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Original article

Identification of groups at high risk for under-coverage of seasonal influenza vaccination: A national study to inform vaccination priorities during the COVID-19 pandemic

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ABSTRACT

Purpose: Seasonal influenza vaccination is an important public health strategy to reduce preventable illness, hospitalization, and death. Because of overlapping risk factors for severe illness from seasonal influenza and COVID-19, uptake of the seasonal influenza vaccination has heightened importance during the COVID-19 pandemic. We analyzed receipt of seasonal influenza vaccination among COVID-19 priority groups and further examined socio-demographic and behavioral factors associated with receiving the seasonal influenza vaccine among US adults.

Methods: Using the 2018 National Health Interview Survey, we classified 24,772 adults into four COVID-19 priority groups: healthcare workers, medically vulnerable, non-healthcare essential workers, and the general population. We performed multiple logistic regression to compare the relative odds of receiving the influenza vaccine by COVID-19 priority group, socio-demographics, and health-related factors.

Results: Healthcare workers, medically vulnerable adults, essential workers, and the general population comprised 8.9%, 58.4%, 6.6%, and 26.1 % of the US population, respectively. Compared with healthcare workers, the adjusted odds ratio (aOR) of receiving influenza vaccine were significantly lower in medically vulnerable adults (aOR=0.43, 95% CI=0.37, 0.48), essential workers (aOR=0.28, 95% CI=0.23, 0.34), and the general population (aOR=0.32, 95% CI=0.28, 0.37). Being young, male, Black, and having no health insurance were associated with lower relative odds of receiving the flu vaccine.

Conclusions: Patterns of influenza vaccine cause concern for under-coverage of populations at high risk for both seasonal influenza and COVID-19. Achieving optimal protection against vaccine-preventable respiratory illness in US adults will require emphasis on those employed outside of the healthcare sector, younger age groups, and adults with lower socioeconomic resources.

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Background

Influenza is a major cause of preventable illness, hospitalization, and death in the United States. Experts have warned that the concurrent circulation of the seasonal influenza virus and the SARS-Cov-2 virus have the potential to give rise to a “twindemic” during the winter months when circulation of the seasonal influenza

virus is high [1,2]. While the nation was spared high rates of concurrent influenza and COVID-19 illness in the 2020-2021 winter—ostensibly due to low influenza illness because of social distancing and masking—there are concerns that increased mobility in the 2021-2022 combined with the circulation of new coronavirus variants may manifest as a twindemic in the future.

Evidence shows that influenza vaccination is effective at preventing influenza infection [3] and reducing illness severity [4] and ICU admissions [5] in people with breakthrough infections, yielding a critical population-wide benefit at a time when the health care system strained by COVID-19 related hospitalizations [2].

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Coinfection of influenza and COVID-19 substantially raises the relative odds of death compared with either infection in isolation [6]. Moreover, groups at high risk for influenza infection (such as healthcare workers) and severe illness (such as the elderly, those with underlying comorbidities, and those in long-term care facilities) are also at high risk for COVID-19 infection and severe illness. There are also emerging data suggesting that being immunized against influenza is protective against severe COVID-19 illness [7,8], suggesting that *vulnerability* to and *protection* against seasonal influenza and COVID-19 infection may be intertwined.

Although vaccination against seasonal influenza and COVID-19 are recommended for virtually all adults and vaccines are in large supply in the United States, vaccination uptake is far from universal. As of November 2021, the US Centers for Disease Control and Prevention reported that 40.9% of the US adult population has received an annual influenza vaccine [9] and 70.9% of adults have been fully vaccinated against COVID-19 [10]. With influenza vaccination lagging behind COVID-19 vaccination, improving influenza vaccination coverage will be increasingly important as individuals return to in-person activities and the emphasis on masking declines.

To inform public health priorities around influenza vaccination in light of the COVID-19 pandemic, we examined historical differences and likelihood of getting influenza vaccine by commonly identified priority groups for COVID-19, including healthcare workers, medically vulnerable, non-healthcare essential workers, and the general population. We also examined social and behavioral factors associated with receiving influenza vaccine among all adults and by race and ethnicity.

Methods

Data and sample

The National Health Interview Survey (NHIS) is a cross-sectional, representative household interview survey which collects information on the health of non-institutionalized US population across the 50 states through the use of a complex multistage design [11]. We used the publicly available 2018 NHIS adults sample data (collected in 2018) to obtain nationally representative measures of flu vaccine uptake, detailed occupational codes, chronic diseases, and socioeconomic and demographic characteristics. Our study was restricted to adult respondents because of our interest in describing influenza vaccination uptake in relation to priority groups for COVID-19, and COVID-19 illness is documented to be more severe in adults than children [12]. Of 25,417 respondents aged 18–85 years, 2.5% were excluded from the analysis because of missing information on a study variable, resulting in an unweighted analytic sample size of 24,772.

