

Predictors of vaccine uptake during a pandemic: The interplay of lifetime discrimination, educational attainment, and family support

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Abstract

The experience of discrimination can have significant health implications, especially during a global pandemic. This study examines how lifetime discrimination, educational attainment (measured in years of education), and family support individually and interactively predict COVID-19 vaccine uptake. Low educational attainment may amplify the impact of discrimination due to increased vulnerability to misinformation. Conversely, family support can buffer the negative effects of discrimination on health behaviors by mitigating how stressors adversely influence health decisions. We utilized national data from the Midlife in the United States ($N = 2004$; aged 25–74). The results showed that although lifetime discrimination did not predict vaccine uptake, interaction analyses revealed that lifetime discrimination, in combination with higher educational attainment predicted lower vaccine uptake. In addition, family support moderated the relationship between lifetime discrimination and vaccine uptake, buffering its negative impact. These findings highlight the complex interplay of factors influencing COVID-19 vaccination decisions.

Keywords

COVID-19 vaccine uptake, educational attainment, family support, lifetime discrimination, longitudinal study

Introduction

The COVID-19 pandemic set in motion new lines of health science related to COVID-19 vaccine acceptance, framed as the intention (plan) to get vaccinated, or to receive the vaccination. While some individuals were more receptive to COVID-19 vaccines, others were vaccine-hesitant or resistant—either reluctant to receive the vaccine or actively opposed to it. This study uses a national longitudinal sample of Americans to examine a targeted set of predictive factors of COVID-19 vaccination:

Perceived lifetime discrimination, low educational attainment, and family support. Rationales for each are covered individually below, followed by a section that integrates them.

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Focus on perceived lifetime discrimination

Discrimination refers to unfair or differential treatment based on one's actual or perceived group membership, such as gender, race/ethnicity, socioeconomic status, or physical appearance (Slopen et al., 2016). Experiences of discrimination have been shown to significantly influence health (Williams and Mohammed, 2013). The stress of discrimination has been linked to increased inflammatory burden (Ong and Williams, 2019), increased chronic conditions, increased functional limitations, and worse self-rated mental and physical health (Leger et al., 2022). Those who experience discrimination also tend to engage in fewer positive health behaviors (e.g. cancer screening; Jacobs et al., 2014) and, concomitantly, more unhealthy behaviors (e.g. smoking; Pascoe and Smart Richman, 2009).

In the context of the COVID-19 pandemic, the experience of discrimination had a significant influence on who received vaccinations. Specifically, those with past experiences of racial discrimination showed 21% higher COVID-19 vaccine hesitancy compared to those who did not experience discrimination (Savoia et al., 2021). Using a panel study from the United Kingdom, Paul et al. (2022) found that those who experienced racial/ethnic discrimination had a doubled rate of vaccine refusal. Another inquiry showed that African Americans had lower odds of vaccine intention if they experienced racial discrimination compared to those who did not experience discrimination (Brumbaugh et al., 2023).

Such reluctance to receive the COVID-19 vaccines may be linked in part to medical mistrust, as those with prior experiences of discrimination show negative expectations when receiving healthcare services and anticipate being targets of discrimination (e.g. Hammond, 2010). Repeated unfair treatment leads to heightened threat appraisals and vigilance, thereby possibly increasing distrust of healthcare services and decreasing the use of preventive healthcare services (El-Krab et al., 2023).

Supporting such ideas, Williamson et al. (2019) found that personal experiences of discrimination predicted medical mistrust, regardless of racial/ethnic background. Similarly, those discriminated against due to race/ethnicity, age, or gender showed higher COVID-19 vaccine refusal via lower trust in the health system (Paul et al., 2022). Martin et al. (2023) also demonstrated that marginalized individuals who felt less cared for in the health services reported lower medical trust, consequently leading to lower COVID-19 vaccine acceptance.

Most prior queries on how discrimination influenced COVID-19 vaccine acceptance focused on domain-specific racial discrimination (e.g. Savoia et al., 2021). However, discrimination can happen based on other characteristics as well, such as gender, age, or weight. Individuals discriminated against due to other characteristics, such as sexual orientation, also exhibit COVID-19 vaccine hesitancy (Azucar et al., 2022). Most prior literature has also focused on how everyday discrimination is linked with vaccine acceptance (e.g. Paul et al., 2022), while the impact of lifetime exposure to major discrimination on vaccination decisions has been notably overlooked. *Lifetime* discrimination thus captures major discriminatory experiences accumulated across multiple domains of life, such as being denied a job, bank loan, or scholarship (Cuevas et al., 2021; Ong and Williams, 2019). Lifetime discrimination differs from everyday discrimination in that it encompasses major past experiences of unfair treatment, in contrast to everyday, daily occurrences of discrimination. It is essential to examine how experiences of lifetime discrimination relate to receiving COVID-19 vaccines, given that lifetime discrimination has a lasting impact on health behaviors (Forde et al., 2021) and health consequences, such as inflammation (Ong and Williams, 2019).

