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Influenza vaccination accuracy among adults: Self-report compared with electronic health record data

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Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Declaration of competing interest

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

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2024.03.052.

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Abstract

Objective: To assess the validity of electronic health record (EHR)-based influenza vaccination data among adults in a multistate network.

Methods: Following the 2018–2019 and 2019–2020 influenza seasons, surveys were conducted among a random sample of adults who did or did not appear influenza-vaccinated (per EHR data) during the influenza season. Participants were asked to report their influenza vaccination status; self-report was treated as the criterion standard. Results were combined across survey years.

Results: Survey response rate was 44.7% (777 of 1740) for the 2018–2019 influenza season and 40.5% (505 of 1246) for the 2019–2020 influenza season. The sensitivity of EHR-based influenza vaccination data was 75.0% (95% confidence interval [CI] 68.1, 81.1), specificity 98.4% (95% CI 92.9, 99.9), and negative predictive value 73.9% (95% CI 68.0, 79.3).

Conclusions: In a multistate research network across two recent influenza seasons, there was moderate concordance between EHR-based vaccination data and self-report.

Keywords

Influenza vaccination; Adults; Accuracy; Self-report; Electronic health records

1. Introduction

Because of the substantial morbidity and mortality caused by influenza viruses every year in the United States [1], annual influenza vaccination is recommended for all individuals aged 6 months and older [2]. Achieving high influenza vaccination coverage is a national health goal [3], and vaccination coverage is closely monitored [4]. Coverage data can be used to measure adherence with recommendations, identify populations with low coverage, prompt targeted vaccination campaigns, and guide public health activities [5].

National influenza vaccination coverage in adults is routinely assessed through surveys, such as the National Health Interview Survey (NHIS) [4], the Behavioral Risk Factor Surveillance Survey (BRFSS) [6], and Internet panel surveys [7]. While survey-based assessments have many strengths, and remain the foundation of national coverage surveillance, limitations exist. Influenza vaccination is determined by self-report, and these platforms are not designed to verify self-report against provider records [4,6,7]. Respondents may report influenza vaccination despite not being vaccinated (due to social desirability), may mistake influenza for another vaccine, or may not recall whether they received the vaccine this season versus a prior season [8,9]. Survey response rates generally are declining, and survey-based methods are subject to selection and response biases [10]. Electronic health record (EHR) [11] and claims [12] data have also been used to assess influenza vaccination

coverage; however, these data sources may not completely capture vaccines received (e.g., vaccines administered in workplaces or pharmacies).

The primary objective of this study was to assess by survey the validity of EHR-based influenza vaccination data among adults in a multistate research network. A secondary objective was to determine whether survey respondents differed from non-respondents by demographic and clinical characteristics.

2. Methods

2.1. Overview

This study was conducted in the Vaccine Safety Datalink (VSD), a collaboration between the Centers for Disease Control and Prevention and 9 large healthcare organizations [13]. After identifying study-eligible adults, we conducted surveys among a random sample who, according to the EHR, did or did not appear influenza-vaccinated during the influenza season. Participants were asked to report their influenza vaccination status for the current season, which was compared with EHR-based vaccination data. We considered self-reported vaccination as the criterion standard. The Kaiser Permanente (KP) Colorado Institutional Review Board approved the study, and other study sites ceded oversight to KP Colorado. Written consent was not required for survey administration; individuals could opt out of participating by email or telephone.

2.2. Study population

Using EHR and health insurance enrollment data, we identified all adults aged ≥18 years enrolled at a VSD site during the 2018–2019 or 2019–2020 influenza seasons. Study-eligible adults were required to have continuous health insurance enrollment through the influenza season. Persons pregnant during the influenza season were excluded because they were surveyed as part of a separate study [14]. At one VSD site, which provides care to uninsured as well as insured patients, ≥1 outpatient visit was used as a proxy for continuous insurance enrollment. Additionally, we excluded individuals with diagnosis codes for vaccine allergies, and individuals with presumed vaccine data errors or off-label use (e.g., receipt of a nonindicated vaccine, such as high-dose influenza vaccine in someone aged <65 years). For the 2018–2019 survey, 37,232 of 7,925,295 individuals (0.47 %) were excluded for vaccine allergy or vaccine data errors; for the 2019–2020 survey, 36,856 of 8,288,084 individuals (0.44 %) were excluded.