Outcome

Our outcome was seasonal influenza vaccine uptake, measured as a binary variable describing whether or not the respondent received the flu vaccine in the past 12 months.

COVID-19 Vaccination priorities and eligibility

Advisory Committee on Immunization Practices (ACIP) framework [13] recommended three criteria for determining phased priorities for vaccination: employment in the healthcare field, medical

vulnerability (including the elderly), and employment in other essential occupations. States exercised discretion in determining eligibility [14]. To provide a picture of how different priority groups may respond to the vaccine campaign, we categorized US adults into four broad groups that have commonly been used to determine eligibility for vaccination thus far: healthcare workers, the medically vulnerable, essential occupations outside of healthcare, and the remaining general population [13]. Healthcare workers included all healthcare-related occupations identified in NHIS 2018, such as healthcare practitioners, nurses, funeral service workers etc. The medically vulnerable group included adults who had one or more high risk medical conditions for COVID-19, including cancer, type 2 diabetes, chronic kidney disease, chronic obstructive pulmonary disease, obesity body mass index ≥ 30 , heart condition, asthma, stroke, hypertension, dementia, liver disease and also adults over the age of 65 who were not already covered in the healthcare group. Other essential occupations included adults who were not already covered in the healthcare or medically vulnerable group and those employed in occupations critical to the daily functioning of America, such as first responders, teachers, retail store workers, food and agriculture workers, manufacturing workers, and motor vehicle operators. The general population included all other adults over the age of 18 not included in another group.

Factors potentially impacting adult vaccine uptake

We considered several demographic, socioeconomic, and health factors in the analysis. Demographic characteristics were age at interview (categorized as five groups: 18–24, 25–44, 45–64, 65–74, and 75 and above), gender (men and women), race/ethnicity (Non-Hispanic White, Non-Hispanic Black, Hispanic, Non-Hispanic Asian, Non-Hispanic American Indian and Native Alaskan, and Non-Hispanic Other), and place of birth (US-born and foreign-born). Socioeconomic factors included combined family income in USD (less than \$30,000, \$30,000–\$59,999, \$60,000–\$99,999, and \$100,000 and above), educational attainment (high school or less, less than 4 years of college, and 4 or more years of college). Factors related to healthcare behaviors included smoking behavior (smoker, former smoker, and never-smoker), health insurance (some health insurance, no health insurance), and past use of internet to research health information (yes/no), and history of delaying healthcare due to lack of transportation (yes/ no). We also included region (Northeast, Midwest/Central, South, and West) to provide insight into differences across the United States.

Statistical Analysis

We first described the composition of the four COVID-19 priority groups as defined above. To investigate the association of priority grouping and socio-demographic and health-related behavioral factors with influenza vaccine, we performed adjusted and unadjusted logistic regression analysis. The unadjusted model estimated the bivariate association of influenza vaccination with priority grouping and covariates of interest. The adjusted model included priority groups and all covariates under consideration. We further examined the association between social and behavioral factors and influenza vaccination for each race and ethnic group separately. The total sample and race-stratified models demonstrated good discrimination (c-statistics ranging from 0.68 to 0.72). All analyses were conducted using SAS 9.4 software (SAS Insti-

Table 1
Demographic composition of US adults overall and classified by COVID-19 vaccination priority groups, NHIS 2018

