Medical Mistrust, Perceived Discrimination, and Race: a Longitudinal Analysis of Predictors of COVID-19 Vaccine Hesitancy in US Adults

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Abstract

The current manuscript has two aims. First, we examined whether race and ethnicity, perceived discrimination, medical mistrust, and other demographic factors were predictors of COVID-19 vaccine hesitancy and vaccine behavior. Second, we sought to assess whether medical mistrust and perceived discrimination mediate the relationship between race and ethnicity and vaccine behavior. Specifically, we hypothesized that individuals of color had increased COVID-19 vaccine hesitancy as compared to White individuals and perceived discrimination and medical mistrust mediated this relationship. Results revealed that when accounting for sociodemographic characteristics and COVID-19-related variables those with greater medical mistrust were more likely to have vaccine hesitancy. Additionally, after accounting for medical mistrust, Black non-Hispanic/Black Hispanic/ White Hispanic individuals had lower odds of having the COVID-19 vaccine compared to White non-Hispanic individuals. Furthermore, combined perceived discrimination and medical mistrust indirectly mediated the relationship between race and ethnicity and having the COVID-19 vaccine. The findings of this study indicate the need for public health efforts to address sentiments of medical mistrust and experiences of perceived discrimination when combating COVID-19 vaccine hesitancy, especially within communities of color.

Keywords Vaccine hesitancy · Medical mistrust · Perceived discrimination · COVID-19

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Introduction

Communities of color in the United States (US) have been disproportionately impacted by the COVID-19 pandemic and are at increased risk of being hospitalized or dying from the virus [1]. Data from the Centers for Disease Control and Prevention (CDC) in March 2022 showed that COVID-19 hospitalization rates were 2.4 times higher for Black non-Hispanic and for Hispanic or Latinx people than White non-Hispanic people [2]. Factors that have contributed to the increased risk of infection, hospitalization, and death from the virus in racial and ethnic minorities include discrimination, lower healthcare access, and occupation types such as healthcare workers or individuals unable to work from home [3–5].

In addition to COVID-19 disproportionately affecting communities of color, racial disparities in COVID-19 vaccine hesitancy persist [6]. Thus, it is important to discuss COVID-19 vaccine attitudes among racial groups in the US. For this paper, vaccine hesitancy was defined as "when there is a low perception of need for a

vaccination (termed complacency) and concerns over the efficacy and safety (termed low confidence)" [7]. Prior to the release of COVID-19 vaccines, a US adult population survey found that Black Americans were less likely than White Americans to accept a potential COVID-19 vaccine [6]. Furthermore, in 2020, a nationally conducted Pew Research Center survey found that 54% of Black adults said they would "definitely/probably get a COVID-19 vaccine if it were available today" compared to 74% of White adults and 74% of Hispanic adults of any race [8]. Although the reason for such disparities may be multifaceted, two factors that may drive the differences in vaccination intentions are medical mistrust and racially based discriminatory experiences [9, 10].

Medical mistrust has been identified as an important barrier to healthcare for communities of color. A survey found that 35% of Black adults expressed a great deal of confidence that medical scientists act in the best interest of the public, compared to 43% of White adults [8]. Black individuals are more likely to demonstrate vaccine hesitancy due to their lack of confidence in the safety of vaccines and the healthcare system compared to their White counterparts [11]. Medical mistrust influences behavioral patterns and responses, which can negatively affect satisfaction with care, provider trust, and treatment adherence [12]. A systematic review of the association between medical mistrust and health outcomes found that many participants who belong to marginalized communities report mistrust due to historical experiences of discrimination and injustice [12].

There is additional evidence that racially discriminatory experiences influence healthcare utilization, including the use of vaccines [13, 14]. A healthcare quality study found that people of color were significantly more likely to report experiences of perceived discrimination in healthcare settings [13]. Those who reported racially discriminatory experiences in provider settings were more likely to put off care and not follow medical advice [13]. A study assessing the association between factors such as discrimination and flu vaccine behavior found that for Black individuals, higher perception of discrimination is associated with lower probability of getting the flu vaccine [14]. Furthermore, any past experiences with racial discrimination were a predictor of vaccine hesitancy [10].

