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Black-white disparities in 2009 H1N1 vaccination among adults in the United States: A cautionary tale for the COVID-19 pandemic

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ABSTRACT

Background: Prior research has highlighted racial and ethnic disparities in H1N1 vaccination in the United States. Our study adds to this literature by utilizing an intersectionality framework to examine the joint influence of race and sex on H1N1 vaccination beliefs and behaviors among non-Hispanic blacks and non-Hispanic whites (hereafter blacks and whites).
Methods: Using data from the National H1N1 Flu Survey of U.S. adults, we measured differences in beliefs about the safety and efficacy of the H1N1 vaccine among black women, black men, white women, and white men. We then estimated a series of nested logistic regression models to examine how race/sex vaccination disparities were influenced by health beliefs, socioeconomic status (SES), pre-existing conditions, and healthcare.
Results: Black respondents were more likely than white respondents to express reservations about the safety and efficacy of the H1N1 vaccine. Consistent with those beliefs, white females reported the highest rate of H1N1 vaccination (28.4%), followed by white males (26.3%), black males (21.6%), and black females (17.5%). Differences in health beliefs, SES, pre-existing conditions, and healthcare explained lower odds of H1N1 vaccination among white men and black men, relative to white women. However, black women experienced 35–45% lower odds of vaccination than white women across all models, highlighting the intersectional nature of these associations.
Discussion: The 2009 H1N1 influenza pandemic provides a cautionary tale about the distribution of new vaccines across large populations with diverse racial, sex, and socioeconomic characteristics. Despite differences between the H1N1 and COVID-19 pandemics, our study warns that many black Americans will forego COVID-19 vaccines unless swift action is taken to address black-white disparities in access to vital resources. Public health stakeholders can also encourage widespread adoption of COVID-19 vaccines by tailoring health promotion messages for different groups of racial minorities, especially groups like black women who face intersecting disadvantages.

1. Background

As the first novel-strain influenza outbreak in decades, the 2009 H1N1 pandemic created a substantial burden of excess morbidity and mortality. Between April 2009 and April 2010 in the United States, there were an estimated 60.8 million cases of H1N1, 274,304 hospitalizations, and 12,469 deaths attributable to the outbreak [1]. Although some of these figures have been eclipsed by the current coronavirus disease 2019 (COVID-19) pandemic (e.g., from January 21, 2020 through December 17, 2020 the U.S. Centers for Disease Control and Prevention (CDC) reported 306,427 COVID-19 deaths) [2], important lessons can be learned from the 2009 H1N1 influenza pandemic and applied to the current situation, especially as health agencies design and implement strategies to provide COVID-19 vaccines to the general population.

Shortly after the first cases of an atypical influenza were detected in April 2009, the World Health Organization (WHO) declared H1N1 a phase 6 pandemic in June 2009 [3]. While evidence suggests that older individuals may experience some immunological protection against new influenza viruses [4], most of the U.S. population was at heightened risk of H1N1 infection due to the novel nature of the virus. With effectiveness estimated

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at around 69% [5], the 2009 monovalent H1N1 vaccine significantly reduced the risk of infection and serious outcomes including hospitalization and death. Consequently, the U.S. federal government approved emergency funding in excess of $6 billion USD to facilitate production of the 2009 H1N1 vaccine and promote awareness of the pandemic [6]. With this funding, the 2009 H1N1 monovalent vaccine was provided to health agencies at no cost [7]. Although the H1N1 vaccine was in short supply during the early phases of the pandemic, prompting the CDC to prioritize high-risk populations, it was widely available by late December 2009 [8].

Despite eventual widespread availability, uptake of the H1N1 vaccine was low in the U.S. population, even among groups at highest risk for H1N1 complications [9,10]. Understanding the determinants of low H1N1 vaccination rates will help public health stakeholders as they prepare for the distribution of COVID-19 vaccines. A consistent theme in public health research is enduring disparities in health and health-related behaviors—including vaccination uptake—by sociodemographic characteristics, especially race/ethnicity [11–15]. Such disparities existed during the 2009 H1N1 pandemic, with racial/ethnic minorities in the U.S. reporting lower vaccination rates than non-Hispanic whites [16–19]. However, few studies to date have examined sex differences in H1N1 vaccination uptake even though females were at higher risk of exposure and health complications during the H1N1 pandemic [20]. As noted by the WHO [21], more research is needed to understand sex differences in influenza infection and vaccination behaviors.

Our study goes beyond prior analyses of black-white disparities in H1N1 vaccination by utilizing an intersectionality perspective that considers how race and sex overlap to influence vaccination beliefs and behaviors. For example, distinct lived experiences among black men and black women in the United States may lead to important differences in risk perceptions, levels of social and institutional trust, and related health behaviors relative to white men and white women. Because the intersectionality literature has shown how race and sex jointly affect a range of health beliefs, behaviors, and outcomes [22–24], such an approach may help us better understand the patterns and differentials of H1N1 vaccination uptake relative to studies that have considered race and sex as discrete characteristics. To our best knowledge, no study has investigated the combined influence of race and sex on H1N1 vaccination uptake as we do.