	All adults	Healthcare ^a	Medically vulnerable ^b	Non-healthcare ^c Essential workers	General population ^d	p-value
Unweighted N	24,772	2,210	15,604	1,114	5,844	
Weighted N	242,253,193	21,491,779	141,370,244	16,085,898	63,305,272	
Weighted %	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	
Age		8.9 (8.4, 9.3)	58.4 (57.5, 59.2)	6.6 (6.2, 7.1)	26.1 (25.3, 26.9)	<.001 ^e
18–24	11.7 (11.0, 12.3)	6.8 (5.2, 8.4)	7.4 (6.7, 8.0)	22.2 (19.1, 25.4)	20.2 (18.8, 21.7)	
25–44	34.3 (33.5, 35.2)	41.5 (39.0, 44.1)	25.5 (24.5, 26.5)	46.7 (43.6, 49.8)	48.5 (46.9, 50.2)	
45–64	33.3 (32.5, 34.0)	34.7 (32.2, 37.2)	34.2 (33.3, 35.2)	31.1 (28.2, 33.9)	31.3 (29.7, 32.8)	
65–74	12.4 (11.9, 12.9)	10.7 (9.4, 12.0)	19.6 (18.9, 20.4)	.	.	
75+	8.3 (7.9, 8.7)	6.3 (5.2, 7.3)	13.3 (12.7, 13.9)	.	.	
Male	48.3 (47.5, 49.1)	26.2 (24.0, 28.5)	49.9 (49.0, 50.9)	50.6 (47.2, 54.0)	51.6 (50.1, 53.2)	<0.001
Race/ethnicity						<0.001
Non-Hispanic White	63.5 (61.9, 65.1)	62.0 (59.1, 64.8)	66.9 (65.2, 68.5)	61.8 (58.1, 65.5)	56.9 (54.7, 59.1)	
Non-Hispanic Black	11.5 (10.6, 12.3)	17.0 (14.7, 19.3)	11.3 (10.3, 12.3)	9.6 (7.5, 11.7)	10.5 (9.2, 11.8)	
Hispanic	16.1 (14.8, 17.5)	10.7 (8.9, 12.6)	14.4 (13.1, 15.8)	20.8 (17.6, 23.9)	20.7 (18.8, 22.7)	
Non-Hispanic Asian	6.00 (5.4, 6.6)	7.7 (6.0, 9.4)	4.1 (3.6, 4.7)	6.3 (4.6, 8.0)	9.5 (8.3, 10.7)	
Non-Hispanic American Indian and Alaskan Native	0.8 (0.4, 1.2)	0.9 (0.2, 1.5)	0.9 (0.5, 1.3)	0.5 (0.0, 1.0)	0.6 (0.3, 0.9)	
Non-Hispanic Other	2.1 (1.8, 2.4)	1.7 (1.1, 2.4)	2.4 (2.0, 2.7)	1.0 (0.2, 1.9)	1.8 (1.3, 2.3)	
US born	81.0 (79.8, 82.1)	81.5 (79.0, 84.0)	84.9 (83.7, 86.0)	74.0 (70.7, 77.3)	73.9 (72.0, 75.7)	<0.001
Combined Family Income in USD						<0.001
0–29,999	20.9 (20.0, 21.7)	17.6 (15.9, 19.4)	23.2 (22.2, 24.1)	18.1 (15.7, 20.5)	17.5 (16.2, 18.7)	
30,000–59,999	23.5 (22.7, 24.3)	22.1 (19.8, 24.3)	25.1 (24.2, 26.0)	22.7 (20.0, 25.5)	20.7 (19.2, 22.1)	
60,000–99,999	23.0 (22.3, 23.7)	21.5 (19.4, 23.6)	23.4 (22.5, 24.2)	23.9 (21.3, 26.5)	22.3 (21.0, 23.8)	
100,000+	32.6 (31.5, 33.8)	38.8 (36.3, 41.3)	28.3 (27.1, 29.4)	35.2 (31.9, 38.6)	39.5 (37.6, 41.4)	
Educational attainment						<0.001
High school or less	35.8 (34.7, 36.8)	17.3 (15.4, 19.2)	39.9 (38.8, 41.1)	35.5 (32.1, 39.0)	32.7 (31.0, 34.5)	
< 4 years college	30.6 (29.8, 31.4)	38.9 (36.2, 41.5)	30.2 (29.2, 31.0)	30.0 (26.9, 33.1)	28.9 (27.4, 30.4)	
4 years of college or more	33.6 (32.6, 34.7)	43.8 (41.2, 46.5)	29.9 (28.8, 31.0)	34.4 (31.3, 37.6)	38.4 (36.4, 40.3)	
Smoking behavior						<0.001
Never	64.0 (63.2, 64.9)	69.1 (66.9, 71.4)	58.1 (57.1, 59.1)	72.2 (69.4, 75.1)	73.6 (72.1, 75.0)	
Current smoker	13.7 (13.1, 14.3)	10.5 (9.1, 12.0)	14.7 (14.0, 15.4)	14.2 (12.0, 16.5)	12.5 (11.4, 13.6)	
Former	22.2 (21.6, 22.9)	20.3 (18.4, 22.2)	27.2 (26.3, 28.1)	13.5 (11.5, 15.6)	13.9 (12.9, 15.0)	
Has health Insurance	89.7 (89.1, 90.4)	93.6 (92.4, 94.9)	91.6 (90.9, 92.3)	85.7 (83.8, 88.7)	85.3 (84.0, 86.6)	<0.001
Researched health information on internet	55.6 (54.6, 56.6)	67.0 (64.4, 69.5)	52.8 (51.7, 54.0)	55.1 (51.9, 58.4)	58.1 (56.3, 59.9)	<0.001
Delayed healthcare due to transportation	2.3 (2.1, 2.6)	2.5 (1.6, 3.3)	3.0 (2.6, 3.3)	1.2 (0.5, 1.9)	1.2 (0.8, 1.6)	<0.001
Region						<0.001
Northeast	17.2 (16.3, 18.1)	20.9 (18.6, 23.2)	16.6 (15.7, 17.6)	13.9 (11.4, 16.4)	18.1 (16.5, 19.6)	
Midwest	22.2 (21.3, 23.0)	21.5 (19.4, 23.6)	22.1 (21.2, 23.1)	25.9 (22.8, 28.9)	21.4 (19.8, 23.0)	
South	36.9 (35.8, 38.1)	37.5 (34.9, 40.1)	38.5 (37.2, 39.7)	33.0 (29.6, 36.3)	34.2 (32.3, 36.2)	
West	23.7 (22.6, 24.8)	20.1 (18.2, 22.1)	22.7 (21.5, 23.9)	27.3 (23.7, 30.8)	26.3 (24.4, 28.2)	

