Heliyon 10 (2024) e40476

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Individual and community socioeconomic status and receipt of influenza vaccines among adult primary care patients in a large academic health system: 2017–2019

Sae Takada [a,b,*], Un Young Chung [a], Philippe Bourgois [c,d], O. Kenrik Duru [a], Lillian Gelberg [e,f,g], Maria Han [a], Michael A. Pfeffer [h], Steve Shoptaw [e,i], Kenneth Wells [b,g,i,j], Marjan Javanbakht [k]

[a] *Division of General Internal Medicine and Health Services Research, Department of Medicine, David Geffen School of Medicine, University of California, Los Angeles, United States*
[b] *Greater Los Angeles VA Health System, United States*
[c] *Center for Social Medicine and Humanities, Semel Institute for Neuroscience and Human Behavior, Department of Psychiatry and Biobehavioral Sciences, David Geffen School of Medicine, University of California, Los Angeles, United States*
[d] *Department of Anthropology, University of California, Los Angeles, United States*
[e] *Department of Family Medicine, David Geffen School of Medicine, University of California, Los Angeles, United States*
[f] *Office of Health Care Transformation and Innovation, Greater Los Angeles VA Health System, United States*
[g] *Department of Health Policy and Management, Fielding School of Public Health, University of California, Los Angeles, United States*
[h] *Department of Medicine and Division of Hospital Medicine, Stanford University School of Medicine, United States*
[i] *Department of Psychiatry and Biobehavioral Sciences, David Geffen School of Medicine, University of California, Los Angeles, United States*
[j] *Center for Health Services and Society, Semel Institute for Neuroscience and Human Behavior, Department of Psychiatry and Biobehavioral Sciences, David Geffen School of Medicine, University of California, Los Angeles, United States*
[k] *Department of Epidemiology, Fielding School of Public Health, University of California, Los Angeles, United States*

ARTICLE INFO

Keywords:
Social vulnerability index
Influenza vaccine
Socioeconomic status
Racial disparity

ABSTRACT

Introduction: Influenza causes significant mortality and morbidity in the U.S., yet less than half of adults receive influenza vaccination. We use census-tract level social vulnerability index (SVI) to examine community- and individual-level characteristics of influenza vaccine coverage among primary care patients at an academic health system in Los Angeles, CA.

Methods: We used electronic medical records (EMR) data of 247,773 primary care patients for 2017-18 and 2018-19 influenza seasons. We geocoded patients' addresses to identify their SVI and merged them with EMR data. We specified mixed-effects logistic regression models estimating the association between patient's vaccine receipt and SVI, adjusting for sociodemographics, Charlson Comorbidity Index, and health insurance.

Results: Vaccination coverage was higher during the 2018-19 influenza season (34%) compared to the 2017-18 season (23%). In adjusted analyses, higher SVI, lower individual socioeconomic status and racial and ethnic minority status were independently associated with lower odds of vaccination. Patients on Medicaid had lower odds of vaccine receipt (adjusted Odds Ratio [aOR] = 0.77 for <65, aOR = 0.30 for 65+) than patients on commercial health insurance. Asian Non-Hispanic patients had higher odds than White Non-Hispanic patients (aOR = 2.39 for <65, aOR = 1.91 for 65+), while Black Non-Hispanic patients had lower odds (aOR = 0.49 for <65, aOR = 0.59 for 65+).

* Corresponding author. 1100 Glendon Avenue Suite 850 Los Angeles, CA 90024, United States.
E-mail address: stakada@mednet.ucla.edu (S. Takada).

https://doi.org/10.1016/j.heliyon.2024.e40476
Received 2 November 2023; Received in revised form 14 November 2024; Accepted 14 November 2024
Available online 16 November 2024

Conclusions: Community and individual socioeconomic status and race and ethnicity were associated with influenza vaccination. Health systems can use SVI to identify communities at increased risk of influenza mortality and morbidity, and engage with community partners to develop communication strategies and invest in interventions to increase vaccine accessibility in under-resourced neighborhoods.

1. Introduction

Influenza places a significant burden on the health of people in the U.S., causing an estimated 12,000–52,000 deaths annually [1]. The U.S. Centers for Disease Control and Prevention (CDC) recommends routine influenza vaccination for all people ages 6 months and older [2]. However, influenza vaccine coverage among U.S. adults was 37% in the 2017–2018 season and 45% in the 2018–2019 season [3]. Prior studies have shown that individual demographic characteristics, comorbidities, and socioeconomic status are associated with influenza vaccine coverage. Influenza vaccine coverage is higher among older individuals [4–6], those with chronic medical conditions [4,5], those with higher socioeconomic status (income, education) [5,7], those whose primary language is English [8], and White individuals compared to Non-Hispanic Black or Hispanic/Latino individuals [4,5,7,9].

The disparities in influenza vaccine coverage may contribute to disparities in rates of severe influenza-associated disease. Influenza-related hospitalizations are higher among Non-Hispanic Black and Hispanic individuals compared to White individuals in the U.S. [10]. Higher rates of infections and more severe disease have been associated with lower socioeconomic status [11,12]. A strong commitment to health equity during the COVID-19 pandemic [13] has motivated research to better understand disparities in vaccine coverage. In particular, these studies have shown significant geographic variation in coverage of COVID-19 primary series and booster vaccines between and within states [14,15]. In particular, one study noted large inequities in COVID-19 booster vaccine coverage between low and high income zip codes, even after adjusting for a number of other factors such as age, race and ethnicity distributions [15]. It is likely that these community-level factors may also be linked to differences in annual influenza vaccine coverage.

The CDC social vulnerability index (SVI) is a multi-dimensional measure of community vulnerability calculated nationally at the census-tract level [16]. SVI is composed of 15 U.S. census variables grouped under four themes: Socioeconomic Status, Household Composition and Disability, Minority Status and Language, and Housing and Transportation [16]. The SVI has been used to understand geographic disparities in burden of disease, health care utilization, and disease management. Higher levels of SVI, indicating more vulnerability, have been associated with higher rates of acute and chronic diseases [17–19], poor engagement in care [17], lower rates of preventive care [20,21], and poor chronic disease management [17]. A recent study examined the association between SVI and county-level influenza vaccination rates among Medicare recipients and found that vaccination rates were lower in counties with higher SVI [21]. Our study builds upon this work to understand community- and individual-level characteristics of influenza vaccine coverage by examining influenza vaccine coverage among nearly half a million primary care patient observations in a large academic health system in Los Angeles, CA. We hypothesized that both community and individual socioeconomic status, measured by SVI and health insurance status, respectively, associate with influenza vaccine coverage.

2. Methods

2.1. Study setting and participants

We conducted regression analyses of electronic medical records (EMR) data of primary care patients during the 2017–2018 and 2018–2019 influenza seasons. The study was conducted at a large, urban academic health system that is comprised of four hospitals and over 250 medical practices, and serves over 670,000 unique patients each year [22]. The inclusion criteria were that patients were age 18 or older and were receiving primary care through the health system, defined as having at least one new or follow-up visit at a primary care (Internal Medicine, Internal Medicine & Pediatrics, Family Medicine, or Geriatrics) practice between November 2017 and October 2019. The study was approved by the institutional review board at the University of California, Los Angeles. The need for informed consent was waived.

