Racial/Ethnic Disparities in Healthcare Worker Experiences During the COVID-19 Pandemic: An Analysis of the HERO Registry

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Summary

Background The extent to which healthcare worker (HCWs) experiences during the COVID-19 pandemic vary by race or ethnicity after adjustment for confounding factors is not currently known.

Methods We performed an observational prospective cohort study of 24,769 healthcare workers from 50 U.S. states and the District of Columbia, enrolled between April 10, 2020 and June 30, 2021, and evaluated participant experiences during the COVID-19 pandemic, including testing, diagnosis with COVID-19, emotional experiences, burnout, and interest in vaccines and vaccine clinical trials.

Findings After adjustment for professional role, medical history, and community characteristics, Black and Asian participants were less likely to receive SARS-CoV-2 viral testing (adjusted odds ratio (aOR) 0·82 [0·70, 0·96], p=0·012 and aOR 0·77 [0·67, 0·89], p<0·001 respectively) than White participants. Hispanic participants were more likely to have evidence of COVID-19 infection (aOR 1·23 (1·00, 1·50, p=0·048). Black and Asian participants were less likely to report interest in a COVID-19 vaccine (aOR 0·11 [0·05, 0·25], p<0·001 and aOR 0·48 [0·27, 0·85] p=0·012). Black participants were less likely to report interest in participating in a COVID-19 vaccine trial (aOR = 0·39 [0·28, 0·54], p<0·001). Black participants were also less likely to report 3 or more daily emotional impacts of COVID-19 (aOR = 0·66 [0·53, 0·82], p=<0·001). Black participants were additionally less likely to report burnout (aOR = 0·66 ([0·49, 0·95], p=0·025).

Interpretation In a large, national study of healthcare workers, after adjustment for individual and community characteristics, race/ethnicity disparities in COVID-19 outcomes persist. Future work is urgently needed to understand precise mechanisms behind these disparities and to develop and implement targeted interventions to improve health equity for healthcare workers.

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Introduction

The COVID-19 pandemic has had a devastating impact: in the United States alone, more than 41 million people have been infected with SARS-CoV-2, and over

Research In Context:

Evidence before this study

Healthcare workers are at an elevated risk of occupational exposure, and illness, burnout, and fatigue in the healthcare worker population can have cascading impacts on the quality of medical care provided throughout the health system. We searched the published literature through PubMed in September 2021 with the search COVID-19 OR SARS-Cov-2 OR coronavirus AND healthcare worker AND experiences OR burnout OR vaccine interest OR testing rate AND race OR ethnicity and obtained 64 results. We evaluated the included literature to determine if any study evaluated racial disparities in key experiences for healthcare workers using patient-reported outcomes in a large, national, or multi-institution sample, that collected information on socioeconomic, demographic, and community characteristics and adjusted for potential confounding factors. We did not find any study that met these criteria, but found a range of cross-sectional, single-institution, and patient-reported outcomes studies that explored some of these questions but were unable to robustly adjust for covariates.

Added value of this study

To our knowledge, this is the first study to assess racial and ethnic disparities in COVID-19 experiences among healthcare workers in a large, national sample of healthcare workers, which collected sufficient demographic and clinical detail to robustly adjust for individual and community factors. Our study also assesses several key experiences simultaneously (testing, infection, burnout, emotional experiences, vaccine interest, and vaccine trial interest) by race and ethnicity, providing a rich set of information that will inform policymakers and health systems as they strive to advance health equity.

Implications of all the available evidence

Taken in context with the existing literature, our study provides evidence both for structural drivers of health inequity for healthcare workers (e.g. Black healthcare workers tending to live and practice in areas with higher community spread of COVID-19) and for a contributor of bias and discrimination (e.g. Black healthcare workers being less likely to receive SARS-CoV-2 viral testing after adjusting for individual and community characteristics). These findings are a call to action for policymakers to act upon health disparities in the healthcare worker population.

660,000 people have died from COVID-19.[1] African American/Black and Hispanic populations have been disproportionately affected by the pandemic and carry the greatest burden of the disease due to longstanding systemic and structural racism.[2] Studies in a multiple settings have repeatedly demonstrated that African American/Black and Hispanic populations experience greater risk of infection with SARS-CoV-2.[3,4] Furthermore, there are significant disparities in outcomes after infection: a large body of evidence suggests that African American/Black and Hispanic patients are more likely to be hospitalized, and have higher overall mortality from COVID-19.[2,4,5] There is unfortunately a relative paucity of data evaluating disparities in Asian populations in the United States: however, limited ecological data suggests that Asian patients may be at a higher risk of COVID-19 diagnosis.[2] A recent systematic review also highlighted that ethnic disparities in COVID-19 outcomes are broad global concern.[6]

The racial and ethnic disparities seen throughout the COVID-19 pandemic have created a heightened awareness of the legacy and impact of systemic and structural racism in healthcare as the direct cause of poor health outcomes among historically marginalized racial and ethnic populations. As we continue to understand the impact of COVID-19 on marginalized populations, understanding racial differences in perceptions, attitudes, and COVID-related experiences among health care workers is critical, as healthcare workers are a unique patient population: they have a higher baseline risk of exposure to COVID-19 as an occupational hazard, and may have different attitudes and beliefs about healthcare due to their own experiences working in a healthcare setting.[7]

Emerging literature has begun to explore the attitudes and beliefs of healthcare workers during the COVID-19 pandemic. Significant rates of vaccine hesitancy have been reported among healthcare workers in various contexts.[8,9] Promoting the health and wellbeing of healthcare workers is essential not just because of the size of this population, but because illness and burnout among healthcare workers can threaten the stability of the health system, the quality of patient care, and the health of the population at large.[10] However, little is known about whether barriers to the equitable access of medical care persist among healthcare workers, who may have higher levels of health literacy and access to healthcare services than the general population. We therefore evaluated COVID-19 experiences by race/ethnicity in the Healthcare Worker Exposure Response and Outcomes (HERO) Registry, a large national registry that captures healthcare worker experiences during the pandemic. We set out to evaluate the following hypothesis: that healthcare workers from historically marginalized communities would receive beneficial interventions such as SARS-CoV-2 viral testing at lesser rates and would be more likely to be diagnosed with COVID-19.