Demographic characteristics as weighted prevalence (95% CI) for the whole sample, healthcare workers, medical vulnerable, essential workers, and the general population.
^a Comprises healthcare workers and does not include institutionalized populations (i.e., long-term care facility residents or incarcerated individuals).
^b Comprises individuals 65 years and older and individuals aged 18–64 with at least one medical comorbidity.
^c Comprises non-healthcare essential workers.
^d Comprises all individuals not covered in prior categories.
^e Computed without survey design because survey-adjusted chi-square tests require all cell counts to be greater than zero. Priority categories are assigned according to the CDC COVID-19 Vaccination Program Interim Playbook for Jurisdiction Operations framework. See supplementary methods for further detail on the composition of region and healthcare workers, medically vulnerable individuals, non-healthcare essential workers, and general population.

tute Inc., Cary, NC) accounting for the complex survey design of NHIS.

Results

Table 1 shows the demographic composition of US adults classified by COVID-19 vaccination priority group. A total of 9% adults were classified as healthcare workers, 58% as medically vulnerable, 7% essential workers, and 26% as the general population. All demographic, socioeconomic, and health characteristics were significantly different by priority group (p-value <0.001). Among health-

care workers, the majority were female, whereas all other categories had a relatively even gender distribution. Healthcare workers had an almost even share of older and younger adults, medically vulnerable population had a majority of adults over the age of 45, and essential workers and the general population mostly had individuals under 45. Healthcare workers, medically vulnerable, and essential workers all had similar percentage of Non-Hispanic Whites compared to the general population, which had a slightly lower percentage of Whites. Healthcare workers were the most educated, and the medically vulnerable, the least. Healthcare workers and the general population earned the most income, followed by essential workers, and medically vulnerable.

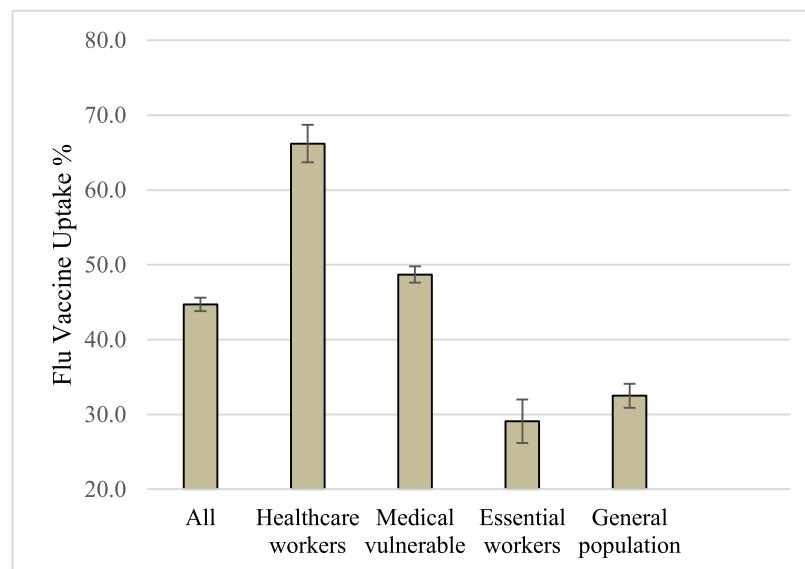


Figure 1. Prior influenza vaccine uptake by COVID-19 vaccination priority group, NHIS 2018. Comparison of influenza vaccine uptake (%) for all US adults, healthcare workers, individuals who are medically vulnerable, essential workers, and the general population. Error bars represent 95% CI.