Racial discrimination, injustice, and exploitation of Black bodies pervade the history of medicine and research. In the South, during the eighteenth and early nineteenth centuries, physicians used enslaved Black people as subjects for experimental surgical procedures. James Marion Sims, known as the "Father of Modern Gynecology," performed experimental reproductive surgeries on enslaved Black women without anesthesia [15]. The exploitation of Black bodies persisted well into the twentieth century. The Tuskegee Syphilis Study, conducted from 1932 until 1972 in which 600 Black men were enlisted without proper consent to explore the natural history of syphilis without access to penicillin treatment, is an egregious example [16]. Another form of medical exploitation present throughout American history is the forced sterilization of Black women. For example, in 1961, Fannie Lou Hamer, a Black woman from rural Mississippi, was sent to surgery to remove a benign tumor and ultimately had her uterus removed without her consent [17]. Racist events such as these, in the context of medical research, have led to efforts such as the establishment of the Belmont Report for the protection of human participants in research. While efforts to protect human subjects were essential steps to promote ethics in research, the lasting influence of historical medical mistreatment may help to explain the higher proportion of vaccine hesitancy and medical mistrust in Black communities.

Ecosocial theory and critical race theory can be employed to further understand how medical mistrust and perceived discrimination can mediate the relationship between race and vaccine hesitancy. Ecosocial theory is centered on the analysis of health predictors on each level of biological, ecological, and social organization [18]. Ecosocial theory predicts that individuals biologically incorporate social experiences which are ultimately expressed through health, disease, and well-being [19]. Ecological and social factors such as the neighborhood environment, access and availability to healthcare services, and quality of care may influence vaccine hesitancy in communities of color. Critical race theory also provides a framework for analyzing varying experiences of perceived discrimination and medical mistrust, by presenting race as an indicator of racism-related exposures [20]. For example, a prospective cohort study found that Black women reporting racial discrimination in three or more situations had an increased chance of giving birth to infants with low birthweight [21]. Race can serve as a signifier of potential risks because of racism. As a result, risk of exposures to experiences such as perceived discrimination can vary by racial category [20].

As both medical mistrust and racially based discriminatory experiences have been associated with decreases in seeking medical treatment, including vaccination, and adhering to medical advice, these two factors may also be associated with the lack of willingness to obtain a COVID-19 vaccine specifically in communities of color [13, 14].This study aimed to assess the association of discrimination and medical mistrust with COVID-19 vaccination hesitancy and behavior among different racial and ethnic groups. We hypothesized that individuals of color had increased COVID-19 vaccine hesitancy as compared to White individuals and perceived discrimination and medical mistrust mediated this relationship.

Methods

Study Design and Data Source

This study was a cross-sectional online survey administered to a sample recruited on Amazon's Mechanical Turk (MTurk) platform by the Center for Addiction & Disease Risk Exacerbation (CADRE) at Brown University School of Public Health. Recruitment details for the baseline sample, collected from June 18 through July 19, 2020, have been described previously [22]. A follow-up survey was conducted in May 2021 for participants who completed the baseline survey with additional questions regarding COVID-19 vaccine hesitancy and beliefs regarding healthcare systems and practices. These surveys assessed the health, behavioral, and psychological impacts of the COVID-19 pandemic in adults. This study focused on five states which had the highest COVID-19 deaths per capita at the time of study: New York, New Jersey, Rhode Island, Massachusetts, and Connecticut [22]. This study was reviewed by the Brown University Institutional Review Board.

Participants

Eligibility criteria included the following: ≥ 18 years old, residing in one of the five eligible states (New York, New Jersey, Rhode Island, Massachusetts, and Connecticut), and having an active MTurk account [22]. Black and Hispanic individuals were oversampled relative to state populations since research has shown that they are disproportionately affected by the pandemic [23]. Race and ethnicity enrollment quotas were as follows: 40% White non-Hispanic, 25% Black non-Hispanic, 25% Black any ethnicity, and 10% non-White non-Hispanic [22]. Detailed information regarding the race/ethnicity and age quotas can be found in Monnig et al. [22].