Hypothesis 1-a: Higher perceived lifetime discrimination predicts a lower likelihood of receiving the COVID-19 vaccine.

Focus on educational attainment

Demographic factors, such as age, gender, race, education, and income, also play a role in understanding who gets vaccinated. Using an online national sample, Warren et al. (2023) found that those who responded “maybe” or “no” to whether they intended to be vaccinated were more likely to be younger, female, Black, less educated, and have lower incomes. Bogg et al. (2023), using a stratified online sample of U.S. adults, found that higher baseline education predicted higher vaccine intention, independent of other factors (e.g. political orientation, preventive behaviors). Likewise, a longitudinal sample from New Zealand showed that among those who were vaccine-willing, 35% held a bachelor’s degree or higher, compared to only 15% of those who were vaccine-hesitant (Moffitt et al., 2022).

Such education-related hesitancy to receive COVID-19 vaccines may arise from being more vulnerable to online health misinformation and believing incorrect vaccine information (Scherer et al., 2021). Yao et al. (2023) reported that about one-third of participants recruited nationwide in Hong Kong indicated that they were exposed to misinformation regarding the safety and efficacy of the COVID-19 vaccine; further, such misinformation was more strongly endorsed by those with lower SES, defined by education level and income. Endorsement of misinformation was also associated with lower vaccine acceptance. Similarly, lower educational attainment is associated with lower health literacy—the ability to understand and make decisions regarding health based on information and services provided (Clouston et al., 2017). Such vulnerabilities among those with lower educational attainment may underlie their lower likelihood of receiving COVID-19 vaccines (Montagni et al., 2021).

Hypothesis 1-b: Lower educational attainment predicts a lower likelihood of receiving the COVID-19 vaccine.

Focus on family support

During a pandemic, experiences of support from family members likely matter for engaging in preventive behaviors. Evidence points to the influence of family support on health behaviors (e.g. Brazeau and Lewis, 2021). For example, diary studies found that daily spousal support positively influenced partners’ diabetes management through engagement in healthy behaviors (Khan et al., 2013), and family support increased the use of glucose monitoring (Rosland et al., 2008). The experience of strong emotional support from family members may foster a sense of responsibility to protect the health of oneself and others (Umberson and Montez, 2010). Such thinking aligns with work linking family support to health-promoting behaviors, including a meta-analysis showing that highly cohesive families that grant emotional support were 1.74 times more likely to adhere to medical regimens than those with low support (DiMatteo, 2004).

Returning to the pandemic, those who had less support from others had lower odds of receiving COVID-19 vaccines (Jaspal and Breakwell, 2022). For example, Datta et al. (2023) showed that adults with less support from others displayed approximately 21% less likelihood of getting vaccinated. Therefore, having strong family support may increase the likelihood of receiving COVID-19 vaccines.

Hypothesis 1-c: Higher family support predicts a higher likelihood of receiving the COVID-19 vaccine.

Interplay of lifetime discrimination, educational attainment, and family support in vaccine uptake

The experience of lifetime discrimination may work against COVID-19 vaccine uptake, but such effects may also be compounded by lower educational attainment. Lifetime discrimination can contribute to hesitancy in receiving health

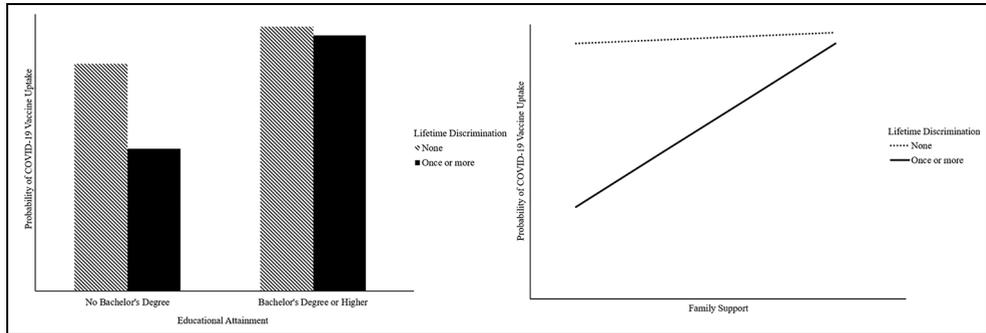


Figure 1. Hypothesized interaction models for Hypothesis 2 (left) and 3 (right).

services from others (Martin et al., 2023; Williamson et al., 2019), which can be even greater for those who are more vulnerable to misinformation regarding the COVID-19 vaccines (Scherer et al., 2021). Thus, a lack of trust in receiving health care coupled with a higher susceptibility to trusting inaccurate information from unidentified sources can further discourage the decision to get vaccinated. Together, we predict that lower educational attainment will amplify the negative relationship between perceived lifetime discrimination and COVID-19 vaccine uptake (see Figure 1 left panel).

