVID-19, we made a unique effort of using a cross-sectional multidimensional measure of social disadvantage to evaluate adherence to preventive strategies against COVID-19.

Socially disadvantaged individuals are more likely to depend on public transport for mobility, live in multigenerational households and experience physical crowding during lockdowns, and are less likely to have jobs with

telecommuting opportunities. Emerging data suggest a lesser mediating role by comorbidity in favor of coronavirus exposure factors in the sociodemographic disparities in COVID-19–related infections and clinical outcomes.<sup>22,29</sup> Vahidy et al<sup>29</sup> reported the role of population density and income in explaining infection rate disparities in non-Hispanic Black populations and Hispanic populations. In a systematic review of 37 fair-quality cohort and cross-sectional studies and 15 good-quality ecological studies, Mackey et al<sup>22</sup> reported from 7 studies, low-quality evidence of COVID-19–related disparities decreased or attenuated after adjustment for exposure factors and health care access.

While adherence to individual mitigation measures tended to decrease with social disadvantage, we observed statistically significant disparities in measures that promote social distancing, including work-from-home opportunity and the ability to cancel or postpone social, recreational, or pleasure activities. In the United States, <30% of workers, usually not of essential services, can

**Table 2. COVID-19 Risk Mitigation Practices Across Quartiles of Cumulative SDOH Index Among Individuals With Cardiovascular Disease**

	Total	SDOH Q1	SDOH Q2	SDOH Q3	SDOH Q4	P value
Sample, n	2036	543 (15.6)	581 (22.3)	468 (27.3)	444 (34.8)	
Personal protection strategy, weighted percentage (95% CI)						
Wear mask	88.6 (85.2–91.3)	93.4 (88.4–96.3)	89.9 (84.9–93.3)	90.3 (83.5–94.5)	84.3 (76.1–90.0)	0.106
Wash/sanitize hands	94.6 (92.1–96.3)	96.1 (91.3–98.3)	98.0 (94.8–99.2)	93.3 (88.3–96.3)	92.6 (86.3–96.1)	0.129
Keep at least 6 feet from people outside of household	89.6 (86.3–92.1)	96.0 (93.1–97.7)	89.6 (82.6–94.0)	87.2 (80.1–92.0)	88.4 (81.3–93.1)	0.172
Social distancing strategy, weighted percentage (95% CI)						
Cancel or postpone recreational activities	66.8 (61.9–71.4)	80.6 (70.9–87.6)	69.3 (61.1–76.5)	64.9 (55.2–73.6)	60.5 (50.8–69.5)	0.032
Avoid public/crowded places	79.4 (74.9–83.3)	88.2 (82.5–92.3)	83.7 (77.0–88.7)	73.1 (63.6–80.9)	77.7 (67.8–85.3)	0.054
Avoid restaurants	73.9 (69.4–77.9)	83.9 (77.1–89.0)	73.1 (65.3–79.7)	67.2 (57.6–75.6)	75.0 (66.2–82.1)	0.068
Avoid high-risk contact	66.3 (61.7–70.5)	68.9 (59.6–76.9)	66.3 (58.5–73.2)	59.4 (50.0–68.3)	70.4 (61.6–77.9)	0.225
Work flexibility, weighted percentage (95% CI)						
Work from home	17.1 (14.2–20.6)	31.7 (24.5–39.9)	18.9 (13.7–25.5)	13.9 (9.0–20.9)	12.0 (7.2–19.4)	0.001
Cancel or postpone work	19.1 (15.9–22.7)	22.2 (15.8–30.3)	17.6 (13.2–23.2)	16.4 (10.8–24.3)	20.6 (14.5–28.5)	0.607

Number (weighted column percentage) shown. Missing data (%): no missing data. COVID-19 indicates coronavirus disease 2019; and SDOH Q, quartile of social determinants of health cumulative index.

afford to work from home.<sup>36</sup> Essential worker positions, such as those in the service industry, tend to involve contact with people and are less likely to have benefits such as paid sick leave, leaving such workers at greater risk of contracting the coronavirus.<sup>37</sup> The ability to work from home has been reported to differ by race and ethnicity with Asians most likely to have telecommuting opportunities (37%) and Hispanics the least likely (16%).<sup>36</sup> Comparably, our study showed 40% of non-Hispanic Asians with CVD could afford to work from home during the pandemic, compared with only 9% of Hispanics and 13% of non-Hispanic Blacks with CVD with such opportunity (Table IV in the [Data Supplement](#)).