2.2. Data collection and measures

We extracted weekly vaccination data from the EMR for 247,773 patients that met the inclusion criteria for this analysis. The primary outcome (i.e., dependent variable) of interest was whether patients received their influenza vaccine during the 2017 and 2018 influenza seasons, defined as September 1, 2017 through April 1, 2018, and September 1, 2018 through April 1, 2019, respectively. In addition to data on influenza vaccinations given at any site within the health system including employee vaccination events, the EMR also receives data on outside influenza vaccinations from Surescripts (a pharmacy benefits manager), the California Immunization Registry, and Care Everywhere (the information exchange application for Epic EMR Systems). Finally, clinicians can manually enter vaccination data during clinical encounters and patients and proxies can enter self-reported vaccination data via the patient portal. When a patient receives an influenza vaccine, the influenza vaccine status is recorded in the EMR as “Completed” for the remainder of the season. (For example, if a patient received the vaccine on September 1, 2017, their influenza vaccination status is recorded as

"Completed" until April 1, 2018, changed to "Not Due" between April 2, 2018 and August 31, 2018, and reset to "Due On January 9, 2018" on September 1, 2018.) Each unique patient contributed one or two observations based whether they met the inclusion criteria during each of the two influenza seasons included in this analysis.

The primary community-level factor of interest was the SVI linked to the patients' primary area of residence. We used the 2018 SVI, which is calculated using 15 U S. Census variables grouped under four themes: socioeconomic status (SES) (below poverty, unemployed, per-capita income, without high school diploma), household composition and disability (aged 65 and older, aged 17 and younger, civilian living with a disability, single-parent household), racial and ethnic minority status and language (minority status and low English language proficiency), and housing type and transportation (multi-unit structures, mobile homes, crowding, households without vehicle, group quarters) [23]. Each U.S. census tract is given a score ranging from 0 (low vulnerability) to 1 (high vulnerability) indicating its national percentile rank for overall SVI and each SVI theme. Each patient's census tract was identified by geocoding their address using a geographic information systems tool and merged with SVI data downloaded from the CDC SVI website.

Individual-level factors of interest extracted from the EMR and included in this analysis were health insurance status, race and ethnicity, primary language, and comorbidities, which have been associated with influenza vaccine coverage in the literature [4–9], as well as age and sex. We used health insurance as a proxy for individual SES. Systematically collected SES measures are rarely available in EMRs, but health insurance information in the EMR is accurate [24], correlated with other measures of SES, such as income [25], and is used as a proxy for individual SES in EMR-based studies [26]. Medicaid enrollment was used as an indicator for low individual SES. In 2017, adults at or below 138% of Federal Poverty Level (FPL) and pregnant women at or below 213% FPL were eligible for Medicaid in California (FPL in 2017 was $12,060 for a single person and $24,600 for a family of 4) [27]. For patients under age 65, Medicare eligibility is an indicator of disability, end-stage renal disease, or Amyotrophic Lateral Sclerosis [28]. When patients were covered by multiple health insurance plans during the study period, in order to identify patients who were eligible for Medicaid, coverage was categorized as follows: "Medicaid" if they were covered by Medicaid plans with any other plans, including patients on Supplemental Security Income who are automatically enrolled into Medicaid in California [29]; "Medicare" if they were covered by Medicare plans with any other plans except Medicaid plans; "Commercial" if they were covered by a commercial plan but not Medicaid or Medicare plans; "Other" if patients were not covered by any of those plans and were covered under worker's compensation insurance or self-pay. For example, if a patient was covered by both Medicare and Medicaid at the same time, the patient's insurance status was categorized as "Medicaid." Patient's race and ethnicity were categorized as Hispanic All Races, White Non-Hispanic, Black Non-Hispanic, Asian Non-Hispanic, and Other (of which 82% identified as "other race," 13% identified as "multiple races," 2% identified as "Native Hawaiian or Other Pacific Islander," and 2% identified "American Indian or Alaska Native"). Primary language was dichotomized into English and Not English, because patients who selected non-English languages made up less than 3% of the

Table 1
Demographic characteristics of unique patients (N = 247,773).

	All patients (n = 247,773)		Under 65 (n = 202,066)		65 & Over (n = 45,707)	
Variable	n or mean	% or SD	n or mean	% or SD	n or mean	% or SD
Age	47	17.3	42	12.7	73.8	7.33
18–24	20,880	8.4 %	20,880	10.3 %		
25–34	48,060	19.4 %	48,060	23.8 %		
35–44	47,911	19.3 %	47,911	23.7 %		
45–54	45,379	18.3 %	45,379	22.5 %		
55–64	39,836	16.1 %	39,836	19.7 %		
65–69	16,081	6.5 %			16,081	35.2 %
70–74	12,175	4.9 %			12,175	26.6 %
75–79	7,863	3.2 %			7,863	17.2 %
80–84	4,850	2.0 %			4,850	10.6 %
85+	4,738	1.9 %			4,738	10.4 %
Sex						
Male	109,430	44.2 %	89,583	44.3 %	19,847	43.4 %
Female	138,330	55.8 %	112,470	55.7 %	25,860	56.6 %
CCI	0.94	1.83	0.69	1.50	2.04	2.61
Health Insurance						
Commercial	197,754	79.8 %	189,935	94.0 %	7,819	17.1 %
Medicare	38,429	15.5 %	4408	2.2 %	34,021	74.4 %
Medicaid	8,656	3.5 %	4,916	2.4 %	3,740	8.2 %
Other	2,249	0.9 %	2,189	1.1 %	60	0.1 %
Race/Ethnicity						
White Non-Hispanic	128,039	51.7 %	98,768	48.9 %	29,271	64.0 %
Black Non-Hispanic	11,343	4.6 %	8,841	4.4 %	2,502	5.5 %
Hispanic All Races	26,831	10.8 %	23,088	11.4 %	3,743	8.2 %
Asian Non-Hispanic	24,369	9.8 %	20,221	10.0 %	4,148	9.1 %
Other	26,588	10.7 %	23,070	11.4 %	3,518	7.7 %
Primary Language						
English	240,986	97.3 %	198,461	98.2 %	42,525	93.0 %
Not English	6,591	2.7 %	3,425	1.7 %	3,166	6.9 %
SVI	0.30	0.24	0.30	0.24	0.27	0.23

CCI, Charlson Comorbity Index; SD, Standard Deviation; SVI, Social Vulnerability Index.

study population. We calculated each patient's Charlson Comorbidity Index (CCI), a score determined based on 19 medical conditions that reflects mortality risk [30], using the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10) [31].

