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Ethnic and racial differences in self-reported symptoms, health status, activity level, and missed work at 3 and 6 months following SARS-CoV-2 infection

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Introduction: Data on ethnic and racial differences in symptoms and health-related impacts following SARS-CoV-2 infection are limited. We aimed to estimate the ethnic and racial differences in symptoms and health-related impacts 3 and 6 months after the first SARS-CoV-2 infection.

Methods: Participants included adults with SARS-CoV-2 infection enrolled in a prospective multicenter US study between 12/11/2020 and 7/4/2022 as

the primary cohort of interest, as well as a SARS-CoV-2-negative cohort to account for non-SARS-CoV-2-infection impacts, who completed enrollment and 3-month surveys ($N = 3,161$; 2,402 SARS-CoV-2-positive, 759 SARS-CoV-2-negative). Marginal odds ratios were estimated using GEE logistic regression for individual symptoms, health status, activity level, and missed work 3 and 6 months after COVID-19 illness, comparing each ethnicity or race to the referent group (non-Hispanic or white), adjusting for demographic factors, social determinants of health, substance use, pre-existing health conditions, SARS-CoV-2 infection status, COVID-19 vaccination status, and survey time point, with interactions between ethnicity or race and time point, ethnicity or race and SARS-CoV-2 infection status, and SARS-CoV-2 infection status and time point.

Results: Following SARS-CoV-2 infection, the majority of symptoms were similar over time between ethnic and racial groups. At 3 months, Hispanic participants were more likely than non-Hispanic participants to report fair/poor health (OR: 1.94; 95%CI: 1.36–2.78) and reduced activity (somewhat less, OR: 1.47; 95%CI: 1.06–2.02; much less, OR: 2.23; 95%CI: 1.38–3.61). At 6 months, differences by ethnicity were not present. At 3 months, Other/Multiple race participants were more likely than white participants to report fair/poor health (OR: 1.90; 95%CI: 1.25–2.88), reduced activity (somewhat less, OR: 1.72; 95%CI: 1.21–2.46; much less, OR: 2.08; 95%CI: 1.18–3.65). At 6 months, Asian participants were more likely than white participants to report fair/poor health (OR: 1.88; 95%CI: 1.13–3.12); Black participants reported more missed work (OR, 2.83; 95%CI: 1.60–5.00); and Other/Multiple race participants reported more fair/poor health (OR: 1.83; 95%CI: 1.10–3.05), reduced activity (somewhat less, OR: 1.60; 95%CI: 1.02–2.51; much less, OR: 2.49; 95%CI: 1.40–4.44), and more missed work (OR: 2.25; 95%CI: 1.27–3.98).

Discussion: Awareness of ethnic and racial differences in outcomes following SARS-CoV-2 infection may inform clinical and public health efforts to advance health equity in long-term outcomes.

KEYWORDS

COVID-19, disparities, cohort, race, ethnicity, SARS-CoV-2, survey

Introduction

The COVID-19 pandemic accentuated health disparities. Early in the pandemic, ethnic and racial minoritized (1, 2) populations were reported to be at greater risk of SARS-CoV-2 infection in association with their overrepresentation in the essential workforce (3, 4), fewer opportunities to work from home (4–7), and less ability to practice social distancing (4, 5, 7, 8). Ethnic or racial minoritized individuals with acute SARS-CoV-2 infection had greater barriers to care, including underinsurance (9), lack of primary care (10), and greater economic consequences from missed work (11, 12). Disparities in health outcomes following acute SARS-CoV-2 infection included higher rates of hospitalization and SARS-CoV-2-related mortality among Black and Hispanic populations (13–20). Converging systems of oppression for ethnic and racial minoritized populations magnified health disparities (21, 22).

Disparities in recovery after SARS-CoV-2 infection remain largely under-explored (23–25). Limitations in the few studies that have reported on ethnic and racial differences in recovery from SARS-CoV-2 include heterogeneity in follow-up duration and definition of post-COVID conditions (26–28), inconsistency of findings (29–32), limited focus on symptom presence (as opposed to impact) (29–31), and lack of adjustment for potential confounding

by social health determinants (29, 30). We sought to evaluate symptoms and health-related impacts following SARS-CoV-2 infection by ethnicity and race to inform effective and equitable health interventions.

Methods

Study design and participant recruitment

This is a secondary analysis of data from the Innovative Support for Patients with SARS-CoV-2 Infections Registry (INSPIRE), a multicenter, longitudinal cohort study of the sequelae of SARS-CoV-2 in the United States. Adult participants were followed prospectively with patient-reported outcomes collected every 3 months via survey and linked to digital health data. Additional methods of the parent study were described previously (33). In this study, we focus on reporting results among SARS-CoV-2-positive participants to address our primary objective, namely to assess for differences in symptoms and health-related impacts by ethnicity and race following a first SARS-CoV-2 infection. The SARS-CoV-2-negative cohort was included in the analysis to account for non-SARS-CoV-2 impacts.

Study sample

Participants with self-reported symptoms suggestive of acute SARS-CoV-2 infection who tested SARS-CoV-2-positive or SARS-CoV-2-negative within the past 42 days were eligible for enrollment in INSPIRE. Participants who completed enrollment and the 3-month post-enrollment surveys were included in this analysis; among those included in the analysis, 6-month post-enrollment survey data were included as available. Participants with a prior SARS-CoV-2-positive test (>42 days before enrollment) were excluded.

Exposures

Ethnicity and race were self-reported at enrollment. Ethnicity was reported as Hispanic or non-Hispanic. Race was reported as American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, white, and/or 'some other race'. This approach was in accordance with the U.S. Office of Management and Budget (OMB) standards (34). Ethnicity and race data were collected separately, first asking participants to indicate whether they were of Hispanic, Latin, or Spanish origin and then asking them to select their race category to permit the most granular presentation of findings and because this is the preferred method for data collection (35). For the analysis, due to the small sample size for some subcategories, race data were collapsed into four categories: Asian, Black, Other/Multiple (participants who identified as American Indian/Alaska Native, Native Hawaiian/Other Pacific Islander, 'some other race', and who selected two or more races), and white.

Other variables

Information on demographics, social determinants of health, and substance use was collected at enrollment. Social determinants of health were assessed using a validated tool and included health insurance status, housing insecurity, food insecurity, utility access, transportation access, and employment (36). Substance use in the past 12 months was assessed for tobacco, alcohol, prescription drugs, marijuana, and illicit drugs. Pre-existing health conditions were collected in the 3-month survey and included asthma, hypertension, diabetes, obesity, emphysema or chronic obstructive pulmonary disease, heart conditions, smoking/tobacco consumption, and kidney and liver disease. Acute SARS-CoV-2 infection status was reported at enrollment and confirmed using the electronic health record (EHR) and/or test result image. In the 3- and 6-month surveys, participants were asked about new SARS-CoV-2 infections. Those who were SARS-CoV-2-negative at enrollment and who subsequently reported testing SARS-CoV-2-positive in their 3- or 6-month survey were censored at that time. COVID-19 vaccination status (receiving any COVID-19 vaccine) was assessed through self-report and EHR data.

Outcomes

The CDC's Person Under Investigation for SARS-CoV-2 symptom list was used to assess 21 COVID-19-like symptoms and/or "other symptoms" at enrollment, 3 months, and 6 months (37). Health status (5-point scale, excellent to poor), activity level compared to before

SARS-CoV-2-like symptoms (same, somewhat less, and much less), and missed work due to health reasons in the past 3 months (0–5 workdays, 6–10 workdays, 10–20 workdays, up to 4 weeks, and do not work; overlap of intervals reflects the answer options presented in the survey) were assessed at 3 and 6 months.

Statistical methods

We described socio-demographic and clinical characteristics across ethnicity and race groups and displayed frequency counts by initial SARS-CoV-2 test results. Outcomes were described at enrollment, 3 months, and 6 months after SARS-CoV-2 infection for each ethnic and racial group.

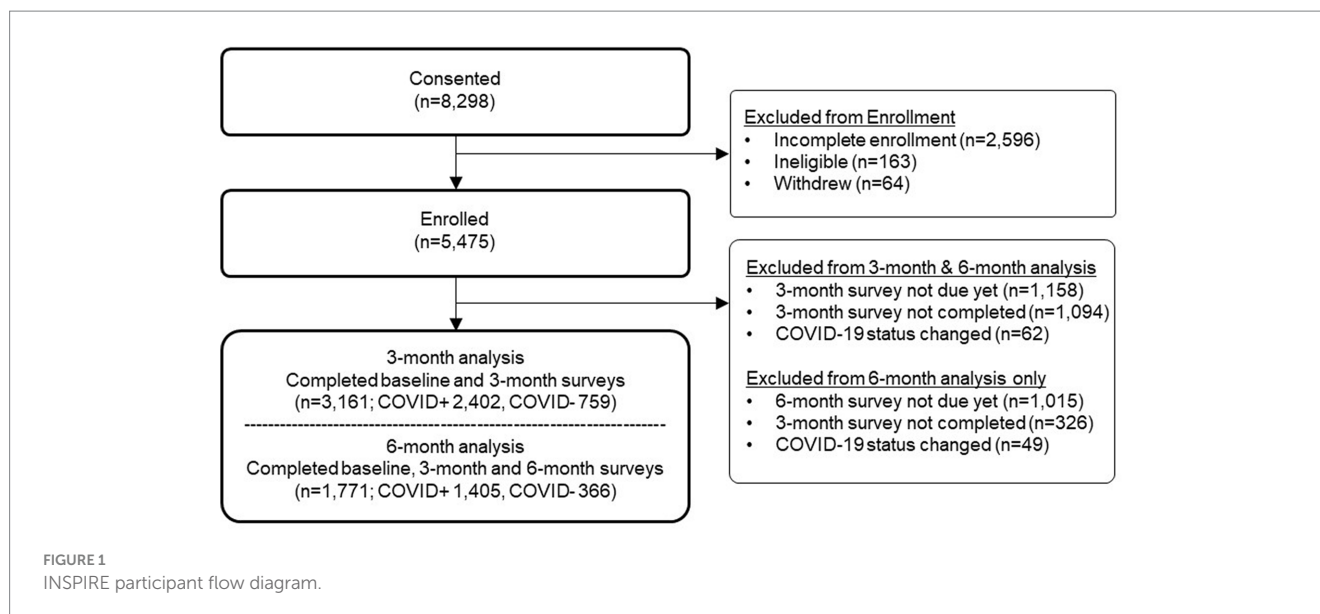
We used generalized estimating equations (GEE) logistic regression to model the association between ethnicity and race (separately) and study outcomes (symptoms, health status, activity level, and missed work) at 3 and 6 months. We leveraged data from the full dataset (including those with and without acute SARS-CoV-2) to fit GEE models with robust standard errors. Independent variables include (1) demographic characteristics (age, gender, education, and family income), social determinants of health, tobacco use, substance use, pre-existing health conditions, and COVID-19 vaccination status (vaccinated or not vaccinated before the index SARS-CoV-2 test); and (2) interactions between ethnicity or race and time point, ethnicity or race and SARS-CoV-2 infection status, and SARS-CoV-2 infection status and time point. Time point was modeled as a categorical variable to account for a non-linear trajectory. Social determinants of health were considered a binary variable coded as "any problem" (vs. no problem) if housing, food security, access to utilities, or access to transportation were unstable (Supplementary Material 1). Substance use was included as present if there was a 'moderate to severe problem' with at least one substance. Individual comorbidities were included as indicator variables. Where appropriate, variable subgroups were collapsed to create larger subgroups.

Using the GEE models, we calculated marginal odds ratios, for brevity referred to as odds ratios hereafter, of individual symptoms (yes, no) by comparing each ethnicity and racial group to the corresponding referent group (non-Hispanic for ethnicity and white for race). For the outcome 'health status', we estimated the odds ratio of being in 'very good' or 'excellent' health and being in 'fair' or 'poor' health compared to 'good' health. For activity level, the odds ratio of being 'somewhat less' and being 'much less' able to do activities was estimated compared to being the 'same as before'. For missed work, the odds ratio of missing >5 workdays in the prior 3 months due to health reasons was compared to '0 to 5 days'.