After identifying all eligible adults as the sampling frame, we randomly sampled individuals for survey administration. For each survey year, sampling was stratified by VSD site and EHR-based influenza vaccination status, with individuals who appeared unvaccinated oversampled. The total sample was 1740 for the 2018–2019 survey and 1246 for the 2019–2020 survey. In the 2018–2019 survey, non-Hispanic Black individuals had a lower survey response rate compared to other racial and ethnic groups; consequently, non-Hispanic Black individuals were oversampled for the 2019–2020 survey.

2.3. Survey design and administration

We designed a survey instrument, reviewed it with eight individuals during cognitive interviews, and revised the instrument accordingly. We based questions on prior published instruments, using exact wording from prior surveys whenever possible [15,16]. A copy of the survey instrument is provided as a supplemental file. For the 2018–2019 influenza season, survey administration began March 15, 2019; for the 2019–2020 influenza season, surveying began February 18, 2020. Surveys were fielded for 15 weeks total. Participants received up to three mailed surveys, up to five emails with a unique hyperlink to an internet-based survey, and up to 2 automated telephone reminders. Outreach stopped after someone completed the survey or opted out. One VSD site did not permit email or telephone contact and required that participants receive a pre-survey letter with an opportunity to opt out; participants at this site received an additional mailed survey. For the 2018–2019 influenza season, a Spanish-language survey was sent to individuals with an EHR designation of preferred language Spanish. Because of resource constraints, the 2019–2020 survey was available in English only. Respondents received a $20 gift card for completing the survey.

2.4. Sources of influenza vaccine data

Vaccination data at VSD sites are derived from several data sources. Influenza vaccines ordered and administered within VSD sites represent a high proportion of available records. Additionally, vaccine data from regional immunization information systems (IIS) are added to a patient's EHR at 6 VSD sites [17]; influenza vaccines administered in pharmacies and workplaces would be integrated into EHR-based vaccination data if the vaccinator submitted data to a regional IIS.

2.5. Analytic methods

Individuals who provided an answer to the survey question "Since July 1 of [the current influenza season] have you had a flu vaccination?" were considered respondents. Pearson chi-squared tests were used to compare respondents to non-respondents. Additionally, we developed a multivariable logistic regression model to assess factors associated with survey non-response, while adjusting for VSD site. Self-reported influenza vaccination status was the criterion standard for all analyses. We accounted for the stratified sampling design, incorporated a finite population correction, and included inverse probability weighting for sampling and survey response probabilities. For the 2018–2019 survey, sampling weights accounted for EHR vaccination status and VSD site; for the 2019–2020 survey, sampling weights also accounted for the over-sampling of non-Hispanic Black individuals. Percentages for survey responses and EHR vaccination validity measures were reported with Clopper-Pearson 95 % confidence intervals [CI]. In the context of this study, sensitivity was the percentage of individuals with EHR documentation of influenza vaccination, among all individuals who self-reported influenza vaccination. Finally, because EHR influenza vaccination status was available for survey respondents and non-respondents, we were able to estimate the potential survey selection bias. This was assessed by calculating the weighted percent of individuals influenza-vaccinated (per EHR data) among the full sample minus the weighted percent vaccinated among survey respondents. We conducted analyses using SAS version 9.4 (SAS Institute, Inc, Cary, NC).