2.3. Statistical analysis

We present descriptive statistics including mean, median, and percentage for the covariates described above for the sample overall and stratified by age (under 65, 65 and older) and by vaccination status. We evaluated differences between patients who were vaccinated and patients who were not vaccinated using two-tailed *t*-test and chi-square methods as appropriate. We conducted bivariate analyses to estimate the associations between influenza vaccine receipt and SVI, sociodemographic variables, CCI, and health insurance. We subsequently conducted a complete case analysis estimating the association between a patient's vaccine receipt and overall SVI, adjusting for individual demographic factors, CCI, and health insurance using a mixed-effects logistic regression model to account for up to two observations for each patient for the two influenza seasons. Patients younger than 65 were analyzed separately from patients 65 or older to account for Medicare eligibility. In addition to the overall SVI model, we repeated the analysis with separate logistic regression models for each of the four SVI themes. All analyses were conducted using STATA (version 16; StataCorp LLC).

3. Results

3.1. Characteristics of the study population

We included 247,773 unique, eligible patients in this analysis (Table 1). The mean age was 47 (standard deviation [SD] 17.3), 56% were female, and those who identified as White, Non-Hispanic comprised the single largest racial and ethnic group (52%). The majority of patients (80%) were covered by commercial plans and only 4% were covered by Medicaid, of which half (53%) were covered by both Medicaid and Medicare. The mean SVI score was 0.30 (SD 0.24).

Table 2
Demographic characteristics for observations (N = 493,325) by influenza vaccination status.

Vaccination status	Vaccinated (n = 140,789)		Not vaccinated (n = 352,536)		p-value for *t*-test or Chi-squared test
Variable	n or mean	% or SD	N or mean	% or SD	
Year					
2017–2018	57,551	23.4 %	188,001	76.6 %	<0.001
2018–2019	83,238	33.6 %	164,535	66.4 %	
Age (years)					
Mean (SD)	53.4	17.8	44.5	16.3	<0.001
18–24	6,305	14.5 %	37,310	85.5 %	
25–34	18,895	19.5 %	78,181	80.5 %	
35–44	23,473	24.7 %	71,658	75.3 %	
45–54	22,832	25.1 %	68,083	74.9 %	
55–64	25,906	32.9 %	52,838	67.1 %	
65–69	13,961	44.5 %	17,415	55.5 %	
70–74	11,867	50.4 %	11,673	49.6 %	
75–79	7,882	52.8 %	7,052	47.2 %	
80–84	4,923	53.5 %	4,286	46.5 %	
85+	4,745	54.0 %	4,040	46.0 %	
Sex					
Male	60,733	27.9 %	157,104	72.1 %	<0.001
Female	80,056	29.1 %	195,407	70.9 %	
CCI	1.49	2.27	0.72	1.58	<0.001
Insurance					
Commercial	98,281	25.0 %	295,097	75.0 %	<0.001
Medicare	36,072	46.9 %	40,784	53.1 %	
Medicaid	5,792	33.5 %	11,476	66.5 %	
Other	573	12.8 %	3,888	87.2 %	
Race/Ethnicity					
White Non-Hispanic	81,040	31.8 %	174,030	68.2 %	<0.001
Black Non-Hispanic	5,865	25.9 %	16,743	74.1 %	
Hispanic All Races	14,996	28.1 %	38,404	71.9 %	
Asian Non-Hispanic	17,887	36.8 %	30,717	63.2 %	
Other	12,061	22.8 %	40,798	77.2 %	
Primary Language					
English	136,111	28.4 %	343,664	71.6 %	<0.001
Not English	4,655	35.4 %	8,508	64.6 %	
SVI	0.28	0.23	0.30	0.24	<0.001

CCI, Charlson Comorbidity Index; SD, Standard Deviation; SVI, Social Vulnerability Index.

3.2. Characteristics of the study population by vaccination status

The 247,773 patients contributed 493,325 observations across the two influenza seasons (Table 2). Vaccination coverage was higher during the 2018–2019 influenza season (34%) compared to the 2017–2018 season (23%) ($p < 0.001$) and increased by age with the lowest levels of vaccination among the youngest age group (15% among those 18–24 years of age). Patients identifying as Asian Non-Hispanic had the highest vaccination coverage (37%), followed by White Non-Hispanic patients (32%), Hispanic patients (28%), and Black Non-Hispanic patients (26%). Patients who were vaccinated had a lower mean overall SVI score (0.28) compared to patients who were not vaccinated (0.30) ($p < 0.001$).

3.3. Factors associated with influenza vaccination

Individual socioeconomic status and race were independently associated with influenza vaccination status (Tables 3 and 4). For patients under 65 years (Table 3), patients on Medicaid had lower odds (adjusted Odds Ratio [aOR] = 0.77, 95 % CI 0.68, 0.88) of receiving the vaccine compared to patients on commercial health insurance. Asian Non-Hispanic patients had higher odds (2.39, 95% CI 2.24, 2.55) of receiving the vaccine compared to White Non-Hispanic patients, while Black Non-Hispanic patients had lower odds (aOR = 0.49, 95% CI 0.45, 0.54). For patients 65 years of age and older, patients on Medicaid (aOR = 0.30, 0.25, 0.35) had lower odds of receiving the influenza vaccine compared to patients on commercial health insurance. Asian Non-Hispanic patients had higher odds (aOR = 1.91, 95% CI 1.67, 2.17) of receiving the influenza vaccine compared to White Non-Hispanic patients, while Black Non-Hispanic patients had lower odds (aOR = 0.59, 95% CI 0.50, 0.69).

Neighborhood disadvantage as measured by SVI was independently associated with influenza vaccination status (Tables 3 and 4). This association held even after adjusting for other individual level factors such as age, race and ethnicity, sex, and insurance status. For instance, among patients less than 65 years of age (Table 3), an increase in SVI from 0 to 1 (i.e., least disadvantaged to the most disadvantaged neighborhood) was associated with a 46% reduction in the odds of having received the influenza vaccine (aOR = 0.54, 95% CI 0.50, 0.59). This association remained significant in the analysis of patients 65 years of age or older, who had a 34% reduced odds of influenza vaccination for an increase in SVI from 0 to 1 (aOR = 0.66, 95% CI 0.55, 0.78). Analyses examining the correlation between influenza vaccine receipt and the four themes of SVI (SES, household composition and language, racial and ethnic minority status and language, and housing and transportation) showed that higher scores on each theme (indicating higher vulnerability) were correlated with lower likelihood of influenza vaccine receipt (see Appendix Tables 1 and 2).

Table 3
Correlates of influenza vaccine receipt for patients under 65 years old.