Methods

Data
The HERO Registry (ClinicalTrials.gov Identifier NCT04342806) was established in March 2020 with funding from the Patient-Centered Outcomes Research

Institute (PCORI). The registry was approved by the WIRB-Copernicus Group Institutional Review Board (WCG IRB). All participants provided written informed consent to participate in the registry. This manuscript was prepared according to the STROBE guidelines for observational cohort studies. Details on governance, recruitment and data collection have been described previously; baseline characteristics and outcomes for the early stage of the pandemic, a sub-cohort of participants included in this study, have been described in a prior publication.[11] In brief, adults who are employed in a setting that provides healthcare services or are affiliated with healthcare settings were eligible to participate. Recruitment is conducted nationally, in collaboration with PCORnet®, the National Patient-Centered Clinical Research Network, and involved institution-wide emails from participating sites, print advertisements, social media advertisements, newsletters, and professional society solicitations. Patients enrolled in the study online. Since patients were not directly approached to participate in the study in a systematic fashion, no denominator of eligible participants could be produced, as any adult healthcare worker was considered a theoretically eligible participant. All data collected in the study are participant-reported data.

This analysis includes 24,769 participants who were consented from April 10, 2020 to June 30, 2021. Online supplement 1 details data collected at enrollment and variable definitions. Participants provided self-identified race as follows: Black or African American, White, Asian/Pacific Islander (aggregated from Asian, Chinese, Filipino, Indian, Vietnamese, Korean, Japanese, or other Asian race not listed; Native Hawaiian/Pacific Islander, Native Hawaiian, Samoan, Chamorro, or other Pacific Islander race not listed); and more than one/other race/ethnicity (inclusive of Native American, "some other race," prefer not to answer, and more than one race). For ethnicity, participants reported Hispanic ethnicity or non-Hispanic ethnicity; for aggregate analyses presented below, Hispanic ethnicity was identified as a discrete group regardless of race selected.

Statistical methods

Baseline characteristics were assessed by race/ethnicity in the primary population (N=24,769) and in the subsamples of respondents to individual surveys. Multivariable logistic regression models were designed to include race/ethnicity as the initial explanatory variable and incrementally adjusted for individual and community characteristics. The unadjusted model included race only; Adjusted model 1 (AM1) included race/ethnicity, timing of survey completion (weeks from study initiation), age groups (18-29, 30-49, 50-64, 65+ years), female gender, professional role (physical therapist (PT), administrative staff, respiratory therapist, environmental services, physician, medical assistant, physician-

in-training (resident/fellow), physician's assistant (PA), nurse practitioner (NP), laboratory technician, pharmacist/pharmacy technician, paramedic/emergency medical technician, dietary/nutrition/food services, other, nurse (RN/LPN)), medical history (hypertension, diabetes mellitus, obesity/overweight, coronary artery disease, chronic obstructive pulmonary disease (COPD), asthma, smoking, chronic kidney disease, autoimmune disease), and type of healthcare facility (skilled nursing facility/nursing facility (SNF/NF), outpatient clinic/facility, urgent care clinic/emergency services, other, hospital); Adjusted model 2 included all AM1 variables, socioeconomic status (median home value, median household income, % college+, % high school+, unemployment rates), rural location, and census division; Adjusted model 3 included all AM1 variables and the first 3 digits of zip codes; zip codes with 0% or 100% events were excluded. Continuous adjustment variables were cubic splined before entering models (weeks from study initiation and SES variables). For the vaccine interest model, a generalized estimating equation (GEE) was used to account for multiple responses per participant over time. The interaction of race and survey timing were examined for both endpoints and were dropped in final models because no significant interaction effects were found (interaction p-values were 0·34 and 0·37 for the two endpoints respectively). Few participants were missing data; for 19 participants missing socioeconomic status variables, SES data were imputed to state median for continuous variables and most common level for categorical variables. 174 participants did not provide their healthcare worker role; these participants were included in a separate level for "missing/did not disclose" for adjusted analysis. Questionnaires for mental health and burnout measures have been described and validated in previous work.[12−14] Participants self-reported whether they had received antibody testing for SARS-CoV-2, and these results were not able to be linked to vaccination status; however, results from the subcohort of participants who responded to the survey prior to the widespread availability of COVID-19 vaccines showed similar trends to the overall cohort.

Analyses were executed using SAS version 9·4 (SAS Institute Inc., Cary, NC, USA). P-values are 2-sided tests and were considered statistically significant at <0·05. P-values for differences between baseline characteristics of healthcare workers are reported in Table 1 but should be interpreted as exploratory analyses.

