

# The Impact of Vaccine Concerns on Racial/Ethnic Disparities in Influenza Vaccine Uptake Among Health Care Workers

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Despite an increase in influenza vaccine uptake among health care workers (HCWs) aged 18 years and older from 64% for the 2010 to 2011 influenza season to 72% for the 2012 to 2013 influenza season,<sup>1</sup> vaccine uptake among HCWs in the United States fails to meet the *Healthy People 2020* goal of 90%.<sup>2</sup> In particular, vaccine uptake historically has been lower among non-Hispanic Blacks and Hispanics than among non-Hispanic Whites not only in the general population but also among HCWs.<sup>3–11</sup> For example, an analysis of National Health Interview Survey data for the 2010 to 2011 influenza season suggested that vaccine uptake was 59% among non-Hispanic White HCWs, whereas vaccine uptake was 44% and 45% among non-Hispanic Black and Hispanic HCWs, respectively.<sup>5</sup> Nevertheless, little is known about the reasons (i.e., mediators) for racial/ethnic disparities in influenza vaccine uptake among HCWs. A greater understanding of mediators of racial/ethnic disparities in influenza vaccine uptake would provide mechanistic insight on a population level and identify targets for intervention to reduce these disparities, which could ultimately increase overall vaccine coverage among HCWs.

Vaccine-related concerns (e.g., about safety, efficacy, and necessity) have been consistently reported as barriers to influenza vaccine uptake for HCWs as a whole.<sup>12–16</sup> For example, HCWs who reported concerns about vaccine safety had between 50% and 78% lower odds of influenza vaccine uptake than HCWs who did not report safety concerns.<sup>14</sup> Nevertheless, vaccine-related concerns have not been systematically explored as potential mediators of racial/ethnic disparities among HCWs. Although vaccine-related concerns have been explored as potential mediators of racial/ethnic disparities in influenza vaccine uptake among the general population<sup>17,18</sup> and among the elderly,<sup>19,20</sup> these studies addressed mediation through approaches that are now

**Objectives.** We explored whether collective concerns about the safety, effectiveness, and necessity of influenza vaccines mediate racial/ethnic disparities in vaccine uptake among health care workers (HCWs).

**Methods.** We used a self-administered Web-based survey to assess race/ethnicity (exposure), concerns about influenza vaccination (mediator; categorized through latent class analysis), and influenza vaccine uptake (outcome) for the 2012 to 2013 influenza season among HCWs at St. Jude Children's Research Hospital in Memphis, Tennessee. We used mediation analysis to estimate prevalence ratios (PRs) and 95% confidence intervals (CIs) for the total, direct, and indirect effects of race/ethnicity on influenza vaccine uptake.

**Results.** Non-Hispanic Blacks had lower influenza vaccine uptake than non-Hispanic Whites (total effect: PR = 0.87; 95% CI = 0.75, 0.99), largely mediated by high concern about influenza vaccines (natural indirect effect: PR = 0.89; 95% CI = 0.84, 0.94; controlled direct effect: PR = 0.98; 95% CI = 0.85, 1.1). Hispanic and Asian HCWs had modestly lower uptake than non-Hispanic Whites, also mediated by high concern about influenza vaccines.

**Conclusions.** Racial/ethnic disparities among HCWs could be attenuated if concerns about the safety, effectiveness, and necessity of influenza vaccines were reduced. (*Am J Public Health.* 2015;105:e35–e41. doi:10.2105/AJPH.2015.302736)

known to be misleading.<sup>21–26</sup> In addition, concerns about vaccine safety, efficacy, and necessity have conventionally been reported as independent barriers to vaccination. An unobserved attitude or behavior likely underlies these vaccine concerns, and efforts to operationalize this underlying latent construct may yield novel insight about vaccine hesitancy that can facilitate intervention.<sup>27</sup> Therefore, we aimed to operationalize the latent construct underlying vaccine concerns, and we used contemporary mediation analysis to address whether these concerns mediate the association between race/ethnicity and influenza vaccine uptake among HCWs in a pediatric comprehensive cancer center where influenza vaccination is offered free of charge to employees and is highly recommended but not mandatory.