3. Results

For the 2018–2019 influenza season, 777 of 1740 participants (44.7 %) responded to the survey; for the 2019–2020 influenza season, 505 of 1246 participants (40.5 %) responded; the response rate was significantly higher for 2018–2019 than for 2019–2020 ($p < 0.02$). Combining both survey years, 44.6 % responded by internet and 55.4 % responded by mail. Survey response rates were lowest among non-Hispanic Black individuals (31.7 % in 2018–2019, 35.0 % in 2019–2020) and highest among non-Hispanic White individuals (52.4 % in 2018–2019, 51.0 % in 2019–2020). As shown in Table 1, survey respondents differed from non-respondents by age group, race and ethnicity, presence of a chronic health condition, and EHR-based influenza vaccination status for the current and prior influenza seasons. In a multivariable model examining factors associated with survey non-response (Table 2), non-Hispanic Black race and ethnicity was significantly associated with non-response (both survey years combined, adjusted odds ratio [aOR] 1.91, 95 % CI 1.10, 3.32) after adjusting for other factors.

As shown in Table 3, the percent having received influenza vaccine per EHR data was higher among survey respondents than among the entire sample, suggesting selection bias. Calculated as an absolute percentage point difference, estimated selection bias was 8.8 % overall. Stratified by race and ethnicity, estimated selection bias was 10.5 % for non-Hispanic Black individuals and 8.7 % for non-Hispanic White individuals.

Combining results from both survey years, 55.7 % of respondents were not vaccinated for influenza according to EHR data; 26.1 % of these self-reported that they were vaccinated. Additionally, 44.3 % of respondents were vaccinated for influenza according to EHR data; 1.5 % of these self-reported that they were unvaccinated. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of EHR-based influenza vaccination data are presented in Table 4. Of all validity measures calculated, NPV was the lowest value; NPV for both years combined was 73.9 % (95 % CI 68.0, 79.3). The validity measures differed by several respondent characteristics (Table 4). For example, the sensitivity of EHR vaccination data was highest for individuals aged ≥65 years at 90.4 % (95 % CI 83.0, 95.3) and lowest for individuals aged 18–24 years at 40.7 % (95 % CI 8.6, 80.4). The level of agreement between EHR-based data and self-report of influenza vaccination status was moderate (kappa coefficient both years combined 0.70, 95 % CI 0.63, 0.77).

All respondents who self-reported vaccination were asked the location of their vaccination. For those who were unvaccinated according to EHR data but reported vaccination (EHR false negatives), 24.5 % were vaccinated in a workplace, 18.1 % in a hospital, and 43.5 % in a physician’s office, clinic, or health center. In contrast, for those vaccinated according to EHR data who also self-reported vaccination (EHR true positives), 2.1 % were vaccinated in a workplace, 26.1 % in a hospital, and 65.3 % in a physician’s office, clinic, or health center. These data are also shown in Supplemental Table 1.

4. Discussion

Approximately 49.4 % of adults in the United States received an influenza vaccine during the 2021–2022 season [6], far below the Healthy People 2030 goal of 70 % coverage [3]. Efforts are needed to improve influenza vaccination coverage, and accurate coverage estimates are necessary to help guide these efforts. In a survey of 1282 adults in a multistate research network, we found moderate agreement between EHR-based influenza vaccination data and self-report, with high specificity (98.4 %) but lower sensitivity (75.0 %) of EHR-based data compared to self-report. Stratified by age, the sensitivity was highest among individuals aged ≥65 years. The NPV of EHR-based influenza vaccination data was 73.9 %, indicating that for respondents who appeared unvaccinated in EHR data, 26.1 % reported having received influenza vaccine. Vaccination outside the medical home (e.g., in the workplace or at a pharmacy) may contribute to disagreement between EHR-based data and self-report.