Role of the funding source

Characteristics		Race/Ethnicity					P Value
	Overall N=24,769	White N=19,232	Black or African American N= 1,148	Hispanic (any race) N= 1,942	Asian[1] + NHPI N= 1,524	Other N= 923	
Demographics							
Age, years, mean (Standard Deviation (SD))							<0·001
Median (Interquartile Range (IQR))	40 (32 - 50)	41 (33 - 51)	42 (33 - 51)	38 (31 - 46)	38 (31 - 46)	39 (32 - 48)	
Female, n (%)	19,442 (78·5)	15,425 (80·2)	913 (79·5)	1,475 (76·0)	1,000 (65·6)	629 (68·1)	<0·001
Type of Healthcare Facility, n (%)							<0·001
Hospital	15,338 (61·9)	11,987 (62·3)	603 (52·5)	1,142 (58·8)	1,055 (69·2)	551 (59·7)	
Outpatient[2]	2,624 (10·6)	2,148 (11·2)	67 (5·8)	205 (10·6)	136 (8·9)	68 (7·4)	
Skilled Nursing Facility	912 (3·7)	707 (3·7)	79 (6·9)	61 (3·1)	28 (1·8)	37 (4·0)	
Emergency services	688 (2·8)	567 (2·9)	23 (2·0)	48 (2·5)	15 (1·0)	35 (3·8)	
Other	5,207 (21·0)	3,823 (19·9)	376 (32·8)	486 (25·0)	290 (19·0)	232 (25·1)	
Professional Role, n (%)							<0·001
Nurse (RN/LPN)	7,450 (30·3)	6,263 (32·8)	239 (21·0)	431 (22·4)	301 (19·9)	216 (23·5)	
Physician	4,276 (17·4)	3,100 (16·2)	99 (8·7)	288 (15·0)	592 (39·1)	197 (21·4)	
Other Health Practitioners	2,911 (11·8)	2,198 (11·5)	155 (13·6)	204 (10·6)	227 (15·0)	127 (13·8)	
Administrative and research	2,819 (11·5)	1,945 (10·2)	250 (22·0)	400 (20·8)	119 (7·9)	105 (11·4)	
PA/NP	1,772 (7·2)	1,531 (8·0)	33 (2·9)	86 (4·5)	68 (4·5)	54 (5·9)	
Paramedic/EMT	708 (2·9)	618 (3·2)	16 (1·4)	39 (2·0)	8 (0·5)	27 (2·9)	
Health tech and support	618 (2·5)	502 (2·6)	30 (2·6)	41 (2·1)	26 (1·7)	19 (2·1)	
Other (free text)	4,041 (16·4)	2,949 (15·4)	315 (27·7)	431 (22·4)	172 (11·4)	174 (18·9)	
Missing, %	174 (0·7)	126 (0·7)	11 (1·0)	22 (1·1)	11 (0·7)	4 (0·4)	
Residence and Healthcare Facility Location, n (%)							
Geographic Region of Residence							<0·001
Northeast	6,069 (24·5)	4,590 (23·9)	246 (21·4)	470 (24·2)	528 (34·6)	235 (25·5)	
Midwest	5,534 (22·3)	4,865 (25·3)	108 (9·4)	201 (10·4)	201 (13·2)	159 (17·2)	
South	10,685 (43·1)	8,010 (41·6)	733 (63·9)	994 (51·2)	553 (36·3)	395 (42·8)	
West	2,481 (10·0)	1,767 (9·2)	61 (5·3)	277 (14·3)	242 (15·9)	134 (14·5)	
Socioeconomic Status[3]							
Median Household Income 2017, x$1,000							<0·001
Median (IQR)	60·0 (52·2 - 75·2)	60·0 (52·2 - 74·6)	56·7 (50·8 - 65·2)	57·3 (49·8 - 70·5)	64·9 (56·7 - 84·1)	60·0 (52·2 - 76·0)	
Mean (SD)	64·3 (17)	64·3 (16·8)	60 (16·1)	62·3 (16·8)	70·9 (19·4)	64·4 (17·1)	

Table 1 (Continued)

Characteristics		Race/Ethnicity					P Value
	Overall N=24,769	White N=19,232	Black or African American N= 1,148	Hispanic (any race) N= 1,942	Asian[1] + NHPI N= 1,524	Other N= 923	
Median Home Value 2013-17, x$1,000							<0·001
Median (IQR)	195 (152 - 266)	188 (151 - 251)	195 (154 - 251)	242 (176 - 350)	251 (180 - 481)	196 (156 - 323)	
Mean (SD)	251·5 (173·9)	238·3 (162·5)	249·4 (166·9)	291 (187·2)	352·6 (234)	276·8 (194·5)	
% Persons 25+ w/ high school or more 2013-17							<0·001
Median (IQR)	89·4 (86·8 - 92·6)	89·9 (87·4 - 92·6)	87·7 (84·2 - 90·2)	87·6 (81·0 - 90·5)	88·2 (86·2 - 92·1)	88·9 (86·5 - 92·1)	
Mean (SD)	89 (4·6)	89·5 (4·2)	87 (4·8)	86·1 (6)	88·2 (4·7)	88·4 (4·8)	
% Persons 25+ w/ 4+ yrs college 2013-17							<0·001
Median (IQR)	34·6 (27·1 - 45·5)	34·6 (26·5 - 45·5)	32·0 (27·2 - 41·4)	32·0 (27·8 - 41·4)	39·1 (30·8 - 48·0)	34·0 (27·8 - 45·5)	
Mean (SD)	35·8 (12·2)	35·6 (12·3)	34·4 (10·8)	34·5 (11·1)	40·1 (11·6)	36 (11·8)	
Unemployment Rate, 16+ 2018							<0·001
Median (IQR)	3·5 (3·2 - 4·0)	3·5 (3·1 - 4·0)	3·7 (3·4 - 4·2)	3·7 (3·4 - 4·0)	3·6 (3·3 - 4·0)	3·6 (3·3 - 4·0)	
Mean (SD)	3·6 (0·9)	3·6 (0·9)	3·9 (0·9)	3·8 (1)	3·6 (0·8)	3·7 (0·9)	
Rural Location							<0·001
Rural	177 (0·7)	159 (0·8)	4 (0·3)	6 (0·3)	4 (0·3)	4 (0·4)	
Urban	1,966 (7·9)	1,784 (9·3)	41 (3·6)	47 (2·4)	32 (2·1)	62 (6·7)	
Metropolitan	22,607 (91·3)	17,275 (89·9)	1,100 (96·1)	1,889 (97·3)	1,487 (97·6)	856 (92·8)	
SES data missing, %	*19 (0·1)*	*14 (0·1)*	*3 (0·3)*	*0 (0·0)*	*1 (0·1)*	*1 (0·1)*	

Table 1: **Characteristics of health care workers in the HERO Registry by race/ethnicity.**

[1] Non-Hispanic Pacific Islander.

[2] Outpatient includes Outpatient Physical Therapy, Speech Pathology, Ambulatory clinic, and Rural Health.

[3] Socioeconomic status measures reported at census-tract level.

Articles

Results

Participant Characteristics

Among 24,769 HERO participants enrolled between April 10, 2020 and June 30, 2021, 19,232 identified as White race, 1,148 as Black race, 1,524 as Asian race; 1,942 as Hispanic ethnicity (any race), and 923 of another race/ethnicity. The average age was 40 years old, 78·5%% were female, 61·9% worked in hospital settings, 30·3% were nurses and 17·4% were physicians (Table 1).