Variables	Bivariate		Multivariable	
	OR	CI	aOR	CI
Year				
2017–2018	1.0	Reference	1.0	Reference
2018–2019	4.05	(3.94, 4.15)***	3.64	(3.54, 3.74)***
Age				
18–24	1.0	Reference	1.0	Reference
25–34	1.98	(1.85, 2.11)***	1.90	(1.76, 2.05)***
35–44	3.58	(3.36, 3.82)***	3.22	(2.98, 3.48)***
45–54	3.92	(3.68, 4.19)***	3.24	(2.99, 3.50)***
55–64	8.36	(7.81, 8.94)***	6.06	(5.59, 6.58)***
Sex				
Male	1.0	Reference	1.0	Reference
Female	1.19	(1.15, 1.23)***	1.13	(1.09, 1.18)***
CCI	1.47	(1.45, 1.48)***	1.43	(1.42, 1.45)***
Insurance[a]				
Commercial	1.0	Reference	1.0	Reference
Medicare	3.01	(2.73, 3.32)***	1.55	(1.38, 1.75)***
Medicaid	1.17	(1.05, 1.31)**	0.77	(0.68, 0.88)***
Other	0.23	(0.19, 0.28)***	0.23	(0.18, 0.30)***
Primary Language				
English	1.0	Reference	1.0	Reference
Not English	0.96	(0.84, 1.09)	0.65	(0.55, 0.76)***
Race				
White Non-Hispanic	1.0	Reference	1.0	Reference
Black Non-Hispanic	0.53	(0.49, 0.58)***	0.49	(0.45, 0.54)***
Hispanic All Races	0.83	(0.79, 0.88)***	0.99	(0.93, 1.05)
Asian Non-Hispanic	1.86	(1.76, 1.97)***	2.39	(2.24, 2.55)***
Other	0.54	(0.51, 0.57)***	0.61	(0.57, 0.65)***
SVI	0.50	(0.46, 0.54)***	0.54	(0.50, 0.59)***

aOR, Adjusted Odds Ratio; CCI, Charlson Comorbity Index; OR, Odds Ratio; SVI, Social Vulnerability Index.
* = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$.
[a] Medicaid enrollment was used as an indicator for low individual socioeconomic status.

Table 4
Correlates of influenza vaccine receipt for patients 65 years and older.

Variables	Bivariate		Multivariable	
	OR	CI	aOR	CI
Year				
2017–2018	1.0	Reference	1.0	Reference
2018–2019	1.93	(1.85, 2.01)***	1.88	(1.80, 1.97)***
Age				
65–69	1.0	Reference	1.0	Reference
70–74	1.68	(1.55, 1.82)***	1.52	(1.40, 1.66)***
75–79	2.16	(1.97, 2.38)***	1.82	(1.64, 2.01)***
80–84	2.38	(2.13, 2.66)***	1.82	(1.61, 2.05)***
85+	2.42	(2.15, 2.72)***	1.63	(1.44, 1.86)***
Sex				
Male	1.0	Reference	1.0	Reference
Female	0.86	(0.80, 0.92)***	0.87	(0.81, 0.93)***
CCI	1.31	(1.29, 1.33)***	1.31	(1.29, 1.33)***
Insurance[a]				
Commercial	1.0	Reference	1.0	Reference
Medicare	0.65	(0.60, 0.72)***	0.62	(0.56, 0.69)***
Medicaid	0.44	(0.38, 0.51)***	0.30	(0.25, 0.35)***
Other	0.10	(0.04, 0.26)***	0.13	(0.04, 0.43)**
Race/Ethnicity				
White Non-Hispanic	1.0	Reference	1.0	Reference
Black Non-Hispanic	0.61	(0.53, 0.71)***	0.59	(0.50, 0.69)***
Hispanic All Races	1.01	(0.89, 1.14)	1.07	(0.93, 1.24)
Asian Non-Hispanic	1.84	(1.63, 2.07)***	1.91	(1.67, 2.17)***
Other	0.33	(0.29, 0.38)***	0.39	(0.34, 0.44)***
Primary Language				
English	1.0	Reference	1.0	Reference
Not English	0.90	(0.79, 1.03)	0.83	(0.70, 0.98)*
SVI	0.64	(0.55, 0.75)***	0.66	(0.55, 0.78)***

aOR, Adjusted Odds Ratio; CCI, Charlson Comorbity Index; OR, Odds Ratio; SVI, Social Vulnerability Index.
* = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$.
[a] Medicaid enrollment was used as an indicator for low individual socioeconomic status.

4. Discussion

In our study among primary care patients at a large academic health system, we found that influenza vaccine coverage was 23% in the 2017–2018 season and 34% in the 2018–2019 season, which was lower than the national average of 37% and 45% [32], respectively, and was associated with both individual and community-level SES, and individual and community-level race and ethnicity and language, adjusting for age, sex, and comorbidities.

The mean SVI score of patients was 0.30 (SD 0.24) compared to the Los Angeles County average SVI of 0.77 in 2018 [33], suggesting that the patients lived in less disadvantaged neighborhoods within the Los Angeles County catchment area for the health system. Even among this population with insurance coverage and primary care access, low influenza vaccine coverage was correlated with both individual and community markers of SES. Living in a census tract with higher overall SVI as well as higher SES vulnerability (below poverty, unemployed, per-capita income, without high school diploma) was associated with lower influenza vaccine coverage, consistent with a prior study examining county-level influenza vaccine coverage and SVI among Medicare beneficiaries [21]. We built upon their findings by accounting for individual-level characteristics, and found that being a Medicaid beneficiary, a marker of individual poverty, was also correlated with lower influenza vaccine coverage. In addition, consistent with prior studies, we found that both individual race and ethnicity and living in a community with higher proportions of racial and ethnic minorities correlated with receipt of influenza vaccine. For both patients 64 years and younger and 65 years and older, Black Non-Hispanic patients were less likely to have received the influenza vaccine compared to White Non-Hispanic patients, and patients who lived in census tracts with higher proportion of racial and ethnic minorities and those with low English language proficiency were less likely to have received the influenza vaccine.

Socioeconomic status and race are interrelated factors [34] that contribute to both access to and attitudes towards the influenza vaccine. People with low socioeconomic status are likely to experience barriers to access to health care and be dissatisfied with their care [35]. Race is a social construct that reflects exposure to historical and current structural, interpersonal, and internalized discrimination, within and outside of healthcare systems [36]. These experiences of racism often lead to medical mistrust and decreased engagement in health care [36]. Studies examining racial differences in influenza coverage reveal differences in access to and attitudes toward the influenza vaccine. A nationally representative survey revealed that, compared to White participants, African American participants reported perceived higher risk of and lower trust in the influenza vaccine and higher barriers to vaccination and these factors were associated with perceptions of racial fairness [37]. Our study examined vaccination coverage prior to the COVID-19 pandemic, but a recent study on COVID-19 vaccine accessibility showed that, in communities with higher percentages of Non-Hispanic

Black residents, healthcare facilities were less likely to administer COVID-19 vaccines vaccines [38]. These findings call for health systems to engage with community partners. Community engagement is critical in mobilizing public health interventions to achieve health equity [39–43]. Community leaders and organizations have been part of designing and planning successful public health interventions, building trust, and communicating with the public [42], and delivering culturally-tailored vaccine promotion campaigns [39]. Health systems should collaborate with community partners to develop more effective communication about influenza vaccine to improve attitudes towards the vaccine, as well as examine and address experiences of racism that may underlie these attitudes. In addition, health systems may examine vaccine availability and invest in interventions, such as mobile vaccine clinics and community vaccination programs hosted by trusted community organizations, to increase accessibility in areas with high levels of neighborhood disadvantage.