## METHODS

All employees at St. Jude Children's Research Hospital in Memphis, Tennessee, effectively

qualify as HCWs according to the Centers for Disease Control and Prevention definition.<sup>28</sup> Our eligible population thus included all individuals employed at St. Jude for at least 30 days between October 1, 2012, and March 31, 2013 (i.e., the 2012–2013 influenza season). The exclusion of HCWs employed less than 30 days is consistent with the National Healthcare Safety Network guidelines for defining the denominator for estimating influenza vaccine uptake for HCWs during the 2012 to 2013 influenza season.<sup>29</sup>

## Variables

We invited employees by e-mail to participate in a self-administered online survey. We sent the invitations on August 1, 2013, and made the survey available until September 15, 2013. We sent HCWs periodic reminders requesting participation. We ascertained information about influenza vaccine uptake and knowledge and attitudes about the vaccine

with standardized questions from national surveys (e.g., the National Health Information Survey), some of which we modified for our setting (Table A, available as a supplement to this article at <http://www.ajph.org>).

Our outcome of interest was influenza vaccine uptake during the 2012 to 2013 influenza season. Our exposure of interest for this study was self-reported race/ethnicity, categorized as non-Hispanic White, non-Hispanic Black, Hispanic, Asian, or other. Our mediator of interest was concern about the influenza vaccine. The available literature consistently documents 4 concerns about the influenza vaccine among HCWs: (1) the vaccine causes influenza, (2) the vaccine has serious side effects, (3) the vaccine is ineffective, and (4) the vaccine is unnecessary.<sup>12–16</sup>

### Data Analysis

Because the 4 concerns about the influenza vaccine likely manifest from an underlying but unobserved attitude or behavior, we first used exploratory latent class analysis<sup>30</sup> to operationalize the unobserved attitude or behavior. Latent class analysis is a model-based statistical method that uses data from observed variables (in our study, the 4 concerns about the influenza vaccine) to distinguish classes of an unobserved (i.e., latent) variable. We specified models with 2 to 4 classes and selected the best-fitting final model according to the Bayesian information criterion, which is a well-established goodness-of-fit criterion that facilitates selection of parsimonious models, where the lowest value is preferred.<sup>31</sup> The class with the highest posterior probability from the final model defined class membership for each individual.

We estimated the total, direct, and indirect effects of race/ethnicity on influenza vaccine uptake through established methods for causal mediation analysis in a potential outcome framework.<sup>21,25,26,32</sup> The purpose of causal mediation analysis is to explore whether the association between an exposure and an outcome is the result of a direct effect or of an indirect effect through a specified mediator. Figure A (available as a supplement to this article at <http://www.ajph.org>) illustrates dependency assumptions in a directed acyclic graph for the relation between race/ethnicity and influenza vaccine uptake, where the

exposure of interest is race/ethnicity, the mediator of interest is vaccine-related concerns, and the outcome of interest is influenza vaccine uptake.<sup>33</sup> We used this directed acyclic graph to specify the causal mediation model, which facilitated decomposition of the total effect (i.e., the combined direct and indirect effects) into separate direct and indirect effects.<sup>21,25,26,32</sup>

Odds ratios overestimate risk ratios when the outcome is common (i.e., >10%),<sup>34</sup> which can distort interpretations about the magnitude of racial/ethnic disparities.<sup>35</sup> Therefore, we used Poisson regression to directly estimate prevalence ratios (PRs) and corresponding 95% confidence intervals (CIs) for total, direct, and indirect effects of race/ethnicity on influenza vaccine uptake, with automated methods for causal mediation analysis by Valeri and Vanderweele.<sup>26</sup> We adjusted PRs for age, gender, occupational category (as a proxy for socioeconomic status), and direct patient contact to reduce confounding bias and strengthen identifiability assumptions for valid interpretation of direct and indirect effects.<sup>26</sup> We estimated both natural and controlled effects. We derived natural indirect effects from the observed values of the mediator; these provided insight about naturally occurring mediation. We calculated the controlled direct effect from an assigned value for the mediator, providing insight about the exposure–outcome relation if the value of the mediator could be changed through intervention (e.g., reduction of vaccine concerns).<sup>21,25</sup>