Exposures to the SARS-CoV-2 Virus

48% of White and 47% of Asian participants reported any exposure to the SARS-CoV-2 virus; Hispanic participants were slightly more likely to report an exposure (51%), and Black participants were less likely to report an exposure (45·5%, p=0·046). Workplace exposures were reported by 43% of participants, and Black participants were less likely to report a workplace exposure (38%, p<0·001, Table 2). Community exposures were reported by 10% of participants; Asian participants were less likely to report an exposure in the community (7%, p<0·001).

SARS-CoV-2 Viral Testing

Approximately 40% of HERO participants had received a viral test for SARS-CoV-2 at the time of enrollment, with more testing in Black and Hispanic individuals (Table 2). Among those tested, test-positivity rates differed by race (p=0·0073), with Black participants reporting higher rates (5·7% vs. 3·9%). Antibody testing rates also differed by race (p=0·015); with lower testing reported among Black participants (12·6% vs. 16·6% overall). Test positivity rates for antibody tests also differed by racial groups (p=0·015), with Black participants having the highest rates of positive tests (7·5% vs. 5·3% overall). Finally, 6·5% of participants had any evidence of SARS-CoV-2 infection or COVID-19 illness, defined as a positive viral test, positive antibody test, or diagnosed COVID-19 without viral testing, and Black and Hispanic participants were more likely to have any evidence of SARS-CoV-2 infection or COVID-19 illness (9·0% and 8·1% respectively, p<0·001).

Emotional Experiences of HCWs During the COVID-19 Pandemic

Participants were also asked about their emotional experiences as HCWs during the COVID-19 pandemic (Table 3). 12,978 (52·4%) of participants provided information about their emotional experiences during the COVID-19 pandemic. White participants were more likely to respond to this survey. The most common daily impacts were feeling tired (53·6% of participants), stressed (50·6% of participants), and having trouble sleeping (40·5%). Hispanic participants were more likely to report several daily impacts (trouble sleeping, worry, sadness, and stress), whereas Asian participants were less likely to report several daily impacts (trouble sleeping, physical pain, and stress). Overall, 44·2% of participants reported at least three daily impacts, and likelihood of reporting at least three indicators varied by race (p=0·0023); Hispanic participants were the most likely to report at least three indicators (47·8%), while Asian and Black participants were the least likely (40·0% for each group). Participants also provided information about feelings of burnout (Table 3B). Around 27·8% of participants responded to questions about burnout; White participants were more likely to respond to questions about burnout. Of respondents, 42·4% endorsed feelings of burnout. There was no significant difference in burnout reported between racial/ethnic groups in univariate analysis.

Interest in Participating in Vaccine Clinical Trials

Approximately 29·1% of participants responded to an optional survey about interest in participating in vaccine clinical trials. White participants were more likely to respond to the optional survey question about vaccine trial interest. Among the respondents, only 41·9% of Black participants were interested in participating in a clinical trial of potential vaccines, compared to 58·2% of Hispanic participants, 63·0% of Asian participants, and 63·2% of White participants (p<0·001) (Table 4).

Multivariable Modeling of Disparities in Experiences for HCWs during the COVID-19 Pandemic

We then performed multivariable modeling to evaluate disparities in experiences for healthcare workers during the COVID-19 pandemic (Table 5 and 6). After extensive adjustment for personal and community characteristics (Online Supplement 2), Black participants were less likely to receive COVID-19 viral testing than White participants (aOR = 0·82 [0·70, 0·96], p=0·012). Asian participants were even less likely to receive COVID-19 viral testing compared to White participants (aOR = 0·77 [0·67, 0·89], p=<0·001). Hispanic patients were more likely to be diagnosed with COVID-19 than White patients (aOR = 1·06 [0·83, 1·35], p=0·048).

In the final multivariable model (Online Supplement 2), Black participants were less likely to report 3 or more daily emotional impacts of COVID-19 than White participants (aOR = 0·66 [0·53, 0·82], p=<0·001). Black participants were also less likely to report burnout than White participants (aOR = 0·66 ([0·49, 0·95], p=0·025). At the same time, Black participants were far less likely to express an interest in a COVID-19 vaccine trial (aOR = 0·39 [0·28, 0·54], p<0·001). There were no significant differences for other racial/ethnic groups.

Variables	Overall N=24,769	Race/Ethnicity					P Value[2]
		White N=19,232	Black or African American N= 1,148	Hispanic (any race) N= 1,942	Asian + NHPI[1] N= 1,524	Other N= 923	
Reported Exposure to SARS-CoV-2 virus, n (%)							
Any Exposure	11,182 (48·2)	8,782 (48·1)	427 (45·5)	892 (50·7)	662 (47·2)	419 (50·7)	0·046
Exposed at work place	9,902 (42·7)	7,804 (42·8)	358 (38·1)	768 (43·6)	603 (42·9)	369 (44·6)	0·042
Exposed in community	2,359 (10·2)	1,842 (10·1)	112 (11·9)	217 (12·3)	94 (6·7)	94 (11·4)	<0·001
Exposed at work place among those reported any exposure	9,902 (88·6)	7,804 (88·9)	358 (83·8)	768 (86·1)	603 (91·1)	369 (88·1)	<0·001
SARS-CoV-2 Viral Test, n (%)							
Ever tested (among overall)	10,164 (41·0)	7,769 (40·4)	536 (46·7)	869 (44·7)	589 (38·6)	401 (43·4)	<0·001
Tested positive (among overall)	956 (3·9)	736 (3·8)	66 (5·7)	68 (3·5)	48 (3·1)	38 (4·1)	0·007
Tested positive (among tested)	956 (9·4)	736 (9·5)	66 (12·3)	68 (7·8)	48 (8·1)	38 (9·5)	0·061
SARS-CoV-2 Antibody Test, n (%)							
Ever tested (among overall)	4,106 (16·6)	3,227 (16·8)	145 (12·6)	337 (17·4)	230 (15·1)	167 (18·1)	0·001
Tested positive (among overall)	484 (2·0)	354 (1·8)	25 (2·2)	58 (3·0)	29 (1·9)	18 (2·0)	0·015
Tested positive (among tested)	484 (11·8)	354 (11·0)	25 (17·2)	58 (17·2)	29 (12·6)	18 (10·8)	0·003
Viral or antibody test positive, n (%)	1,321 (5·3)	989 (5·1)	86 (7·5)	119 (6·1)	74 (4·9)	53 (5·7)	0·004
Physician diagnosed COVID-19 Illness without a diagnostic test, n (%)	346 (1·4)	227 (1·2)	22 (1·9)	53 (2·7)	27 (1·8)	17 (1·8)	<0·001
Any evidence of SARS-CoV-2 infection or COVID-19 illness, n (%)	1,602 (6·5)	1,180 (6·1)	103 (9·0)	158 (8·1)	94 (6·2)	67 (7·3)	<0·001