Figure 1 shows the prevalence of receiving the seasonal influenza vaccine stratified by priority classification. Overall, 45% of US adults (95% CI= 43.8, 45.7) reported receiving the influenza vaccine in the last 12 months. The prevalence of receiving the influenza vaccine in the past 12 months was highest in healthcare workers (66.2%, 95% CI=63.7, 68.8) followed by medically vulnerable (48.7%, CI= 47.6, 49.8), and lowest in essential workers (29.1%, 95% CI=26.2, 30.0) and the general population with 32.5% (95% CI= 30.9, 34.1).

Table 2 shows the unadjusted and adjusted associations of priority classification, demographic, socioeconomic, and health characteristics with receiving seasonal influenza vaccine. Compared with healthcare workers, the unadjusted odds ratio (OR) of influenza vaccine uptake was OR=0.48 (95% CI=0.43, 0.54) for the medically vulnerable population, OR=0.21 (95% CI=0.18, 0.25) for essential workers, and OR= 0.25 (95% CI= 0.22, 0.28) for the general population. These associations remained largely unchanged after adjusting for several demographic, socioeconomic, and healthcare variables.

We observed several statistically significant demographic, socioeconomic, and healthcare correlates of receipt of influenza vaccine in the past 12 months (Table 2). In fully adjusted models, younger age (adjusted ORs [aOR] ranging from 0.18 to 0.63 relative to ages 75 and above), being male (aOR=0.82, 95% CI= 0.77, 0.88), being Non-Hispanic Black (aOR= 0.78, 95% CI= 0.69, 0.88), lower income (aOR ranging from 0.75 to 0.83 relative to \$100,000 or more) and lower educational attainment (high school or less aOR=0.75, 95% CI=0.68, 0.82; less than 4 years of college aOR=0.71, 95% CI= 0.65, 0.78) were inversely associated with receiving the influenza vaccine in the past 12 months. Health behaviors inversely associated influenza vaccine included not researching health related information on the internet (aOR=0.84, 95% CI=0.78, 0.91), current smoking (aOR=0.63, 95% CI=0.57, 0.70), and not having health insurance (aOR= 0.36, 95% CI=0.31, 0.42). Identifying as American Indian or Native Alaskan was sig-

nificantly associated with higher vaccine uptake (aOR=1.47, 95% CI= 1.04, 2.07).

Table 3 shows adjusted associations of priority classification, demographic, socioeconomic, and health characteristics with receiving seasonal influenza vaccine separately for major race and ethnic groups in the United States. Associations were largely consistent with those observed in all adults (Table 2). In all race and ethnic groups other than American Indians and Native Alaskans, the medically vulnerable, non-healthcare essential workers, and the general population were less likely to report receiving an influenza vaccination in the past year when compared with healthcare workers. Similarly, there was a strong inverse association between age (younger age groups vs 75+), education (< 4 years of college vs 4 years of college or more), insurance status (no health insurance vs health insurance) and receiving an influenza vaccination in the majority of race and ethnic groups. Among American Indians and Native Alaskans—a group that was more likely to be vaccinated on average compared with other race and ethnic groups (see Table 2)—only age 18-24, male sex and health insurance status were statistically significantly related to vaccination uptake.

Discussion

The goal of this study was to provide data to describe groups that may be at risk for lower coverage of influenza vaccination in the context of heightened risks of respiratory illness and hospitalization because of the ongoing COVID-19 pandemic. Although 45% of all US adults reported receiving the annual influenza vaccine in the 12 months prior to the 2018 survey, uptake varied from a low of 29% in essential workers to a high of 66% in healthcare workers. These differences in influenza vaccine uptake by priority classification remained even after accounting for demographic, socioeconomic, and health factors. Importantly, compared to health

Table 2

Logistic regression examining unadjusted and adjusted associations of COVID-19 priority grouping and socioeconomic and health-related factors with influenza vaccine uptake NHIS 2018