Of the 3849 individuals who were assessed for eligibility, 1185 completed the entire baseline survey [22]. Detailed information regarding this sample can be found in Monnig et al. [22]. Of those who completed the entire baseline survey, 360 individuals completed the entire follow-up survey. The current study had an eligible sample of 320 individuals. This eligible sample included those who completed both the baseline and follow-up surveys and indicated they were either White non-Hispanic, Black non-Hispanic, White Hispanic, or Black Hispanic. For reference, the mean age of those who completed the follow-up survey compared to those who did not complete the follow-up survey was higher. Additionally, compared to those who completed the follow-up survey, those who did not complete the follow-up survey were more likely to be cisgender males.

Measurements

Exposure

For this study, race and ethnicity were the focal exposures and were assessed with a two-item measure from the 2020 Household Pulse Survey [24]. This was asked in the baseline survey. Participants indicated whether they were Hispanic, Latino, or of Spanish origin and checked all races that applied. For this study, we wanted to examine two racial categories: (1) White and (2) Black or African American in combination with ethnicity. Subsequently, Black non-Hispanic, Black Hispanic, and White Hispanic individuals had to be combined into one category and were compared to White non-Hispanic individuals.

Primary Outcomes

COVID-19 vaccine hesitancy was assessed in the 2021 follow-up survey by taking the average of the seven vaccine hesitancy items adapted from the Oxford COVID-19 Vaccine Hesitancy Scale developed by Freeman et al. ($\alpha = 0.97$) [7]. Only individuals who responded "No" to "Have you gotten the coronavirus vaccine?" were prompted to answer the vaccine hesitancy questions. The responses were scored 1–5 or "don't know" with higher scores indicating higher vaccine hesitancy (the "don't know" response was not scored). Detailed information about the vaccine hesitancy questions can be found in Supplemental Table 1.

Vaccination behavior was measured by asking participants "Have you gotten the coronavirus vaccine?" Participants could respond either yes (1), no (2), or unsure (3); however, there were no unsure responses in this sample. Analytically, we collapsed the responses to no (0) and yes (1).

Mediators

Medical mistrust was measured in the 2021 follow-up survey using adapted versions of the combined medical mistrust measure and medical mistrust index category [25]. Participants were asked seven questions regarding their feelings about healthcare organizations. Responses ranged from strongly disagree (1) to strongly agree (4) ($\alpha = 0.87$) with higher values indicating greater mistrust. For example, questions included the following: "You better be cautious with healthcare organizations," and "Patients have sometimes been deceived or misled by healthcare organizations" [25].

Perceived discrimination was assessed at baseline using an adapted Williams Experience of Discrimination Short form ($\alpha = 0.85$) [26]. Participants were asked a series of

Table 1 Characteristics of the participants in our sample

Sample characteristics

Variable	Total sample* ($n=320$), M (SD) or %	White non-Hispanic ($n=232$), M (SD) or %	Black non-Hispanic, Black Hispanic, White Hispanic ($n=88$), M (SD) or %	χ^2 or t^a	p
Age (19–82)	44.49 (13.93)	46.91 (13.93)	38.11 (11.80)	5.247	**< 0.001**
Gender				0.415	0.813
Cisgender man	44.06%	43.97%	44.32%	-	-
Cisgender woman	54.37%	54.74%	53.41%	-	-
Other	1.56%	1.29%	2.27%	-	-
Employment status				1.744	0.418
Full-time	61.25%	59.05%	67.05%	-	-
Part-time	16.56%	17.67%	13.64%	-	-
Not employed	22.19%	23.28%	19.32%	-	-
Education (high school/equivalent)	10.62%	10.34%	11.36%	0.070	0.792
Living alone (yes)	20.31%	19.40%	22.73%	0.437	0.508
Healthcare coverage				18.445	**< 0.001**
Yes	90.00%	94.40%	78.41%	-	-
No	8.12%	4.31%	18.18%	-	-
Don't know	1.88%	1.29%	3.41%	-	-
Essential worker status (yes)	24.69%	26.72%	19.32%	1.882	0.170
Worry level for COVID-19 infection				3.622	0.305
Very worried	15.94%	15.09%	18.18%	-	-
Moderately worried	28.44%	28.88%	27.27%	-	-
Somewhat worried	32.19%	30.17%	37.50%	-	-
Not worried/had COVID-19	23.44%	25.86%	17.05%	-	-
Do you know anyone who has been hospitalized by COVID-19 (yes)	27.19%	26.29%	29.55%	0.341	0.559
Perceived discrimination due to race/ancestry	0.94 (2.66)	0.20 (1.10)	2.86 (4.17)	− 7.85	**< 0.001**
Medical mistrust	2.5 (0.57)	2.48 (0.57)	2.67 (0.55)	− 2.71	**0.007**
COVID-19 vaccine (yes)	72.19%	76.72%	60.23%	8.648	**0.003**