Table 2: **COVID-19 testing and illness among HERO healthcare workers by race/ethnicity.**

[1] Non-Hispanic Pacific Islander.

[2] Chi-squared test.

a) Daily Impact

Variables	Overall	Race/Ethnicity				Other	P Value[2]
		White	Black or African American	Hispanic (any race)	Asian + NHPI[1]		
Completed questionnaire, n (%)	12,978 (52·4)	10,367 (53·9)	466 (40·6)	1,001 (51·5)	715 (46·9)	429 (46·5)	<0·001
(1) Did you have trouble sleeping last night?	5,237 (40·5)	4,206 (40·7)	183 (39·6)	414 (41·4)	240 (33·7)	194 (45·3)	0·001
(2) Did you feel physical pain a lot of the day yesterday?	2,538 (19·6)	2,053 (19·8)	91 (19·8)	194 (19·4)	104 (14·6)	96 (22·5)	0·007
(3) Did you worry a lot of the day yesterday?	4,849 (37·5)	3,831 (37·1)	161 (34·8)	431 (43·2)	265 (37·2)	161 (37·7)	0·003
(4) Did you feel sad a lot of the day yesterday?	2,637 (20·4)	2,067 (20·0)	88 (19·0)	234 (23·5)	149 (20·9)	99 (23·2)	0·051
(5) Did you feel angry a lot of the day yesterday?	1,813 (14·0)	1,457 (14·1)	48 (10·3)	131 (13·2)	102 (14·4)	75 (17·6)	0·032
(6) Did you feel stress a lot of the day yesterday?	6,550 (50·6)	5,241 (50·7)	211 (45·5)	532 (53·2)	335 (47·1)	231 (54·0)	0·011
(7) Did you feel tired a lot of the day yesterday?	6,934 (53·6)	5,565 (53·8)	246 (53·1)	525 (52·5)	352 (49·4)	246 (57·5)	0·076
Number of indicators endorsed positively							
Median (Interquartile Range)	2 (0 - 4)	2 (0 - 4)	2 (0 - 4)	2 (0 - 4)	2 (0 - 4)	2 (1 - 4)	0·004
Mean (Standard Deviation)	2·4 (2)	2·4 (2)	2·2 (2)	2·5 (2·1)	2·2 (2)	2·6 (2)	0·004
3 or more, n (%)	5,625 (44·2)	4,487 (44·1)	180 (40·0)	472 (47·8)	281 (40·0)	205 (48·6)	0·002

b) Burnout

Variables	Overall N=24,769	Race/Ethnicity				Other N= 923	P Value[1]
		White N=19,232	Black or African American N= 1,148	Hispanic (any race) N= 1,942	Asian + NHPI[1] N= 1,524		
Completed burnout questionnaire, n (%)	6,876 (27·8)	5,698 (29·6)	163 (14·2)	458 (23·6)	349 (22·9)	208 (22·5)	<0·001
Burnout (defined as responses of iii, iv, or v on the HERO burnout instrument, available in online supplement), n (%)	2,914 (42·4)	2,429 (42·7)	63 (38·7)	202 (44·2)	132 (37·8)	88 (42·3)	0·32

Table 3: **Well-being in HERO health care workers by race/ethnicity.**
[1] Non-Hispanic Pacific Islander.
[2] Chi-squared test.

Variables	Overall N=24,769	White N=19,232	Black or African American N= 1,148	Hispanic (any race) N= 1,942	Asian + NHPI[1] N= 1,524	Other N= 923	P Value[2]
Responded to Vaccine Trial Interest Questions	7,196 (29·1)	5,919 (30·8)	191 (16·6)	531 (27·3)	330 (21·7)	225 (24·4)	<0·001
Vaccine Trial Interest, n (%)							<0·001
Yes	4,478 (62·2)	3,742 (63·2)	80 (41·9)	309 (58·2)	208 (63·0)	139 (61·8)	
No	1,479 (20·6)	1,163 (19·6)	71 (37·2)	131 (24·7)	63 (19·1)	51 (22·7)	
I'm not sure	1,239 (17·2)	1,014 (17·1)	40 (20·9)	91 (17·1)	59 (17·9)	35 (15·6)	
By Age Groups							
Age, years <40							<0·001
Yes	1,875 (63·0)	1,560 (64·4)	20 (32·8)	144 (57·1)	99 (66·9)	52 (57·1)	
No	600 (20·2)	465 (19·2)	29 (47·5)	61 (24·2)	24 (16·2)	21 (23·1)	
I'm not sure	501 (16·8)	399 (16·5)	12 (19·7)	47 (18·7)	25 (16·9)	18 (19·8)	
Age, years >=40							0·006
Yes	2,603 (61·7)	2,182 (62·4)	60 (46·2)	165 (59·1)	109 (59·9)	87 (64·9)	
No	879 (20·8)	698 (20·0)	42 (32·3)	70 (25·1)	39 (21·4)	30 (22·4)	
I'm not sure	738 (17·5)	615 (17·6)	28 (21·5)	44 (15·8)	34 (18·7)	17 (12·7)	
November Vaccine Interest, n (%)							
Responded to Vaccine Interest (November 2020) Questions	1,783 (7·2)	1,541 (8·0)	30 (2·6)	94 (4·8)	68 (4·5)	50 (5·4)	<0·001
Full approval vaccine interest	1,275 (71·8)	1,125 (73·2)	9 (30·0)	65 (69·1)	44 (67·7)	32 (64·0)	<0·001
Emergency Use Authorization vaccine interest	987 (55·5)	873 (56·8)	6 (20·0)	52 (55·3)	33 (49·3)	23 (46·0)	<0·001
December Vaccine Interest, n (%)	1,352 (5·5)	1,154 (6·0)	30 (2·6)	77 (4·0)	52 (3·4)	39 (4·2)	
Responded to Vaccine Interest (December 2020)	1,121 (83·0)	978 (84·9)	15 (50·0)	58 (75·3)	44 (84·6)	26 (66·7)	<0·001
Full approval vaccine interest	1,034 (76·8)	901 (78·3)	15 (50·0)	55 (72·4)	41 (78·8)	22 (56·4)	<0·001
Emergency Use Authorization vaccine interest	1,783 (7·2)	1,541 (8·0)	30 (2·6)	94 (4·8)	68 (4·5)	50 (5·4)	<0·001