The lack of culturally competent health messaging on personal protection and social distancing may be contributing to ineffective messaging among certain communities that are made up mostly of African American individuals. In a nationally representative survey of African Americans under shelter-in-place orders, the authors reported suboptimal compliance to social distancing recommendations and suggested lower access to culturally responsive health information as contributory.<sup>11</sup>

Our results may inform COVID-19 vaccination policies that are seeking to prioritize the most vulnerable groups in a period where vaccine availability is limited.

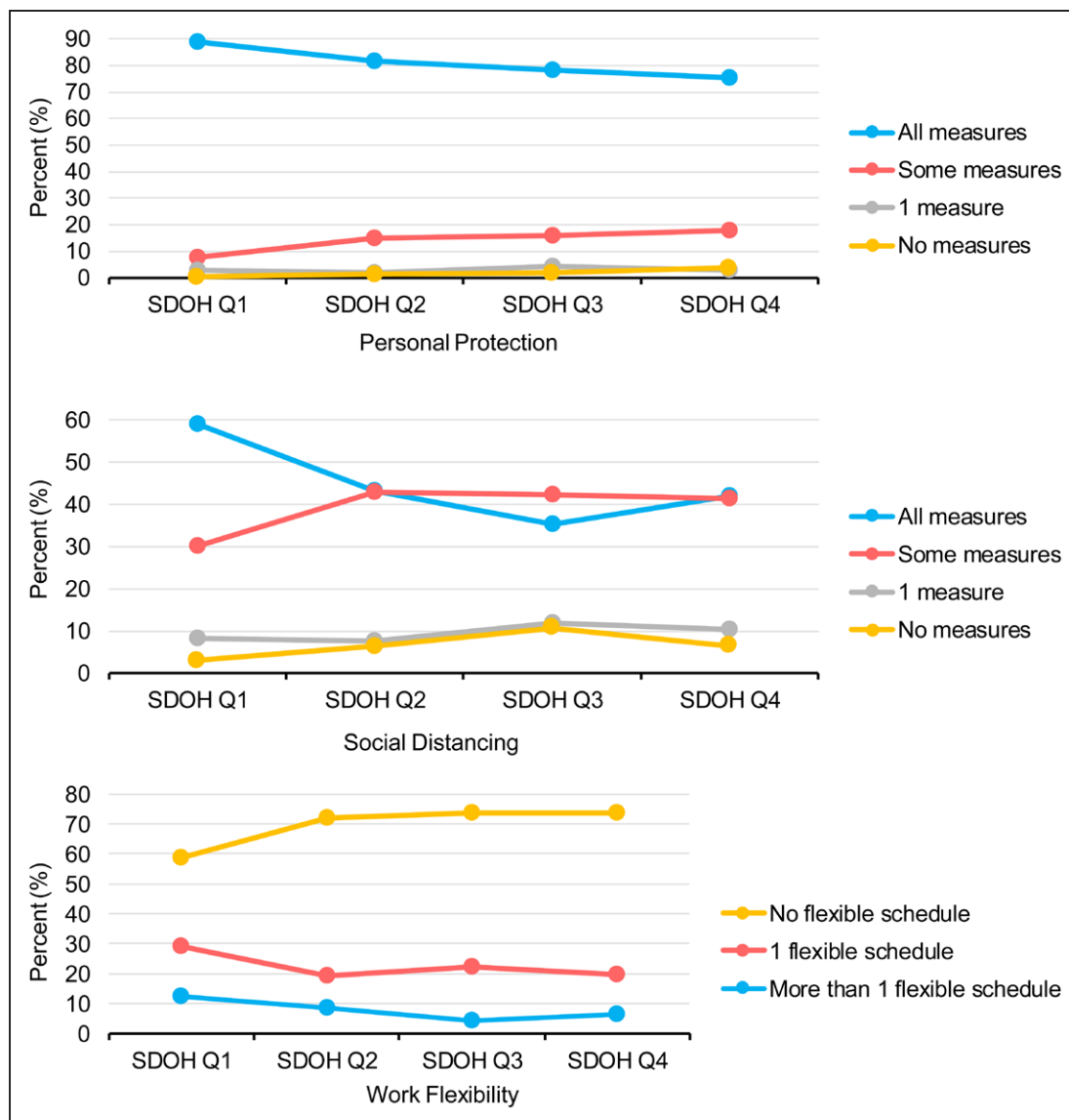
There are some strengths to this study. While previous studies on the COVID-19 pandemic and SDOH evaluated either single individual-level or population-level social characteristics, this is the first study that utilized an aggregate of multiple SDOH features to characterize inequalities. Sampling weight derivation adjusted for non-response, minimizing the bias in our estimates. Also, we used data from a dedicated COVID-19 survey of a representative sample of US adults with SDOH information.