This study is subject to several limitations. This study uses EMR data, which can be limited in the completeness and correctness of data recorded [44]. For example, while data on influenza vaccines given outside of the health system is obtained from multiple sources, including the California Immunization Registry and manual entry by clinicians during clinical encounters and by patients through the patient portal, some vaccines may not be recorded, resulting in lower vaccination rates overall. The influenza vaccine data collected through the patient portal does not require patients to submit evidence of vaccination. We did not have data on where the vaccination data was obtained (e.g. California Immunization Registry vs within the health system). Family characteristics and influences are important drivers of vaccine coverage [45,46], but our data did not allow for us to identify family ties between patients. In addition, we did not have information on whether patients were ineligible for influenza vaccination based on a history of severe allergic reaction to a prior influenza vaccine or its ingredients. Despite limitations, the EMR is an important resource for population health research that allows for accessing rich longitudinal data on large populations that can be linked to contextual data such as SVI [47]. Our study was conducted among primary care patients from a single, urban academic health system in Los Angeles County, and does not reflect the general population in Los Angeles County [48,49]. Therefore, our results may not be generalizable to Los Angeles County and to other populations. Our study does not examine influenza vaccine coverage during the COVID-19 pandemic; other scholars have already examined this important question [50–52]. While this was a unique time that presented unprecedented risks and opportunities for healthcare systems, we focused on the association between individual and community socioeconomic status prior to the COVID-19 pandemic so that our findings would be applicable for designing interventions after the pandemic. Finally, there are inherent challenges in modeling both community- and individual-level characteristics, because community-level measures like SVI are often an aggregate measure derived from individual-level measures [53]. However, individual and community-level characteristics are distinct constructs with independent effects on health [54], and individual and community-level characteristics are not always highly correlated [55]. Community-level attributes are reflections of a community's physical (e.g access to healthcare, quality housing, and healthy foods) and social (e.g. social connectedness, social norms) resources [53, 56, 57]. The studies on community characteristics on health ("neighborhood effects") have highlighted the potential of community interventions in reducing health disparities. Traditionally, these included policies that invest in the quality of housing, public transportation, and reduce residential segregation. However, as health systems increasingly move toward addressing social needs of their patients, there are opportunities to improve the health of their patients through partnering with communities. This study, which combines EMR data with SVI, illuminates one way that health systems can identify communities at risk of adverse health outcomes and evaluate the impact of community-level interventions.

5. Conclusion

In our study of primary care patients in a large, urban academic health system, influenza vaccination coverage was lower among patients with higher neighborhood SVI, lower individual socioeconomic status and racial and ethnic minority status. Our study combines EMR data with SVI and illuminates one way that health systems can identify communities at risk and develop targeted community-level interventions to address components of SVI, including socioeconomic status, racial disparities, language barriers, and housing security. To reduce disparities in influenza mortality and morbidity, health systems should engage with community partners to address disparities in access to and attitudes toward the influenza vaccine particularly among those who live in areas with high SVI.

CRediT authorship contribution statement

Sae Takada: Writing – original draft, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Un Young Chung:** Writing – review & editing, Software, Data curation. **Philippe Bourgois:** Writing – review & editing, Supervision. **O. Kenrik Duru:** Writing – review & editing, Supervision, Resources. **Lillian Gelberg:** Writing – review & editing, Supervision, Resources. **Maria Han:** Writing – review & editing, Supervision, Resources. **Michael A. Pfeffer:** Writing – review & editing, Supervision, Resources. **Steve Shoptaw:** Writing – review & editing, Resources. **Kenneth Wells:** Writing – review & editing, Supervision. **Marjan Javanbakht:** Writing – review & editing, Supervision, Methodology, Formal analysis.

Data availability statement

The data associated with this study has not been deposited into a publicly available repository. The data that has been used is derived from electronic medical records and are confidential.

Ethics

The study was approved by the institutional review board at the University of California, Los Angeles (IRB#20–000802). The need for informed consent was waived by the ethics committee.

Financial disclosure

Steve Shoptaw received clinical supplies from Moderna Inc. for his research project on COVID-19. All other authors have no financial disclosures.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:Steve Shoptaw reports equipment, drugs, or supplies was provided by Moderna Inc. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Sae Takada acknowledges K12 career development support from the Agency for Healthcare Research and Quality (AHRQ) and the Patient-Centered Outcomes Research Institute (PCORI) under grant number K12HS26407-01. Steve Shoptaw acknowledges salary support from the administrative core Center for HIV Identification, Prevention and Treatment Services under grant number P30 MH058107. This work was supported by the NIH/National Center for Advancing Translational Science UCLA CTSI grant number UL1TR001881.

Appendix Table 1. Correlation between SVI themes and influenza vaccine receipt for patients under 65

Variable	Socioeconomic Status		Household Composition		Minority Status and language		Housing and Transportation	
	aOR	CI	aOR	CI	aOR	CI	aOR	CI
Year								
2017–2018	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
2018–2019	3.64	(3.54, 3.74) ***	3.64	(3.54, 3.74) ***	3.64	(3.54, 3.74) ***	3.64	(3.54, 3.74) ***
Age								
18–24	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
25–34	1.91	(1.77, 2.07) ***	1.86	(1.72, 2.00) ***	1.90	(1.76, 2.05) ***	1.90	(1.75, 2.04) ***
35–44	3.22	(2.98, 3.48) ***	3.22	(2.98, 3.48) ***	3.23	(2.99, 3.49) ***	3.22	(2.98, 3.48) ***
45–54	3.21	(2.97, 3.48) ***	3.30	(3.05, 3.57) ***	3.25	(3.00, 3.51) ***	3.25	(3.01, 3.52) ***
55–64	6.00	(5.52, 6.51) ***	6.21	(5.72, 6.74) ***	6.07	(5.59, 6.58) ***	6.10	(5.62, 6.62) ***
Sex								
Male	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Female	1.13	(1.09, 1.18) ***	1.14	(1.09, 1.19) ***	1.13	(1.09, 1.18) ***	1.14	(1.09, 1.18) ***
CCI	1.44	(1.42, 1.46) ***	1.43	(1.41, 1.45) ***	1.43	(1.42, 1.45) ***	1.43	(1.41, 1.45) ***
Insurance								
Commercial	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Medicare	1.56	(1.38, 1.75) ***	1.55	(1.38, 1.74) ***	1.55	(1.37, 1.74) ***	1.55	(1.38, 1.74) ***
Medicaid	0.78	(0.69, 0.89) ***	0.73	(0.64, 0.83) ***	0.76	(0.66, 0.86) ***	0.73	(0.64, 0.83) ***
Other	0.23	(0.19, 0.30) ***	0.23	(0.18, 0.29) ***	0.23	(0.18, 0.30) ***	0.23	(0.18, 0.29) ***
Race/Ethnicity								
White Non-Hispanic	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Black Non-Hispanic	0.51	(0.46, 0.56) ***	0.45	(0.41, 0.50) ***	0.49	(0.44, 0.54) ***	0.45	(0.41, 0.50) ***
Hispanic All Races	1.01	(0.95, 1.08)	0.91	(0.85, 0.97) **	0.98	(0.92, 1.04)	0.92	(0.86, 0.98) **
Asian Non-Hispanic	2.37	(2.23, 2.53) ***	2.34	(2.19, 2.49) ***	2.44	(2.28, 2.60) ***	2.36	(2.21, 2.51) ***
Other	0.61	(0.57, 0.65) ***	0.60	(0.56, 0.64) ***	0.61	(0.57, 0.65) ***	0.60	(0.56, 0.64) ***
Primary Language								
English	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Not English	0.66	(0.56, 0.77) ***	0.61	(0.52, 0.72) ***	0.65	(0.55, 0.75) ***	0.62	(0.53, 0.73) ***
SVI Theme								
Socioeconomic Status	0.45	(0.41, 0.49) ***						
Household Composition			0.83	(0.76, 0.90) ***				
Minority Status and Language					0.61	(0.56, 0.67) ***		
Housing and Transportation							0.76	(0.71, 0.82) ***