[a]The χ^2 and t tests are comparing White non-Hispanic individuals to Black non-Hispanic/Black Hispanic/White Hispanic individuals

Bolded p values indicate significance at $\alpha \leq 0.05$

five questions regarding experiences of discrimination during their day-to-day life. Responses included almost every day (5), at least once a week (4), a few times a month (3), a few times a year (2), less than once a year (1), and never (0). Participants were then asked what they thought the main reasons for those experiences were. They could select only one response option, and response options included race and ancestry/national origins. Analytically, the sum score of the responses was used (0–25). Those who did not respond race or ancestry/national origins as their main reason were given a sum score of 0.

Covariates

Demographic characteristics included age, sex, gender identity, essential worker status, education level, employment status, healthcare coverage, number of people living in the household, perceived risk of COVID-19 infection, and knowing anyone who had been hospitalized by COVID-19. These variables were chosen a priori because prior research has shown that factors such as age, gender, and perceived susceptibility or perceived COVID-19 infection risk were associated with COVID-19 vaccine acceptance [27, 28].

Statistical Analysis

Descriptive analyses assessed the univariate distributions of demographic characteristics, COVID-19-related variables, medical mistrust, perceived discrimination, vaccine hesitancy, and the vaccination behavior outcome. Vaccine hesitancy was regressed onto the focal exposure and covariates using ordinary least-squares (OLS) linear regression

model with a continuous outcome and categorical and continuous independent variables (Table 2). While vaccine hesitancy was regressed onto the focal exposure and covariates, a statistical power analysis was performed for sample size estimation with an alpha of 0.05 and power of 0.80 [29]. It is important to note that the projected sample size needed is approximately $N = 134$, while our sample size was $N = 80$. Additionally, vaccination behavior was regressed onto the focal exposure and covariates using a logistic regression model (Table 3). Covariates tested for inclusion included the following: age (continuous), gender (cisgender female [reference], cisgender male, or other), education (high school/equivalent [reference], or anything above high school), amount of people living in the household besides yourself (lives alone [reference], or lives with other people), employment status (full-time [reference], part-time, or not employed or student), healthcare coverage (yes [reference], or no), worried about COVID-19 infection (very worried, moderately worried, somewhat worried, or had COVID/ not worried [reference]), do you personally know someone who has been hospitalized due to COVID-19 (yes, or no

[reference]), essential worker status (yes [reference], or no), and race (White, non-Hispanic [reference], or Black non-Hispanic/Black Hispanic/White Hispanic). For the partially adjusted models, non-significant COVID-19-related covariates were removed from the model as they were exploratory. Next for the fully adjusted models, the focal independent variables of medical mistrust and perceived discrimination were added in two separate models. Medical mistrust and perceived discrimination were mean-centered.

Due to the small sample size of vaccine hesitancy respondents, we conducted a mediation analysis examining perceived discrimination and medical mistrust as potential mediators in the relationship between race/ethnicity (exposure) and vaccination behavior (outcome). We examined the total effect of race/ethnicity on vaccine behavior, the effect of race/ethnicity on our two potential mediators, the effect of our potential mediators on vaccine behavior, and the separate and combined indirect effect of the three regressions. The total, direct, and indirect effects accounted for all demographic variables and the significant COVID-19-related variables. Standardized estimates

Table 2 Linear regression models of associations between vaccine hesitancy and perceived discrimination and medical mistrust, accounting for covariates in our sample