For these reasons, our study examines disparities in H1N1 vaccination uptake across four race/sex groups: non-Hispanic black women, non-Hispanic black men, non-Hispanic white women, and non-Hispanic white men (hereafter black women, black men, white women, and white men). We did not include Hispanics in our analysis since previous research has carefully examined Hispanic H1N1 vaccination disparities in the United States, including the influence of nativity status (a characteristic which we were unable to include in the current study) on vaccination uptake [16]. We expect black participants to express higher levels of mistrust in the H1N1 vaccine than white participants, given current and historical discriminatory experiences among blacks with respect to the medical community [25,26]. We also expect that black females, who face multiple disadvantages (e.g., high rates of household poverty and low rates of healthcare coverage), will report lower rates of H1N1 vaccination than black males or whites of either sex. Finally, we anticipate that controlling for differences in beliefs about the H1N1 vaccine, socioeconomic status, preexisting conditions, and health care access will largely explain race/sex disparities in H1N1 vaccination uptake. Below, we briefly discuss each factor that may account for associations between race/sex and H1N1 vaccination uptake.

1.1. Health beliefs

The health-belief model (HBM) asserts that perceptions of risks, benefits, and barriers influence health behaviors [15]. Specific concepts measured by the HBM include perceived susceptibility to a health condition, perceived severity of the condition, perceived barriers to treatment, and perceived benefits of treatment [27]. While a few studies have employed the HBM to explain H1N1 vaccination uptake in local populations [28–30], to our knowledge no study has yet evaluated the extent to which health beliefs may account for race/sex disparities in H1N1 vaccination uptake among a nationally representative sample of U.S. adults. We anticipate that intersections between race and sex (which affect social position and life experiences [31]), are associated with beliefs regarding the H1N1 pandemic and its vaccine—and that these health beliefs are in turn associated with H1N1 vaccine uptake.

1.2. Socioeconomic status

Socioeconomic status (SES) can shape health trajectories and health behaviors [32]. Previous research suggests that household income and employment are important determinants of vaccination uptake for seasonal influenza [30,33,34]. Interestingly, however, some studies have found that income was not a predictor of vaccination uptake during the H1N1 pandemic [9,16], which may be attributable to the subsidization of the H1N1 vaccine by the U.S. government. Nevertheless, we account for income as well as educational attainment and marital status (which is tied to SES [35]), as prior research has linked these variables to H1N1 vaccination uptake [16]. These socioeconomic factors provide knowledge and social support that may lead to more frequent health care utilization even when medical interventions are free to the public [36]. In light of clear disadvantages in SES and marriage formation among blacks (particularly black females) [35], we expect that controlling for SES differences across race/sex groups will help account for observed disparities in H1N1 vaccination uptake.

1.3. High-risk status

During the 2009 H1N1 pandemic, the CDC's Advisory Committee on Immunization Practices (ACIP) urged vaccination for the following high-risk groups: pregnant women; health care workers and emergency medical services personnel; persons in close contact with infants aged <6 months; persons aged 6 months to 24 years; and persons aged 25–64 with medical conditions that increase susceptibility to H1N1-related complications [37]. Demographic, epidemiological, and employment surveys indicate that several of these risk factors (e.g., certain medical conditions and employment in health care) were unequally distributed by race and sex in the U.S. during the H1N1 pandemic [38–41].

1.4. Healthcare access and encounters

In an analysis of health insurance data from 2008 to 2019, the U. S. Census Bureau identified large and persistent racial inequalities in health insurance coverage, with blacks experiencing lower rates of coverage than whites [42]. Since healthcare coverage is associated with preventative care [43], including basic health information and vaccine access, it likely encouraged H1N1 vaccination uptake. In addition to healthcare coverage, we examine the role that vaccine recommendations from a healthcare provider play in the decision to vaccinate against H1N1. Like other covariates that we consider, healthcare access and encounters may help explain why race/sex is associated with disparities in H1N1 vaccination uptake.

By combining health beliefs with conventional explanations for racial disparities in vaccination uptake such as SES and healthcare coverage, we aim to account more fully for differences in vaccination uptake during the H1N1 pandemic. Our study also extends prior research on vaccination disparities during the 2009 H1N1 pandemic by considering how black-white disparities intersect with sex to influence vaccination behaviors. Results from our investigation are important, as they may highlight barriers to widespread vaccination against COVID-19 in the diverse U.S. adult population.