We did not adjust for multiple comparisons, given the exploratory nature of this study. All tests were two-sided with an alpha criterion of 0.05. Statistical analyses were performed using the GENMOD procedure of SAS 9.4 (SAS Institute Inc., Cary, NC). Additional information about our GEE methods is available (Supplementary Material 2).

Human subjects approval

This study was approved by the Institutional Review Boards of all eight study sites (33).



Results

The participant flow diagram is shown in [Figure 1](#). Three-month data were available for all participants ($N = 3,161$), and 6-month data were available for 1,771 participants. Of the 3,161 total participants, ethnicity was reported by 3,155 participants, and race was reported by 3,133 participants. There were differences by ethnicity and race in the proportion of participants completing the follow-up surveys, with lower completion among Hispanic compared to non-Hispanic participants and among Black participants compared to other race groups ([Supplementary Material 3](#)).

Participant characteristics

Among 2,354 SARS-CoV-2-positive participants with ethnicity data, 330 (14.0%) were Hispanic and 2,024 (86.0%) were non-Hispanic. Among 801 SARS-CoV-2-negative participants with ethnicity data, 132 (16.5%) were Hispanic and 669 (83.5%) were non-Hispanic. Assessing both SARS-CoV-2-positive and SARS-CoV-2-negative participants, compared with non-Hispanic participants, Hispanic participants were younger, less educated, more likely never married, and had lower family income ([Table 1](#)). Hispanic participants were more likely to lack health insurance, experience housing and/or food insecurity, have limited access to utilities and transportation, and be non-health essential workers working outside the home throughout the pandemic. Hispanic participants were more likely to report prescription abuse and pre-existing obesity and less likely to report hypertension and having no pre-existing health conditions. The proportion of SARS-CoV-2-positive participants was similar among Hispanic and non-Hispanic participants (75.2% vs. 71.4%, respectively, value of $p = 0.089$). Hispanic participants were less likely to be vaccinated against COVID-19, and the two groups utilized different COVID-19 testing sites ([Table 1](#)).

Among 2,341 SARS-CoV-2-positive participants with race data, 258 (11.0%) were Asian, 186 (7.9%) were Black, 232 (9.9%) were Other/Multiple races, and 1,665 (71.1%) were white ([Table 2](#)). Among 792 SARS-CoV-2-negative participants with race data, 117 (14.8%) were Asian, 104 (13.1%) were Black, 64 (8.1%) were Other/Multiple races,

and 507 (64.0%) were white. Assessing both SARS-CoV-2-positive and SARS-CoV-2-negative participants, Black participants had the highest prevalence of low family income, lack of health insurance, housing insecurity, and food insecurity, limited utility access, and limited transportation access, followed by Other/Multiple race participants in most instances. Black participants also had the highest prevalence of pre-existing health conditions. Employment in essential services was highest among Black and Other/Multiple race participants, and healthcare setting employment was highest among Asian and Other/Multiple race participants. Black participants were most likely to be tested for COVID-19 in a hospital setting, and COVID-19 vaccination was lowest among Black and Other/Multiple race participants.

Symptoms, health status, activity level, and work among SARS-CoV-2-positive participants

At each time point, the reported prevalence of symptoms, health status, activity level, and missed work among SARS-CoV-2-positive participants varied by ethnicity and race ([Table 3](#); results for the SARS-CoV-2-negative cohort included in [Supplementary Material 4](#)).

Association between ethnicity and race and study outcomes among SARS-CoV-2-positive participants

[Figure 2](#) presents adjusted odds ratios for having 21 COVID-like symptoms or “other symptoms” (22 symptoms queried total) comparing Hispanic to non-Hispanic participants and comparing different races to white participants who tested positive for SARS-CoV-2 at 3 and 6 months (entire cohort results are included in [Supplementary Materials 5.1–5.3](#) GEE adjusted odds ratio output).

Compared to non-Hispanic participants, at 3 and 6 months, Hispanic participants reported headaches more frequently (3 months, OR: 1.70, 95%CI: 1.20–2.42; 6 months, OR: 1.97, 95%CI: 1.25–3.11),

TABLE 1 Characteristics by ethnicity of adult INSPIRE participants stratified by SARS-CoV-2 infection status (N = 3,155).

| | SARS-CoV-2-positive ^a | | | SARS-CoV-2-negative ^a | | |
|--|----------------------------------|---------------------------------|----------------------|----------------------------------|-------------------------------|--------------------|
| | Hispanic (N = 330) | Non- Hispanic (N = 2,024) | Total (N = 2,354) | Hispanic (N = 132) | Non- Hispanic (N = 669) | Total (N = 801) |
| | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
| <i>Age</i> | | | | | | |
| 18–34 years | 179 (54.2) | 810 (40.0) | 989 (42.0) | 62 (47.0) | 304 (45.4) | 366 (45.7) |
| 35–49 years | 107 (32.4) | 638 (31.5) | 745 (31.6) | 48 (36.4) | 176 (26.3) | 224 (28.0) |
| 50–64 years | 36 (10.9) | 405 (20.0) | 441 (18.7) | 20 (15.2) | 128 (19.1) | 148 (18.5) |
| 65+ years | 8 (2.4) | 171 (8.4) | 179 (7.6) | 2 (1.5) | 61 (9.1) | 63 (7.9) |
| <i>Gender</i> | | | | | | |
| Female | 214 (66.0) | 1,322 (66.6) | 1,536 (66.6) | 97 (75.8) | 476 (72.7) | 573 (73.2) |
| Male | 104 (32.1) | 641 (32.3) | 745 (32.3) | 30 (23.4) | 160 (24.4) | 190 (24.3) |
| Transgender/Non-binary | 6 (1.9) | 21 (1.1) | 27 (1.2) | 1 (0.8) | 19 (2.9) | 20 (2.6) |
| <i>Education</i> | | | | | | |
| Less than high school | 10 (3.2) | 14 (0.7) | 24 (1.0) | 3 (2.5) | 6 (0.9) | 9 (1.2) |
| High school graduate | 33 (10.7) | 120 (6.0) | 153 (6.7) | 17 (13.9) | 62 (9.5) | 79 (10.2) |
| Some college | 65 (21.1) | 282 (14.2) | 347 (15.1) | 29 (23.8) | 120 (18.4) | 149 (19.2) |
| 2-year degree | 35 (11.4) | 137 (6.9) | 172 (7.5) | 13 (10.7) | 52 (8.0) | 65 (8.4) |
| 4-year degree | 90 (29.2) | 718 (36.1) | 808 (35.1) | 31 (25.4) | 157 (24.0) | 188 (24.3) |
| More than 4 years | 75 (24.4) | 720 (36.2) | 795 (34.6) | 29 (23.8) | 256 (39.2) | 285 (36.8) |
| <i>Marital status</i> | | | | | | |
| Married/partner | 186 (57.1) | 1,176 (58.7) | 1,362 (58.4) | 58 (45.0) | 310 (47.0) | 368 (46.6) |
| Divorced/Widowed/Separated | 20 (6.1) | 200 (10.0) | 220 (9.4) | 12 (9.3) | 86 (13.0) | 98 (12.4) |
| Never married | 120 (36.8) | 629 (31.4) | 749 (32.1) | 59 (45.7) | 264 (40.0) | 323 (40.9) |
| <i>Annual family income</i> | | | | | | |
| <10,000 | 23 (7.0) | 105 (5.2) | 128 (5.4) | 14 (10.6) | 58 (8.7) | 72 (9.0) |
| 10,000-34,999 | 62 (18.8) | 197 (9.7) | 259 (11.0) | 22 (16.7) | 76 (11.4) | 98 (12.2) |
| 35,000-49,999 | 53 (16.1) | 166 (8.2) | 219 (9.3) | 26 (19.7) | 83 (12.4) | 109 (13.6) |
| 50,000-74,999 | 52 (15.8) | 269 (13.3) | 321 (13.6) | 14 (10.6) | 91 (13.6) | 105 (13.1) |
| 75,000+ | 115 (34.8) | 1,153 (57.0) | 1,268 (53.9) | 43 (32.6) | 288 (43.0) | 331 (41.3) |
| Prefer not to answer | 25 (7.6) | 134 (6.6) | 159 (6.8) | 13 (9.8) | 73 (10.9) | 86 (10.7) |
| <i>Health insurance</i> | | | | | | |
| Private only | 224 (67.9) | 1,507 (74.5) | 1,731 (73.5) | 90 (68.2) | 453 (67.7) | 543 (67.8) |
| Public only | 70 (21.2) | 367 (18.1) | 437 (18.6) | 31 (23.5) | 170 (25.4) | 201 (25.1) |
| Private and public | 8 (2.4) | 80 (4.0) | 88 (3.7) | 0 (0.0) | 27 (4.0) | 27 (3.4) |
| None | 28 (8.5) | 70 (3.5) | 98 (4.2) | 11 (8.3) | 19 (2.8) | 30 (3.7) |
| <i>Housing insecurity</i> | | | | | | |
| I have a steady place to live | 301 (92.3) | 1,922 (95.9) | 2,223 (95.4) | 112 (86.8) | 609 (92.1) | 721 (91.3) |
| I have a place to live today, but I am worried about losing it in the future | 21 (6.4) | 63 (3.1) | 84 (3.6) | 14 (10.9) | 43 (6.5) | 57 (7.2) |
| I do not have a steady place to live | 4 (1.2) | 20 (1.0) | 24 (1.0) | 3 (2.3) | 9 (1.4) | 12 (1.5) |
| <i>Food insecurity</i> | | | | | | |
| Often true | 30 (9.2) | 78 (3.9) | 108 (4.6) | 14 (10.9) | 43 (6.5) | 57 (7.2) |

(Continued)

TABLE 1 (Continued)