### Sensitivity Analysis

We explored the sensitivity of potential misclassification of vaccination status on our estimate for the total effect of race/ethnicity on vaccine uptake. Direct estimates for the sensitivity and specificity of self-reported vaccination status to adjust for misclassification were not available for our population. Therefore, we derived our initial values from a published report about the validity of self-reported vaccination status, which compared self-report with information in an immunization registry.<sup>36</sup> From these initial values, we assumed nondifferential misclassification but varied the specificity of self-reported vaccination status more than the sensitivity because for HCWs in our setting, social desirability may motivate

greater false-positive than false-negative reporting.<sup>37</sup>

We computed misclassification-adjusted estimates by the following formula<sup>38</sup>:

$$(1) A = (A^* - FpN) / (Se + Sp - 1),$$

where  $A$  is the adjusted count for the racial/ethnic subgroup,  $A^*$  is the observed count,  $Fp$  is the false-positive probability,  $N$  is the sample size for the racial/ethnic subgroup,  $Se$  is sensitivity, and  $Sp$  is specificity.  $A/N$  thus estimated the misclassification-adjusted influenza vaccine uptake for each subgroup. We then compared these adjusted vaccine uptakes among racial/ethnic subgroups (i.e., non-Hispanic Black and White HCWs) to estimate misclassification-adjusted PRs.<sup>38</sup>

## RESULTS

The eligible population comprised 3366 HCWs, of whom 2340 (70%) participated in the survey. The exclusion of participants with missing exposure, mediator, or outcome information resulted in a sample of 2003 HCWs (60% of eligible population). Table 1 summarizes the characteristics of the final study population. Briefly, the median age of respondents was 44 years (interquartile range = 35–54 years). The majority of HCWs were female (71%) and non-Hispanic White (72%). The proportion of non-Hispanic Blacks (16%) was comparable to the proportion of Black HCWs in the United States (15%).<sup>39</sup> The majority of participants were research (32%) and clinical (physicians, nurses, etc.; 26%) personnel, and 32% of HCWs reported having direct patient contact. Finally, 82% of respondents supported mandatory influenza vaccination.

Table 1 also summarizes overall and subgroup-specific influenza vaccine uptake. Overall, uptake was 87%, with no meaningful variation by gender (87% of women and 86% of men). We observed variation in vaccine uptake by age group, race/ethnicity, occupational category, direct patient contact, and support for mandatory vaccination. Uptake was highest among non-Hispanic White HCWs (90%) and lowest among non-Hispanic Black HCWs (77%). Clinical personnel reported the highest (96%), and research personnel the lowest (81%) uptake. HCWs with direct patient contact reported higher vaccine uptake (94%)

**TABLE 1—Characteristics of Health Care Workers Who Participated in 2012–2013 Influenza Vaccine Survey: St. Jude Children’s Research Hospital, Memphis, TN**