	Unadjusted associations*		Adjusted associations**	
	OR	95% CI	OR	95% CI
Priority groups				
Healthcare workers	Ref		Ref	
Medically vulnerable and elderly – comorbidity and/or >75 y	0.48	0.43, 0.54	0.43	0.37, 0.48
Non-healthcare essential workers	0.21	0.18, 0.25	0.28	0.23, 0.34
General population	0.25	0.22, 0.28	0.32	0.28, 0.37
Age				
18–24	0.14	0.12, 0.17	0.18	0.15, 0.22
25–44	0.19	0.17, 0.21	0.21	0.18, 0.24
45–64	0.28	0.25, 0.31	0.30	0.27, 0.34
65–74	0.65	0.57, 0.74	0.63	0.56, 0.71
75+	Ref		Ref	
Sex				
Female	Ref		Ref	
Male	0.72	0.68, 0.77	0.82	0.77, 0.88
Race/ethnicity				
Non-Hispanic White	Ref		Ref	
Non-Hispanic Asian	1.01	0.86, 1.18	1.16	0.96, 1.40
Non-Hispanic Black	0.63	0.56, 0.69	0.78	0.69, 0.88
Hispanic	0.61	0.55, 0.67	1.05	0.92, 1.19
Non-Hispanic American Indian and Native Alaskan	0.85	0.61, 1.18	1.47	1.04, 2.07
Non-Hispanic Other	0.62	0.50, 0.79	0.84	0.66, 1.09
Combined family Income USD				
0–29,999	0.70	0.64, 0.76	0.83	0.75, 0.93
30,000–59,999	0.69	0.64, 0.75	0.76	0.69, 0.83
60,000–99,999	0.76	0.70, 0.82	0.80	0.74, 0.88
100,000+	Ref		Ref	
Educational attainment				
4 years college +	Ref		Ref	
High school or less	0.58	0.54, 0.62	0.75	0.68, 0.82
< 4 years college	0.63	0.58, 0.68	0.71	0.65, 0.78
Region				
Northeast	Ref		Ref	
South	0.75	0.68, 0.84	0.90	0.80, 1.01
Midwest	0.88	0.78, 0.98	1.01	0.89, 1.13
West	0.84	0.74, 0.95	0.96	0.85, 1.09
US birth				
Born in US	Ref		Ref	
Not born in US	0.81	0.74, 0.87	0.91	0.80, 1.04
Transportation				
No Healthcare delays due to transportation	Ref		Ref	
Healthcare delays due to transportation	0.90	0.73, 1.11	1.05	0.84, 1.32
Healthcare information				
Researched health information on the internet	Ref		Ref	
Did not research health information on the internet	0.82	0.77, 0.87	0.84	0.78, 0.91
Smoking behavior				
Never smoker	Ref		Ref	
Former smoker	1.38	1.28, 1.50	1.05	0.97, 1.15
Current smoker	0.53	0.48, 0.58	0.63	0.57, 0.70
Health insurance				
Health insurance	Ref		Ref	
No health insurance	0.21	0.18, 0.25	0.36	0.31, 0.42

* Unadjusted associations of priority group and covariates with flu vaccine uptake. Models were simultaneously adjusted for all variables shown in the table.

** Adjusted associations of priority group and covariates with flu vaccine. Models were simultaneously adjusted for all variables shown in the table. Bold: Statistically significant at alpha=0.05.

care workers, individuals in medically vulnerable group, essential non-healthcare occupations and general population were less than half as likely to have received the annual influenza vaccine. Collectively, these findings suggest that achieving optimal protection against vaccine-preventable respiratory illness in adults with medical vulnerability, employed in essential non-healthcare occupa-

tions, and in the general population may be more challenging than meeting vaccination targets in healthcare workers. In addition, we identified several demographic and health barriers of vaccine uptake. We found that younger age groups, men, those with lower socio-economic status, and adults without health insurance had lower odds of receiving influenza vaccine. Conversely, facilitators

Table 3

Logistic regression examining adjusted associations* of COVID-19 priority grouping and socioeconomic and health-related factors with influenza vaccine uptake for major US race and ethnic groups, NHIS 2018