| | SARS-CoV-2-positive ^a | | | SARS-CoV-2-negative ^a | | |
|---|----------------------------------|---------------------------------|----------------------|----------------------------------|-------------------------------|--------------------|
| | Hispanic (N = 330) | Non- Hispanic (N = 2,024) | Total (N = 2,354) | Hispanic (N = 132) | Non- Hispanic (N = 669) | Total (N = 801) |
| | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
| Sometimes true | 69 (21.2) | 209 (10.4) | 278 (11.9) | 34 (26.4) | 101 (15.3) | 135 (17.1) |
| Never true | 227 (69.6) | 1,718 (85.7) | 1,945 (83.4) | 81 (62.8) | 516 (78.2) | 597 (75.7) |
| <i>Utility insecurity</i> | | | | | | |
| Never shut off services | 296 (90.5) | 1,924 (96.0) | 2,220 (95.2) | 112 (86.8) | 618 (93.5) | 730 (92.4) |
| Threatened to shut off services | 29 (8.9) | 76 (3.8) | 105 (4.5) | 16 (12.4) | 37 (5.6) | 53 (6.7) |
| Already shut off services | 2 (0.6) | 4 (0.2) | 6 (0.3) | 1 (0.8) | 6 (0.9) | 7 (0.9) |
| <i>Transportation access</i> | | | | | | |
| It has kept me from medical appointments or getting medications | 13 (3.9) | 47 (2.3) | 60 (2.5) | 13 (9.8) | 39 (5.8) | 52 (6.5) |
| It has kept me from non-medical meetings, non-medical appointments, work, or getting things that I need | 21 (6.4) | 55 (2.7) | 76 (3.2) | 4 (3.0) | 32 (4.8) | 36 (4.5) |
| It has not kept me from getting things I need | 296 (89.7) | 1,922 (95.0) | 2,218 (94.2) | 115 (87.1) | 598 (89.4) | 713 (89.0) |
| <i>Employment</i> | | | | | | |
| Employed, essential | 149 (45.7) | 832 (41.5) | 981 (42.1) | 52 (40.3) | 265 (40.2) | 317 (40.2) |
| Employed, non-essential | 121 (37.1) | 828 (41.3) | 949 (40.7) | 48 (37.2) | 234 (35.5) | 282 (35.7) |
| Not employed | 56 (17.2) | 345 (17.2) | 401 (17.2) | 29 (22.5) | 161 (24.4) | 190 (24.1) |
| <i>Were you employed before the coronavirus outbreak?</i> | | | | | | |
| No | 56 (17.2) | 345 (17.2) | 401 (17.2) | 29 (22.5) | 161 (24.4) | 190 (24.1) |
| Yes | 270 (82.8) | 1,661 (82.8) | 1,931 (82.8) | 100 (77.5) | 500 (75.6) | 600 (75.9) |
| <i>Do you work in a healthcare setting such as a hospital, clinic, or nursing/rehabilitation care facility?</i> | | | | | | |
| No | 208 (77.0) | 1,240 (74.7) | 1,448 (75.0) | 73 (73.0) | 351 (70.3) | 424 (70.8) |
| Yes | 262 (3.0) | 421 (25.3) | 483 (25.0) | 27 (27.0) | 148 (29.7) | 175 (29.2) |
| <i>Are you a non-health essential worker that was asked to work outside the home throughout the pandemic?</i> | | | | | | |
| No | 178 (65.7) | 1,216 (73.4) | 1,394 (72.3) | 68 (68.0) | 365 (73.3) | 433 (72.4) |
| Yes | 93 (34.3) | 441 (26.6) | 534 (27.7) | 32 (32.0) | 133 (26.7) | 165 (27.6) |
| <i>Tobacco use</i> | | | | | | |
| Daily or near daily | 12 (3.7) | 122 (6.1) | 134 (5.7) | 12 (9.3) | 45 (6.8) | 57 (7.2) |
| Weekly | 5 (1.5) | 42 (2.1) | 47 (2.0) | 2 (1.6) | 13 (2.0) | 15 (1.9) |
| Monthly | 4 (1.2) | 32 (1.6) | 36 (1.5) | 1 (0.8) | 8 (1.2) | 9 (1.1) |
| Less than monthly | 18 (5.5) | 95 (4.7) | 113 (4.8) | 10 (7.8) | 24 (3.6) | 34 (4.3) |
| Not at all | 287 (88.0) | 1,715 (85.5) | 2,002 (85.8) | 104 (80.6) | 569 (86.3) | 673 (85.4) |
| <i>Excessive alcohol usage</i> | | | | | | |
| Daily or near daily | 2 (0.6) | 36 (1.8) | 38 (1.6) | 2 (1.6) | 9 (1.4) | 11 (1.4) |
| Weekly | 32 (9.8) | 214 (10.7) | 246 (10.5) | 6 (4.7) | 47 (7.1) | 53 (6.7) |
| Monthly | 44 (13.5) | 265 (13.2) | 309 (13.3) | 22 (17.1) | 66 (10.0) | 88 (11.2) |
| Less than monthly | 82 (25.1) | 443 (22.1) | 525 (22.5) | 33 (25.6) | 144 (21.9) | 177 (22.5) |
| Not at all | 167 (51.1) | 1,047 (52.2) | 1,214 (52.1) | 66 (51.2) | 393 (59.6) | 459 (58.2) |

(Continued)

TABLE 1 (Continued)

| | SARS-CoV-2-positive ^a | | | SARS-CoV-2-negative ^a | | |
|---|----------------------------------|---------------------------------|----------------------|----------------------------------|-------------------------------|--------------------|
| | Hispanic (N = 330) | Non- Hispanic (N = 2,024) | Total (N = 2,354) | Hispanic (N = 132) | Non- Hispanic (N = 669) | Total (N = 801) |
| | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
| <i>Prescription abuse</i> | | | | | | |
| Daily or near daily | 9 (2.8) | 21 (1.0) | 30 (1.3) | 4 (3.1) | 13 (2.0) | 17 (2.2) |
| Weekly | 1 (0.3) | 11 (0.5) | 12 (0.5) | 3 (2.3) | 8 (1.2) | 11 (1.4) |
| Monthly | 7 (2.1) | 13 (0.6) | 20 (0.9) | 1 (0.8) | 10 (1.5) | 11 (1.4) |
| Less than monthly | 17 (5.2) | 50 (2.5) | 67 (2.9) | 10 (7.8) | 21 (3.2) | 31 (3.9) |
| Not at all | 293 (89.6) | 1,910 (95.3) | 2,203 (94.5) | 111 (86.0) | 607 (92.1) | 718 (91.1) |
| <i>Marijuana use</i> | | | | | | |
| Daily or near daily | 24 (7.4) | 94 (4.7) | 118 (5.1) | 6 (4.7) | 38 (5.8) | 44 (5.6) |
| Weekly | 18 (5.5) | 108 (5.4) | 126 (5.4) | 5 (3.9) | 25 (3.8) | 30 (3.8) |
| Monthly | 13 (4.0) | 91 (4.5) | 104 (4.5) | 6 (4.7) | 30 (4.6) | 36 (4.6) |
| Less than monthly | 33 (10.2) | 236 (11.8) | 269 (11.5) | 12 (9.3) | 68 (10.3) | 80 (10.2) |
| Not at all | 237 (72.9) | 1,476 (73.6) | 1,713 (73.5) | 100 (77.5) | 497 (75.5) | 597 (75.9) |
| <i>Drug use</i> | | | | | | |
| Daily or near daily | 0 (0.0) | 8 (0.4) | 8 (0.3) | 2 (1.6) | 4 (0.6) | 6 (0.8) |
| Weekly | 1 (0.3) | 5 (0.2) | 6 (0.3) | 0 (0.0) | 1 (0.2) | 1 (0.1) |
| Monthly | 0 (0.0) | 11 (0.5) | 11 (0.5) | 0 (0.0) | 3 (0.5) | 3 (0.4) |
| Less than monthly | 19 (5.8) | 106 (5.3) | 125 (5.4) | 3 (2.3) | 23 (3.5) | 26 (3.3) |
| Not at all | 306 (93.9) | 1,875 (93.5) | 2,181 (93.6) | 124 (96.1) | 628 (95.3) | 752 (95.4) |
| <i>Pre-existing health conditions^b</i> | | | | | | |
| Asthma | 36 (11.4) | 246 (12.6) | 282 (12.4) | 21 (16.2) | 108 (16.5) | 129 (16.4) |
| Hypertension | 34 (10.7) | 279 (14.2) | 313 (13.7) | 15 (11.5) | 111 (16.9) | 126 (16.1) |
| Diabetes | 18 (5.7) | 98 (5.0) | 116 (5.1) | 7 (5.4) | 52 (7.9) | 59 (7.5) |
| Obesity | 104 (32.8) | 514 (26.2) | 618 (27.1) | 48 (36.9) | 191 (29.2) | 239 (30.4) |
| Emphysema/COPD | 1 (0.3) | 16 (0.8) | 17 (0.7) | 3 (2.3) | 12 (1.8) | 15 (1.9) |
| Heart conditions | 5 (1.6) | 50 (2.6) | 55 (2.4) | 5 (3.8) | 27 (4.1) | 32 (4.1) |
| Smoking/tobacco Consumption | 7 (2.2) | 94 (4.8) | 101 (4.4) | 11 (8.5) | 36 (5.5) | 47 (6.0) |
| Kidney disease | 3 (0.9) | 27 (1.4) | 30 (1.3) | 1 (0.8) | 14 (2.1) | 15 (1.9) |
| Liver disease | 1 (0.3) | 15 (0.8) | 16 (0.7) | 3 (2.3) | 9 (1.4) | 12 (1.5) |
| None | 37 (11.7) | 383 (19.5) | 420 (18.4) | 17 (13.1) | 101 (15.4) | 118 (15.0) |
| I do not know | 79 (24.9) | 427 (21.8) | 506 (22.2) | 28 (21.5) | 107 (16.3) | 135 (17.2) |
| Prefer not to answer | 25 (7.9) | 95 (4.8) | 120 (5.3) | 9 (6.9) | 42 (6.4) | 51 (6.5) |
| <i>COVID-19 vaccination^c</i> | | | | | | |
| Yes | 175 (65.1) | 1,164 (68.4) | 1,339 (67.9) | 73 (68.2) | 438 (78.4) | 511 (76.7) |
| <i>Testing location</i> | | | | | | |
| At home testing kit | 22 (6.7) | 164 (8.1) | 186 (7.9) | 9 (6.8) | 63 (9.4) | 72 (9.0) |
| Clinic including urgent care | 48 (14.6) | 300 (14.9) | 348 (14.8) | 25 (18.9) | 124 (18.5) | 149 (18.6) |
| Emergency department | 7 (2.1) | 86 (4.3) | 93 (4.0) | 9 (6.8) | 50 (7.5) | 59 (7.4) |
| Hospital | 33 (10.0) | 176 (8.7) | 209 (8.9) | 14 (10.6) | 68 (10.2) | 82 (10.2) |
| Other | 36 (10.9) | 130 (6.4) | 166 (7.1) | 21 (15.9) | 89 (13.3) | 110 (13.7) |
| Tent/drive-up testing site | 183 (55.6) | 1,160 (57.5) | 1,343 (57.3) | 54 (40.9) | 275 (41.1) | 329 (41.1) |

^aTable excludes participants with missing ethnicity data for COVID-19-positive ($n=48$) or COVID-19-negative ($n=20$). ^bPre-existing conditions question only asked on 3-month survey beginning 4-14-2021 and has missing data for COVID-19-positive ($n=77$) and COVID-19-negative ($n=16$). ^cCOVID-19 vaccination indicates participants with at least one dose before the index SARS-CoV-2 test; Vaccination initiation information was obtained from linked electronic health record data for 922 (29%) participants, using survey data for 1718 (54%) participants, and was missing for 521 (16%) participants.

and at 6 months, they reported more nausea or vomiting (OR: 2.20, 95%CI: 1.01–4.77) and 'other symptoms' (OR: 2.32, 95%CI: 1.14–4.72) (Figure 2; Supplementary Material 5.1).

By race, compared to white participants, at 3 months, Asian participants reported more sore throat (OR: 1.72, 95%CI: 1.09–2.72) and less shortness of breath (OR: 0.32, 95%CI: 0.14–0.74); Black participants reported less loss of smell (OR: 0.45, 95%CI: 0.25–0.82), wheezing (OR: 0.29, 95%CI: 0.09–0.98) and 'other symptoms' (OR: 0.35, 95%CI: 0.13–0.95); and Other/Multiple race participants reported more wheezing (OR: 2.22, 95%CI: 1.04–4.75). At 6 months, Other/Multiple race participants had less loss of smell than white participants (OR: 0.23, 95%CI: 0.05–0.95) (Figure 2; Supplementary Materials 5.2, 5.3).

Evaluating health status, activity level, and missed work at 3 and 6 months after SARS-CoV-2 infection, some minoritized groups had worse health status, less physical activity, and more missed days of work. At 3 months, Hispanic compared to non-Hispanic participants were more likely to report fair/poor health (OR: 1.94, 95%CI: 1.36–2.78) and less activity (somewhat less, OR: 1.47, 95%CI: 1.06–2.02; much less, OR: 2.23, 95%CI: 1.38–3.61) (Figure 2, estimates reported in Supplementary Material 5.1). These differences in health and activity level by ethnicity were not found at 6 months (Figure 2, estimates reported in Supplementary Material 5.1). There were no significant differences in missed work at 3 or 6 months by ethnicity.

By race, there were differences in health status and activity level at 3 months and in health status, activity level, and work missed at 6 months. At 3 months, Other/Multiple race compared to white participants fared worse in terms of health (fair/poor health, OR: 1.90, 95%CI: 1.25–2.88) and activity level (somewhat less, OR: 1.72, 95%CI: 1.21–2.46; much less, OR: 2.08, 95%CI: 1.18–3.65). At 6 months, these differences persisted for Other/Multiple race participants in terms of health (fair/poor health, OR: 1.83, 95%CI: 1.10–3.05) and activity level (somewhat less, OR: 1.60, 95%CI: 1.02–2.51; much less, OR: 2.49, 95%CI: 1.40–4.44), and higher odds of missed work was found (OR: 2.25, 95%CI: 1.27–3.98). There were no differences at 3 months between Asian and Black participants compared to white participants. At 6 months, Asian compared to white participants reported more fair/poor health (OR: 1.88, 95%CI: 1.13–3.12). At 6 months, Black compared to white participants reported more missed work (OR: 2.83, 95%CI: 1.60–5.00) (Figure 2, estimates reported in Supplementary Materials 5.2, 5.3).