## Study Limitations

Our study has some limitations as well. First, all variables of interest including CVD status, SDOH variables, and medical conditions were self-reported, which may have resulted in information bias or recall bias. Importantly, there was a lower CVD prevalence in our sample when compared with other national estimates (7% versus 9%).<sup>38</sup> Our study utilized analytic weights that extrapolate estimates to adults living in 18 geographic areas of the nation, which may not be representative of the burden of CVD of the entire country.

High SDOH burden is associated with limited knowledge and awareness about CVD. Further, the item for ascertaining CVD status, "Has a doctor or other health care provider ever told you that you have any heart disease, heart attack or stroke?" likely restricts a positive response to respondents who would have access to a clinician, since access to care varies by SDOH burden. These may underestimate the relationship between SDOH burden and adherence to COVID-19 risk mitigation measures. Second, the fixed time frame of the survey, April to June 2020, implies that our data would not capture health-related behaviors that may evolve at various phases of the pandemic (eg, decision fatigue). Further, the parameters used to develop the cumulative index of SDOH are not exhaustive. The COVID Impact survey lacks data on determinants like housing quality, built environment and walkability, transportation, and proximity to health care facility.<sup>18</sup> Additionally, some of the domains, like food, were not adequately captured, posing potential misclassification of SDOH burden. There were only 2 items for the 30-day food security scale<sup>39</sup>—a scale already less sensitive





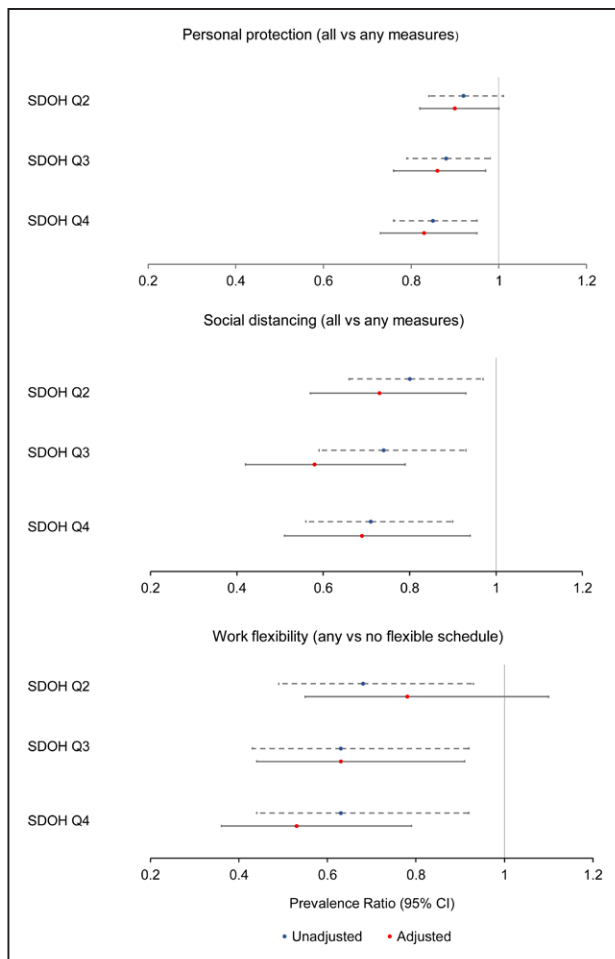
**Figure 3.** Adherence to broad coronavirus disease 2019 (COVID-19) risk mitigation strategies by social determinants of health (SDOH) burden among adults with cardiovascular disease.