Hypothesis 2: The adverse impact of perceived lifetime discrimination on vaccine uptake will be stronger among those with lower educational attainment. That is, those with the combination of both lifetime discrimination and low education will show the lowest levels of vaccine uptake.

Conversely, family support may act as a protective factor for health and health behaviors (Gibbons and Stock, 2018). Support from close others can change health behaviors and, in turn, impact overall health (Cohen, 1988). In line with this, higher levels of family support can buffer against the distress caused by discrimination (Wei et al., 2013) and foster greater resilience among minority individuals (Fuller and Riggs, 2018). Similarly, while those experiencing life stressors are more prone to resort to

habitual smoking, individuals with strong family support are less likely to do so (Lee et al., 2020). The stress-buffering effect of family support can help counter adverse health decisions often seen among individuals who have experienced lifetime discrimination, making them more likely to receive the COVID-19 vaccine (Gibbons and Stock, 2018; see Figure 1 right panel).

Hypothesis 3: The adverse impact of perceived lifetime discrimination on vaccine uptake will be less pronounced among those who had higher levels of family support. That is, high levels of family support will increase vaccine uptake among those who have experienced lifetime discrimination.

Overview of the present research

The present study sought to integrate perceived lifetime discrimination, low educational attainment, and family support to examine who chose to be vaccinated during the COVID-19 pandemic. The guiding idea is that past experiences and personal histories can impact current health behaviors. Moffitt et al. (2022) encapsulated this claim, arguing the importance of personal *histories* that let us know “where people are coming from” regarding vaccine acceptance. Their five-decade cohort study showed that those with adverse childhood experiences, or a history of mental health problems were more

prone to be vaccine-resistant, possibly stemming from mistrust in others, apathy, avoidance, vulnerability to conspiracy theories, and poor decision-making (Moffitt et al., 2022). Underscoring the complexity of the vaccination landscape, we examine how lifetime discrimination, educational attainment, and family support each contribute to COVID-19 vaccine uptake. Specifically, the current study draws on past experiences of discrimination, perceived family support, and educational attainment assessed in prior waves of the Midlife in the United States longitudinal study that predates the pandemic to target how past experiences shape current vaccine behavior. Furthermore, we expand our scope by bringing together how past experiences of lifetime discrimination interplay with educational attainment and family support as to the question of COVID-19 vaccine uptake.

Method

Data and samples

We utilized the MIDUS Refresher (MR) sample (2011–2014), which is a national probability sample that included English-speaking adults aged 25–74 in the United States ($N = 4084$). Of these, 3577 were recruited from across the U.S. and 507 African Americans were from Milwaukee, WI. The baseline MR data obtained from a heterogeneous national sample assessed wide-ranging behavioral and psychosocial factors that may influence well-being and health. Data were collected via a computer-assisted telephone interview (CATI) or computer-assisted personal interview (CAPI), and subsequently a self-administered questionnaire (SAQ). Between 2021 and 2022, participants from the MR sample were invited to complete a new questionnaire that included information on COVID-19 vaccine uptake. A total of 2444 participants out of the eligible baseline MR participants responded to the COVID-19 questionnaire (mortality-adjusted response rate: 63.53%).

The analytic sample consists of MR participants who responded to the vaccination item in the COVID-19 questionnaire as well as CATI/CAPI and SAQ assessments in the baseline study. A total of 2004 participants fulfilled the conditions and were included in the analytic sample. With the exception of vaccine uptake, all analytic variables were drawn from the baseline MR data assessed from 2011 to 2014. MR participants who responded to the COVID-19 SAQs were more likely to be older, in better health, have higher educational attainment, and experienced greater family support than those who did not respond to the COVID-19 SAQs. There were no differences in gender, race/ethnicity, and the experience of lifetime discrimination in the two samples.

Measures

COVID-19 vaccine uptake (2021–2022). We assessed participants' vaccine uptake using a single item (“Have you received any COVID-19 vaccine, even if only the first shot?”; 0 = *Not vaccinated*, 1 = *Vaccinated*).

Educational attainment (2011–2014). Educational attainment was measured on a 12-point scale (e.g. 1 = “no school/some grade school,” 5 = “graduated from high school,” 9 = “bachelor’s degree,” 12 = “advanced degree such as Ph.D.”). Guided by prior research (Moffitt et al., 2022), we recoded educational attainment into a binary scale (0 = *no Bachelor’s degree* and 1 = *Bachelor’s degree or higher*).