Characteristic	No. (%) <sup>a</sup>	Vaccine Uptake, No. (%) <sup>b</sup>
Overall	2003	1742 (87)
Age, y		
18–29	187 (9)	156 (83)
30–39	551 (28)	465 (84)
40–49	518 (26)	449 (87)
50–59	513 (26)	452 (88)
≥ 60	234 (12)	220 (94)
Gender		
Female	1423 (71)	1243 (87)
Male	580 (29)	499 (86)
Race/ethnicity		
Non-Hispanic White	1438 (72)	1293 (90)
Non-Hispanic Black	313 (16)	241 (77)
Hispanic	40 (2)	33 (83)
Asian	150 (8)	122 (81)
Other	62 (3)	53 (85)
Occupational category		
Administrative	377 (19)	326 (86)
Clinical laboratory	95 (5)	84 (88)
Clinical (e.g., physician, nurse)	514 (26)	495 (96)
Support services (e.g., food services, facilities management)	200 (10)	174 (87)
Research	645 (32)	523 (81)
Other	172 (9)	140 (81)
Direct patient contact		
Yes	645 (32)	606 (94)
No	1358 (68)	1136 (84)
Support mandatory vaccination		
Yes	1636 (82)	1464 (89)
No	227 (11)	171 (75)
Uncertain	140 (7)	107 (76)

<sup>a</sup>Percentage refers to column distribution. For example, 71% women and 29% men for distribution by gender.

<sup>b</sup>Percentage refers to each stratum (row). For example, influenza vaccine uptake among women was 87%.

than HCWs without direct patient contact (84%). HCWs who supported mandatory vaccination reported higher vaccine uptake (89%) than HCWs who were opposed (75%).

Table B (available as a supplement to this article at <http://www.ajph.org>) summarizes the goodness-of-fit characteristics of the latent class models used to operationalize the unobserved attitude or behavior that underlay concerns about the influenza vaccine. A 2-class model (high concern and low concern) best fit the underlying attitude or behavior. Table 2 summarizes the conditional probabilities of responses

to individual questions about vaccine concerns conditional on membership in each class. We defined the 2 classes as high and low concern because of the relative abundance of concerns about the influenza vaccine in the former class and relatively minimal concerns in the latter. In particular, the high-concern group had a high conditional probability (97%) of reporting concern about vaccine side effects, whereas the low-concern group had a low conditional probability of reporting this concern (11%).

Figure 1 illustrates the overall and race/ethnicity-specific influenza vaccine uptake by

level of concerns about the influenza vaccine. The *Healthy People 2020* goal of 90% influenza vaccination coverage was satisfied overall and for all racial/ethnic subgroups with low concern about the vaccine except among Asians (87%). The high-concern group of HCWs, overall and broken down into racial/ethnic subgroups, failed to meet the *Healthy People 2020* goal; vaccine uptake was below 50% for the high-concern non-Hispanic Black and Hispanic subgroups.

Table 3 summarizes the total, direct, and indirect effects (mediated by high concern about the influenza vaccine) of race/ethnicity on vaccine uptake among HCWs. Non-Hispanic Blacks had lower influenza vaccine uptake than non-Hispanic Whites (total effect: PR = 0.87; 95% CI = 0.75, 0.99), which was largely mediated by high concern about influenza vaccines (natural indirect effect: PR = 0.89; 95% CI = 0.84, 0.94; controlled direct effect: PR = 0.98; 95% CI = 0.85, 1.1). By contrast, the total effects of Hispanic and Asian race/ethnicity on influenza vaccine uptake among HCWs were more modest, but these modest effects were also mediated by high concern about influenza vaccines (Hispanics, natural indirect effect: PR = 0.95, 95% CI = 0.87, 1.0; controlled direct effect: PR = 1.0, 95% CI = 0.70, 1.4; Asians, natural indirect effect: PR = 0.97; 95% CI = 0.93, 1.0; controlled direct effect: PR = 0.99; 95% CI = 0.81, 1.2).

Table C (available as a supplement to this article at <http://www.ajph.org>) summarizes the results of our sensitivity analysis exploring the impact of potential outcome misclassification on estimates for the effect of race/ethnicity on influenza vaccine uptake. The PRs modestly but consistently moved further away from the null with progressively lower sensitivity and specificity. For example, when we used the sensitivity and specificity estimates reported by Irving et al.,<sup>36</sup> adjustment for misclassification yielded a 16% relative difference in uptake between non-Hispanic Black and non-Hispanic White HCWs, by contrast to the 13% relative difference in our original estimate.