aOR, Adjusted Odds Ratio; CCI, Charlson Comorbity Index; OR, Odds Ratio; SVI, Social Vulnerability Index.

Appendix Table 2. Correlation between SVI themes and influenza vaccine receipt for patients 65 and older

	Socioeconomic Status		Household Composition		Minority Status and language		Housing and Transportation	
Variable	aOR	CI	aOR	CI	aOR	CI	aOR	CI
Year								
2017–2018	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
2018–2019	1.88	(1.80, 1.97) ***	1.88	(1.8, 1.97) ***	1.88	(1.80, 1.97) ***	1.88	(1.80, 1.97) ***
Age								
65–69	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
70–74	1.52	(1.40, 1.65) ***	1.53	(1.40, 1.66) ***	1.52	(1.40, 1.66) ***	1.53	(1.40, 1.66) ***
75–79	1.81	(1.64, 2.00) ***	1.83	(1.66, 2.03) ***	1.82	(1.64, 2.01) ***	1.83	(1.65, 2.02) ***
80–84	1.81	(1.61, 2.05) ***	1.84	(1.63, 2.08) ***	1.82	(1.61, 2.05) ***	1.84	(1.63, 2.07) ***
85+	1.62	(1.43, 1.84) ***	1.66	(1.46, 1.88) ***	1.63	(1.43, 1.85) ***	1.65	(1.45, 1.87) ***
Sex								
Male	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Female	0.87	(0.81, 0.93) ***	0.87	(0.81, 0.93) ***	0.87	(0.81, 0.93) ***	0.87	(0.81, 0.94) ***
CCI	1.31	(1.29, 1.33) ***	1.31	(1.29, 1.33) ***	1.31	(1.29, 1.33) ***	1.31	(1.29, 1.33) ***
Insurance								
Commercial	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Medicare	0.62	(0.56, 0.69) ***	0.63	(0.57, 0.70) ***	0.62	(0.56, 0.69) ***	0.62	(0.56, 0.69) ***
Medicaid	0.30	(0.25, 0.35) ***	0.29	(0.25, 0.34) ***	0.30	(0.25, 0.35) ***	0.29	(0.25, 0.34) ***
Other	0.13	(0.04, 0.43) ***	0.13	(0.04, 0.43) ***	0.13	(0.04, 0.43) ***	0.13	(0.04, 0.43) ***
Race/Ethnicity								
White Non-Hispanic	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Black Non-Hispanic	0.59	(0.50, 0.69) ***	0.56	(0.47, 0.66) ***	0.59	(0.49, 0.69) ***	0.54	(0.46, 0.64) ***
Hispanic All Racnes	1.07	(0.93, 1.24)	1.03	(0.89, 1.18)	1.07	(0.93, 1.24)	1.02	(0.89, 1.18)
Asian Non-Hispanic	1.89	(1.66, 2.15) ***	1.87	(1.64, 2.12) ***	1.94	(1.71, 2.21) ***	1.87	(1.65, 2.13) ***
Other	0.39	(0.34, 0.44) ***	0.38	(0.33, 0.44) ***	0.39	(0.34, 0.45) ***	0.38	(0.33, 0.44) ***
Primary Language								
English	1.0	Reference	1.0	Reference	1.0	Reference	1.0	Reference
Not English	0.83	(0.70, 0.98)*	0.81	(0.69, 0.96)*	0.83	(0.70, 0.98)*	0.82	(0.69, 0.96)*
SVI Theme								
Socioeconomic Status	0.66	(0.55, 0.80) ***						
Household Composition			0.73	(0.63, 0.85) ***				
Minority Status and Language					0.71	(0.60, 0.85) ***		
Housing and Transportation							0.87	(0.76, 1.00)

aOR, Adjusted Odds Ratio; CCI, Charlson Comorbity Index; OR, Odds Ratio; SVI, Social Vulnerability Index.

References

[1] U.S. Centers for Disease Control and Prevention. Disease Burden of Flu. Accessed March 16, 2023, https://www.cdc.gov/flu/about/burden/index.html.

[2] L.A. Grohskopf, L.H. Blanton, J.M. Ferdinands, et al., Prevention and control of seasonal influenza with vaccines: recommendations of the advisory committee on immunization practices - United States, 2022-23, Influenza Season. MMWR Recomm Rep 71 (1) (2022) 1–28, https://doi.org/10.15585/mmwr.rr7101a1. Aug 26.

[3] U.S. Centers for Disease Control and Prevention. FluVaxView. https://www.cdc.gov/fluvaxview/interactive/general-population-coverage.html. (Accessed 24 September 2024).

[4] P.J. Lu, M.C. Hung, A. Srivastav, et al., Surveillance of vaccination coverage among adult populations -United States, 2018, MMWR Surveill Summ 70 (3) (May 14 2021) 1–26, https://doi.org/10.15585/mmwr.ss7003a1.

[5] J. Maurer, K.M. Harris, L. Uscher-Pines, Can routine offering of influenza vaccination in office-based settings reduce racial and ethnic disparities in adult influenza vaccination? J. Gen. Intern. Med. 29 (12) (2014) 1624–1630, https://doi.org/10.1007/s11606-014-2965-z, 2014/12/01.

[6] P. Schmid, D. Rauber, C. Betsch, G. Lidolt, M.-L. Denker, Barriers of influenza vaccination intention and behavior – a systematic review of influenza vaccine hesitancy, 2005 – 2016, PLoS One 12 (1) (2017) e0170550, https://doi.org/10.1371/journal.pone.0170550.

[7] K.G. Wooten, P.M. Wortley, J.A. Singleton, G.L. Euler, Perceptions matter: beliefs about influenza vaccine and vaccination behavior among elderly white, black and Hispanic Americans, Vaccine 30 (48) (2012) 6927–6934, https://doi.org/10.1016/j.vaccine.2012.08.036, 2012/11/06/.

[8] W.S. Pearson, G. Zhao, E.S. Ford, An analysis of language as a barrier to receiving influenza vaccinations among an elderly hispanic population in the United States, Adv Prev Med 2011 (2011) 298787, https://doi.org/10.4061/2011/298787.