Lifetime discrimination (2011–2014). Lifetime discrimination was assessed using an 11-item measure encompassing various experiences of major discrimination that one can experience throughout life, with the counting of the events (0 = no experience of discrimination). Sample items include: “you were not given a promotion”, “you were denied a scholarship,” and

“you were hassled by the police.” As the data were highly skewed, a summary index was used (0 = *None*, 1 = *Once or more*).

Family support (2011–2014). Family support included spousal support and other family members’ support. Spousal support was measured with six items, including questions such as “How much does he or she appreciate you?” and “How much does he or she understand the way you feel about things?” ($\alpha = 0.91$). Other family members’ support was assessed with four items about how much emotional support was available from their families. Sample items include: “Can you rely on them for help if you have a serious problem?” and “Can you open up to them if you need to talk about your worries?” ($\alpha = 0.84$). For both measures, participants rated their agreement with each item on a 4-point scale ranging from 1 (*A lot*) to 4 (*Not at all*). Items were reverse-coded so that higher scores indicate greater family support. The two measures were averaged to form a single index of family support. The family support score for unmarried individuals reflected the score without spousal support, whereas the family support score of married individuals reflected the averaged score of both family and spousal support.

Covariates (2011–2014). Analytical models were adjusted for demographic variables, including age, gender (0 = *male*, 1 = *female*), and race/ethnicity (1 = *non-Hispanic White*, 2 = *non-Hispanic Black*, 3 = *multiracial/others*). We further dummy-coded race/ethnicity to be 0 (*non-Hispanic White*) and 1 (*non-Hispanic Black or multiracial/others*). Additionally, we controlled for self-rated health, as prior research indicates that those with worse self-rated health were more likely to be hesitant to receive COVID-19 vaccines (Wong et al., 2021). Self-rated health was assessed with a single-item measure (“In general, would you say your physical health is . . .?”) on a 5-point scale

ranging from 1 (*Excellent*) to 5 (*Poor*). The item was reverse-coded so that higher scores indicate better self-rated (physical) health.

Analytic plan

Binary logistic regressions were used to predict vaccine uptake with lifetime discrimination, educational attainment, and family support, as well as interactions among them. All analyses used the *glm* and *emmeans* packages in R (R Core Team, 2023). To test Hypothesis 1a–c, we entered the predictors (lifetime discrimination, educational attainment, and family support) and covariates (age, gender, race/ethnicity, self-rated physical health). To dissect the interaction effects proposed by Hypotheses 2 and 3, we examined the odds ratios of vaccination at different levels of educational attainment (having a bachelor’s degree or not), experiences of lifetime discrimination, and family support levels ($M \pm 1SD$). All continuous variables in the interaction models were mean-centered prior to analysis. The test of variance inflation factor (VIF) indicated that all predictors in the subsequent model had a value less than 2, affirming minimal potential bias due to multicollinearity (O’Brien, 2007).

Results

Descriptive statistics

Descriptive statistics and bivariate correlations are presented in Table 1. The majority of analytic sample self-identified as non-Hispanic White (73.95%), followed by non-Hispanic Black (10.38%), and multiracial/other (15.22%). The sample had a mean age of 52.16 ($SD = 13.76$) at the baseline MR data collection, with 54.69% of participants being female. Overall, 78.89% of individuals were vaccinated, with varying doses. There were significant gender differences in vaccine uptake such that females had a lower vaccine uptake than males, $OR = 0.73$, $SE = 0.08$, $p < 0.01$. Participants with

histories of lifetime discrimination were less likely to be vaccinated, compared to those without lifetime discrimination, OR = 0.77, SE = 0.09, $p = 0.02$. Those who had higher educational attainment were more likely to be vaccinated compared to those with lower educational attainment, OR = 2.60, SE = 0.31, $p < 0.001$. Those who had high family support were more likely to be vaccinated, compared to those who had less family support, OR = 1.25, SE = 0.12, $p = 0.02$. Overall, the effect of educational attainment was strong, whereas the effects of lifetime discrimination and family support were relatively small.

To test Hypotheses 1a–c, we regressed COVID-19 vaccine uptake on three predictors (i.e. perceived lifetime discrimination, educational attainment, and family support) and relevant covariates. As shown in Table 2 Model 1, Hypothesis 1b was supported in that lower educational attainment was significantly associated with lower levels of COVID-19 vaccine uptake. Those with a bachelor's degree or higher were approximately three times more likely to be vaccinated compared to those who did not have a bachelor's degree (OR = 2.80, SE = 0.36, $p < 0.001$). Therefore, lower educational attainment served as a risk factor against vaccine uptake. However, Hypotheses 1a and 1c were not supported as perceived lifetime discrimination and family support were not significantly related to COVID-19 vaccine uptake.