## DISCUSSION

Influenza vaccine uptake in our study population was 87% for the 2012 to 2013

**TABLE 2—Latent Class Analysis Results for Conditional Probabilities for High or Low Concern About Influenza Vaccines Among Health Care Workers Who Participated in 2012–2013 Influenza Vaccine Survey: St. Jude Children’s Research Hospital, Memphis, TN**

Response	High Concern, %	Low Concern, %
Vaccine causes influenza		
Yes	63	0.5
No	37	99.5
Concern about side effects		
Yes	97	11
No	3.5	89
Vaccine is ineffective		
Yes	52	3
No	48	97
Vaccine is unnecessary		
Yes	28	2
No	72	98

Note. High-concern group, n = 263 (13% of participants); low-concern group, n = 1740 (87% of participants).

influenza season, but uptake differed by race/ethnicity. In particular, uptake was 13% (95% CI = 1.0%, 25%) lower among non-Hispanic Black than White HCWs. We identified distinct classes of HCWs with high and low concern about influenza vaccines. Our results suggest that high concern about influenza vaccines substantially mediates the association between race/ethnicity and vaccine uptake (i.e., the apparent disparities in uptake may be attributable to high concern about influenza vaccines among racial/ethnic minorities), particularly for non-Hispanic Blacks. Nevertheless, our results suggest that racial/ethnic disparities could be attenuated if high concern about the influenza vaccine were reduced. The resulting increase in vaccine uptake could facilitate meeting the *Healthy People 2020* goal of 90% coverage.

Racial/ethnic disparities in influenza vaccine uptake among HCWs have consistently been reported in the literature.<sup>3–11</sup> In particular, the

relative difference in uptake between non-Hispanic Black and White HCWs reported in studies published between 2002 and 2013 ranges from 25% to 47%.<sup>3–10</sup> The 13% relative difference in uptake between non-Hispanic Black and White HCWs that we observed is thus lower than in previous studies, but our attenuated estimate may be attributable to a comprehensive influenza vaccination program at our institution that targets HCWs with direct patient contact and provides vaccination free of charge.<sup>40</sup> Our population thus had high vaccine uptake overall and less potential for variation between subgroups. Nevertheless, previous studies did not explore potential mediating factors in the association between race/ethnicity and influenza vaccine uptake. Therefore, our study provides unique information about the mechanism by which race/ethnicity may influence vaccine uptake.

### Limitations

The cross-sectional nature of our data introduced ambiguity about the temporal sequence of vaccine concerns (our mediator) and vaccination acceptance. Nevertheless, even longitudinal studies among HCWs may not necessarily be able to distinguish this sequence because concerns about the vaccine and vaccine uptake in previous seasons may precede ever becoming an HCW. Our analysis thus assumed that vaccine concerns occurred prior to vaccination and that the mediator–outcome relation was materially insensitive to unmeasured confounding, but these assumptions were untestable.