It is informative to compare these findings to prior studies, particularly studies which treated self-reported influenza vaccination as the criterion standard. Greene and colleagues compared EHR-based data to self-report among adults aged 50–70 years following the 2007–2008 influenza season; the NPV of EHR-based influenza vaccination data was 66.6 % [18]. In a study by Sy and colleagues among adults aged 50–79 years, also following the 2007–2008 season, the NPV of EHR-based influenza vaccination data was 79.5 % [19]. Our study included adults aged ≥18 years, and age may affect NPV: although confidence intervals were wide and overlapping, the NPV point estimate was lowest (60.5 %) for adults aged 18–24 years and highest (84.6 %) for adults aged 50–64 years. It is plausible that younger adults are more likely to receive vaccines outside their medical home.

Our findings highlight the risk of response bias in survey-based assessments of influenza vaccination coverage [14]. In weighted analyses, the percent vaccinated per EHR data was higher among respondents than among the full sample, overall and for non-Hispanic White, non-Hispanic Black, and non-Hispanic other groups, although estimates were imprecise. This suggests that the weighting of national survey estimates may not fully mitigate non-response bias, and national surveys possibly overestimate true influenza vaccination coverage. However, it is also important to recognize that our survey was introduced as related to “flu vaccination” whereas other surveys such as NHIS [4] and BRFSS [10] concern health more broadly, and response bias could differ across different survey platforms.

In addition to response bias, this study is subject to other limitations. First, self-reported vaccination was treated as the criterion standard, but respondents could have been mistaken in their self-report. Second, EHR-derived race and ethnicity data could have been misclassified. Third, these results largely reflect a pre-pandemic landscape, and the COVID-19 pandemic may have fundamentally altered what immunization information is shared across entities. Fourth, the VSD comprises large healthcare organizations caring for predominantly insured populations [13,20]; results may not be generalizable to other settings.

In conclusion, in surveys conducted among adults in a multistate research network across two recent influenza seasons, there was moderate agreement between EHR-based vaccination data and self-report, with 26.1 % of respondents who appeared unvaccinated in EHR data reporting having received influenza vaccine. A possible selection bias was detected. More accurate assessments of national coverage may be possible by integrating multiple sources of influenza vaccination data.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data availability

Data will be made available on request.

Abbreviations:

ACIP	Advisory Committee on Immunization Practices
CDC	Centers for Disease Control and Prevention

EHR	electronic health records
KP	Kaiser Permanente
VSD	Vaccine Safety Datalink

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Table 1

Characteristics of respondents and non-respondents to surveys administered to adults during the 2018–19 and 2019–20 influenza seasons, Vaccine Safety Datalink.[a,b]

Characteristic	2018–2019 respondents, n (%)	2018–2019 non-respondents, n (%)	p value[c]	2019–2020 respondents, n (%)	2019–2020 non-respondents, n (%)	p value[c]
Total	777	963		505	741	
Age group (yrs)						
18–24	67 (8.6)	157 (16.3)	<0.0001	35 (6.9)	114 (15.4)	<0.0001
25–34	125 (16.1)	184 (19.1)		85 (16.8)	144 (19.4)	
35–49	201 (25.9)	278 (28.9)		128 (25.3)	227 (30.6)	
50–64	232 (29.9)	250 (26.0)		144 (28.5)	185 (25.0)	
≥65	152 (19.6)	94 (9.8)		113 (22.4)	71 (9.6)	
Race and ethnicity[d]						
Non-Hispanic White	494 (63.6)	449 (46.6)	<0.0001	182 (36.0)	175 (23.6)	0.0002
Non-Hispanic Black	33 (4.2)	71 (7.4)		226 (44.8)	420 (56.7)	
Hispanic	109 (14.0)	194 (20.1)		49 (9.7)	73 (9.9)	
Non-Hispanic Asian	46 (5.9)	62 (6.4)		14 (2.8)	20 (2.7)	
Non-Hispanic other	28 (3.6)	35 (3.6)		8 (1.6)	12 (1.6)	
Missing	67 (8.6)	152 (5.8)		26 (5.1)	41 (5.5)	
Chronic health condition[e]						
Yes	235 (30.2)	225 (23.4)	0.0012	249 (49.3)	273 (36.8)	<0.0001
No	542 (69.8)	738 (76.6)		256 (50.7)	468 (63.2)	
Vaccinated for influenza in current season (per EHR)						
Yes	212 (27.3)	135 (14.0)	<0.0001	184 (36.4)	138 (18.6)	<0.0001
No	565 (72.7)	828 (86.0)		321 (63.6)	603 (81.4)	
Vaccinated for influenza in prior season (per EHR)						
Yes	265 (34.1)	209 (21.7)	<0.0001	201 (39.8)	211 (28.5)	<0.0001
No	512 (65.9)	754 (78.3)		304 (60.2)	530 (71.5)	