2. Methods

2.1. Data

The National 2009 H1N1 Flu Survey (NHFS) was a concerted effort to study the 2009 H1N1 pandemic in the U.S. through a collaboration between the National Center for Immunization and Respiratory Disease (NCIRD), the National Center for Health Statistics (NCHS), and the Centers for Disease Control and Prevention (CDC) [44]. Administered from October 2009 through June 2010, data from the NHFS provide nationally representative estimates of H1N1 vaccination uptake among non-institutionalized U.S. adults using a dual-frame sampling design of both landline (33.7% response rate) and cellular telephone users (26.1% response rate) with 45,599 completed adult household interviews [45]. In addition to data on H1N1 vaccination uptake, the NHFS includes measures of sociodemographic characteristics and health status—as well as survey items that align well with HBM constructs, such as perceptions about the safety and efficacy of the H1N1 vaccine.

2.2. Measures

2.2.1. Dependent variable

The NHFS asked respondents if they received the separately administered H1N1 vaccination as well as the mode of vaccination (injection or nasal spray). Because this study is concerned with vaccination receipt and not the mode of vaccination, we code both nasal spray and intradermal shots as a vaccination. As noted, the vaccine was not available in the general population until the end of 2009. Therefore, to reduce bias in the analysis from the inclusion of false negatives (i.e., individuals who eventually received the vaccine, but were not vaccinated at the time of the survey) we limit the analyses to respondents who were interviewed between January 2010 and June 2010—an approach validated by previous research in the estimation of seasonal influenza vaccinations [46].

2.2.2. Independent variables

To account for the intersectionality of race and sex, we create a composite variable that identifies four separate groups: black females; black males; white females; and white males. Additionally, the NHFS contains various measures of sociodemographic characteristics, such as age, education, and household income that we include in the analysis. Allowing for comparisons between younger populations (which were at greater risk of H1N1 infection) and the older population, we categorize age into three groups: 18–34; 35–64; and 65+. We collapse educational attainment into four levels: less than 12 years of formal schooling; 12 years of schooling (equivalent to a high school degree in most cases); some college; and college graduate. The NHFS offers a convenient, albeit somewhat limited, measure of annual household income/poverty: below poverty; above poverty but <=$75,000; and >$75,000. The NHFS also provides information on current marital status, which we include in our analyses. We considered additional measures of SES such as employment status and home ownership, but inclusion of these variables did not improve the explanatory power of the regression models and were therefore excluded.

Based on health information provided by respondents, we combine asthma or other lung conditions, kidney conditions, sickle cell anemia or other anemia, neurological or neuromuscular conditions, liver conditions, or a weakened immune system caused by chronic illness or medicines taken for a chronic illness into a dichotomous measure of chronic illness. In addition, the NHFS provides dichotomous variables to indicate whether an individual (a) has regular contact with children under 6 months of age, and/or (b) is a health care worker with regular direct patient contact; because such individuals belonged to at-risk populations during the 2009 H1N1 pandemic, we use these variables in our analysis. We also include a self-reported measure of whether the respondent received a doctor's recommendation (yes/no) to receive the H1N1 vaccine—a question asked of all respondents regardless of whether they reported going to a doctor. Healthcare coverage is also measured through a dichotomous variable, with the respondent indicating either (a) yes, they have access to some type of health insurance coverage, or (b) no, they lack access to such coverage.

The NHFS is an important asset in understanding H1N1 vaccination behavior as it includes several items that reflect important HBM theoretical constructs. Specifically, the NHFS asks respondents (1) how concerned they are about H1N1 (*perceived severity*), (2) how likely it is that they will become sick from H1N1 *(perceived susceptibility*), (3) how worried they are about getting sick from the H1N1 vaccination (*perceived barrier*), and (4) how effective they believe the H1N1 vaccination is in preventing disease (*perceived benefit).* The NHFS reports all these HBM-related measures using a four-point balanced Likert-type scale, which we collapse into two categories (e.g., low concern or high concern about H1N1 infection) due to relatively few respondents in the more extreme perception categories.

2.3. Analyses

All our analyses account for the complex sampling design of the NHFS. Using STATA 15, we provide descriptive statistics for H1N1 vaccination uptake across race/sex groups, along with other control variables previously mentioned [47]. Then using Mplus 8, we estimate a series of nested logistic regression models [48]. In these models, we use the full-information maximum likelihood (FIML) estimation method to address missing data issues in the NHFS. In most cases where there are missing data, FIML is preferable to listwise deletion because it makes weaker assumptions about patterns of missing data. In addition, FIML has clear advantages in terms of statistical power [49]. Listwise deletion would exclude approximately 40% of NHFS participants from the final model, inflating standard errors and potentially introducing bias into the analysis.