The relative importance of ethnicity and race in driving study outcomes compared to other covariates

The adjusted GEE models (fit using the complete dataset of SARS-CoV-2-positive and negative participants) were examined to explore associations between included covariates and study outcomes to gauge the relative importance of ethnicity and race, respectively, in driving study outcomes (Supplementary Materials 6.1–6.3 summary plots of GEE model parameter estimates). Adjusted GEE parameter estimates demonstrate a broad positive association between SARS-CoV-2-positive status, older age, female gender, any problem in social determinants of health, asthma, and lack of COVID vaccination and the 22 symptoms assessed (Supplementary Materials 6.1, 6.2 summary plots of GEE model parameter estimates). By contrast, infrequent

associations between ethnicity or race and symptoms were found when adjusting for other covariates.

Examining associations of covariates that were adjusted for in the model with health status, activity level, and missed work, prominent associations were found between identifying as female or transgender, any problem in social determinants of health, asthma, and obesity and worse study outcomes (Supplementary Material 6.3 summary plot of GEE model parameter estimates).

Discussion

In this prospective longitudinal cohort of individuals with acute SARS-CoV-2-like symptoms, there were few differences in adjusted odds of symptoms by ethnicity or race at 3 and 6 months among SARS-CoV-2-positive participants. However, there were differences in health status, activity level, and missed work. By ethnicity, at 3 months, Hispanic compared to non-Hispanic participants had worse health and lower activity levels; these differences were not present at 6 months. By race, at 3 months, Other/Multiple races compared to white participants had worse health and lower activity levels; at 6 months, these differences persisted. Additionally, at 6 months, higher odds of worse health were found for Asian participants and of missed work for Black and Other/Multiple race participants compared to white participants. The definition currently used to identify post-COVID conditions (i.e., Long COVID) is limited in scope to continuing or developing "signs, symptoms, and conditions" following acute SARS-CoV-2 infection. Notably, the differential impacts on participants' lives by ethnicity and race identified in this study would not be captured within the current definition of post-COVID conditions. A broadening of our understanding of post-COVID conditions may be necessary to fully capture the health-related consequences of SARS-CoV-2. The strength of the association between health status, activity level, and missed work following acute SARS-CoV-2 illness and ethnicity or race is eclipsed by the strength of the association between these impacts and other determinants that we adjusted for in our model, including pre-existing health conditions and social determinants of health.

Few prior studies have evaluated longer-term sequelae of COVID-19 through the lens of ethnicity and race. Several studies used a threshold of ≥ 28 days to define Long COVID symptoms (28–30). We assessed the presence of SARS-CoV-2-like symptoms at least 3 months after initial infection in accordance with the current World Health Organization definition of Long COVID (38). We accounted for known ethnic and racial disparities in social determinants of health, adjusted for demographic characteristics and pre-existing health conditions, controlled for non-SARS-CoV-2 impacts through the inclusion of participants testing negative for SARS-CoV-2, and considered not only differences in persisting symptoms but other overall health measures as well. Associations between SARS-CoV-2-like symptoms and SARS-CoV-2 infection status, time point from the onset of acute symptoms, pre-existing health conditions, and lack of vaccination found in our GEE models are consistent with what is known in the literature, supporting the validity of our results.

Others have reported inconsistent associations between ethnicity and race and Long COVID symptoms. The Arizona CoVHORT study and a study of American SARS-CoV-2-positive adults who tested positive during the Omicron surge reported no significant

TABLE 2 Characteristics by race of adult INSPIRE participants stratified by SARS-CoV-2 status (N = 3,133).

| | SARS-CoV-2-positive ^a | | | | | SARS-CoV-2-negative ^a | | | | |
|--|----------------------------------|--------------------|---------------------------------|----------------------|----------------------|----------------------------------|--------------------|--------------------------------|--------------------|--------------------|
| | Asian (N = 258) | Black (N = 186) | Other/ Multiple (N = 232) | White (N = 1,665) | Total (N = 2,341) | Asian (N = 117) | Black (N = 104) | Other/ Multiple (N = 64) | White (N = 507) | Total (N = 792) |
| | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
| <i>Age</i> | | | | | | | | | | |
| 18–34 years | 157 (60.9) | 71 (38.2) | 114 (49.1) | 634 (38.1) | 976 (41.7) | 77 (65.8) | 44 (42.3) | 38 (59.4) | 204 (40.2) | 363 (45.8) |
| 35–49 years | 74 (28.7) | 63 (33.9) | 80 (34.5) | 525 (31.5) | 742 (31.7) | 29 (24.8) | 30 (28.8) | 16 (25.0) | 143 (28.2) | 218 (27.5) |
| 50–64 years | 19 (7.4) | 41 (22.0) | 32 (13.8) | 345 (20.7) | 437 (18.7) | 8 (6.8) | 23 (22.1) | 9 (14.1) | 107 (21.1) | 147 (18.6) |
| 65+ years | 8 (3.1) | 11 (5.9) | 6 (2.6) | 161 (9.7) | 186 (7.9) | 3 (2.6) | 7 (6.7) | 1 (1.6) | 53 (10.5) | 64 (8.1) |
| <i>Gender</i> | | | | | | | | | | |
| Female | 170 (66.9) | 138 (74.6) | 156 (67.8) | 1,062 (65.4) | 1,526 (66.6) | 76 (66.7) | 81 (79.4) | 42 (68.9) | 364 (73.4) | 563 (72.8) |
| Male | 83 (32.7) | 46 (24.9) | 69 (30.0) | 539 (33.2) | 737 (32.2) | 34 (29.8) | 20 (19.6) | 19 (31.1) | 118 (23.8) | 191 (24.7) |
| Transgender/Non-binary | 1 (0.4) | 1 (0.5) | 5 (2.2) | 22 (1.4) | 29 (1.3) | 4 (3.5) | 1 (1.0) | 0 (0.0) | 14 (2.8) | 19 (2.5) |
| <i>Education</i> | | | | | | | | | | |
| Less than High school | 1 (0.4) | 5 (2.7) | 6 (2.6) | 14 (0.9) | 26 (1.1) | 0 (0.0) | 3 (2.9) | 0 (0.0) | 6 (1.2) | 9 (1.2) |
| High school graduate | 14 (5.4) | 36 (19.6) | 18 (7.9) | 86 (5.2) | 154 (6.7) | 10 (8.8) | 20 (19.6) | 6 (9.4) | 43 (8.6) | 79 (10.2) |
| Some College | 20 (7.8) | 52 (28.3) | 50 (21.9) | 221 (13.5) | 343 (14.8) | 27 (23.7) | 26 (25.5) | 18 (28.1) | 78 (15.7) | 149 (19.2) |
| 2-year degree | 12 (4.7) | 24 (13.0) | 25 (11.0) | 114 (6.9) | 175 (7.6) | 8 (7.0) | 11 (10.8) | 4 (6.3) | 41 (8.2) | 64 (8.2) |
| 4-year degree | 105 (40.9) | 36 (19.6) | 75 (32.9) | 591 (36.0) | 807 (34.9) | 29 (25.4) | 22 (21.6) | 16 (25.0) | 121 (24.3) | 188 (24.2) |
| More than 4 years | 105 (40.9) | 31 (16.8) | 54 (23.7) | 615 (37.5) | 805 (34.8) | 40 (35.1) | 20 (19.6) | 20 (31.3) | 209 (42.0) | 289 (37.1) |
| <i>Marital status</i> | | | | | | | | | | |
| Married/partner | 131 (50.8) | 66 (36.3) | 106 (46.7) | 1,046 (63.4) | 1,349 (58.2) | 41 (35.0) | 30 (29.1) | 23 (37.1) | 265 (53.2) | 359 (46.0) |
| Divorced/Widowed/ Separated | 9 (3.5) | 24 (13.2) | 28 (12.3) | 158 (9.6) | 219 (9.5) | 5 (4.3) | 22 (21.4) | 9 (14.5) | 62 (12.4) | 98 (12.6) |
| Never married | 118 (45.7) | 92 (50.5) | 93 (41.0) | 446 (27.0) | 749 (32.3) | 71 (60.7) | 51 (49.5) | 30 (48.4) | 171 (34.3) | 323 (41.4) |
| <i>Annual family income</i> | | | | | | | | | | |
| <10,000 | 16 (6.2) | 27 (14.5) | 22 (9.5) | 58 (3.5) | 123 (5.3) | 15 (12.8) | 20 (19.2) | 5 (7.8) | 30 (5.9) | 70 (8.8) |
| 10,000–34,999 | 20 (7.8) | 47 (25.3) | 37 (15.9) | 154 (9.2) | 258 (11.0) | 7 (6.0) | 29 (27.9) | 13 (20.3) | 47 (9.3) | 96 (12.1) |
| 35,000–49,999 | 15 (5.8) | 31 (16.7) | 31 (13.4) | 138 (8.3) | 215 (9.2) | 13 (11.1) | 17 (16.3) | 13 (20.3) | 62 (12.2) | 105 (13.3) |
| 50,000–74,999 | 35 (13.6) | 28 (15.1) | 32 (13.8) | 225 (13.5) | 320 (13.7) | 16 (13.7) | 16 (15.4) | 7 (10.9) | 65 (12.8) | 104 (13.1) |
| 75,000+ | 148 (57.4) | 42 (22.6) | 89 (38.4) | 987 (59.3) | 1,266 (54.1) | 46 (39.3) | 15 (14.4) | 15 (23.4) | 255 (50.3) | 331 (41.8) |
| Prefer not to answer | 24 (9.3) | 11 (5.9) | 21 (9.1) | 103 (6.2) | 159 (6.8) | 20 (17.1) | 7 (6.7) | 11 (17.2) | 48 (9.5) | 86 (10.9) |
| <i>Health insurance</i> | | | | | | | | | | |
| Private only | 212 (82.2) | 92 (49.5) | 148 (63.8) | 1,263 (75.9) | 1,715 (73.3) | 89 (76.1) | 49 (47.1) | 45 (70.3) | 352 (69.4) | 535 (67.6) |
| Public only | 34 (13.2) | 76 (40.9) | 64 (27.6) | 266 (16.0) | 440 (18.8) | 25 (21.4) | 49 (47.1) | 14 (21.9) | 112 (22.1) | 200 (25.3) |
| Private and public | 7 (2.7) | 4 (2.2) | 4 (1.7) | 72 (4.3) | 87 (3.7) | 2 (1.7) | 1 (1.0) | 2 (3.1) | 22 (4.3) | 27 (3.4) |
| None | 5 (1.9) | 14 (7.5) | 16 (6.9) | 64 (3.8) | 99 (4.2) | 1 (0.9) | 5 (4.8) | 3 (4.7) | 21 (4.1) | 30 (3.8) |
| <i>Housing insecurity</i> | | | | | | | | | | |
| I have a steady place to live | 253 (98.1) | 159 (87.4) | 214 (93.4) | 1,588 (96.4) | 2,214 (95.6) | 108 (92.3) | 87 (84.5) | 55 (88.7) | 464 (93.0) | 714 (91.4) |
| I have a place to live today, but I am worried about losing it in the future | 5 (1.9) | 17 (9.3) | 11 (4.8) | 46 (2.8) | 79 (3.4) | 8 (6.8) | 11 (10.7) | 6 (9.7) | 30 (6.0) | 55 (7.0) |
| I do not have a steady place to live | 0 (0.0) | 6 (3.3) | 4 (1.7) | 14 (0.8) | 24 (1.0) | 1 (0.9) | 5 (4.9) | 1 (1.6) | 5 (1.0) | 12 (1.5) |

(Continued)