[9] S.M. Mahmud, L. Xu, L.L. Hall, et al., Effect of race and ethnicity on influenza vaccine uptake among older US Medicare beneficiaries: a record-linkage cohort study, The Lancet Healthy Longevity 2 (3) (2021) e143–e153, https://doi.org/10.1016/S2666-7568(20)30074-X, 2021/03/01/.

[10] A.C. O'Halloran, R. Holstein, C. Cummings, et al., Rates of influenza-associated hospitalization, intensive care unit admission, and in-hospital death by race and ethnicity in the United States from 2009 to 2019, JAMA Netw. Open 4 (8) (2021) e2121880, https://doi.org/10.1001/jamanetworkopen.2021.21880.

[11] J.L. Hadler, K. Yousey-Hindes, A. Pérez, et al., Influenza-related hospitalizations and poverty levels - United States, 2010-2012, MMWR Morb. Mortal. Wkly. Rep. 65 (5) (Feb 12 2016) 101–105, https://doi.org/10.15585/mmwr.mm6505a1.

[12] S.E. Mamelund, C. Shelley-Egan, O. Rogeberg, The association between socioeconomic status and pandemic influenza: systematic review and meta-analysis, PLoS One 16 (9) (2021) e0244346, https://doi.org/10.1371/journal.pone.0244346.

[13] J.T. Moore, C. Luna-Pinto, H. Cox, et al., Promoting health equity during the COVID-19 pandemic, United States. Bull world health organ 100 (2) (2022) 171–173, https://doi.org/10.2471/blt.21.286074.

[14] I.T. Agaku, C. Adeoye, T.G. Long, Geographic, occupational, and sociodemographic variations in uptake of COVID-19 booster doses among fully vaccinated US adults, december 1, 2021, to January 10, 2022, JAMA Netw. Open 5 (8) (2022) e2227680, https://doi.org/10.1001/jamanetworkopen.2022.27680.

[15] J. Bor, S.A. Assoumou, K. Lane, et al., Inequities in COVID-19 vaccine and booster coverage across Massachusetts ZIP codes after the emergence of Omicron: a population-based cross-sectional study, PLoS Med. 20 (1) (2023) e1004167, https://doi.org/10.1371/journal.pmed.1004167.