Table 4: **Vaccine interests by race/ethnicity**

[1] Non-Hispanic Pacific Islander.

[2] Chi-squared test.

Articles

Outcomes	Race/Ethnicity	Unadjusted Model OR (95% CI)	P Value	Adjusted Model 1 OR (95% CI)	P Value	Adjusted Model 2 OR (95% CI)	P Value	Adjusted Model 3 OR (95% CI)	P Value
COVID-19 viral testing done (n= 24,769)	Black or African-American	1·29 (1·15, 1·46)	<0·001	0·93 (0·80, 1·07)	0·31	0·84 (0·73, 0·98)	0·024	0·82 (0·70, 0·96)	0·012
	Hispanic (any race)	1·19 (1·09, 1·31)	<0·0001	1·24 (1·11, 1·39)	<0·001	1·07 (0·95, 1·21)	0·24	1·07 (0·94, 1·21)	0·33
	Asian + Non-Hispanic Pacific Islander (NHPI)	0·93 (0·84, 1·03)	0·18	0·91 (0·80, 1·04)	0·18	0·79 (0·69, 0·91)	<0·001	0·77 (0·67, 0·89)	<0·001
COVID-19 infection from tests or diagnoses (n=24,769)	Black or African-American	1·51 (1·22, 1·86)	<0·001	1·26 (1·01, 1·57)	0·041	1·19 (0·95, 1·48)	0·14	1·06 (0·83, 1·35)	0·65
	Hispanic (any race)	1·35 (1·14, 1·61)	<0·001	1·35 (1·13, 1·62)	<0·001	1·14 (0·94, 1·37)	0·19	1·23 (1·00, 1·50)	0·048
	Asian + NHPI	1·01 (0·81, 1·25)	0·96	1·03 (0·82, 1·28)	0·82	0·85 (0·68, 1·07)	0·17	0·91 (0·72, 1·16)	0·45
Reuse respirator or surgical masks for most or all patients (n=12,171)	Black or African-American	0·66 (0·54, 0·81)	<0·001	0·87 (0·70, 1·09)	0·23	0·85 (0·68, 1·06)	0·16	0·84 (0·66, 1·06)	0·14
	Hispanic (any race)	0·86 (0·75, 0·99)	0·031	0·97 (0·84, 1·12)	0·67	0·94 (0·81, 1·09)	0·40	0·98 (0·84, 1·16)	0·83
	Asian + NHPI	1·13 (0·97, 1·33)	0·12	1·04 (0·88, 1·23)	0·61	0·98 (0·82, 1·16)	0·78	0·97 (0·81, 1·17)	0·78
Reported 3 or more daily impact items (n=12,736)	Black or African-American	0·84 (0·70, 1·02)	0·087	0·77 (0·63, 0·94)	0·0098	0·70 (0·57, 0·86)	<0·001	0·66 (0·53, 0·82)	<0·001
	Hispanic (any race)	1·16 (1·02, 1·32)	0·027	1·16 (1·01, 1·33)	0·035	1·07 (0·92, 1·23)	0·39	1·14 (0·98, 1·33)	0·092
	Asian + NHPI	0·85 (0·72, 0·99)	0·04	0·97 (0·82, 1·14)	0·68	0·87 (0·73, 1·03)	0·096	0·86 (0·72, 1·02)	0·085
Burnout (n=6,866)	Black or African-American	0·85 (0·61, 1·16)	0·30	0·74 (0·53, 1·04)	0·081	0·71 (0·51, 1·00)	0·049	0·66 (0·46, 0·95)	0·026
	Hispanic (any race)	1·06 (0·88, 1·29)	0·53	1·01 (0·83, 1·23)	0·92	0·96 (0·79, 1·18)	0·73	0·97 (0·78, 1·21)	0·80
	Asian + NHPI	0·82 (0·65, 1·02)	0·07	0·86 (0·68, 1·08)	0·20	0·81 (0·64, 1·03)	0·081	0·80 (0·62, 1·03)	0·085
Interested in COVID-19 vaccine trial (n=7,196)	Black or African-American	0·42 (0·31, 0·56)	<0·001	0·41 (0·31, 0·56)	<0·001	0·43 (0·32, 0·58)	<0·001	0·39 (0·28, 0·54)	<0·001
	Hispanic (any race)	0·81 (0·68, 0·97)	0·022	0·77 (0·64, 0·93)	0·006	0·87 (0·72, 1·06)	0·18	0·93 (0·75, 1·16)	0·52
	Asian + NHPI	0·99 (0·79, 1·25)	0·94	0·82 (0·65, 1·04)	0·11	0·88 (0·69, 1·13)	0·32	0·89 (0·69, 1·16)	0·39