In the initial logistic regression model (Model 1), we estimate the effect of race/sex, while controlling for the age of the respondent. Model 2 introduces HBM variables into the analysis, allowing us to observe the extent to which health beliefs are associated with vaccination uptake and account for race/sex differences observed in Model 1. Model 3 adds socioeconomic measures (poverty status, education, and marital status), which may also partly mediate associations between race/sex and H1N1 vaccination uptake. Model 4 introduces variables representing high-risk status (individuals who have frequent close contact with infants less than 6 months of age, health care workers, and those with at least one chronic condition), and Model 5 introduces health insurance coverage and a measure of whether the respondent's doctor recommended the vaccine.

3. Results

3.1. Sociodemographic characteristics and H1N1 vaccination

Overall, rates of H1N1 vaccination were low (Table 1). Among the four race/sex groups we evaluated, white females were most likely to report vaccination against H1N1 (28.4%) and black females the least (17.5%). In addition, black men and women tended to be younger and poorer than their white counterparts with a high percentage of black females and males below the poverty line (32.3% and 26.4% respectively). Educational attainment was lower among blacks than whites, regardless of sex. The percentage of married blacks was low relative to whites, especially among females. Blacks were also much less likely than whites to have health insurance. For example, 29.0% of black males reported no health insurance, compared to 11.9% of white males. Black females were most likely to report contact with children under 6 months of age (11.7%), employment as a health care worker (22.5%), and at least one chronic condition (33.5%). Finally, most respondents (75–80%) reported that they *did not* receive a doctor's recommendation to obtain the H1N1 vaccine, regardless of race or sex.

3.2. Health beliefs

In Table 2, we present descriptive statistics for the four items used to measure HBM concepts regarding H1N1 and its vaccine. Measures of perceived severity and susceptibility pertain to the H1N1 virus, and measures of perceived barriers and benefits refer to the vaccine. First, concern about H1N1 was higher among blacks, with >60% of black females and males reporting a high level of concern. Among whites, concern was lowest among males (41.0% reported high concern). Black-white differences were much smaller with respect to the perceived risk of becoming sick from an H1N1 infection, particularly among females. At the same time, blacks tended to be more concerned than whites about potential adverse effects from the H1N1 vaccine. For example, 22.2% of white

Table 1
Descriptive Statistics for H1N1 Vaccination and Sociodemographic Characteristics of Respondents in the National 2009 H1N1 Flu Survey.

Characteristics	White Female			White Male			Black Female			Black Male		
	%	95% CI −/+		%	95% CI −/+		%	95% CI −/+		%	95% CI −/+	
H1N1 Vaccination												
No	71.6%	70.5%	72.8%	73.7%	72.3%	75.0%	82.5%	79.4%	85.2%	78.4%	73.9%	82.3%
Yes	28.4%	27.2%	29.5%	26.3%	25.0%	27.7%	17.5%	14.8%	20.6%	21.6%	17.7%	26.1%
Valid n	17,846			12,197			1997			1125		
Age												
65+	21.4%	20.5%	22.3%	18.1%	17.1%	19.1%	15.6%	13.3%	18.3%	13.6%	11.0%	16.6%
35–64	53.1%	51.9%	54.4%	56.0%	54.5%	57.5%	51.9%	48.0%	55.7%	51.2%	46.1%	56.2%
18–34	25.5%	24.2%	26.7%	25.9%	24.5%	27.4%	32.5%	28.8%	36.4%	35.2%	30.3%	40.5%
Valid n	17,907			12,266			2013			1143		
Poverty Status												
Below poverty	10.1%	9.2%	10.9%	6.7%	5.9%	7.6%	32.3%	28.4%	36.3%	26.4%	21.2%	32.3%
<=$75,000	56.0%	54.6%	57.4%	52.8%	51.2%	54.5%	51.1%	46.9%	55.2%	54.8%	49.2%	60.3%
>$75,000	33.9%	32.6%	35.3%	40.5%	38.8%	42.1%	16.7%	13.7%	20.1%	18.8%	15.0%	23.2%
Valid n	14,885			10,375			1623			898		
Education												
<12 Years	7.4%	6.7%	8.2%	6.3%	5.6%	7.1%	14.1%	11.8%	16.8%	14.4%	11.6%	17.9%
12 Years	22.0%	20.9%	23.0%	20.8%	19.6%	22.0%	25.2%	21.9%	28.7%	30.1%	25.8%	34.9%
Some Coll.	29.4%	28.2%	30.6%	26.6%	25.2%	27.9%	36.4%	32.4%	40.6%	33.4%	28.6%	38.6%
Coll. Grad	41.2%	40.0%	42.5%	46.3%	44.8%	47.9%	24.3%	21.4%	27.6%	22.0%	18.4%	26.1%
Valid n	17,078			11,550			1895			1068		
Marital Status												
Not Married	41.6%	40.3%	42.9%	39.8%	38.3%	41.4%	71.7%	68.1%	75.0%	62.6%	57.4%	67.5%
Married	58.4%	57.1%	59.7%	60.2%	58.6%	61.7%	28.3%	25.0%	31.9%	37.4%	32.5%	42.6%
Valid n	17,036			11,548			1882			1065		
Close Contact with Child <6 Months												
No	90.5%	89.7%	91.3%	92.2%	91.2%	93.1%	88.3%	85.4%	90.7%	92.7%	90.1%	94.6%
Yes	9.5%	8.7%	10.3%	7.8%	6.9%	8.8%	11.7%	9.3%	14.6%	7.3%	5.4%	9.9%
Valid n	17,355			11,840			1934			1106		
Healthcare Worker												
No	82.1%	81.0%	83.1%	89.5%	88.3%	90.5%	77.5%	73.7%	80.9%	90.9%	87.5%	93.4%
Yes	17.9%	16.9%	19.0%	10.5%	9.5%	11.7%	22.5%	19.1%	26.3%	9.1%	6.6%	12.5%
Valid n	17,331			11,823			1932			1101		
Chronic Condition												
No	71.4%	70.2%	72.5%	76.3%	75.0%	77.5%	66.5%	62.7%	70.2%	76.7%	72.2%	80.6%
Yes	28.6%	27.5%	29.8%	23.7%	22.5%	25.0%	33.5%	29.8%	37.3%	23.3%	19.4%	27.8%
Valid n	17,248			11,789			1914			1095		
Health Insurance Status												
No	9.5%	8.6%	10.5%	11.9%	10.8%	13.0%	20.3%	16.5%	24.7%	29.0%	23.8%	34.9%
Yes	90.5%	89.5%	91.4%	88.1%	87.0%	89.2%	79.7%	75.3%	83.5%	71.0%	65.1%	76.2%
Valid n	14,635			9822			1592			899		
Dr. Recommended Vaccine												
No	75.3%	74.2%	76.4%	80.0%	78.7%	81.2%	74.7%	71.2%	77.8%	78.6%	73.7%	82.8%
Yes	24.7%	23.6%	25.8%	20.0%	18.8%	21.3%	25.3%	22.2%	28.8%	21.4%	17.2%	26.3%
Valid n	17,805			12,191			2002			1135		