[16] B.E. Flanagan, E.J. Hallisey, E. Adams, A. Lavery, Measuring community vulnerability to natural and anthropogenic hazards: the centers for disease control and prevention's social vulnerability index, J. Environ. Health 80 (10) (Jun 2018) 34–36.
[17] F. Elenwa, Z. Gant, X. Hu, A.S. Johnson, A census tract-level examination of HIV care outcomes and social vulnerability among black/african American, hispanic/latino, and white adults in the southern United States, 2018, J. Community Health (Feb 24 2023) 1–18, https://doi.org/10.1007/s10900-023-01191-y.
[18] S. Dasgupta, V.B. Bowen, A. Leidner, et al., Association between social vulnerability and a county's risk for becoming a COVID-19 hotspot — United States, June 1–July 25, 2020, Journal Article. MMWR Morb Mortal Wkly Rep 69 (42) (2020) 1535–1541, 69(42).
[19] L.K. Zottarelli, H.O. Sharif, X. Xu, T.S. Sunil, Effects of social vulnerability and heat index on emergency medical service incidents in San Antonio, Texas, in 2018, J. Epidemiol. Community Health 75 (3) (Mar 2021) 271–276, https://doi.org/10.1136/jech-2019-213256.
[20] C. Bauer, K. Zhang, Q. Xiao, J. Lu, Y.-R. Hong, R. Suk, County-level social vulnerability and breast, cervical, and colorectal cancer screening rates in the US, 2018, JAMA Netw. Open 5 (9) (2022) e2233429, https://doi.org/10.1001/jamanetworkopen.2022.33429.
[21] K.W. Strully, T.-C. Yang, County social vulnerability and influenza vaccine rates: national and local estimates for Medicare recipients, Am. J. Prev. Med. 62 (1) (2022) e1–e9, https://doi.org/10.1016/j.amepre.2021.06.015, 2022/01/01/.
[22] UCLA Health, About UCLA health. https://www.uclahealth.org/why-choose-us/about. (Accessed 5 July 2022).
[23] Agency for Toxic Substances and Disease Registry USCfDCaP, CDC SVI documentation 2018. https://www.atsdr.cdc.gov/placeandhealth/svi/documentation/SVI_documentation_2018.html. (Accessed 17 March 2023).
[24] J. Heintzman, M. Marino, M. Hoopes, et al., Supporting health insurance expansion: do electronic health records have valid insurance verification and enrollment data? J. Am. Med. Inf. Assoc. 22 (4) (Jul 2015) 909–913, https://doi.org/10.1093/jamia/ocv033.
[25] J.A. Casey, J. Pollak, M.M. Glymour, E.R. Mayeda, A.G. Hirsch, B.S. Schwartz, Measures of SES for electronic health record-based research, Am. J. Prev. Med. 54 (3) (Mar 2018) 430–439, https://doi.org/10.1016/j.amepre.2017.10.004.
[26] S.G. Rasmussen, E.L. Ogburn, M. McCormack, et al., Association between unconventional natural gas development in the marcellus shale and asthma exacerbations, JAMA Intern. Med. 176 (9) (2016) 1334–1343, https://doi.org/10.1001/jamainternmed.2016.2436.
[27] California Health Care Foundation, Medi-Cal Facts and Figures, 2017. https://www.chcf.org/wp-content/uploads/2013/05/MediCalFactsFigures2017.pdf. (Accessed 15 March 2023).
[28] U.S. Department of Health and Human Services, Who's eligible for Medicare. https://www.hhs.gov/answers/medicare-and-medicaid/who-is-eligible-for-medicare/index.html. (Accessed 23 March 2023).
[29] Supplemental Security Income (SSI) in California, 2024. https://www.ssa.gov/pubs/EN-05-11125.pdf. (Accessed 14 March 2024).
[30] M.E. Charlson, P. Pompei, K.L. Ales, C.R. MacKenzie, A new method of classifying prognostic comorbidity in longitudinal studies: development and validation, J. Chron. Dis. 40 (5) (1987) 373–383, https://doi.org/10.1016/0021-9681(87)90171-8.
[31] W.P. Glasheen, T. Cordier, R. Gumpina, G. Haugh, J. Davis, A. Renda, Charlson comorbidity index: ICD-9 update and ICD-10 translation, Am Health Drug Benefits 12 (4) (Jun-Jul 2019) 188–197.
[32] Centers for Disease Control and Prevention National Center for Immunization and Respiratory Diseases, FluVaxView, influenza Vaccination coverage. https://www.cdc.gov/flu/fluvaxview/interactive-general-population.htm. (Accessed 22 August 2023).
[33] Agency for Toxic Substances and Disease Registry USCfDCaP, Overall SVI nationwide comparison. https://www.atsdr.cdc.gov/placeandhealth/svi/interactive_map.html. (Accessed 24 September 2024).
[34] D.R. Williams, N. Priest, N.B. Anderson, Understanding associations among race, socioeconomic status, and health: patterns and prospects, Health Psychol. 35 (4) (Apr 2016) 407–411, https://doi.org/10.1037/hea0000242.
[35] G. Becker, E. Newsom, Socioeconomic status and dissatisfaction with health care among chronically ill African Americans, Am. J. Publ. Health 93 (5) (May 2003) 742–748, https://doi.org/10.2105/ajph.93.5.742.
[36] L.M. Bogart, S. Takada, W.E. Cunningham, Medical mistrust, discrimination, and the domestic HIV epidemic, in: B.O. Ojikutu, V.E. Stone (Eds.), HIV in US Communities of Color, Springer International Publishing, 2021, pp. 207–231.
[37] S.C. Quinn, A. Jamison, V.S. Freimuth, J. An, G.R. Hancock, D. Musa, Exploring racial influences on flu vaccine attitudes and behavior: results of a national survey of White and African American adults, Vaccine 35 (8) (2017) 1167–1174, https://doi.org/10.1016/j.vaccine.2016.12.046, 2017/02/22/.
[38] I. Hernandez, S. Dickson, S. Tang, N. Gabriel, L.A. Berenbrok, J. Guo, Disparities in distribution of COVID-19 vaccines across US counties: a geographic information system–based cross-sectional study, PLoS Med. 19 (7) (2022) e1004069, https://doi.org/10.1371/journal.pmed.1004069.
[39] J. Garcia, N. Vargas, C. de la Torre, Magana alvarez M, clark JL. Engaging latino families about COVID-19 vaccines: a qualitative study conducted in Oregon, USA, Health Educ. Behav. 48 (6) (2021) 747–757, https://doi.org/10.1177/10901981211045937.
[40] J.J. Joseph, A. Glover, J.N. Olayiwola, et al., Mask up: academic-community-government partnerships to advance public health during COVID-19, Popul. Health Manag. 24 (4) (2021) 430–432, https://doi.org/10.1089/pop.2020.0305, 2021/08/01.
[41] K.B. Wells, L. Jones, B. Chung, et al., Community-partnered cluster-randomized comparative effectiveness trial of community engagement and planning or resources for Services to address depression disparities, J. Gen. Intern. Med. 28 (10) (2013) 1268–1278, https://doi.org/10.1007/s11606-013-2484-3, 2013/10/01.
[42] G. Brynne, N. Rawlance, T. Adalbert, et al., Community engagement for COVID-19 prevention and control: a rapid evidence synthesis, BMJ Glob. Health 5 (10) (2020) e003188, https://doi.org/10.1136/bmjgh-2020-003188.
[43] B.D. Smedley, S.L. Syme, Promoting health: intervention strategies from social and behavioral research, Am. J. Health Promot. 15 (3) (Jan-Feb 2001) 149–166, https://doi.org/10.4278/0890-1171-15.3.149.
[44] R.A. Verheij, V. Curcin, B.C. Delaney, M.M. McGilchrist, Possible sources of bias in primary care electronic health record data use and reuse, J. Med. Internet Res. 20 (5) (2018) e185, https://doi.org/10.2196/jmir.9134. May 29.
[45] E. Bonsang, E. Pronkina, Family size and vaccination among older individuals: the case of COVID-19 vaccine, Econ. Hum. Biol. 50 (Aug 2023) 101256, https://doi.org/10.1016/j.ehb.2023.101256.
[46] S. Mudenda, J.C. Meyer, J.O. Fadare, et al., COVID-19 vaccine uptake and associated factors among adolescents and youths: findings and implications for future vaccination programmes, PLOS Global Public Health 3 (9) (2023) e0002385, https://doi.org/10.1371/journal.pgph.0002385.
[47] J.A. Casey, B.S. Schwartz, W.F. Stewart, N.E. Adler, Using electronic health records for population health research: a review of methods and applications, Annu. Rev. Publ. Health 37 (1) (2016) 61–81, https://doi.org/10.1146/annurev-publhealth-032315-021353, 2016/03/18.
[48] S.A.B. Charles, S. H., Wolstein, J. W, The state of health insurance in California: findings from the 2019 and 2020 California health interview survey. https://healthpolicy.ucla.edu/sites/default/files/2023-06/stateofhealthinsuranceincalifornia-report-ada-compliant-jan2022.pdf, 2022. (Accessed 12 March 2024).
[49] United States Census Bureau, Quick facts Los Angeles county, California. https://www.census.gov/quickfacts/fact/table/losangelescountycalifornia,losangelescitycalifornia/PST045222. (Accessed 12 March 2024).
[50] J. Lin, C. Li, W. He, Trends in influenza vaccine uptake before and during the COVID-19 pandemic in the USA, Publ. Health 225 (2023) 291–298, https://doi.org/10.1016/j.puhe.2023.10.028, 2023/12/01/.
[51] H. Lymon, L. Meng, H.E. Reses, et al., Declines in influenza vaccination coverage among health care personnel in acute care hospitals during the COVID-19 pandemic - United States, 2017-2023, MMWR Morb. Mortal. Wkly. Rep. 72 (45) (2023) 1244–1247, https://doi.org/10.15585/mmwr.mm7245a6. Nov 10.
[52] I. McGovern, A. Bogdanov, K. Cappell, S. Whipple, M. Haag, Influenza vaccine uptake in the United States before and during the COVID-19 pandemic, Vaccines (Basel) 10 (10) (2022), https://doi.org/10.3390/vaccines10101610. Sep. 26.
[53] A.V. Diez Roux, C. Mair, Neighborhoods and health, Ann. N. Y. Acad. Sci. 1186 (1) (2010) 125–145, https://doi.org/10.1111/j.1749-6632.2009.05333.x.
[54] J. Ludwig, L. Sanbonmatsu, L. Gennetian, et al., Neighborhoods, obesity, and diabetes–a randomized social experiment, N. Engl. J. Med. 365 (16) (2011) 1509–1519, https://doi.org/10.1056/NEJMsa1103216. Oct 20.

[55] S. Xie, R.A. Hubbard, B.E. Himes, Neighborhood-level measures of socioeconomic status are more correlated with individual-level measures in urban areas compared with less urban areas, Ann. Epidemiol. 43 (Mar 2020) 37–43, https://doi.org/10.1016/j.annepidem.2020.01.012, e4.
[56] A.V. Diez Roux, Neighborhoods and health: what do we know? What should we do? Am. J. Publ. Health 106 (3) (Mar 2016) 430–431, https://doi.org/10.2105/ajph.2016.303064.
[57] M.C. Arcaya, R.D. Tucker-Seeley, R. Kim, A. Schnake-Mahl, M. So, S.V. Subramanian, Research on neighborhood effects on health in the United States: a systematic review of study characteristics, Soc. Sci. Med. 168 (2016) 16–29, https://doi.org/10.1016/j.socscimed.2016.08.047, 2016/11/01/.