Variable	Model 1 ($n=80$) R^2 0.1246 Estimate (95% CI)	Model 2 ($n=80$) R^2 0.3075 Estimate (95% CI)	Model 3 ($n=61$) R^2 0.1631 Estimate (95% CI)
Intercept	3.58 (1.74, 5.42)	2.80 (1.11, 4.49)	4.22 (2.22, 6.22)
Age	0.02 (−0.02, 0.03)	0.01 (−0.02, 0.03)	−0.01 (−0.03, 0.02)
Gender (ref: cisgender female)	−0.39 (−1.00, 0.23)	−0.27 (−0.82, 0.28)	−0.09 (−0.76, 0.56)
Employment status (ref: full-time)			
Part-time	−0.25 (−0.98, 0.48)	−0.31 (−1.00, 0.35)	−0.70 (−1.47, 0.07)
Not employed	0.02 (−0.76, 0.79)	0.23 (−0.48, 0.94)	−0.17 (−1.06, 0.72)
Education (ref: high school/equivalent)	0.10 (−0.60, 0.81)	0.11 (−0.53, 0.74)	−0.18 (−1.00, 0.63)
Amount of people in the household (ref: lives alone)	−0.02 (−0.81, 0.76)	0.18 (−0.53, 0.89)	−0.04 (−0.84, 0.76)
Healthcare coverage (ref: yes)			
No	0.20 (−0.61, 1.02)	0.14 (−0.60, 0.87)	0.30 (−0.61, 1.20)
Don't know	0.12 (−1.65, 1.89)	0.69 (−0.92, 2.30)	0.39 (−1.33, 2.10)
Worry level for COVID-19 Infection (ref: had COVID/not worried)			
Very worried	−0.69 (−1.65, 0.27)	**−0.87** (−1.74, −0.01)	−0.58 (−1.72, 0.56)
Moderately worried	−0.58 (−1.26, 0.09)	−0.42 (−1.03, 0.19)	−0.45 (−1.21, 0.31)
Somewhat worried	**−0.93** (−1.72, −0.13)	−0.47 (−1.22, 0.28)	−0.82 (−1.73, 0.09)
Race (ref: White, non-Hispanic)	0.41 (−0.27, 1.08)	0.39 (−0.22, 1.00)	0.13 (−0.75, 1.02)
Medical mistrust	N/A	**0.91** (0.48, 1.35)	N/A
Perceived discrimination due to race/ancestry	N/A	N/A	0.04 (−0.08, 0.15)

Model 1: Partially adjusted results, covariates only

Model 2: Fully adjusted results for medical mistrust

Model 3: Fully adjusted results for perceived discrimination

Bolded values indicate significance at $\alpha \leq 0.05$

Table 3 Logistic regression models of associations between vaccination behavior and perceived discrimination and medical mistrust, accounting for covariates in our sample

	Model 1 ($n = 315$)	Model 2 ($n = 315$)	Model 3 ($n = 244$)
	R^2	R^2	R^2
	0.1332	0.1990	0.1317
Variable	OR (95% CI)	OR (95% CI)	OR (95% CI)
Intercept	0.65 (0.13, 3.33)	0.93 (0.16, 5.29)	0.38 (0.05, 2.83)
Age	1.00 (0.98, 1.02)	0.99 (0.97, 1.02)	1.00 (0.92, 3.42)
Gender (ref: cisgender female)	**2.01** (1.13, 3.58)	**2.11** (1.15, 3.88)	1.77 (0.92, 3.42)
Employment status (ref: full-time)			
Part-time	0.52 (0.25, 1.10)	0.59 (0.27, 1.27)	0.70 (0.30, 1.62)
Not employed	1.30 (0.63, 2.69)	1.25 (0.59, 2.64)	1.41 (0.62, 3.19)
Education	**2.67** (1.17, 6.08)	**2.71** (1.14, 6.44)	**2.81** (1.07, 7.34)
Amount of people in the household (ref: lives alone)	0.73 (0.36, 1.48)	0.66 (0.32, 1.39)	1.03 (0.47, 2.25)
Healthcare coverage (ref: yes)			
No	**0.34** (0.13, 0.89)	0.42 (0.15, 1.18)	0.51 (0.18, 1.48)
Don't know	1.11 (0.15, 8.31)	1.34 (0.18, 10.12)	0.97 (0.13, 7.12)
Worry level for COVID-19 infection (ref: had COVID/not worried)			
Very worried	**4.28** (1.73, 10.63)	**5.16** (1.96, 13.53)	**3.78** (1.32, 10.81)
Moderately worried	**2.26** (1.11, 4.58)	**2.22** (1.05, 4.67)	2.07 (0.93, 4.63)
Somewhat worried	**5.20** (2.42, 11.19)	**4.26** (1.91, 9.50)	**5.65** (2.29, 13.93)
Race (ref: White, non-Hispanic)	**0.40** (0.21, 0.76)	**0.45** (0.23, 0.89)	**0.44** (0.20, 0.97)
Medical mistrust	N/A	**0.26** (0.15, 0.46)	N/A
Perceived discrimination due to race/ancestry	N/A	N/A	0.92 (0.81, 1.05)