Perceived lifetime discrimination and lower educational attainment

To test for the interaction of perceived lifetime discrimination and educational attainment (Hypothesis 2), we entered the predictors, interaction term, and covariates (see Table 2 Model 2). The current model with the perceived lifetime discrimination \times educational attainment interaction term showed better model-fit indices compared to the null model without the two-way interaction term ($-2LL = 1807.60$ vs

1801.96, Nagelkerke $R^2 = 0.136$ vs 0.140, respectively), $\chi^2(1) = 5.64$, $p = 0.02$.

In support of Hypothesis 2, we found that perceived lifetime discrimination and educational attainment modulated each other to predict COVID-19 vaccine uptake, OR = 0.56, SE = 0.14, $p = 0.02$.¹ To explicate the nature of the interaction, we used a pairwise comparison between those who experienced lifetime discrimination and those who did not experience lifetime discrimination among those with low education (i.e. no bachelor's degree) or high education (i.e. bachelor's degree or higher). The results showed no difference in COVID-19 vaccine uptake contingent on perceived lifetime discrimination among those with low educational attainment, OR = 1.01, SE = 0.15, $p = 0.96$ (see Figure 2 left panel). However, significant differences emerged in vaccine uptake for those with a bachelor's degree or higher contingent on whether or not one experienced lifetime discrimination, OR = 1.78, SE = 0.36, $p < 0.01$. Specifically, among those with low educational attainment, there were comparably lower levels of vaccine uptake regardless of the experiences of lifetime discrimination. However, among adults with a bachelor's degree or higher, vaccine uptake was significantly lower among those who experienced lifetime discrimination compared to those who did not experience lifetime discrimination. This result was not in the hypothesized direction and is further considered in the Discussion section.

Perceived lifetime discrimination and family support

To examine whether family support moderated the associations between perceived lifetime discrimination and COVID-19 vaccine uptake (Hypothesis 3), we tested for the interaction of perceived lifetime discrimination \times family support. The model with the interaction term had a significantly better fit than the model without the interaction term ($-2LL = 1807.60$ vs

Table 1. Descriptive statistics and bivariate correlations for the variables of interest.

Variables	Vaccine uptake								
	M (SD) or %								
	Not vaccinated (N = 423)			Vaccinated (N = 1581)			Total		
	M (SD)		M (SD)		M (SD)		M (SD)		M (SD)
Age	46.61 (13.25)		53.64 (13.52)		52.16 (13.76)				
Gender: Female	60.76%		53.07%		—				
Race/ethnicity: NH White	67.85%		75.59%		—				
NH Black	15.13%		9.11%		—				
Multiracial/others	16.31%		14.93%		—				
Self-rated health	3.44 (1.12)		3.62 (1.05)		3.58 (1.07)				
Perceived lifetime discrimination:	48.18%		41.73%		—				
Once or more									
Educational attainment:	30.26%		53.04%		—				
BD or higher									
Family support	3.41 (0.62)		3.48 (0.55)		3.47 (0.57)				
	1	2	3	4	5	6	7	8	9
1. Age	—	-0.02	-0.12***	-0.10***	-0.03	-0.05*	-0.04	0.03	0.21***
2. Gender	—	—	0.09***	0.06**	-0.06*	-0.07***	0.06*	0.04	-0.06**
3. NH Black	—	—	—	-0.15***	-0.15***	-0.13***	0.13***	-0.06*	-0.08***
4. Multiracial/others	—	—	—	—	-0.06**	-0.01	0.12***	-0.03	-0.02
5. Self-rated health	—	—	—	—	—	0.27***	-0.10***	0.10***	0.07**
6. Lifetime discrimination	—	—	—	—	—	—	-0.02	-0.17***	-0.05**
7. Educational attainment	—	—	—	—	—	—	—	—	-0.19***
8. Family support	—	—	—	—	—	—	—	—	0.05*
9. Vaccine uptake	—	—	—	—	—	—	—	—	—

NH: non-Hispanic; BD: Bachelor's degree.
 * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Table 2. Logistic regression models predicting COVID-19 vaccine uptake: impacts of lifetime discrimination, educational attainment, and family support.