Abbreviations: EHR, electronic health records; yrs, years.

[a]Vaccine Safety Datalink sites are located in Minnesota, Wisconsin, Colorado, California, Oregon, and Washington.

[b] Individuals unvaccinated for influenza in the current season (per EHR) were oversampled in both survey years; individuals of non-Hispanic Black race and ethnicity were oversampled for the 2019–2020 survey.

[c] Pearson chi-square test, with $p < 0.05$ considered significant.

[d] For respondents and non-respondents, data regarding race and ethnicity were obtained from EHR data.

[e] Chronic health conditions not related to pregnancy which increased risk of influenza-related morbidity and mortality were identified from EHR encounters using International Classification of Diseases, 10th Revision diagnoses codes.

Table 2

Multivariable analyses of characteristics associated with not responding to influenza vaccination surveys during the 2018–19 and 2019–20 influenza seasons, Vaccine Safety Datalink.[a,b]

Characteristic	2018–2019 influenza season, aOR (95 % CI)[c]	2019–2020 influenza season, aOR (95 % CI)[c]	Both seasons combined, aOR (95 % CI)[c]
Age group (yrs)			
18–24	Ref	Ref	Ref
25–34	0.44 (0.22, 0.86)	0.32 (0.11, 0.97)	0.38 (0.19, 0.77)
35–49	0.61 (0.32, 1.15)	0.61 (0.20, 1.80)	0.63 (0.32, 1.25)
50–64	0.63 (0.34, 1.17)	0.40 (0.13, 1.23)	0.52 (0.27, 1.03)
≥65	0.27 (0.12, 0.59)	0.27 (0.07, 1.05)	0.28 (0.12, 0.62)
Race and ethnicity[d]			
Non-Hispanic White	Ref	Ref	Ref
Non-Hispanic Black	2.42 (1.01, 5.76)	1.43 (0.79, 2.59)	1.91 (1.10, 3.32)
Hispanic	1.51 (0.90, 2.55)	0.94 (0.43, 2.04)	1.19 (0.74, 1.93)
Non-Hispanic Asian	1.51 (0.75, 3.03)	1.30 (0.43, 3.90)	1.45 (0.74, 2.83)
Non-Hispanic other	2.16 (0.82, 5.69)	0.63 (0.18, 2.25)	1.17 (0.53, 2.59)
Missing	1.58 (0.86, 2.91)	1.56 (0.51, 4.81)	1.59 (0.87, 2.88)
Chronic health condition[e]			
Yes	Ref	Ref	Ref
No	1.05 (0.65, 1.70)	1.15 (0.62, 2.12)	1.08 (0.73, 1.61)
Vaccinated for influenza in current season (per EHR)			
Yes	Ref	Ref	Ref
No	1.69 (1.03, 2.79)	1.37 (0.64, 2.94)	1.49 (0.97, 2.30)
Vaccinated for influenza in prior season (per EHR)			
Yes	Ref	Ref	Ref
No	1.11 (0.68, 1.82)	1.24 (0.62, 2.48)	1.13 (0.75, 1.72)

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; EHR, electronic health records; Ref, referent category.