Table 5: **Association of race/ethnicity with outcomes in HERO health care workers (reference group: White) in logistic regression modeling.**
Unadjusted model included race only; Adjusted model 1 (AM1) included race/ethnicity, timing of survey completion (weeks from study initiation), age groups (18-29, 30-49, 50-64, 65+ years), female, professional role (physical therapist (PT), administrative staff, respiratory therapist, environmental services, physician, medical assistant, physician-in-training (resident/fellow), physician's assistant (PA), nurse practitioner (NP), laboratory technician, pharmacist/pharmacy technician, paramedic/emergency medical technician, dietary/nutrition/food services, other, nurse (RN/LPN)), medical History (hypertension, diabetes mellitus, obesity/overweight, coronary artery disease, chronic obstructive pulmonary disease (COPD), asthma, smoking, chronic kidney disease, autoimmune disease), and type of healthcare facility (skilled nursing facility/nursing facility (SNF/NF), outpatient clinic/facility, urgent care clinic/emergency services, other, hospital); Adjusted model 2 included all AM1 variables, socioeconomic status (median home value, median household income, % college+, % high school+, unemployment rates), rural location, and census division; Adjusted model 3 included all AM1 variables and the first 3 digits of zip codes, zip codes with 0% or 100% events were excluded. Continuous adjustment variables were cubic splined before entering models (weeks from study initiation and SES variables).

Outcomes	Race/Ethnicity	Base Model		Adjusted Model 1		Adjusted Model 2		Adjusted Model 3	
		OR (95% CI)	P Value	OR (95% CI)	P Value	OR (95% CI)	P Value	OR (95% CI)	P Value
Interested in fully-approved COVID-19 vaccine	Black or African-American	0.17 (0.09, 0.32)	<0.001	0.14 (0.07, 0.26)	<0.001	0.14 (0.07, 0.27)	<0.001	0.11 (0.05, 0.25)	<0.001
	Hispanic (any race)	0.70 (0.46, 1.05)	0.086	0.65 (0.42, 1.00)	0.052	0.72 (0.46, 1.12)	0.15	0.75 (0.46, 1.21)	0.24
	Asian + NHPI	0.83 (0.54, 1.30)	0.42	0.56 (0.34, 0.93)	0.024	0.58 (0.35, 0.97)	0.037	0.48 (0.27, 0.85)	0.012

Table 6: Association of Race/Ethnicity with COVID-19 Vaccine Interest (reference group: White) in logistic regression modelling.
Number of responses analyzed, and number of unique participants are shown as n resp. All model variables are the same as in Table 6, except the addition of the vaccine interest survey timing variable (Nov. vs Dec.) in all four models, and the use of GEE to account for multiple responses from the same participant. The interaction of race and survey timing were examined for both endpoints and were dropped in final models because no significant interaction effects were found (interaction p-values were 0·34 and 0·37 for the two endpoints respectively).

In the sub-group of participants who responded to an optional question about interest in receiving COVID-19 vaccines, Black and Asian participants were less likely to be interested in receiving a fully approved COVID-19 vaccine; differences were particularly large for Black participants, who were just 10% as likely as White participants to express an interest in receiving a fully approved COVID-19 vaccine (aOR = 0·11 (0·05, 0·25), p<0·001).

Discussion

In this study, we analyzed racial disparities in COVID-19 outcomes for healthcare workers enrolled in the HERO registry, expanding on prior preliminary findings from a sub-cohort of registry participants that found disparities in the likelihood of receiving a positive test.[11] We hypothesized that healthcare workers from historically marginalized communities would receive beneficial interventions such as SARS-CoV-2 viral testing at lesser rates and would be more likely to be diagnosed with COVID-19. After adjustment for individual and community characteristics: 1) Black and Asian participants were less likely than White participants to receive COVID-19 viral testing; 2) Hispanic participants were more likely to be diagnosed with COVID-19 than White participants; 3) Black participants reported less daily impacts of the pandemic and less burnout than White participants, despite the concurrent broad societal awakening to social injustice experienced by Black people and added effect of racism experienced in and outside the workplace; 4) Black participants were much less likely to express interest in participating in a COVID-19 vaccine trial, and Black and Asian participants were much less interested in receiving a COVID-19 vaccine under either full or emergency use authorization, consistent with national trends. These findings may highlight the pervasive impact of structural and systemic racism that impacts historically marginalized race and ethnic populations, including those who are healthcare workers, demonstrating the critical need for researchers and healthcare systems to more effectively engage their employees and the communities they belong to in authentic partnerships and collaborations to advance health equity in the workplace and in the community.

Our results ought to be interpreted with the context that healthcare workers may be a distinctive patient population. For example, several studies have reported that embarrassment or discomfort with the patient role, peer pressure from colleagues not to seek care, as well as time and cost were barriers to physicians seeking medical care.[15,16] Similarly, several studies have shown that nurses have unique challenges as patients and may feel caught between the healthcare provider and patient roles.[17,18] Our study likewise suggests that many healthcare workers report stressful emotional experiences as

patients and as workers during the COVID-19 pandemic.

In unadjusted, univariate analysis, Black participants were more likely to receive COVID-19 viral testing; however, the direction of this relationship was reversed after adjustment for personal characteristics and community features. Our ultimate finding that Black participants were less likely to receive COVID-19 testing is broadly consistent with recent literature showing decreased rates of COVID-19 testing in the general population for Black patients compared to White patients.[19] One hypothesis for this association is that system-level disparities in testing access (i.e. decreased access to testing in communities with a higher percentage of Black residents) drives decreased testing rates for Black patients, for which there is mixed evidence in the literature.[19,20] It is possible that healthcare workers had greater access to testing than the general population, which, in conjunction with the hypothesis that Black healthcare workers tended to live and practice in areas with higher COVID-19 prevalence, could explain why Black healthcare workers in our study were more likely to receive COVID-19 testing before adjustment; however, after adjustment for community and individual characteristics, this association was reversed, perhaps suggesting that Black healthcare workers were less likely to be referred for testing than White healthcare workers of similar personal and community characteristics.