Model 1: Partially adjusted results, covariates only

Model 2: Fully adjusted results for medical mistrust

Model 3: Fully adjusted results for perceived discrimination

Bolded values indicate significance at $\alpha \leq 0.05$

with confidence intervals were utilized. Analyses were conducted using STATA Version 15.0 and RStudio version 1.1.456 using the *lavaan* package [29–31].

Results

Demographic Characteristics of the Participants

Detailed demographic information can be found in Table 1. In the sample, Black non-Hispanic/Black Hispanic/White Hispanic individuals had a significantly higher mean score of perceived discrimination due to race/ancestry than White non-Hispanic individuals (2.86 vs. 0.20, $p < 0.001$). These individuals also had a higher mean score for medical mistrust compared to White non-Hispanic individuals (2.67 vs. 2.48, $p = 0.007$). Additionally, 76.7% of White non-Hispanic individuals indicated they got the COVID-19 vaccine and 60.2% of Black non-Hispanic/Black Hispanic/White Hispanic individuals indicated they got the COVID-19 vaccine.

COVID-19 Vaccine Hesitancy

The results of the partially adjusted model and the fully adjusted models are reported in Table 2. The partially adjusted linear regression model with vaccination hesitancy included all demographic variables and only significant COVID-19-related variables (Model 1). Variables retained in the models were age, gender, education, employment status, healthcare coverage, living alone, and worry level for COVID-19 infection. For the fully adjusted model with medical mistrust (Model 2), being Black non-Hispanic/Black Hispanic/White Hispanic was not significantly associated with increased vaccine hesitancy. However, those with greater medical mistrust were more likely to have vaccine hesitancy. For our fully adjusted model with perceived discrimination (Model 3), being Black non-Hispanic/Black Hispanic/White Hispanic was not significantly associated with increased vaccine hesitancy. Additionally, greater perceived discrimination was not significantly associated with increased vaccine hesitancy.

Vaccination Behavior

The results of the partially adjusted model and the fully adjusted models are reported in Table 3. Our first logistic regression model with vaccination behavior included all demographic and COVID-19-related variables. For our final models, we maintained all demographic variables and removed any COVID-19-related variables that were not significant (Model 1). Variables retained in the models were age, gender, education, employment status, healthcare coverage, living alone, and worry level for COVID-19 infection. For our fully adjusted model with medical mistrust (Model 2), the odds of having the COVID-19 vaccine was 0.45 for Black non-Hispanic/Black Hispanic/White Hispanic individuals compared to White, non-Hispanic individuals. Additionally, the odds of having the COVID-19 vaccine decreased (OR = 0.26) for each one-unit increase in medical mistrust. In our fully adjusted model with perceived discrimination (Model 3), the odds of having the COVID-19 vaccine was 0.44 for Black non-Hispanic/Black Hispanic/White Hispanic individuals compared to White, non-Hispanic individuals.
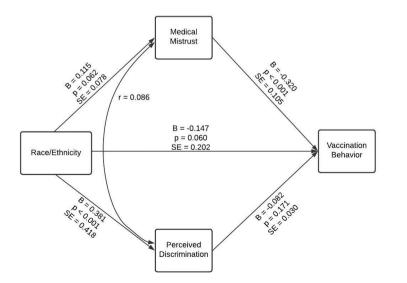
The results of the final mediation analysis model are reported in Fig. 1. Race and ethnicity were positively associated with perceived discrimination due to race or ancestry/origin. However, the association between race and ethnicity, and medical mistrust, was not statistically significant. Medical mistrust was negatively associated with having the COVID-19 vaccine. Perceived discrimination due to race or ancestry/origin did not have a statistically significant negative association with COVID-19 vaccination. Medical mistrust and perceived discrimination were not independently significant mediators in the relationship between race/ethnicity and COVID-19 vaccination. However, the indirect effect through both mediators was significant.