TABLE 2 (Continued)

| | SARS-CoV-2-positive ^a | | | | | SARS-CoV-2-negative ^a | | | | |
|---|----------------------------------|--------------------|---------------------------------|----------------------|----------------------|----------------------------------|--------------------|--------------------------------|--------------------|--------------------|
| | Asian (N = 258) | Black (N = 186) | Other/ Multiple (N = 232) | White (N = 1,665) | Total (N = 2,341) | Asian (N = 117) | Black (N = 104) | Other/ Multiple (N = 64) | White (N = 507) | Total (N = 792) |
| | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
| <i>Food insecurity</i> | | | | | | | | | | |
| Often true | 5 (1.9) | 20 (11.0) | 18 (7.9) | 63 (3.8) | 106 (4.6) | 3 (2.6) | 23 (22.5) | 6 (9.7) | 25 (5.0) | 57 (7.3) |
| Sometimes true | 29 (11.2) | 66 (36.3) | 34 (14.9) | 145 (8.8) | 274 (11.8) | 20 (17.1) | 27 (26.5) | 17 (27.4) | 71 (14.2) | 135 (17.3) |
| Never true | 224 (86.8) | 96 (52.7) | 176 (77.2) | 1,441 (87.4) | 1,937 (83.6) | 94 (80.3) | 52 (51.0) | 39 (62.9) | 403 (80.8) | 588 (75.4) |
| <i>Utility insecurity</i> | | | | | | | | | | |
| Never shut off services | 256 (99.2) | 139 (76.4) | 215 (93.9) | 1,598 (97.0) | 2,208 (95.3) | 113 (96.6) | 82 (79.6) | 55 (88.7) | 472 (94.6) | 722 (92.4) |
| Threatened to shut off services | 2 (0.8) | 41 (22.5) | 13 (5.7) | 47 (2.9) | 103 (4.4) | 3 (2.6) | 20 (19.4) | 6 (9.7) | 23 (4.6) | 52 (6.7) |
| Already shut off services | 0 (0.0) | 2 (1.1) | 1 (0.4) | 3 (0.2) | 6 (0.3) | 1 (0.9) | 1 (1.0) | 1 (1.6) | 4 (0.8) | 7 (0.9) |
| <i>Transportation access</i> | | | | | | | | | | |
| It has kept me from medical appointments or getting medications | 9 (3.5) | 13 (7.0) | 13 (5.6) | 22 (1.3) | 57 (2.4) | 9 (7.7) | 12 (11.5) | 4 (6.3) | 27 (5.3) | 52 (6.6) |
| It has kept me from non-medical meetings, non-medical appointments, work, or getting things that I need | 14 (5.4) | 18 (9.7) | 11 (4.7) | 33 (2.0) | 76 (3.2) | 7 (6.0) | 11 (10.6) | 1 (1.6) | 17 (3.4) | 36 (4.5) |
| It has not kept me from getting things I need | 235 (91.1) | 155 (83.3) | 208 (89.7) | 1,610 (96.7) | 2,208 (94.3) | 101 (86.3) | 81 (77.9) | 59 (92.2) | 463 (91.3) | 704 (88.9) |
| <i>Employment</i> | | | | | | | | | | |
| Employed, essential | 112 (43.4) | 89 (48.9) | 98 (42.8) | 677 (41.1) | 976 (42.1) | 40 (34.5) | 49 (47.6) | 26 (41.9) | 197 (39.5) | 312 (40.0) |
| Employed, non-essential | 101 (39.1) | 59 (32.4) | 84 (36.7) | 702 (42.6) | 946 (40.8) | 41 (35.3) | 35 (34.0) | 18 (29.0) | 185 (37.1) | 279 (35.8) |
| Not employed | 45 (17.4) | 34 (18.7) | 47 (20.5) | 269 (16.3) | 395 (17.0) | 35 (30.2) | 19 (18.4) | 18 (29.0) | 117 (23.4) | 189 (24.2) |
| <i>Were you employed before the coronavirus outbreak?</i> | | | | | | | | | | |
| No | 45 (17.4) | 34 (18.7) | 47 (20.5) | 269 (16.3) | 395 (17.0) | 35 (29.9) | 19 (18.4) | 18 (29.0) | 117 (23.4) | 189 (24.2) |
| Yes | 213 (82.6) | 148 (81.3) | 182 (79.5) | 1,380 (83.7) | 1,923 (83.0) | 82 (70.1) | 84 (81.6) | 44 (71.0) | 382 (76.6) | 592 (75.8) |
| <i>Do you work in a healthcare setting such as a hospital, clinic, or nursing/rehabilitation care facility?</i> | | | | | | | | | | |
| No | 136 (63.8) | 105 (70.9) | 145 (79.7) | 1,058 (76.7) | 1,444 (75.1) | 51 (63.0) | 62 (73.8) | 27 (61.4) | 276 (72.3) | 416 (70.4) |
| Yes | 77 (36.2) | 43 (29.1) | 37 (20.3) | 322 (23.3) | 479 (24.9) | 30 (37.0) | 22 (26.2) | 17 (38.6) | 106 (27.7) | 175 (29.6) |
| <i>Are you a non-health essential worker who was asked to work outside the home throughout the pandemic?</i> | | | | | | | | | | |
| No | 173 (81.2) | 99 (66.9) | 118 (64.8) | 997 (72.4) | 1,387 (72.2) | 67 (82.7) | 53 (63.1) | 31 (70.5) | 281 (73.8) | 432 (73.2) |
| Yes | 40 (18.8) | 49 (33.1) | 64 (35.2) | 380 (27.6) | 533 (27.8) | 14 (17.3) | 31 (36.9) | 13 (29.5) | 100 (26.2) | 158 (26.8) |
| <i>Tobacco use</i> | | | | | | | | | | |
| Daily or near daily | 8 (3.1) | 15 (8.2) | 17 (7.5) | 93 (5.6) | 133 (5.7) | 4 (3.4) | 10 (9.7) | 6 (9.7) | 36 (7.2) | 56 (7.2) |
| Weekly | 4 (1.6) | 7 (3.8) | 5 (2.2) | 32 (1.9) | 48 (2.1) | 3 (2.6) | 1 (1.0) | 3 (4.8) | 8 (1.6) | 15 (1.9) |
| Monthly | 3 (1.2) | 1 (0.5) | 6 (2.6) | 26 (1.6) | 36 (1.6) | 3 (2.6) | 2 (1.9) | 2 (3.2) | 2 (0.4) | 9 (1.2) |
| Less than monthly | 10 (3.9) | 12 (6.6) | 14 (6.1) | 77 (4.7) | 113 (4.9) | 5 (4.3) | 4 (3.9) | 4 (6.5) | 22 (4.4) | 35 (4.5) |
| Not at all | 233 (90.3) | 147 (80.8) | 186 (81.6) | 1,422 (86.2) | 1,988 (85.8) | 101 (87.1) | 86 (83.5) | 47 (75.8) | 430 (86.3) | 664 (85.2) |

(Continued)

TABLE 2 (Continued)

| | SARS-CoV-2-positive ^a | | | | | SARS-CoV-2-negative ^a | | | | |
|---|----------------------------------|--------------------|---------------------------------|----------------------|----------------------|----------------------------------|--------------------|--------------------------------|--------------------|--------------------|
| | Asian (N = 258) | Black (N = 186) | Other/ Multiple (N = 232) | White (N = 1,665) | Total (N = 2,341) | Asian (N = 117) | Black (N = 104) | Other/ Multiple (N = 64) | White (N = 507) | Total (N = 792) |
| | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
| <i>Excessive alcohol usage</i> | | | | | | | | | | |
| Daily or near daily | 2 (0.8) | 5 (2.7) | 2 (0.9) | 30 (1.8) | 39 (1.7) | 1 (0.9) | 3 (2.9) | 1 (1.6) | 6 (1.2) | 11 (1.4) |
| Weekly | 22 (8.5) | 19 (10.4) | 25 (10.9) | 179 (10.9) | 245 (10.6) | 4 (3.4) | 12 (11.7) | 2 (3.2) | 34 (6.8) | 52 (6.7) |
| Monthly | 27 (10.5) | 14 (7.7) | 28 (12.2) | 239 (14.5) | 308 (13.3) | 16 (13.8) | 9 (8.7) | 9 (14.5) | 50 (10.0) | 84 (10.8) |
| Less than monthly | 59 (22.9) | 35 (19.2) | 59 (25.8) | 369 (22.4) | 522 (22.5) | 26 (22.4) | 23 (22.3) | 23 (37.1) | 100 (20.1) | 172 (22.1) |
| Not at all | 148 (57.4) | 109 (59.9) | 115 (50.2) | 832 (50.5) | 1,204 (51.9) | 69 (59.5) | 56 (54.4) | 27 (43.5) | 308 (61.8) | 460 (59.1) |
| <i>Prescription abuse</i> | | | | | | | | | | |
| Daily or near daily | 4 (1.6) | 4 (2.2) | 7 (3.1) | 13 (0.8) | 28 (1.2) | 2 (1.7) | 5 (4.9) | 3 (4.8) | 7 (1.4) | 17 (2.2) |
| Weekly | | 0 (0.0) | 3 (1.3) | 9 (0.5) | 12 (0.5) | 0 (0.0) | 1 (1.0) | 2 (3.2) | 8 (1.6) | 11 (1.4) |
| Monthly | 2 (0.8) | 3 (1.6) | 6 (2.6) | 8 (0.5) | 19 (0.8) | 2 (1.7) | 2 (1.9) | 2 (3.2) | 5 (1.0) | 11 (1.4) |
| Less than monthly | 12 (4.7) | 8 (4.4) | 8 (3.5) | 39 (2.4) | 67 (2.9) | 3 (2.6) | 4 (3.9) | 5 (8.1) | 16 (3.2) | 28 (3.6) |
| Not at all | 240 (93.0) | 167 (91.8) | 205 (89.5) | 1,580 (95.8) | 2,192 (94.6) | 109 (94.0) | 91 (88.3) | 50 (80.6) | 462 (92.8) | 712 (91.4) |
| <i>Marijuana use</i> | | | | | | | | | | |
| Daily or near daily | 4 (1.6) | 15 (8.2) | 16 (7.0) | 80 (4.9) | 115 (5.0) | 4 (3.4) | 8 (7.8) | 6 (9.7) | 26 (5.2) | 44 (5.7) |
| Weekly | 13 (5.0) | 11 (6.0) | 19 (8.3) | 82 (5.0) | 125 (5.4) | 1 (0.9) | 7 (6.9) | 2 (3.2) | 20 (4.0) | 30 (3.9) |
| Monthly | 5 (1.9) | 3 (1.6) | 13 (5.7) | 82 (5.0) | 103 (4.4) | 9 (7.8) | 2 (2.0) | 5 (8.1) | 19 (3.8) | 35 (4.5) |
| Less than monthly | 30 (11.6) | 16 (8.8) | 35 (15.3) | 184 (11.2) | 265 (11.4) | 12 (10.3) | 15 (14.7) | 7 (11.3) | 46 (9.2) | 80 (10.3) |
| Not at all | 206 (79.8) | 137 (75.3) | 146 (63.8) | 1,219 (74.0) | 1708 (73.7) | 90 (77.6) | 70 (68.6) | 42 (67.7) | 387 (77.7) | 589 (75.7) |
| <i>Drug use</i> | | | | | | | | | | |
| Daily or near daily | 0 (0.0) | 0 (0.0) | 1 (0.4) | 7 (0.4) | 8 (0.3) | 1 (0.9) | 2 (1.9) | 1 (1.6) | 2 (0.4) | 6 (0.8) |
| Weekly | 0 (0.0) | 1 (0.5) | 1 (0.4) | 4 (0.2) | 6 (0.3) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 1 (0.2) | 1 (0.1) |
| Monthly | 0 (0.0) | 1 (0.5) | 5 (2.2) | 5 (0.3) | 11 (0.5) | 0 (0.0) | 0 (0.0) | 1 (1.6) | 2 (0.4) | 3 (0.4) |
| Less than monthly | 21 (8.1) | 5 (2.7) | 11 (4.8) | 86 (5.2) | 123 (5.3) | 1 (0.9) | 3 (2.9) | 4 (6.5) | 18 (3.6) | 26 (3.3) |
| Not at all | 237 (91.9) | 175 (96.2) | 211 (92.1) | 1,546 (93.8) | 2,169 (93.6) | 114 (98.3) | 98 (95.1) | 56 (90.3) | 475 (95.4) | 743 (95.4) |
| <i>Pre-existing health conditions^b</i> | | | | | | | | | | |
| Asthma | 28 (11.2) | 38 (22.0) | 42 (18.8) | 171 (10.6) | 279 (12.3) | 13 (11.3) | 21 (21.0) | 13 (21.3) | 82 (16.4) | 129 (16.6) |
| Hypertension | 19 (7.6) | 47 (27.2) | 128 (2.6) | 221 (13.7) | 315 (13.9) | 9 (7.8) | 26 (26.0) | 8 (13.1) | 84 (16.8) | 127 (16.4) |
| Diabetes | 10 (4.0) | 17 (9.8) | 15 (6.7) | 74 (4.6) | 116 (5.1) | 4 (3.5) | 16 (16.0) | 5 (8.2) | 34 (6.8) | 59 (7.6) |
| Obesity | 35 (13.9) | 65 (37.6) | 76 (34.1) | 441 (27.3) | 617 (27.3) | 17 (14.8) | 36 (36.0) | 19 (31.1) | 163 (32.6) | 235 (30.3) |
| Emphysema/COPD | 0 (0.0) | 4 (2.3) | 0 (0.0) | 14 (0.9) | 18 (0.8) | 0 (0.0) | 5 (5.0) | 1 (1.6) | 9 (1.8) | 15 (1.9) |
| Heart Conditions | 4 (1.6) | 9 (5.2) | 5 (2.2) | 37 (2.3) | 55 (2.4) | 2 (1.7) | 7 (7.0) | 2 (3.3) | 22 (4.4) | 33 (4.3) |
| Smoking/tobacco Consumption | 7 (2.8) | 17 (9.8) | 15 (6.7) | 62 (3.8) | 101 (4.5) | 5 (4.3) | 6 (6.0) | 8 (13.1) | 28 (5.6) | 47 (6.1) |
| Kidney Disease | 4 (1.6) | 6 (3.5) | 2 (0.9) | 19 (1.2) | 31 (1.4) | 2 (1.7) | 3 (3.0) | 1 (1.6) | 9 (1.8) | 15 (1.9) |
| Liver Disease | 1 (0.4) | 3 (1.7) | 0 (0.0) | 12 (0.7) | 16 (0.7) | 0 (0.0) | 2 (2.0) | 0 (0.0) | 9 (1.8) | 11 (1.4) |
| None | 50 (19.9) | 17 (9.8) | 33 (14.8) | 321 (19.9) | 421 (18.6) | 27 (23.5) | 9 (9.0) | 12 (19.7) | 70 (14.0) | 118 (15.2) |
| I do not know | 84 (33.5) | 19 (11.0) | 45 (20.2) | 351 (21.7) | 499 (22.1) | 30 (26.1) | 14 (14.0) | 12 (19.7) | 81 (16.2) | 137 (17.7) |
| Prefer not to answer | 15 (6.0) | 11 (6.4) | 16 (7.2) | 75 (4.6) | 117 (5.2) | 13 (11.3) | 7 (7.0) | 1 (1.6) | 27 (5.4) | 48 (6.2) |
| <i>COVID-19 vaccination^c</i> | | | | | | | | | | |
| Yes | 165 (80.5) | 72 (46.5) | 133 (67.9) | 964 (68.6) | 1,334 (68.0) | 76 (80.9) | 61 (73.5) | 35 (66.0) | 339 (78.5) | 511 (77.2) |
| No | 40 (19.5) | 83 (53.5) | 63 (32.1) | 441 (31.4) | 627 (32.0) | 18 (19.1) | 22 (26.5) | 18 (34.0) | 93 (21.5) | 151 (22.8) |