Variables	Model 1			Model 2			Model 3		
	B (SE)	OR	p	B (SE)	OR	p	B (SE)	OR	p
Covariates									
Age	9.12 (0.00)	1.04	<0.001	9.14 (0.00)	1.04	<0.001	9.26 (0.00)	1.04	<0.001
Gender	-1.86 (0.10)	0.80	0.06	-1.76 (0.10)	0.81	0.08	-1.67 (0.10)	0.81	0.09
Non-Hispanic Black ^a	-0.49 (0.16)	0.92	0.63	-0.44 (0.17)	0.92	0.66	-0.47 (0.17)	0.92	0.64
Multiracial or others ^a	0.56 (0.18)	1.10	0.58	0.45 (0.18)	1.08	0.65	0.45 (0.18)	1.09	0.59
Self-rated health	0.76 (0.06)	1.04	0.45	0.72 (0.06)	1.04	0.47	0.81 (0.06)	1.05	0.42
Predictors									
Lifetime discrimination	-1.59 (0.10)	0.82	0.11	0.09 (0.15)	1.01	0.93	8.05 (0.10)	0.83	0.14
Educational attainment	8.01 (0.36)	2.80	<0.001	7.30 (0.67)	3.73	<0.001	8.05 (0.36)	2.80	<0.001
Family support	1.39 (0.12)	1.15	0.16	1.45 (0.12)	1.16	0.15	-1.34 (0.15)	0.89	0.48
Interactions									
Lifetime discrimination × Educational attainment				-2.37 (0.14)	0.56	0.02			
Lifetime discrimination × Family support							2.04 (0.32)	1.54	0.04
Nagelkerke R ²	0.136			0.140			0.139		
χ ²				5.64*			4.27*		

Changes in χ² for Models 2 and 3 are relative to Model 1.

Gender: 0 = Male, 1 = Female; Educational attainment: 0 = No Bachelor's degree, 1 = Bachelor's degree or higher; Lifetime discrimination: 0 = None, 1 = Once or More.

^aReference = Non-Hispanic White. Bold text indicates p < 0.05.

*p < 0.05.

1803.33, Nagelkerke $R^2 = 0.136$ vs 0.139 , respectively), $\chi^2(1) = 4.27, p = 0.04$.

After adjusting for the covariates, we regressed the three predictors and the interaction term of perceived lifetime discrimination and family support (see Table 2 Model 3). The results indicated that perceived lifetime discrimination significantly interacted with family support to predict the odds of COVID-19 vaccine uptake ($OR = 1.54, SE = 0.32, p = 0.04$)² (see Figure 2 right panel). Specifically, among individuals who did not experience lifetime discrimination, the odds of vaccine uptake did not significantly differ based on levels of family support ($OR = 0.87, SE = 0.17, p = 0.48$). However, higher family support was associated with significantly higher odds of vaccine uptake among those who experienced one or more instances of lifetime discrimination ($OR = 1.43, SE = 0.21, p = 0.02$). Alternatively, those who received higher levels of family support (+1SD) were not influenced by lifetime discrimination regarding COVID-19 vaccine uptake ($OR = 0.94, SE = 0.16, p = 0.72$). However, those who had lower levels of family support (-1SD) showed that having no experience of lifetime discrimination was linked to 1.53 times higher odds of being vaccinated compared to those who did experience lifetime discrimination, $OR = 1.53, SE = 0.26, p = 0.01$. Thus, in support of Hypothesis 3, family support acted as a buffer for the detrimental effect of lifetime discrimination on COVID-19 vaccine uptake.

Discussion

This study used a longitudinal, nationally representative sample, including a city-specific oversample of African Americans, to examine the role of three targeted key variables on COVID-19 vaccine uptake. Specifically, we investigated how perceived lifetime discrimination, educational attainment, and family support independently and interactively predicted vaccine uptake. Supporting Hypothesis 1-b, lower educational attainment predicted lower COVID-19

vaccine uptake. However, Hypothesis 1-a and 1-c were not supported, as the main effects of lifetime discrimination and family support were not significant. Although numerous findings document the robust influence of educational attainment on vaccine intention, most have treated it as one of multiple demographic variables, or as a covariate (e.g. Martin et al., 2023). Our findings extend the previous research showing that lower educational attainment, particularly not having a bachelor's degree, substantially lowered the odds of vaccine uptake, above and beyond other demographic factors.

Such hesitation among the lower educated individuals may reflect increased difficulty in comprehending complex vaccine information (Biasio, 2017; Moffitt et al., 2022). Biasio (2017) delineates how limited health literacy impedes protective behaviors, such as receiving vaccines, which necessitate understanding of complex information and vaccination procedures. Notably, the COVID-19 pandemic presented a unique challenge as it required rapid approval and rollout of vaccines. Recurring adjustments in vaccine protocols and uncertainty surrounding vaccination could have made those with less education more hesitant to receive vaccines. In times of emergency authorization of vaccines such as COVID-19, it may be beneficial to educate the general public to help with comprehension of incoming information and to craft vaccine messages that are clear and intuitive. However, this interpretation remains speculative, and the current study does not provide evidence for this point.