The personal protection strategy comprises wearing a face mask, washing/sanitizing hands, and physical distancing of 6 feet from nonhousehold person. The social distancing strategy comprises canceling/postponing pleasure, social or recreational activities, avoiding public/crowded places, avoiding restaurants, and avoiding high-risk contact. The work flexibility strategy comprises working from home and canceling/postponing work activities. Some measures means >1 measure but not all the measures simultaneously. Results presented as proportion of individuals in each quartile practicing the number of measures of each broad strategy. SDOH Q indicates quartile of social determinants of health cumulative index.

than the 12-month alternative in identifying food-insecure households. Despite these issues, our analysis is the most comprehensive to date in terms of SDOH domains included.

Though we adjusted for demographic and clinical factors, the categorical nature of the covariates may have led to loss of information and potential residual confounding. Categorization of the SDOH indices by quartiles—a data-driven method—might limit the generalizability of our estimates and the statistical efficiency of the analyses.<sup>40</sup> However, quantile categorization of the index allowed us to rank respondents by levels of SDOH burden in the absence of clinically

relevant cutoff values. We also viewed the relative risk type measure of association from the categorization of the independent variable as a more intuitive measure of association rather than a  $\beta$ -coefficient change. Finally, in our linear dose-response evaluation, we treated SDOH index as a continuous independent variable. Further, the contributory variables of the SDOH index have considerable interplay and correlations for which more rigorous statistical methods will be needed to produce an appropriately weighted score. Nevertheless, given the upstream nature of SDOH and the paucity of validated and transportable instruments of the SDOH profile, such crude analysis is informative.



**Figure 4.** Prevalence ratios for associations between quartiles of the Social Determinants of Health Index (SDOH Q; quartile 1 as reference category) and the practice of all (vs less than all) measures of personal protective strategy, all (vs less than all) measures of social distancing strategy, and affording any (vs no) flexible work schedule among adults with cardiovascular disease.

Model 1: unadjusted. Model 2: model 1+age group, sex, race/ethnicity, number of comorbidities, and interview wave.

We developed our models using complete case analysis, which might result in some bias in our estimates and SEs. However, majority of participants (81%) had complete data, and missingness in the race/ethnicity (11%- the highest of the variables of interest) was weakly correlated with the study outcomes, likely limiting bias in our estimates. Moreover, in a sensitivity analysis, we included participants with missing race/ethnicity data (classified as missing) and compared the results with those from the current analysis, which showed consistent findings overall. Finally, the cross-sectional nature of the analysis limits our ability to make causal inferences.

Despite the considerable similarities between various SDOH frameworks, the lack of validated multidimensional instruments of SDOH profile limits efforts to illustrate SDOH–COVID-19 association comprehensively across vulnerable populations. There is a need for concerted research efforts toward developing robust SDOH

indices that adequately capture upstream social adversity at the individual and aggregate levels.

## Conclusions

Unfavorable SDOH is associated with lower likelihood of practicing COVID-19 risk mitigation guidelines, including personal protection and social distancing, and opportunities for flexible work schedules in individuals with CVD. Prioritizing socially disadvantaged populations in public health policies and programs, such as health messaging and vaccination delivery, may help reduce existing disparities in COVID-19 infection risk and outcomes, which continue to affect high-risk populations disproportionately.

## ARTICLE INFORMATION

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## Supplemental Materials

Expanded Methods  
Tables I–IV  
Figures I–X

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