(Continued)

TABLE 2 (Continued)

| | SARS-CoV-2-positive ^a | | | | | SARS-CoV-2-negative ^a | | | | |
|------------------------------|----------------------------------|--------------------|---------------------------------|----------------------|----------------------|----------------------------------|--------------------|--------------------------------|--------------------|--------------------|
| | Asian (N = 258) | Black (N = 186) | Other/ Multiple (N = 232) | White (N = 1,665) | Total (N = 2,341) | Asian (N = 117) | Black (N = 104) | Other/ Multiple (N = 64) | White (N = 507) | Total (N = 792) |
| | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
| <i>Testing location</i> | | | | | | | | | | |
| At home testing kit | 24 (9.3) | 2 (1.1) | 15 (6.5) | 144 (8.7) | 185 (7.9) | 12 (10.3) | 7 (6.7) | 8 (12.5) | 46 (9.1) | 73 (9.2) |
| Clinic including urgent care | 21 (8.1) | 26 (14.1) | 28 (12.1) | 271 (16.4) | 346 (14.8) | 14 (12.0) | 16 (15.4) | 8 (12.5) | 111 (21.9) | 149 (18.8) |
| Emergency department | 6 (2.3) | 29 (15.7) | 11 (4.7) | 49 (3.0) | 95 (4.1) | 7 (6.0) | 18 (17.3) | 5 (7.8) | 26 (5.1) | 56 (7.1) |
| Hospital | 18 (7.0) | 41 (22.2) | 23 (9.9) | 128 (7.7) | 210 (9.0) | 8 (6.8) | 17 (16.3) | 7 (10.9) | 47 (9.3) | 79 (10.0) |
| Other | 16 (6.2) | 9 (4.9) | 23 (9.9) | 117 (7.1) | 165 (7.1) | 27 (23.1) | 8 (7.7) | 15 (23.4) | 59 (11.6) | 109 (13.8) |
| Tent/drive up testing site | 173 (67.1) | 78 (42.2) | 132 (56.9) | 948 (57.2) | 1,331 (57.1) | 49 (41.9) | 38 (36.5) | 21 (32.8) | 218 (43.0) | 326 (41.2) |

^aTable excludes participants with missing race data for COVID-19-positive (61) or COVID-19-negative ($n=29$). ^bPre-existing conditions question only asked on 3-month survey beginning 4-14-2021 and has missing data for COVID-19-positive ($n=78$) and COVID-19-negative ($n=16$). ^cCOVID-19 vaccination indicates participants with at least one dose prior to the index SARS-CoV-2 test; Vaccination initiation information was obtained from linked electronic health record data for 922 (29%) participants, using survey data for 1718 (54%) participants, and was missing for 521 (16%) participants.

differences by race in self-reported Long COVID symptoms (29, 30). Conversely, a U.S. Veterans Affairs EHR-based cohort study found differences between Black and white participants at 6 months, though not to the detriment of one particular group (31). The COVID States Project, a 6-weekly internet survey conducted in all 50 states and the District of Columbia between February 2021 and July 2022 ($N > 16,000$), found that Hispanic, Other, and white participants testing positive for SARS-CoV-2 were more likely than Asian participants to report Long COVID symptoms (32). Multiple prior studies found ethnic and racial minoritized populations to have a higher risk of Long COVID (28, 39–41). Some investigations have indicated that differences by ethnicity and race might be partially accounted for by other factors. In the RECOVER Program, a retrospective study using EHR data of participants with and without COVID-19, Black and Hispanic participants experienced higher symptom burden and a different distribution of symptoms/conditions 31–180 days after testing positive for SARS-CoV-2 than white participants (27); however, adjusting for neighborhood-level socioeconomic status attenuated several differences. In the University of California Los Angeles COVID Ambulatory Monitoring Program, a prospective cohort study of adults with SARS-CoV-2, no significant difference in symptoms 60 days after acute illness was found by ethnicity or race after adjusting for other factors, including demographic/clinical characteristics, insurance type, social vulnerability index, and baseline function (26).

Differences that we observed among ethnic and racial minoritized populations in health-related outcomes 3 and 6 months following acute SARS-CoV-2 illness might be explained by additional factors, beyond those adjusted for in this study. Several potential factors are described in the literature on health disparities. Socioeconomic deprivation has independently been associated with a higher risk of Long COVID and may mediate disparities in SARS-CoV-2 impact for ethnic and racial minoritized populations (42). Higher loss of work days may be driven by the overrepresentation of minoritized populations in physically demanding frontline industries without the

option to work from home (6, 43, 44). Poor health outcomes may result from barriers to care, including inadequate health insurance and medical mistrust (6, 43–46). Mistrust and fear have been shown to deter ethnic and racial minoritized individuals with persistent SARS-CoV-2 symptoms from seeking care, compounding structural and systemic barriers (47). Ethnic and racial inequities in access to care have been illustrated in an administrative claims study, which showed that for Asian, Black, and Hispanic patients, a significantly longer time elapsed between initial infection and Long COVID diagnosis than for non-Hispanic white patients (48). Activity levels among ethnic and racial minoritized groups have been associated with differences in the built environments where they live (49–55). Finally, sequelae of COVID-19 among ethnic and racial minoritized populations may be driven by institutional, cultural, and structural racism. Experiences of discrimination adversely impact mental health and physical health through inflammation, telomere shortening, cortisol dysregulation, and increased allostatic load (56–58). Experiences of discrimination have been shown to negatively affect the quality of care and form a barrier to seeking help (59, 60). Further research is needed to understand the remaining variation in SARS-CoV-2's impact on health status, activity level, and missed work by ethnicity and race.

Our study has several limitations. First, various ethnic and racial subgroups had small sample sizes, which reduced precision in identifying differences within these subgroups. Second, sparse data precluded adjustment for insurance and frontline worker status in GEE analysis. Third, individuals who agreed to participate in this study may not have been representative of their larger ethnic and racial subgroups. Fourth, representativeness across survey time points may have been further impacted by non-response bias. Given the variation in response rates by ethnicity and race, these limitations likely differentially impact the conclusions for specific ethnic and racial groups. Fifth, we did not evaluate important neurological and mental health sequelae of SARS-CoV-2, including cognitive impairment, difficulty concentrating, and anxiety (26, 31). Sixth, participants were recruited at different stages of the pandemic, and

TABLE 3 Symptoms, health status, activity level, and missed work over time among adult INSPIRE SARS-CoV-2-positive participants by ethnicity and race.