Note: % and confidence interval (CI) estimates account for the NHFS complex sampling design Valid *n* = unweighted sample.

Table 2
Descriptive Statistics for Health Beliefs among Respondents in the National 2009 H1N1 Flu Survey.

Characteristics	White Female			White Male			Black Female			Black Male		
	%	95% CI −/+		%	95% CI −/+		%	95% CI −/+		%	95% CI −/+	
How Concerned about H1N1 (HBM: Severity)												
Low Concern	46.2%	44.9%	47.4%	59.0%	57.5%	60.5%	31.9%	28.4%	35.7%	39.5%	34.6%	44.7%
High Concern	53.9%	52.6%	55.1%	41.0%	39.5%	42.5%	68.1%	64.4%	71.6%	60.5%	55.3%	65.4%
Valid n	17,844			12,227			2003			1132		
Risk of Getting Sick with H1N1 (HBM: Susceptibility)												
Low Risk	71.2%	70.0%	72.4%	80.7%	79.5%	81.9%	73.2%	69.5%	76.6%	73.9%	69.2%	78.1%
High Risk	28.8%	27.6%	30.0%	19.3%	18.1%	20.6%	26.8%	23.4%	30.5%	26.1%	22.0%	30.8%
Valid n	16,959			11,603			1856			1063		
Worry about Getting Sick from H1N1 Vaccine (HBM: Barrier)												
High Worry	31.0%	29.8%	32.2%	22.2%	21.0%	23.5%	39.0%	35.3%	42.9%	34.9%	29.9%	40.2%
Low Worry	69.0%	67.8%	70.2%	77.8%	76.5%	79.1%	61.0%	57.1%	64.7%	65.1%	59.8%	70.1%
Valid n	17,539			12,023			1956			112		
Effectiveness of H1N1 Vaccine (HBM: Benefit)												
Low Effectiveness	11.5%	10.6%	12.4%	12.9%	11.9%	14.1%	21.7%	18.3%	25.6%	14.6%	11.6%	18.4%
High Effectiveness	88.5%	87.6%	89.4%	87.1%	85.9%	88.2%	78.3%	74.5%	81.8%	85.4%	81.6%	88.4%
Valid n	14,987			10,137			1634			942		

Note: % and confidence interval (CI) estimates account for the NHFS complex sampling design.
Valid *n* = unweighted sample.

males were concerned about getting sick from the vaccine, compared to 34.9% of black males. In addition, both whites and blacks generally agreed that the H1N1 vaccine was effective in preventing disease; however, more than 1 in 5 black females felt the vaccine had a low level of benefit.