Discussion

This study tested whether race and ethnicity were associated with COVID-19 vaccine behavior, and if perceived discrimination and medical mistrust mediated this relationship. Our hypothesis was partially supported in that medical mistrust was significantly related to COVID-19 vaccine hesitancy. When accounting for medical mistrust, Black non-Hispanic/Black Hispanic/White Hispanic individuals had lower odds of having the COVID-19 vaccine compared to White non-Hispanic individuals. Similarly, when accounting for perceived discrimination, Black non-Hispanic/Black Hispanic/White Hispanic individuals were less likely than White non-Hispanic individuals to have any dose of the COVID-19 vaccine. Additionally, medical mistrust, but not perceived discrimination, was related to receiving any dose of the COVID-19 vaccine. While these constructs did not independently mediate the relationship between race/ethnicity and vaccination behavior, their combined effect was significant, suggesting that a complex and multifactorial process may drive the observed disparities due to race/ethnicity. Similar to our results, previous studies have found that racially discriminatory experiences influence vaccine usage [13, 14].

From an ecosocial theory perspective, we observed that when accounting for medical mistrust and perceived discrimination those who at least attended high school were more likely to have the COVID-19 vaccine as compared to those who did not. Additionally, those who were more worried about COVID-19 infection were more likely to have the COVID-19 vaccine as compared to those who were not worried. Those who at least attended high school may have higher health literacy and be more likely to accept messages surrounding vaccination [32]. This may

Fig. 1 Mediation analysis of the relationship between race/ethnicity and vaccination behavior with medical mistrust and perceived discrimination as mediators, accounting for covariates in our sample. This graphic was created using Lucidchart

help explain why those individuals were more likely to have the COVID-19 vaccine as compared to those who did not complete high school. Additionally, those who were more worried about COVID-19 infection may be of older age, have conditions that put them at greater risk of hospitalization due to COVID-19, or have family members who had COVID-19 [27]. Factors such as these may explain why those individuals were more likely to have the vaccine compared to those who were not worried or had COVID-19 previously. In the future, potential interventions to promote vaccination may consider utilizing educational materials to ensure all individuals understand the risks of COVID-19 infection and the benefits of COVID-19 vaccination. More studies are needed to assess how social and environmental factors such as these may shape vaccine behavior especially in communities of color.

Within communities of color, experiences of medical mistrust have been demonstrated to impact vaccine hesitancy as well as perceived discrimination [10, 11]. Critical race theory presents race as a marker for racism-related exposures such as perceived discrimination and medical mistrust [20]. We hypothesized that due to their race and ethnicity, individuals of color would have more experiences of perceived discrimination and higher levels of medical mistrust. The demographic characteristics of our sample showed that on average Black non-Hispanic/Black Hispanic/White Hispanic had significantly higher perceived discrimination scores as compared to White non-Hispanic individuals. Additionally, on average Black non-Hispanic/Black Hispanic/White Hispanic individuals had higher medical mistrust scores as compared to White non-Hispanic individuals. Our findings indicate that as a result of systemic racism, individuals of color are subject to more experiences of discrimination in their day-to-day lives. Additionally, our finding of higher levels of medical mistrust in communities of color may illustrate that Black and Latinx individuals internalize historical impacts of medical exploitation as well as discriminatory experiences with providers and medical systems. A lack of trust in medical systems and interventions may explain why individuals of color had decreased odds of having the COVID-19 vaccine.

A major implication of our findings is that increased levels of perceived discrimination and medical mistrust in communities of color may be one mediator of decreased COVID-19 vaccine usage. This interpretation may be speculative as we were unable to look at the outcomes of COVID-19 vaccine hesitancy and vaccine behavior between each individual racial and ethnic group. Given our initial findings regarding the mediators between race/ethnicity and COVID-19 vaccine behavior, further work on this topic is needed. Our findings indicate that initiatives to combat COVID-19 vaccine hesitancy, especially within communities of color, need to explicitly consider experiences of racial discrimination and the enduring effect of historical medical exploitation that targeted communities of color. More research is needed to better understand the major drivers of vaccine hesitancy within different racial and ethnic groups and how to effectively combat these factors when promoting vaccination.