| Symptom category | Enrollment ^a | | | | | | 3-Month ^a | | | | | | 6-Month ^b | | | | | |
|-----------------------|-------------------------|-----------------------------|--------------------|--------------------|---------------------------------|----------------------|-----------------------|-----------------------------|--------------------|--------------------|---------------------------------|----------------------|-----------------------|-----------------------------|--------------------|--------------------|---------------------------------|----------------------|
| | Ethnicity | | Race | | | | Ethnicity | | Race | | | | Ethnicity | | Race | | | |
| | Hispanic (N = 330) | Non-Hispanic (N = 2,024) | Asian (N = 258) | Black (N = 186) | Other/ Multiple (N = 232) | White (N = 1,665) | Hispanic (N = 330) | Non-Hispanic (N = 2,024) | Asian (N = 258) | Black (N = 186) | Other/ Multiple (N = 232) | White (N = 1,665) | Hispanic (N = 174) | Non-Hispanic (N = 1,208) | Asian (N = 142) | Black (N = 109) | Other/ Multiple (N = 124) | White (N = 1,000) |
| | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
| <i>Constitutional</i> | | | | | | | | | | | | | | | | | | |
| Tired | 257 (78.4) | 1,641 (81.7) | 204 (79.1) | 127 (69.8) | 196 (85.6) | 1,365 (82.6) | 69 (20.9) | 465 (23.1) | 43 (16.9) | 44 (23.8) | 69 (29.9) | 379 (22.9) | 32 (18.7) | 241 (20.1) | 22 (15.7) | 20 (18.7) | 30 (24.4) | 198 (19.9) |
| Chills | 173 (52.7) | 1,013 (50.4) | 138 (53.5) | 100 (54.9) | 126 (55.0) | 809 (48.9) | 31 (9.4) | 115 (5.7) | 11 (4.3) | 20 (10.8) | 18 (7.8) | 97 (5.9) | 8 (4.7) | 54 (4.5) | 6 (4.3) | 5 (4.7) | 3 (2.4) | 47 (4.7) |
| Feeling hot | 159 (48.5) | 941 (46.9) | 113 (43.8) | 81 (44.5) | 130 (56.8) | 767 (46.4) | 22 (6.7) | 106 (5.3) | 11 (4.3) | 14 (7.6) | 19 (8.2) | 85 (5.1) | 7 (4.1) | 53 (4.4) | 8 (5.7) | 4 (3.7) | 3 (2.4) | 46 (4.6) |
| Fever | 105 (32.0) | 613 (30.5) | 90 (34.9) | 54 (29.7) | 66 (28.8) | 505 (30.6) | 15 (4.5) | 61 (3.0) | 6 (2.4) | 9 (4.9) | 11 (4.8) | 51 (3.1) | 2 (1.2) | 27 (2.3) | 4 (2.9) | 3 (2.8) | 2 (1.6) | 19 (1.9) |
| Shakes | 65 (19.8) | 288 (14.3) | 32 (12.4) | 43 (23.6) | 49 (21.4) | 226 (13.7) | 13 (3.9) | 40 (2.0) | 7 (2.7) | 9 (4.9) | 5 (2.2) | 32 (1.9) | 2 (1.2) | 17 (1.4) | 4 (2.9) | 1 (0.9) | 1 (0.8) | 12 (1.2) |
| <i>HEENT</i> | | | | | | | | | | | | | | | | | | |
| Headache | 217 (66.2) | 1,334 (66.4) | 165 (64.0) | 114 (62.6) | 153 (66.8) | 1,109 (67.1) | 67 (20.3) | 265 (13.2) | 25 (9.8) | 32 (17.3) | 44 (19.0) | 235 (14.2) | 27 (15.8) | 131 (10.9) | 13 (9.3) | 16 (15.0) | 15 (12.2) | 115 (11.6) |
| Runny nose | 196 (59.8) | 1,407 (70.1) | 180 (69.8) | 93 (51.1) | 148 (64.6) | 1,174 (71.0) | 36 (10.9) | 193 (9.6) | 20 (7.8) | 20 (10.8) | 28 (12.1) | 160 (9.7) | 11 (6.4) | 114 (9.5) | 13 (9.3) | 9 (8.4) | 12 (9.8) | 91 (9.2) |
| Loss of smell | 147 (44.8) | 975 (48.6) | 117 (45.3) | 80 (44.0) | 116 (50.7) | 798 (48.3) | 45 (13.6) | 267 (13.3) | 26 (10.2) | 22 (11.9) | 30 (13.0) | 232 (14.0) | 13 (7.6) | 126 (10.5) | 15 (10.7) | 8 (7.5) | 7 (5.7) | 108 (10.9) |
| Loss of taste | 133 (40.5) | 895 (44.6) | 103 (39.9) | 75 (41.2) | 111 (48.5) | 733 (44.3) | 36 (10.9) | 215 (10.7) | 22 (8.6) | 21 (11.4) | 27 (11.7) | 177 (10.7) | 7 (4.1) | 100 (8.3) | 8 (5.7) | 7 (6.5) | 2 (1.6) | 91 (9.2) |
| Sore throat | 180 (54.9) | 1,142 (56.9) | 188 (72.9) | 80 (44.0) | 123 (53.7) | 927 (56.1) | 33 (10.0) | 149 (7.4) | 26 (10.2) | 16 (8.6) | 27 (11.7) | 114 (6.9) | 11 (6.4) | 74 (6.2) | 9 (6.4) | 6 (5.6) | 7 (5.7) | 63 (6.3) |
| Loss of hair | 20 (6.1) | 70 (3.5) | 9 (3.5) | 8 (4.4) | 9 (3.9) | 61 (3.7) | 34 (10.3) | 114 (5.7) | 15 (5.9) | 15 (8.1) | 16 (6.9) | 99 (6.0) | 14 (8.2) | 68 (5.7) | 7 (5.0) | 8 (7.5) | 9 (7.3) | 56 (5.6) |
| <i>Pulmonary</i> | | | | | | | | | | | | | | | | | | |
| Cough | 188 (57.3) | 1,266 (63.0) | 165 (64.0) | 96 (52.7) | 135 (59.0) | 1,053 (63.7) | 25 (7.6) | 145 (7.2) | 22 (8.6) | 20 (10.8) | 23 (10.0) | 109 (6.6) | 7 (4.1) | 64 (5.3) | 9 (6.4) | 6 (5.6) | 5 (4.1) | 52 (5.2) |
| Shortness of breath | 110 (33.5) | 591 (29.4) | 56 (21.7) | 69 (37.9) | 84 (36.7) | 486 (29.4) | 34 (10.3) | 182 (9.0) | 6 (2.4) | 23 (12.4) | 36 (15.6) | 150 (9.0) | 16 (9.4) | 89 (7.4) | 5 (3.6) | 10 (9.3) | 14 (11.4) | 75 (7.5) |
| Wheezing | 37 (11.3) | 217 (10.8) | 20 (7.8) | 26 (14.3) | 39 (17.0) | 168 (10.2) | 8 (2.4) | 54 (2.7) | 5 (2.0) | 4 (2.2) | 15 (6.5) | 39 (2.4) | 5 (2.9) | 29 (2.4) | 1 (0.7) | 3 (2.8) | 6 (4.9) | 23 (2.3) |
| <i>Cardiovascular</i> | | | | | | | | | | | | | | | | | | |
| Chest pains | 79 (24.1) | 487 (24.3) | 40 (15.5) | 55 (30.2) | 68 (29.7) | 400 (24.2) | 20 (6.1) | 105 (5.2) | 9 (3.5) | 12 (6.5) | 15 (6.5) | 88 (5.3) | 6 (3.5) | 49 (4.1) | 6 (4.3) | 5 (4.7) | 6 (4.9) | 41 (4.1) |
| Palpitations | 33 (10.1) | 158 (7.9) | 12 (4.7) | 12 (6.6) | 28 (12.2) | 138 (8.3) | 18 (5.5) | 69 (3.4) | 6 (2.4) | 9 (4.9) | 11 (4.8) | 61 (3.7) | 11 (6.4) | 38 (3.2) | 1 (0.7) | 4 (3.7) | 8 (6.5) | 34 (3.4) |

(Continued)

TABLE 3 (Continued)

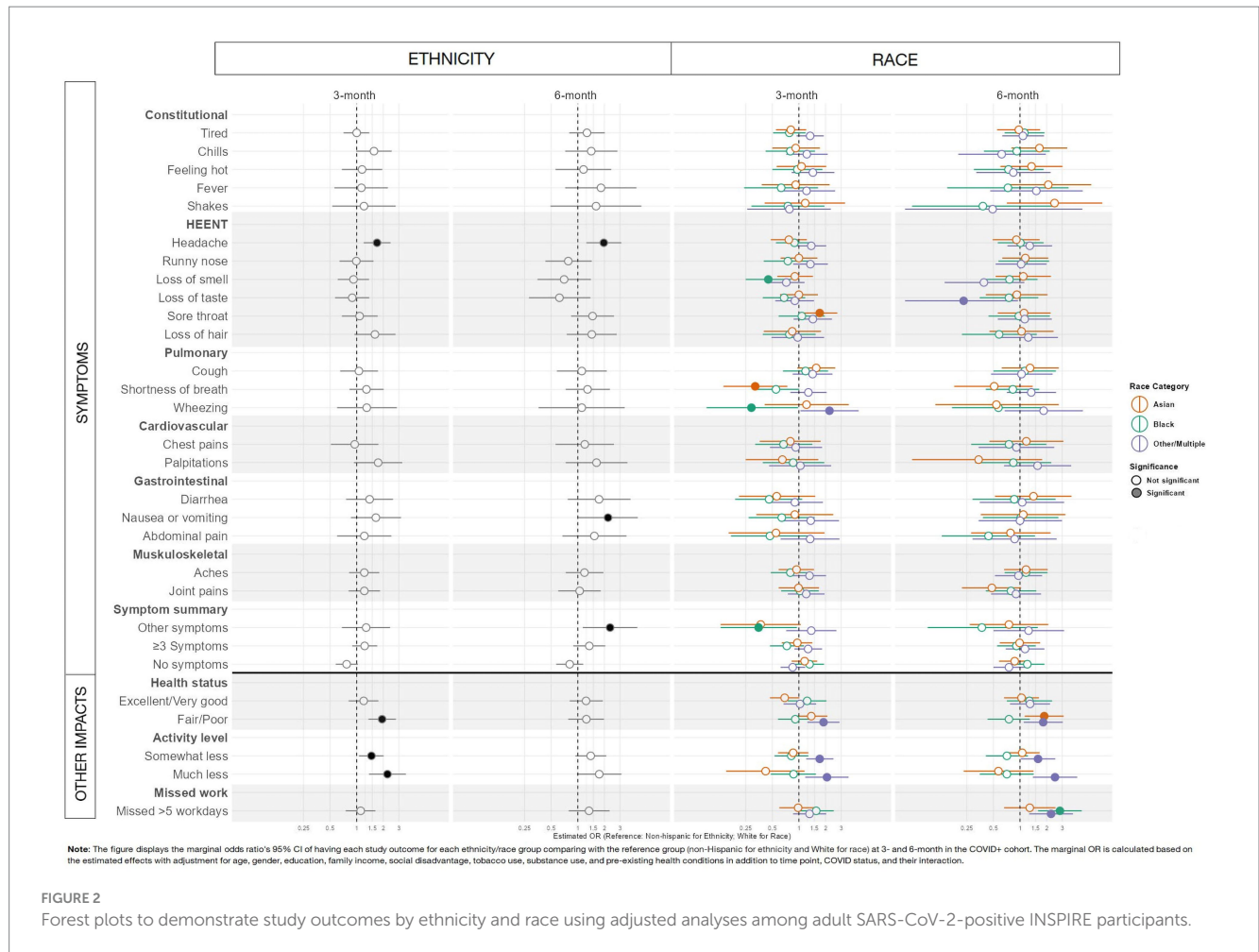
| Symptom category | Enrollment ^a | | | | | | 3-Month ^a | | | | | | 6-Month ^b | | | | | |
|------------------------------------|-------------------------|-----------------------------|--------------------|--------------------|---------------------------------|----------------------|-----------------------|-----------------------------|--------------------|--------------------|---------------------------------|----------------------|-----------------------|-----------------------------|--------------------|--------------------|---------------------------------|----------------------|
| | Ethnicity | | Race | | | | Ethnicity | | Race | | | | Ethnicity | | Race | | | |
| | Hispanic (N = 330) | Non-Hispanic (N = 2,024) | Asian (N = 258) | Black (N = 186) | Other/ Multiple (N = 232) | White (N = 1,665) | Hispanic (N = 330) | Non-Hispanic (N = 2,024) | Asian (N = 258) | Black (N = 186) | Other/ Multiple (N = 232) | White (N = 1,665) | Hispanic (N = 174) | Non-Hispanic (N = 1,208) | Asian (N = 142) | Black (N = 109) | Other/ Multiple (N = 124) | White (N = 1,000) |
| | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
| <i>Gastrointestinal</i> | | | | | | | | | | | | | | | | | | |
| Diarrhea | 88 (26.8) | 429 (21.4) | 44 (17.1) | 54 (29.7) | 65 (28.4) | 353 (21.4) | 17 (5.2) | 60 (3.0) | 5 (2.0) | 6 (3.2) | 7 (3.0) | 60 (3.6) | 5 (2.9) | 32 (2.7) | 5 (3.6) | 2 (1.9) | 3 (2.4) | 28 (2.8) |
| Nausea or vomiting | 79 (24.1) | 347 (17.3) | 36 (14.0) | 42 (23.1) | 59 (25.8) | 292 (17.7) | 13 (3.9) | 59 (2.9) | 7 (2.7) | 6 (3.2) | 9 (3.9) | 51 (3.1) | 8 (4.7) | 34 (2.8) | 2 (1.4) | 5 (4.7) | 4 (3.3) | 31 (3.1) |
| Abdominal pain | 44 (13.4) | 214 (10.7) | 20 (7.8) | 28 (15.4) | 38 (16.6) | 171 (10.3) | 10 (3.0) | 43 (2.1) | 5 (2.0) | 4 (2.2) | 6 (2.6) | 39 (2.4) | 12 (7.0) | 31 (2.6) | 1 (0.7) | 2 (1.9) | 4 (3.3) | 35 (3.5) |
| <i>Musculoskeletal</i> | | | | | | | | | | | | | | | | | | |
| Aches | 189 (57.6) | 1,163 (57.9) | 155 (60.1) | 107 (58.8) | 140 (61.1) | 938 (56.7) | 48 (14.5) | 249 (12.4) | 20 (7.8) | 33 (17.8) | 43 (18.6) | 200 (12.1) | 22 (12.9) | 139 (11.6) | 13 (9.3) | 18 (16.8) | 14 (11.4) | 116 (11.7) |
| Joint pains | 106 (32.3) | 567 (28.2) | 51 (19.8) | 55 (30.2) | 73 (31.9) | 486 (29.4) | 40 (12.1) | 221 (11.0) | 23 (9.0) | 32 (17.3) | 32 (13.9) | 172 (10.4) | 15 (8.8) | 131 (10.9) | 5 (3.6) | 15 (14.0) | 15 (12.2) | 112 (11.3) |
| <i>Symptom summary</i> | | | | | | | | | | | | | | | | | | |
| Other symptoms | 42 (12.8) | 281 (14.0) | 21 (8.1) | 15 (8.2) | 44 (19.2) | 242 (14.6) | 13 (3.9) | 91 (4.5) | 6 (2.4) | 4 (2.2) | 14 (6.1) | 82 (4.9) | 10 (5.8) | 49 (4.1) | 3 (2.1) | 3 (2.8) | 4 (3.3) | 50 (5.0) |
| ≥3 symptoms (not including others) | 293 (89.3) | 1845 (91.9) | 241 (93.4) | 150 (82.4) | 204 (89.1) | 1,528 (92.4) | 82 (24.8) | 430 (21.4) | 39 (15.3) | 54 (29.2) | 63 (27.3) | 341 (20.6) | 38 (22.2) | 225 (18.8) | 19 (13.6) | 27 (25.2) | 26 (21.1) | 192 (19.3) |
| No symptoms | 7 (2.1) | 26 (1.3) | 0 (0.0) | 6 (3.3) | 5 (2.2) | 22 (1.3) | 172 (52.1) | 1,148 (57.1) | 165 (64.7) | 99 (53.5) | 115 (49.8) | 929 (56.0) | 97 (56.7) | 714 (59.5) | 90 (64.3) | 62 (57.9) | 64 (52.0) | 590 (59.4) |
| <i>Health status</i> | | | | | | | | | | | | | | | | | | |
| Excellent | | | | | | | 26 (8.0) | 212 (10.6) | 29 (11.4) | 20 (10.9) | 21 (9.2) | 167 (10.2) | 17 (9.9) | 137 (11.4) | 17 (12.1) | 10 (9.3) | 11 (8.9) | 113 (11.4) |
| Very good | | | | | | | 78 (24.0) | 559 (28.0) | 56 (22.0) | 31 (16.8) | 47 (20.6) | 500 (30.4) | 49 (28.5) | 354 (29.4) | 43 (30.5) | 21 (19.4) | 32 (25.8) | 310 (31.2) |
| Good | | | | | | | 102 (31.4) | 746 (37.3) | 103 (40.6) | 67 (36.4) | 68 (29.8) | 607 (36.9) | 54 (31.4) | 399 (33.2) | 37 (26.2) | 37 (34.3) | 33 (26.6) | 340 (34.2) |
| Fair | | | | | | | 86 (26.5) | 380 (19.0) | 57 (22.4) | 47 (25.5) | 66 (28.9) | 290 (17.6) | 33 (19.2) | 257 (21.4) | 40 (28.4) | 27 (25.0) | 34 (27.4) | 187 (18.8) |
| Poor | | | | | | | 29 (8.9) | 92 (4.6) | 8 (3.1) | 17 (9.2) | 23 (10.1) | 73 (4.4) | 17 (9.9) | 46 (3.8) | 4 (2.9) | 8 (7.4) | 12 (9.7) | 39 (3.9) |
| Do not know | | | | | | | 4 (1.2) | 7 (0.3) | 1 (0.4) | 0 (0.0) | 2 (0.9) | 8 (0.5) | 2 (1.2) | 9 (0.7) | 0 (0.0) | 4 (3.7) | 2 (1.6) | 6 (0.6) |
| No answer | | | | | | | 0 (0.0) | 3 (0.1) | 0 (0.0) | 2 (1.1) | 1 (0.4) | 0 (0.0) | 0 (0.0) | 1 (0.1) | 0 (0.0) | 1 (0.9) | 0 (0.0) | 0 (0.0) |
| <i>Activity level^d</i> | | | | | | | | | | | | | | | | | | |
| Same as before | | | | | | | 191 (58.8) | 1,349 (67.5) | 192 (75.6) | 100 (54.3) | 125 (54.8) | 1,114 (67.8) | 109 (63.4) | 822 (68.3) | 105 (74.5) | 64 (59.3) | 74 (59.7) | 678 (68.1) |