3.3. Nested logistic regression models

In Table 3, we present results from logistic regression models that utilize FIML estimation to address missing data as noted above. We express results as exponentiated regression coefficients (i.e., adjusted odds ratios (AORs)) to ease interpretations. Model 1 shows the odds of H1N1 vaccination were significantly higher among white females than the other three race/sex groups, after accounting for differences in age. White males, black males, and black females reported 9%, 29%, and 45% lower odds of vaccination than white females, respectively. Model 1 also shows significantly lower odds of vaccination among individuals <65 years of age—an observation that persists across all our models.

Model 2 introduces the HBM measures into the analysis. Worry about the safety of the H1N1 vaccine was not a significant predictor of vaccination uptake. However, perceived risk of H1N1 infection (AOR = 5.87, $p < .001$) and perceived effectiveness of the H1N1 vaccine (AOR = 4.70, $p < .001$) were strong predictors of vaccination. Also, concern about H1N1 plays a smaller, yet still significant, role in vaccination uptake (AOR = 1.16, $p < .01$). Despite strong associations between some health beliefs and vaccination behavior, race/sex disparities were largely unchanged from Model 1. The one exception is that odds of vaccination for white males were significantly *higher* than those of white females, after accounting for differences in health beliefs.

Model 3 builds on the previous model by adding measures of socioeconomic status. We did not find any difference in vaccination odds between those below poverty and higher income groups. But high education is associated with increased odds of vaccination; respondents with a college degree reported 91% higher odds of vaccination than those with <12 years of school. In addition, Model 3 shows a positive impact of marriage on vaccination uptake (AOR = 1.25, $p < .001$). More importantly, including these SES variables in Model 3 eliminated statistical differences between black males and white females observed in the previous model. Other race/sex differences were also attenuated but remained statistically significant.

Model 4 introduces measures to indicate whether the respondent is at-risk of H1N1 infection or complications or is in close contact with vulnerable populations. Persons in regular contact with a child <6 months of age had 50% higher odds of H1N1 vaccination than persons without such contact. We also observed higher odds of vaccination uptake among those with a self-reported chronic condition (AOR = 1.40; $p < .001$) compared to those without a chronic condition. The odds of vaccination among health care workers were 2.26 times higher than persons not employed in healthcare. The inclusion of the risk-status variables further attenuated differences between white females and black males. However, the odds of vaccination among black females were still 40% lower than white females ($p < .001$).

In Model 5, we add healthcare coverage and physician recommendation for the H1N1 vaccine. Those with some form of healthcare coverage reported about 2 times higher odds of receiving the H1N1 vaccine than those with no coverage. In addition, the odds of vaccination were 5.5 times higher among respondents who received a physician's recommendation. Despite these strong associations, the substantial disadvantage among black females remained intact (AOR = 0.57, $p < .001$). Relative to females, the odds of receiving the H1N1 vaccine were 28% higher among white males in Model 5. There were no discernable differences observed between black males and white females.

4. Discussion

Guided by an intersectional framework, our analysis revealed considerable differences in H1N1 vaccination uptake by race and sex. In contrast to prior research on H1N1 that has considered race and sex as discrete characteristics—thereby observing (only) differences between blacks and whites *or* males and females—our investigation found that race and sex combined to produce important differences in vaccination uptake and beliefs during the 2009 H1N1 pandemic. In the age-adjusted logistic regression model, we observed an advantage among white females in obtaining vaccinations over white males, black males, and black females. Con-

Table 3
Logistic Regression Models Predicting 2009 H1N1 Influenza Vaccination in the National 2009 H1N1 Flu Survey.