Our findings also demonstrate that the interplay of the above factors predicted vaccine uptake. The results showed that perceived lifetime discrimination and educational attainment interacted to predict COVID-19 vaccine uptake. The guiding prediction was that the negative impact of limited education on vaccine uptake would be exacerbated among those with prior experiences of lifetime discrimination. However,

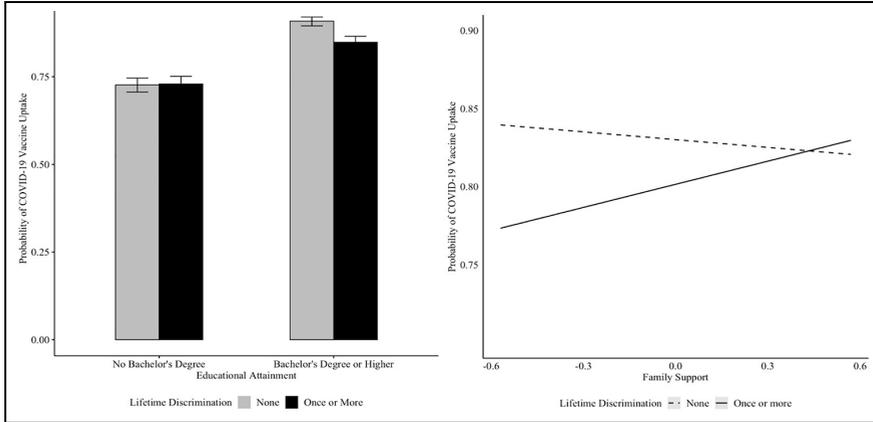


Figure 2. Probability of COVID-19 vaccine uptake: impacts of lifetime discrimination contingent on educational attainment (left) and family support (right). Models are adjusted for the covariates.

the obtained pattern showed something different. First, among those with limited education, there were no differences in the probability of vaccine uptake between those with or without lifetime discrimination—that is, both groups had lower levels of vaccine uptake compared to those with higher educational attainment. However, among those with a bachelor’s degree or higher, vaccine uptake was significantly lower among those who experienced lifetime discrimination than among those who did not.

We consider several interpretations of this result. Among those with bachelor’s degrees who are exposed to higher levels of discriminatory behavior from others, there may be heightened vigilance about such experiences (Cheng et al., 2015). Becoming aware of such discrimination may provoke higher discontentment and more skepticism in following guidelines outlined by the government, such as a fast uptake of the COVID-19 vaccines. In addition, experiences of lifetime discrimination may dampen perceptions of future or possible selves among those with higher educational attainment. That is, higher educational attainment may nurture higher self-expectations going forward (Markus and Nurius, 1986). Prior research has shown that those with positive possible selves are more likely to adopt

health-promoting behaviors and engage less in health-risk behaviors (Corte et al., 2022). Encountering lifetime discrimination may thus challenge positive self-narratives, and thereby potentially undermine engagement in protective health behaviors, such as getting vaccinated.

A further significant interaction pertained to perceived lifetime discrimination and family support. The guiding prediction was that family support would serve as a buffer against the negative impact of perceived lifetime discrimination on COVID-19 vaccine uptake. The findings supported this prediction, showing higher vaccine uptake among those with lifetime discrimination when they reported higher levels of family support. Alternatively, among those not reporting prior experiences of discrimination, vaccine uptake did not significantly vary depending on reported levels of family support.

The above result echoes how emotional support from close others can safeguard those who experienced discrimination from becoming vaccine-hesitant. Specifically, recognizing and validating past experiences of discrimination by close others can be an important step toward reducing the barriers to vaccination. Rather than repeatedly emphasizing the safety of vaccines, it may be crucial to set long-term goals to

mitigate distrust by considering deeper reasons for vaccine hesitancy. For example, providing accurate and detailed information about the potential risks and benefits increased COVID-19 vaccine uptake among minorities. Additionally, when such information was limited, warm and competent medical professionals who inspired more trust also increased vaccine intention (Juanchich et al., 2024). Adopting such an approach could help tailor effective vaccination messaging and address the mixed effects of current strategies (Moffitt et al., 2022).

Strengths and limitations

Our findings reflect a novel approach that examines how educational attainment interacts with past experiences to shape vaccine decisions. Limited prior research has investigated the interplay of psychosocial factors with education to predict vaccination, given the use of educational attainment largely as one of the demographic factors in COVID-19 vaccine research (Bogg et al., 2023). However, educational attainment can profoundly influence how experiences are interpreted and thereby have input on subsequent behaviors (Scherer et al., 2021). Consistent with this understanding, our findings document the unique interplay of educational attainment with lifetime discrimination in understanding vaccine uptake.

The current study used a national probability sample. Most prior research on COVID-19 vaccine intention or acceptance has, however, utilized online participants, which rely on convenience sampling (e.g. Bogg et al., 2023). Only a few studies have used national probability samples to investigate COVID-19 vaccine uptake, typically with cross-sectional data (e.g. Datta et al., 2023), or focused on vaccine *intention* rather than vaccine uptake (e.g. Warren et al., 2023). Consequently, our study benefits from the strength of a nationally representative sample with an oversample of African Americans, bringing greater sociodemographic

heterogeneity to the inquiry. Additionally, the longitudinal design allows for a deeper understanding of how past life history influences an amalgam of factors pertinent to COVID-19 vaccine uptake. The vaccination rate of the current sample was 79%, comparable to the national average of 81% (Centers for Disease Control and Prevention, 2023). Nonetheless, the high COVID-19 vaccine uptake may have limited our ability to probe factors that undermine the decision to get vaccinated.