(Continued)

TABLE 3 (Continued)

| Symptom category | Enrollment ^a | | | | | | 3-Month ^a | | | | | | 6-Month ^b | | | | | |
|--|-------------------------|-----------------------------|--------------------|--------------------|---------------------------------|----------------------|-----------------------|-----------------------------|--------------------|--------------------|---------------------------------|----------------------|-----------------------|-----------------------------|--------------------|--------------------|---------------------------------|----------------------|
| | Ethnicity | | Race | | | | Ethnicity | | Race | | | | Ethnicity | | Race | | | |
| | Hispanic (N = 330) | Non-Hispanic (N = 2,024) | Asian (N = 258) | Black (N = 186) | Other/ Multiple (N = 232) | White (N = 1,665) | Hispanic (N = 330) | Non-Hispanic (N = 2,024) | Asian (N = 258) | Black (N = 186) | Other/ Multiple (N = 232) | White (N = 1,665) | Hispanic (N = 174) | Non-Hispanic (N = 1,208) | Asian (N = 142) | Black (N = 109) | Other/ Multiple (N = 124) | White (N = 1,000) |
| | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
| Somewhat less than before | | | | | | | 99 (30.5) | 502 (25.1) | 53 (20.9) | 61 (33.2) | 76 (33.3) | 404 (24.6) | 45 (26.2) | 286 (23.8) | 32 (22.7) | 25.9 (28) | 34 (27.4) | 239 (24.0) |
| Much less than before | | | | | | | 35 (10.8) | 147 (7.4) | 9 (3.5) | 23 (12.5) | 27 (11.8) | 126 (7.7) | 18 (10.5) | 95 (7.9) | 4 (2.8) | 14.8 (16) | 16 (12.9) | 78 (7.8) |
| <i>Missed work due to health reasons past 3 months</i> | | | | | | | | | | | | | | | | | | |
| 0–5 workdays | | | | | | | 213 (65.5) | 1,376 (68.9) | 198 (78.0) | 99 (53.8) | 140 (61.4) | 1,147 (69.8) | 119 (69.2) | 889 (73.9) | 114 (80.9) | 60 (55.6) | 78 (62.9) | 752 (75.6) |
| 6–10 workdays | | | | | | | 30 (9.2) | 156 (7.8) | 12 (4.7) | 26 (14.1) | 19 (8.3) | 125 (7.6) | 11 (6.4) | 70 (5.8) | 8 (5.7) | 12 (11.1) | 10 (8.1) | 50 (5.0) |
| 11–20 workdays | | | | | | | 16 (4.9) | 79 (4.0) | 7 (2.8) | 10 (5.4) | 12 (5.3) | 65 (4.0) | 9 (5.2) | 34 (2.8) | 2 (1.4) | 10 (9.3) | 9 (7.3) | 20 (2.0) |
| Up to 4 weeks | | | | | | | 16 (4.9) | 58 (2.9) | 9 (3.5) | 16 (8.7) | 15 (6.6) | 34 (2.1) | 6 (3.5) | 23 (1.9) | 3 (2.1) | 5 (4.6) | 5 (4.0) | 15 (1.5) |
| Do not work | | | | | | | 50 (15.4) | 328 (16.4) | 28 (11.0) | 33 (17.9) | 42 (18.4) | 272 (16.6) | 27 (15.7) | 187 (15.5) | 14 (9.9) | 21 (19.4) | 22 (17.7) | 158 (15.9) |

^aIncluded COVID-19-positive participants who completed both enrollment and 3-month surveys; excluded participants with missing ethnicity ($n = 48$) and with missing symptom responses ($n = 18$ for enrollment survey; $n = 12$ for 3-month survey); excluded participants with missing race ($n = 61$) and missing symptom responses ($n = 19$ for enrollment survey; $n = 12$ for 3-month survey). ^bIncluded COVID-19-positive participants who completed enrollment, 3-month, and 6-month surveys; excluded participants with missing ethnicity ($n = 23$) and with missing symptom responses ($n = 11$); excluded participants with missing race ($n = 30$) and with missing symptom responses ($n = 11$). ^cHEENT = head, ears, eyes, nose, throat. ^dExcluded participants with missing health status ($n = 30$ for 3-month survey; $n = 7$ for 6-month survey), or activity level ($n = 31$ for 3-month survey; $n = 7$ for 6-month survey), or missed work variable ($n = 32$ for 3-month survey; $n = 7$ for 6-month survey).



the ethnic and racial composition of newly recruited participants fluctuated over time (61). Heterogeneity in symptom profile and SARS-CoV-2 impact by ethnicity and race may be influenced by differences in the dominant SARS-CoV-2 variant at the time of enrollment. Finally, we did not adjust for multiple comparisons, and the generated hypotheses should be tested in confirmatory studies.

Conclusion

Despite similar symptom prevalence, ethnic minoritized populations compared to non-Hispanic populations and racial minoritized populations compared to white populations experience more negative impacts following SARS-CoV-2 infection in terms of health status, activity level, and missed work. Increased focus on understanding drivers of ethnic and racial differences in health impacts may inform approaches to advance health equity after SARS-CoV-2 infection.

Data availability statement

The datasets presented in this article are not readily available because the data are not approved for outside use. Requests to access the datasets should be directed to KNO, kolaugh@uw.edu.

Ethics statement

Ethics approval of this protocol has been obtained at each individual site including Rush University (protocol number: 20030902, approved 3/14/2020), Yale University (2000027976, approved 4/30/2020), the University of Washington (UW Human Subjects Division, STUDY00009920, approved 4/2/2020), Thomas Jefferson University (20p.1150, approved 1/21/2021), the University of Texas Southwestern Medical Center (STU 2020-1352, approved 2/3/2021), the University of Texas, Houston (HSC-MS-20-0981, approved 9/10/2020), the University of California, San Francisco (20-32222, approved 1/25/2021) and the University of California, Los Angeles (20-001683, approved 12/18/2020). The Yale University ethics approval includes the role as the analytic lead. Additionally, the Rush University ethics approval includes INSPIRE data storage on the Hugo platform and transfer of data to Rush for secure storage. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

KNO: Conceptualization, Methodology, Writing – original draft, Investigation. REK: Conceptualization, Methodology, Writing

– original draft. IEM: Data curation, Formal analysis, Writing – review & editing. NLG: Conceptualization, Methodology, Writing – review & editing, Investigation. REG: Conceptualization, Methodology, Writing – review & editing, Investigation. ZZ: Conceptualization, Methodology, Writing – original draft. HY: Data curation, Formal analysis, Methodology, Writing – review & editing. S-XL: Data curation, Formal analysis, Visualization, Writing – review & editing. KCGC: Conceptualization, Methodology, Writing – review & editing. ESS: Investigation, Writing – review & editing. RCW: Investigation, Writing – review & editing. ML: Investigation, Writing – review & editing. RAW: Funding acquisition, Investigation, Writing – review & editing. IDP: Writing – review & editing. MG: Investigation, Writing – review & editing. RMH: Investigation, Writing – review & editing. MH: Writing – review & editing. JGE: Investigation, Writing – review & editing. MJH: Investigation, Writing – review & editing. MK: Investigation, Writing – review & editing. SM: Investigation, Writing – review & editing. KLR: Investigation, Writing – review & editing. RMR: Investigation, Writing – review & editing. AV: Investigation, Methodology, Writing – review & editing. AHI: Investigation, Writing – review & editing. MS: Investigation, Writing – review & editing. KK: Investigation, Writing – review & editing. SS: Conceptualization, Methodology, Writing – review & editing. GN: Conceptualization, Methodology, Writing – original draft. KAS: Conceptualization, Methodology, Writing – original draft.

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Conflict of interest

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The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2023.1324636/full#supplementary-material>

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