Characteristics	Model 1			Model 2			Model 3			Model 4			Model 5		
	AOR	95% CI −/+		AOR	95% CI −/+		AOR	95% CI −/+		AOR	95% CI −/+		AOR	95% CI −/+	
Race/Sex															
White, Female	1.00			1.00			1.00			1.00			1.00		
White, Male	0.91*	0.83	0.99	1.15**	1.04	1.27	1.11*	1.01	1.24	1.20**	1.08	1.34	1.28***	1.15	1.43
Black, Male	0.71**	0.55	0.92	0.71*	0.54	0.95	0.84	0.63	1.12	0.91	0.68	1.22	0.98	0.72	1.32
Black, Female	0.55***	0.44	0.67	0.55***	0.44	0.69	0.65***	0.52	0.82	0.60***	0.47	0.75	0.57***	0.45	0.73
Age															
65+	1.00			1.00			1.00			1.00			1.00		
35–64	0.85**	0.77	0.93	0.75***	0.67	0.83	0.64***	0.57	0.72	0.61***	0.55	0.69	0.67***	0.59	0.75
18–34	0.76***	0.67	0.87	0.67***	0.57	0.77	0.67***	0.57	0.78	0.63***	0.54	0.74	0.67***	0.57	0.79
Concern about H1N1															
Low Concern				1.00			1.00			1.00			1.00		
High Concern				1.16**	1.04	1.29	1.17**	1.05	1.30	1.17**	1.05	1.30	1.11†	0.99	1.24
Risk of H1N1 Infection															
Low Risk				1.00			1.00			1.00			1.00		
High Risk				5.87***	5.25	6.56	6.06***	5.42	6.78	5.44***	4.85	6.10	4.75***	4.21	5.37
Worry about Vaccine															
High Worry				1.00			1.00			1.00			1.00		
Low Worry				0.92	0.82	1.04	0.88*	0.78	0.99	0.89†	0.79	1.01	0.94	0.83	1.06
Effectiveness of Vaccine															
Low Effectiveness				1.00			1.00			1.00			1.00		
High Effectiveness				4.70***	3.67	6.03	4.45***	3.46	5.71	4.59***	3.55	5.94	4.31***	3.30	5.62
Poverty Status															
Below Poverty							1.00			1.00			1.00		
<=$75,000, above poverty							1.00	0.81	1.23	0.98	0.79	1.22	0.95	0.76	1.17
>$75,000							1.19	0.94	1.50	1.17	0.92	1.48	1.06	0.84	1.34
Education															
<12 Years							1.00			1.00			1.00		
12 Years							1.24†	0.97	1.57	1.22	0.95	1.56	1.14	0.89	1.46
Some College							1.36**	1.08	1.72	1.26	0.99	1.61	1.13	0.88	1.45
College Graduate							1.91***	1.51	2.40	1.83***	1.44	2.33	1.61***	1.25	2.06
Marital Status															
Not Married							1.00			1.00			1.00		
Married							1.25***	1.11	1.40	1.24***	1.11	1.39	1.15*	1.01	1.30
Close Contact Child <6 months															
No										1.00			1.00		
Yes										1.50***	1.24	1.82	1.28*	1.05	1.54
Healthcare Worker															
No										1.00			1.00		
Yes										2.26***	1.95	2.62	2.13***	1.84	2.47
Chronic Condition															
No										1.00			1.00		
Yes										1.40***	1.25	1.57	1.14*	1.02	1.29
Health Insurance Status															
No													1.00		
Yes													2.04***	1.63	2.55
Dr. Recommendation															
No													1.00		
Yes													5.51***	4.92	6.17
Valid n	33,165			27,000			23,426			23,256			19,869		
Analytical n	33,329			33,329			33,329			33,329			33,329		

Note: Adjusted Odds Ratio (AOR) and Confidence Interval (CI) calculated using FIML estimation (Mplus).
† $p < 0.1$.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

trolling for SES variables that likely mediate the association between race/sex and vaccination uptake, such as educational attainment, substantially reduced the disparity between black males and white females. However, the odds of vaccination among black females were 35–45% lower than white females across all our models.

Relatively poor uptake of the H1N1 vaccine among black females is consistent with our expectation that multiple disadvantages in this group would translate into vaccination disparities. However, it is worth noting that even when controlling for demographic variables, socioeconomic status, chronic conditions, healthcare status, and health beliefs about H1N1, black females were less likely than white females (and other groups) to receive the H1N1 vaccine. We anticipated that differences in health beliefs and socioeconomic position would help explain black-white vaccination disparities among both men and women. However, black women's low odds of vaccination uptake are generally not explained by these factors. This pronounced and largely unexplained disparity in H1N1 vaccination between black females and other race/sex groups is troubling. We urge further research into understanding health behaviors among black women, especially regarding health interventions such as vaccinations. Additional knowledge regarding black-white disparities in vaccination behavior—and how this varies among men and women—is essential to minimize unequal uptake of COVID-19 vaccines in the U.S.

It is interesting to note that controlling for sociodemographic characteristics, especially education and marital status, substantially reduced vaccination disparities between black males and white females (the reference group in our study). This finding suggests that addressing racial inequalities in educational attainment and social support would improve vaccine uptake among black males. At the same time, our findings highlight the intersectional nature of these associations, as large black-white disparities in vaccination persisted among females after accounting for these factors. This implies that social determinants of health operate differently by sex among blacks, at least with respect to vaccination uptake behaviors. As further evidence for differing impacts of sex and race on vaccination outcomes, our findings also revealed that white males reported the highest odds of H1N1 vaccination, after interpersonal differences in health beliefs were considered.

In our final model that included all covariates, the strongest predictor of H1N1 vaccine uptake was a physician's recommendation. In the NHFS, females, persons at-risk of health complications from H1N1, and persons with access to health insurance were most likely to receive encouragement from their doctors to get vaccinated. A recent report from the CDC estimated that 13.6% of black Americans lacked healthcare coverage in 2019 [50]; this is a substantial improvement over the 24.1% non-insurance rate we observed among blacks in the 2009–2010 NHFS. Even though physicians' recommendations did not eliminate black-white vaccination disparities in our H1N1 analyses, especially among black women, recent improvements in health insurance coverage among blacks could, if sustained, facilitate contact with health care professionals who are likely to recommend properly vetted vaccines, including COVID-19, in the future.