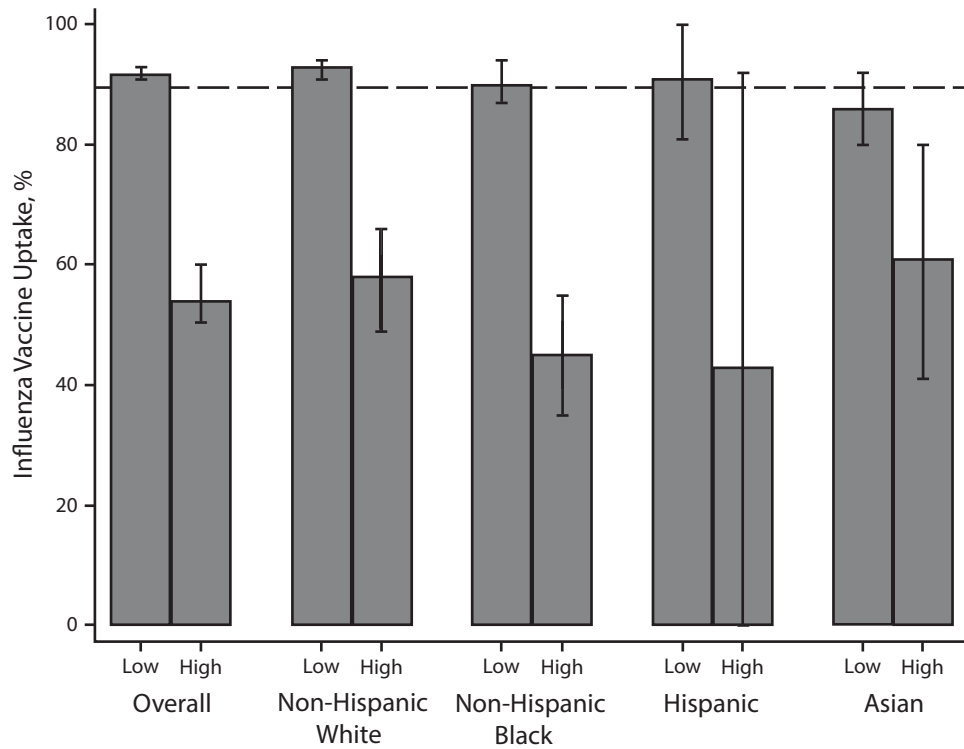
As with all studies that use self-reported vaccination status for outcome measurement, our results may have been sensitive to outcome misclassification. We explored the impact of potential misclassification on our comparisons of influenza vaccine uptake among non-Hispanic Black and White HCWs. The results of our sensitivity analysis suggested modest underestimation of the relative difference in uptake between these racial/ethnic subgroups. Nevertheless, we encourage conservative interpretation of these results because the misclassification rate in our HCW population may have differed from the misclassification rate in the general population sample we used to derive sensitivity and specificity estimates. In

addition, we assumed a nondifferential misclassification mechanism, but differential misclassification could result in bias toward or away from the null depending on the misclassification rates for each racial/ethnic subgroup. Unfortunately, the overall or race-specific validity of self-reported vaccination status is unknown for HCWs. Future studies should consider either incorporating validation studies or using more accurate measures of vaccination status.

Despite the high participation proportion in our survey even after exclusion of HCWs with missing values for relevant covariates, the estimate of influenza vaccine uptake in our final sample may have been sensitive to bias from nonparticipation. If nonparticipants had lower vaccine uptake, then we may have overestimated overall uptake in the source population (i.e., all eligible HCWs). In addition, we cannot exclude the possibility that our estimates for direct and indirect effects were sensitive to selection bias from nonparticipation. For example, if non-Hispanic Whites (our reference population) with high concern about the influenza vaccine and low vaccine uptake composed a high proportion of nonparticipants, then we might have overestimated the mediating effect of vaccine concerns. We also might have overestimated the mediating effect of vaccine concerns if racial/ethnic minorities with high concern about the influenza vaccine and low uptake composed a high proportion of nonparticipants. Unfortunately, the inherent lack of data about nonparticipants limits our understanding about which scenario prevailed in our population.

### Conclusions

Our results suggest that despite high vaccination coverage overall, uptake was still lower for non-Hispanic Black than White HCWs. More importantly, our findings suggest that greater concerns about the safety, effectiveness, and necessity of the influenza vaccine among non-Hispanic Black HCWs mediated this racial/ethnic disparity. Assuming that bias did not appreciably affect the interpretation of our results, the practical value of our study is the identification of a modifiable factor (i.e., vaccine concerns) to target for reducing racial/ethnic disparities in influenza vaccine coverage among HCWs. Interventions to



Note. Dashed reference line represents the *Healthy People 2020* goal of 90% influenza vaccine coverage for health care workers. Error bars represent 95% confidence intervals. Overall: low-concern group, n = 1740; high-concern group, n = 263. Non-Hispanic Whites: low-concern group, n = 1438; high-concern group, n = 120. Non-Hispanic Blacks: low-concern group, n = 220; high-concern group, n = 93. Hispanics: low-concern group, n = 33; high-concern group, n = 7. Asians: low-concern group, n = 122; high-concern group, n = 28.