It is important to acknowledge that national samples are not without limitations. The MIDUS sample is relatively well-educated compared to the general U.S. population (Radler and Ryff, 2010). Presently, 48% of the current sample holds a bachelor's degree or higher, which exceeds the national average of 37% (U.S. Census Bureau, 2023). Moreover, the COVID-19 SAQs were administered during the peak of the pandemic, making it possible that those going through the biggest life challenges were not able to participate. Caveats regarding the positive selection bias thus need to be considered when interpreting the results.

Furthermore, the current study assessed vaccine uptake by asking participants whether they had received the COVID-19 vaccine. This measure does not capture individuals who have not yet been vaccinated but intend to do so. While we speculate that the high vaccination rate in the sample suggests the results are unlikely to change significantly due to those with vaccination intentions, the findings should be interpreted as reflecting actual vaccine behavior rather than intention.

Lastly, lifetime discrimination was measured several years before the COVID-19 vaccination data were collected. More recent measures of lifetime discrimination might provide additional understanding of how such experiences relate to vaccination decisions. Therefore, future research should investigate whether discrimination measured concurrently with vaccination behavior would reveal similar patterns to prior assessments of lifetime discrimination.

Future directions

Numerous psychosocial variables remain unexplored in the literature on pandemic vaccination. Prior research highlighted other factors, such as existential isolation and alienation (Galgali et al., 2023), motivation (Ku et al., 2023), and the experience of adverse childhood (Moffitt et al., 2022), as crucial predictors of COVID-19 vaccine uptake. Galgali et al. (2023) underscored that a one-point increase in existential isolation and alienation (i.e. the perception that one's experience is not shared with others) predicted approximately 18.3% and 21.7% of lower COVID-19 vaccine acceptance, respectively. MIDUS offers other potentially relevant psychosocial measures as well, including other risk factors, such as the hardships of the Great Recession, or cumulative stress, and other protective factors, such as life satisfaction and psychological well-being. Numerous future possibilities thus exist for exploring factors that may influence health behaviors during a pandemic.

Finally, the COVID-19 vaccine uptake was much politicized in the United States in that those leaning conservative were less likely to be vaccinated compared to liberals (Stoler et al., 2022). Therefore, the polarized political context may have exerted further influences on how individuals evaluated and acted on preventive health behaviors during a serious pandemic. MIDUS does not assess political affiliation, thus underscoring the need for other studies to investigate how a charged political environment might shape one's view of how to best protect personal health during a pandemic.

Conclusions

The COVID-19 pandemic is unlikely to be the last, and future pandemics are likely to affect individuals on a global scale as well (Saunders-Hastings and Krewski, 2016). Therefore, identifying how and why individuals' receptiveness to vaccines during the pandemic varies is an important issue to address. Taking from the

COVID-19 pandemic, the current study explored how the past experiences of lifetime discrimination, educational attainment, and family support independently and interactively predicted vaccine uptake in the United States. The current results underscore that these factors do not operate in isolation; rather, it is the interplay among them that shapes COVID-19 vaccine uptake.

Author contributions

Seung Eun Cha served as a lead for conceptualization, data curation, formal analysis, investigation, methodology, project administration, visualization, and writing-original draft and contributed equally to writing-review and editing. Carol D Ryff served as lead for funding acquisition, resources, supervision, contributed equally to writing-review and editing, and served in a supporting role for conceptualization. Jieun Song contributed equally to writing-review and editing and served in a supporting role for conceptualization.

Data availability statement

The Midlife in the United States (MIDUS) Refresher 1 data are publicly available on the MIDUS portal (<https://midus.colectica.org/>) and ICPSR (<https://www.icpsr.umich.edu/web/pages/index.html>). The additional COVID-19 questionnaire that was administered in 2021–2022 is available upon request from the Institute on Aging at the University of Wisconsin-Madison.

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethics approval

All procedures were approved by the Institutional Review Board of the University of Wisconsin-Madison for the MIDUS Refresher study (IRB protocol No. 2016-1051), and for the additional COVID-19 questionnaire that was administered in 2021–2022 (IRB protocol No. 2021-0382).

Informed consent

All participants provided verbal consent to the interview.

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Notes

1. Although not a guiding hypothesis, the interaction of lifetime discrimination and educational attainment in predicting vaccine uptake did not significantly differ between races/ethnicities.
2. The two-way interaction of family support and lifetime discrimination did not vary by race/ethnicity.

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