Our analyses of NHFS data showed that a majority of black and white Americans believed that the H1N1 vaccine was safe and effective. Despite this favorable disposition, only 20–25% of respondents in our study received a doctor's recommendation to receive the H1N1 vaccine. Furthermore, fewer than 30% of respondents worried about the risk of falling ill with a H1N1 infection, regardless of race or sex. As noted, a doctor's recommendation and perceived susceptibility to H1N1 infection were the two strongest predictors of H1N1 vaccination (Model 5, Table 3). Because (1) these two variables link strongly to vaccination uptake, and (2) relatively few black or white respondents received a doctor's recommendation or felt themselves to be at high risk of H1N1 infection, it is not surprising that a low proportion of the U.S. populace received the H1N1 monovalent vaccine. Just as importantly, these findings suggest that there are promising opportunities to combat the COVID-19 pandemic. For instance, public health stakeholders could encourage widespread adoption of COVID-19 vaccines by continuing to educate Americans about the considerable health risks presented by this novel coronavirus—and by tailoring these health promotion messages for different groups of racial minorities, including black Americans.

Health campaigns designed to address the unique concerns of various racial and ethnic minorities could be a crucial component in reducing health inequalities. In a report published in December 2020 by the PEW Research Center, 60% of U.S. adults expressed willingness to receive a COVID-19 vaccine, which PEW attributes to the increasing public confidence that pharmaceutical companies are producing safe and effective coronavirus vaccines [51]. However, in this same report, PEW notes that only 42% of black respondents expressed willingness to receive a COVID-19 vaccine. Additional studies confirm racial differences in willingness to vaccinate against COVID-19 [52,53], emphasizing the urgent need to promote COVID-19 vaccines in communities of color. Failure to provide equitable distribution of the COVID-19 vaccine, and to convince all racial/ethnic groups that it is safe and effective, may result in vaccination disparities that mimic those we observe from the H1N1 pandemic.

Paradoxically, while a smaller proportion of blacks vaccinated against H1N1, a larger proportion of blacks expressed a high degree of general concern about the pandemic. Blacks were also more likely than whites to express concerns about the safety of the H1N1 vaccine. However, our analyses showed that neither general concern about the pandemic nor fears about vaccination were strong predictors of H1N1 vaccination, relative to other health beliefs (i.e., perceived susceptibility to infection and perceived benefits of the vaccine). The apparent lack of influence that general concerns about the severity of the H1N1 pandemic had on individual vaccination decisions may be, in part, because our analysis only includes respondents interviewed from January 2010 through June 2010, which is after the initial outbreak of the 2009 H1N1 virus. It is plausible that perceived severity is more acute the closer one is to the initial outbreak, and that these concerns might wane over time, dissuading people from receiving vaccines when they become available. As of December 2020, with approximately 71% of U.S. adults feeling the worst of the coronavirus outbreak is 'still to come' [51], waning concern about COVID-19 is not likely to be an issue.

Although the inclusion of attitudinal measures related to H1N1 influenza and vaccination is a major strength of our investigation, the paucity of items used to describe each of the four main components of the HBM in the NHFS is a limitation since they may not reflect all aspects of perceived severity, susceptibility, barriers, and benefits. While providing important insights into H1N1 vaccination behavior, previous studies incorporating more intricate measures of HBM concepts often relied on localized samples [26–28], hindering generalization to the U.S. adult population. An important contribution of our study, which uses a nationally representative sample of U.S. adults, is its ability to make broader generalizations about the interrelationships between health beliefs, the intersection of race and sex, and vaccination behaviors.

5. Conclusion

Although the H1N1 and COVID-19 pandemics fundamentally differ in many respects (e.g., morbidity and mortality burdens), the 2009 H1N1 influenza pandemic nevertheless offers a cautionary tale about the distribution of new vaccines across large populations with diverse racial, sex, and socioeconomic characteristics. Descriptive analyses of NHFS data verified that 2009 H1N1 vaccination in the U.S. was less common among blacks than whites. Multivariate regression models revealed that race and sex intersect to affect vaccination uptake through different mediating variables. For example, accounting for differences in educational attainment and marital status substantially reduced vaccination disparities between black males and white females. In addition, if white males had possessed the same health beliefs as white females, they would have been more likely to receive the H1N1 vaccine. However, a disconcerting finding was the low odds of vaccination among black females, even after controlling for differences between them and white females in health beliefs, SES, health status, and health insurance. It is likely that low vaccination rates led to an increased burden of H1N1-related morbidity and mortality among non-Hispanic blacks in the U.S. [17,54]. Understanding the causes of vaccine hesitancy during the 2009 H1N1 pandemic may help public health stakeholders reduce the disease burden created by COVID-19, particularly among black Americans and other racial/ethnic minorities.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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