**FIGURE 1—Overall and race/ethnicity-specific influenza vaccine uptake by level of concern about influenza vaccines among health care workers: St. Jude Children’s Research Hospital, Memphis, TN, 2012–2013 influenza season.**

address vaccine concerns may need to be tailored to racial/ethnic groups not only for culturally sensitive content but also for delivery.<sup>41</sup> A key component of tailored approaches is the promotion of trust.<sup>42</sup> For

example, engaging opinion leaders—both within the institution and in the community—who can promote vaccination and provide culturally targeted messaging may aid in reducing racial/ethnic disparities.<sup>43</sup> Approaches

to promoting trust in different institutions and populations may vary, and thus tailored interventions will require understanding local circumstances.

A mandatory vaccination policy, which is being more widely adopted across health care institutions in the United States,<sup>44</sup> may seem to be an appealing solution to racial/ethnic disparities because it applies to all racial/ethnic groups of HCWs. Nevertheless, mandatory vaccination is controversial and does not address the fundamental issues underlying vaccine hesitancy. Furthermore, no studies have addressed whether mandatory vaccination improves actual clinical outcomes.<sup>45</sup> Consequently, addressing vaccine concerns should be a continued focus even at institutions that adopt a mandatory vaccination policy.<sup>46</sup>

Finally, HCWs are often viewed as an isolated group, which is an inadequate socio-cultural perspective for understanding

**TABLE 3—Total, Direct, and Indirect Effects of Race/Ethnicity on Vaccine Uptake Among Health Care Workers Who Participated in 2012–2013 Influenza Vaccine Survey: St. Jude Children’s Research Hospital, Memphis, TN**

Effect Type	Non-Hispanic Blacks, <sup>a</sup> PR (95% CI)	Hispanics, PR (95% CI)	Asians, PR (95% CI)
Total effect	0.87 (0.75, 0.99)	0.95 (0.67, 1.35)	0.97 (0.80, 1.18)
Natural direct effect	0.97 (0.84, 1.13)	1.00 (0.70, 1.41)	1.00 (0.82, 1.22)
Natural indirect effect <sup>b</sup>	0.89 (0.84, 0.94)	0.95 (0.87, 1.04)	0.97 (0.93, 1.02)
Controlled direct effect	0.98 (0.85, 1.14)	1.00 (0.70, 1.45)	0.99 (0.81, 1.22)

Note. CI = confidence interval; PR = prevalence ratio.

<sup>a</sup>Prevalence ratio and 95% CIs adjusted for age, gender, and occupation; each racial/ethnic group was compared with non-Hispanic Whites.

<sup>b</sup>Mediated by high concern about influenza vaccines.

barriers to vaccination. Multilevel perspectives such as the socioecological model of health promotion recognize that individuals cluster in social networks and that social networks cluster in communities.<sup>47</sup> This model has been used to better understand the context of barriers to vaccination and propose multilevel interventions.<sup>48</sup> Future studies should explore multilevel perspectives to better understand how sociocultural phenomena affect racial/ethnic disparities in influenza vaccine uptake among HCWs. ■

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### Contributors

R. P. Ojha developed the study concept and design, collected and analyzed the data, interpreted the results, and drafted the article. S. Stallings-Smith helped analyze the data. P. M. Flynn, E. E. Adderson, T. N. Offutt-Powell, and A. H. Gaur helped design the study and interpret results. All authors developed the article.

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### Human Participant Protection

This study was assessed by the St. Jude Children's Research Hospital institutional review board and considered exempt from oversight because of an anonymous survey procedure that precluded identification of participants in any way.

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