	Non-Hispanic White (n=16989)	Non-Hispanic Black(n=2737)	Hispanic(n=3073)	Non-Hispanic Asian(n=1236)	Non-Hispanic American Indian and Native Alaskan(n=226)	Non-Hispanic Other(n=511)
Priority groups						
Healthcare workers	ref	ref	ref	ref	ref	ref
Medically vulnerable and elderly – comorbidity and/or >75 y	0.40 (0.34,0.47)	0.54 (0.39,0.74)	0.57 (0.38,0.84)	0.35 (0.20,0.62)	0.56 (0.14,2.24)	0.26 (0.11,0.61)
Non-healthcare essential workers	0.26 (0.20,0.32)	0.24 (0.14,0.43)	0.43 (0.26,0.70)	0.21 (0.10,0.46)	1.62 (0.28,9.41)	0.07 (0.01,0.73)
General population	0.31 (0.26,0.37)	0.37 (0.25,0.55)	0.42 (0.28,0.62)	0.19 (0.11,0.33)	0.35 (0.10,1.20)	0.39 (0.15,1.00)
Age						
18–24	0.16 (0.13,0.20)	0.27 (0.16,0.46)	0.29 (0.17,0.48)	0.25 (0.11,0.60)	0.15 (0.03,0.67)	0.03 (0.01,0.11)
25–44	0.20 (0.17,0.23)	0.22 (0.15,0.32)	0.29 (0.20,0.44)	0.25 (0.12,0.51)	0.85 (0.24,3.03)	0.07 (0.02,0.22)
45–64	0.28 (0.24,0.32)	0.35 (0.24,0.52)	0.42 (0.28,0.63)	0.31 (0.16,0.62)	1.36 (0.37,4.98)	0.10 (0.03,0.28)
65–74	0.60 (0.52,0.69)	0.63 (0.43,0.94)	0.91 (0.58,1.43)	0.61 (0.30,1.24)	1.16 (0.30,4.56)	0.21 (0.07,0.65)
75+	ref	ref	ref	ref	ref	ref
Sex						
Female	ref	ref	ref	ref	ref	ref
Male	0.83 (0.76,0.89)	0.92 (0.72,1.18)	0.72 (0.60,0.87)	0.86 (0.65,1.14)	0.49 (0.25,0.94)	0.88 (0.55,1.40)
Combined family Income USD						
0–29,999	0.77 (0.68,0.89)	1.33 (0.94,1.86)	0.86 (0.65,1.14)	0.97 (0.60,1.57)	1.10 (0.44,2.71)	0.57 (0.28,1.14)
30,000–59,999	0.71 (0.63,0.79)	1.02 (0.75,1.40)	0.95 (0.72,1.25)	0.61 (0.39,0.94)	1.04 (0.34,3.24)	0.44 (0.20,0.95)
60,000–99,999	0.78 (0.70,0.87)	1.16 (0.83,1.64)	0.86 (0.65,1.14)	0.79 (0.53,1.18)	0.69 (0.19,2.55)	0.43 (0.19,0.97)
100,000+	ref	ref	ref	ref	ref	ref
Educational attainment						
4 years college +	ref	ref	ref	ref	ref	ref
High school or less	0.70 (0.62,0.79)	0.72 (0.55,0.95)	0.86 (0.66,1.13)	0.80 (0.51,1.27)	1.63 (0.49,5.36)	0.72 (0.38,1.38)
< 4 years college	0.73 (0.65,0.81)	0.68 (0.52,0.88)	0.73 (0.55,0.97)	0.55 (0.39,0.78)	1.35 (0.39,4.72)	0.70 (0.37,1.31)
Region						
Northeast	ref	ref	ref	ref	ref	ref
South	0.94 (0.83,1.07)	0.92 (0.65,1.29)	0.68 (0.50,0.93)	1.04 (0.66,1.62)	0.61 (0.06,6.58)	1.39 (0.62,3.12)
Midwest	1.04 (0.91,1.18)	1.01 (0.69,1.49)	0.85 (0.57,1.25)	0.87 (0.52,1.47)	0.62 (0.06,6.48)	1.06 (0.42,2.70)
West	0.95 (0.82,1.09)	1.10 (0.71,1.70)	0.97 (0.72,1.30)	0.81 (0.52,1.25)	0.53 (0.05,5.24)	1.27 (0.57,2.82)
US birth						
Born in US	ref	ref	ref	ref	ref	ref
Not born in US	0.66 (0.54,0.80)	1.69 (1.19,2.39)	0.95 (0.75,1.18)	0.94 (0.62,1.43)	1.95 (0.42,8.91)	0.77 (0.34,1.77)
Transportation						
No Healthcare delays due to transportation	ref	ref	ref	ref	ref	ref
Healthcare delays due to transportation	1.07 (0.78,1.47)	0.81 (0.50,1.31)	1.53 (0.92,2.54)	1.16 (0.39,3.48)	0.32 (0.07,1.46)	0.70 (0.27,1.82)
Healthcare information						
Researched health information on the internet	ref	ref	ref	ref	ref	ref
Did not research health information on the internet	0.82 (0.75,0.89)	0.88 (0.70,1.09)	0.87 (0.72,1.05)	0.90 (0.67,1.23)	1.26 (0.51,3.15)	0.57 (0.33,0.98)
Smoking behavior						
Never smoker	ref	ref	ref	ref	ref	ref
Former smoker	1.06 (0.96,1.17)	1.08 (0.78,1.50)	1.00 (0.78,1.29)	1.12 (0.72,1.75)	1.07 (0.47,2.41)	1.08 (0.57,2.01)
Current smoker	0.62 (0.54,0.70)	0.77 (0.57,1.05)	0.78 (0.57,1.07)	0.46 (0.26,0.82)	0.94 (0.40,2.18)	0.76 (0.37,1.54)
Health insurance						
Health insurance	ref	ref	ref	ref	ref	ref
No health Insurance	0.30 (0.23,0.39)	0.29 (0.20,0.41)	0.42 (0.31,0.57)	0.45 (0.23,0.86)	0.34 (0.16,0.74)	0.63 (0.28,1.40)