Asian healthcare workers had no significant differences in testing rates compared with White healthcare workers until individual and community characteristics were corrected for. Unfortunately, Asian healthcare workers have been particularly understudied in the United States, and current literature is sparse on testing disparities for the Asian population at large; one large, single-institution study found no differences in testing rates between racial groups.[21] Gaps in the current literature are particularly concerning given the increased rates of racism and xenophobia against Asian people in the United States since the start of the COVID-19 pandemic. [22] Our study provides the most compelling, multi-institutional evidence that racial disparities exist in testing rates for Black and Asian healthcare workers even after correction for individual and community characteristics and is a call to action for future research to investigate this disparity, as disparities in testing could allow for greater spread of the virus in Black and Asian communities.

We also found that Hispanic participants were more likely to be diagnosed with COVID-19 than White participants. This finding is broadly concordant with the body of literature in non-healthcare workers suggesting that Hispanic individuals are at higher risk for COVID-19 infection. Furthermore, we add one of the first large-scale, multi-institution studies, that corrects for potential confounding associations, to uncover this relationship in healthcare workers, expanding on several single-

institution studies and epidemiologic studies that were unable to correct for personal and community characteristics in as granular of detail as this study.[23,24] The fact that initial disparities in Hispanic and Black populations were attenuated by correction for individual characteristics and geography strongly suggests that systemic and structural factors have a major contribution to disparities in COVID-19 outcomes for healthcare workers. At the same time, our results indicate that, at least for Hispanic participants, measured structural and community characteristics are insufficient to explain the disparity in COVID-19 infection rates. Next, we observed that Black participants reported less daily emotional impacts of the pandemic and less burnout when compared with White participants. This is an unexpected finding on face. While no systematic investigation into factors associated with healthcare worker stress and race has been conducted, anecdotal reports would suggest that many Black healthcare workers have experienced significant secondary moral injury due to the disproportionate impact the COVID-19 pandemic has had on their communities.[25] Additionally, there is compelling evidence that depression and anxiety symptoms tend to spike among Black people after police killings, and that the murder of George Floyd was a major stressor for many Black people, including healthcare workers.[26,27] However, our result is not unprecedented; a recently published longitudinal study showed that Black people were less likely to report anxiety or depression symptoms during the pandemic than White people.[28] The body of psychological research on racial differences in resilience may contextualize these findings: several studies have suggested that Black people, particularly those who face and navigate historic and current racism and social injustices, may be more resilient than White people.[29,30] Overall, our findings show that more direct investigation to understand risk factors and mechanisms underlying stress and burnout in a diverse population of healthcare workers is necessary to protect the long-term wellbeing of the healthcare workforce. This finding also highlights the need to evaluate the intersectionality between various components of identity, such as (but not limited to) race, gender identity, and socioeconomic status, when evaluating disparities in the views and experiences of healthcare workers.

Finally, our findings that Black participants were less likely to express interest in a COVID-19 vaccine trial is consistent with emerging literature suggesting that Black healthcare workers frequently expressed concerns about receiving the COVID-19 vaccine, particularly early in the vaccine rollout.[31] The horrifying history of racism in medical institutions in the United States and Canada and systematic discrimination against Black people and other historically marginalized groups likely contributes to this hesitancy.[32] While one could hypothesize that Black healthcare workers would have more trust in the healthcare system than Black people more broadly,

Black healthcare workers also bear witness to the inequities in healthcare and episodes of discrimination and racism that continue to run rampant in American healthcare institutions, which may counteract any contact-mediated increased trust.[33]

Strengths of our study include its large sample size across a broad range of geographic locations and healthcare settings. Our study population comprised participants in a broad range of healthcare roles, who work in a wide range of inpatient and outpatient healthcare settings at hundreds of institutions and sites. Furthermore, our study includes detailed information on participant medical history and geographic area of residence, allowing for rigorous adjustment for geography and socioeconomic status.

Our study also has several limitations. This is a participant-reported outcomes, observational study, meaning that there is the potential for response bias among participants; at the same time, the use of participant-reported outcomes ensures that the responses are reflective of the lived experiences of actual healthcare workers. This is a convenience sample, and therefore our sample cannot be considered to be nationally representative of the broader population of healthcare workers. In fact, our study has a larger proportion of White, female, age <50, RN/LPN, and medical assistant participants compared to the national population of U.S. healthcare workers. Furthermore, academic centers participating in PCORnet served as the primary focal points for targeted recruitment, although the online-focused recruitment strategy allowed for recruitment outside of academic healthcare settings.

Additionally, approximately 80% of the study population was White, a minority of participants responded to optional surveys around vaccine trial interest and interest in receiving COVID-19 vaccines, and White participants were more likely to respond to these questions, so these results may not be fully representative of the entire population. Surveys about the number of emotional impacts experienced in the pandemic may not adequately capture the qualitative complexity and depth of emotional experiences but nonetheless provide a unified frame of comparison to detect and evaluate disparities. This study was also unable to directly assess the mindset and beliefs of participants about key issues such as trust in the medical system. Finally, despite the use of a large national registry of almost 25,000 healthcare workers, results may not be generalizable outside of healthcare workers in the United States.

The COVID-19 pandemic has highlighted the pervasive nature of structural and systemic racism, and this study shows that significant racial/ethnic disparities exist in COVID-19 outcomes for healthcare workers. Urgent action is needed to create health equity for healthcare workers and better understand the drivers of health disparities.

Author Contributions
JBL: writing—original draft, writing—review and editing, investigation; HX: methodology, formal analysis, writing—review and editing; LET: methodology, formal analysis, writing—review and editing; LWC: project administration, writing—review and editing; AFH: funding acquisition, supervision; CBF: writing—review and editing; HJM: writing—review and editing; KT: writing—review and editing; ECO: funding acquisition, conceptualization, methodology, supervision, writing—review and editing; NJB: conceptualization, supervision, writing—original draft; writing—review and editing.

Data sharing statement
Authors wishing to utilize the data described in this manuscript may submit an ancillary study proposal to Hero-Research@duke.edu.

Supplementary materials
Supplementary material associated with this article can be found in the online version at doi:10.1016/j.eclinm.2022.101314.

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