Limitations

As noted in Monnig et al. [22], the limitations of this study include a non-representative convenience sample and self-reported data. Additionally, our findings are not generalizable to the US population as a whole, but our estimates and associations should be used to inform future research. Another major limitation was that race and ethnicity were collapsed due to the small sample size of our race and ethnicities of interest that reported vaccine hesitancy. For this study, we wanted to look at race and ethnicity independently, but those comparisons were difficult due to the number of participants in the respective subcategories, which would have made estimation of robust standard errors challenging. The combination of racial and ethnic groups limits our ability to fully understand how medical mistrust and perceived discrimination drive vaccine hesitancy in different communities. Future studies may seek to maintain distinct racial/ethnic categories to provide more insight on this relationship. Additionally, another limitation was the absence of COVID-19 vaccine hesitancy data for all of the longitudinal survey respondents. Since only those who did not already have the COVID-19 vaccine were asked the vaccine hesitancy questions, our sample size was smaller than expected. We did not observe statistical associations between race and ethnicity and vaccine hesitancy when accounting for medical mistrust and perceived discrimination along with our other covariates. For our racial and ethnic categories of interest, the study may not have had sufficient power to detect differences in COVID-19 vaccine hesitancy. Future studies may seek to address this limitation by presenting vaccine hesitancy questions to all survey participants regardless of vaccine status.

Conclusions

In a convenience sample of adults living in the northeastern US, we found that Black non-Hispanic/Black Hispanic/White Hispanic individuals on average had higher levels of perceived discrimination and medical mistrust compared to White non-Hispanic individuals. When accounting for sociodemographic characteristics and COVID-19-related variables, we found that those with greater medical mistrust also had greater vaccine hesitancy. After accounting for medical mistrust, Black non-Hispanic/Black Hispanic/White Hispanic individuals had lower odds of having the COVID-19

vaccine compared to White non-Hispanic individuals. Furthermore, combined perceived discrimination and medical mistrust mediated the relationship between race and ethnicity and having the COVID-19 vaccine, after accounting for sociodemographic characteristics and COVID-19-related variables. The findings of this study indicate the need for public health efforts to address sentiments of medical mistrust and experiences of perceived discrimination when combating COVID-19 vaccine hesitancy, especially within communities of color.

Recode Information

Race: We created a combined race/ethnicity variable recoded to White, non-Hispanic if race = white and ethnicity = not Hispanic and no other racial categories were endorsed, Black non-Hispanic if race = black and ethnicity = not Hispanic and no other racial categories were endorsed, Black Hispanic if race = black and ethnicity = Hispanic and no other racial categories were endorsed, and White Hispanic if race = white and ethnicity = Hispanic and no other racial categories were endorsed.

Gender: We created a combined sex and gender variable recoded to cisgender male if sex = male and gender = man and no other gender identities were endorsed, cisgender female if sex = female and gender = woman and no other gender identities were endorsed, other for all other combinations.

Living alone: We created a binary variable for people living in the household and recoded to living alone if people living in the house besides myself = 0 and living with other people if people living in the house besides myself ≥ 1.

Education: We created a binary variable for education recoded to high school/equivalent if last grade or year in school = high school/equivalent, and anything else if last grade or year in school = some college, college, or graduate degree.

Employment status: We recoded full-time employee if current job status = employment full-time, part-time if current job status = employment part-time, and not employed or student if current job status = student, retired, homemaker, or currently not employed.

Essential worker status: We recoded not essential worker status if essential worker status = no or essential worker status = not sure.

Perceived discrimination due to race or ancestry/origin: We created a combined perceived discrimination and reasons for discrimination variable recoded to perceived discrimination due to race or ancestry/origin if the individual had a perceived discrimination sum score and indicated that they were discriminated against because of their race or their ancestry/origin.

Declarations

Ethics Approval This study was reviewed by the Brown University Institutional Review Board and was determined to be exempt from requiring Institutional Review Board approval as a minimal risk study per federal regulations.

Consent to Participate Informed written consent was obtained from all participants before beginning the survey.

Conflict of Interest Dr. Jasjit S. Ahluwalia received sponsored funds for travel expenses as a speaker for the 2021 annual GTNF conference. Dr. Ahluwalia serves as a consultant and has equity in a start-up company, Respira Technologies.

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