* Adjusted associations of priority group and covariates with flu vaccine uptake. Models were simultaneously adjusted for all variables shown in the table. Bold: Statistically significant at alpha=0.05.

of receiving the seasonal influenza vaccine included having used the internet to research health related information. Most of these factors were significant correlates of influenza vaccination across racial and ethnic groups.

Both influenza and COVID-19 vaccination uptake may be hindered by both systemic barriers, such as access, and individual

barriers, such as vaccine hesitancy [15,16]. Our findings show that socioeconomically disadvantaged groups, such as low-income and less educated individuals, were less likely to receive the influenza vaccine. These same groups are expected to experience substantial systemic and individual barriers to vaccine access [15].

In addition, we observed that Black adults were less likely to receive the influenza vaccination, even after accounting for socioeconomic characteristics. This is consistent with previous studies of influenza vaccination in older adults [17]. The lower influenza vaccine uptake in Black adults is particularly concerning given that this demographic is at higher risk of both influenza and COVID-19 related hospitalization and death [18,19], and less likely to express intention to receive the COVID-19 vaccine [20–22]. Strategies to overcome reported vaccine hesitancy and other barriers to vaccine uptake are needed in socioeconomically disadvantaged and minority communities.

A strength of the study was our use of the most recent nationally representative data to quantify facilitators and barriers of influenza vaccination uptake among US adults. We examined influenza vaccination patterns in relation to COVID-19 priority groups based on the ACIP criteria to offer insight on under-vaccination of high risk groups. Several limitations of this study should be acknowledged. We analyzed surveys collected prior to the COVID-19 pandemic, and the subsequent pandemic may have altered uptake of the influenza vaccine. Available data to date, however, suggest that influenza vaccine uptake was relatively stable from pre-pandemic to pandemic [23]. We could not analyze institutionalized adults (e.g., those living in nursing homes or prisons) as NHIS does not target institutionalized populations. Our healthcare worker priority group category included all healthcare-related occupations because we were not able to restrict to specific healthcare occupations within the NHIS data. Furthermore, we could not analyze some specific occupations as proposed by ACIP for the essential care worker category, due to lack of specificity in the public-use NHIS occupational data.

Public Health Implications

Influenza and COVID-19 are vaccine preventable respiratory illnesses that cause substantial morbidity and mortality in the US population. Available data indicate that severe illness is exacerbated in individuals co-infected with both seasonal influenza and SARS-CoV-2, and that immunization against seasonal influenza may offer protection against COVID-19 disease. Anticipating which groups exhibit low influenza vaccine uptake among those vulnerable to COVID-19 can be an important dimension of the national strategy to protect population health and ease the burden on the healthcare system. Our findings reinforce previous data that younger adults, men, Black Americans, and those without insurance may be particularly vulnerable to under-coverage of influenza vaccination. We also observed that all COVID-19 priority groups apart from healthcare workers were less likely to receive seasonal influenza vaccines. Evidence-based and tailored communication strategies and vaccination delivery policies must be implemented to directly address barriers to COVID-19 vaccine uptake among adult populations with a history of lower coverage of recommended vaccinations in this country. These efforts are particularly important in light of new and highly transmissible variants of the novel coronavirus, such as Delta and Omicron, that threaten the progress made to date.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.annepidem.2021.12.008.

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