[a] Vaccine Safety Datalink sites are located in Minnesota, Wisconsin, Colorado, California, Oregon, and Washington.

[b] Individuals unvaccinated for influenza in the current season (per EHR) were oversampled in both survey years; individuals of non-Hispanic Black race and ethnicity were oversampled for the 2019–2020 survey.

[c] Each column represents a separate multivariable regression model; models were adjusted for all variables listed and VSD site.

[d] For respondents and non-respondents, data regarding race and ethnicity were obtained from EHR data.

[e] Chronic health conditions not related to pregnancy which increased risk of influenza-related morbidity and mortality were identified from EHR encounters using International Classification of Diseases, 10th Revision diagnoses codes.

Table 3

The percent who received influenza vaccine per EHR data, comparing full sample to survey respondents.[a]

	Full sample weighted percent vaccinated	95 % CI	Survey respondents, weighted percent vaccinated	95 % CI	Absolute difference (estimated selection bias)
Year 1 survey (2018–2019)	45.3	40.5, 50.0	54.7	48.2, 61.1	9.4
Year 2 survey (2019–2020)	43.4	36.1, 51.0	51.5	41.1, 61.9	8.1
Years 1 and 2 combined	44.3	39.9, 48.8	53.1	46.9, 59.1	8.8
Years 1 and 2 combined, stratified by race and ethnicity[b]					
Non-Hispanic White	51.6	45.2, 57.9	60.3	52.3, 67.9	8.7
Non-Hispanic Black	43.4	32.6, 54.7	53.9	37.4, 69.7	10.5
Hispanic	27.1	18.5, 37.2	26.2	13.7, 42.4	−0.9
Non-Hispanic other	46.8	37.7, 56.0	59.3	45.9, 71.7	12.5

Abbreviations: CI, confidence interval; EHR, electronic health record.

[a]Analyses accounted for the stratified sampling design, incorporated a finite population correction, and included inverse probability weighting for sampling and survey response probabilities.

[b]For respondents and non-respondents, data regarding race and ethnicity were obtained from EHR data.

Table 4

Sensitivity, specificity, positive and negative predictive values, and kappa of electronic health record documentation of influenza vaccination compared to self-reported vaccination status, 2018–19 and 2019–20 influenza seasons.[a,b]

Characteristic	n	Sensitivity, % (95 % CI)[c]	Specificity, % (95 % CI)[c]	Positive predictive value, % (95 % CI)[c]	Negative predictive value, % (95 % CI)[c]	Kappa coefficient (95 % CI)[d]
Year 1 survey (2018–19)	777	79.0 (72.2, 84.8)	97.0 (86.7, 99.8)	97.0 (86.8, 99.8)	78.7 (72.9, 83.7)	0.74 (0.66, 0.82)
Year 2 survey (2019–20)	505	71.6 (59.4, 81.8)	99.9 (98.2, 100.0)	99.9 (97.8, 100.0)	69.5 (59.2, 78.6)	0.66 (0.55, 0.78)
Years 1 and 2 combined	1282	75.0 (68.1, 81.1)	98.4 (92.9, 99.9)	98.5 (93.3, 99.9)	73.9 (68.0, 79.3)	0.70 (0.63, 0.77)
Years 1 and 2 combined, by specific strata						
Age group (yrs)						
18–24	102	40.7 (8.6, 80.4)	97.9 (89.0, 99.9)	95.4 (72.1, 100.0)	60.5 (39.3, 79.1)	0.38 (0.02, 0.74)
25–34	210	58.3 (33.7, 80.2)	99.9 (96.9, 100.0)	99.8 (90.1, 100.0)	76.0 (62.3, 86.7)	0.61 (0.39, 0.84)
35–49	329	57.1 (40.3, 72.8)	99.7 (97.4, 100.0)	99.6 (94.4, 100.0)	68.4 (55.9, 79.2)	0.56 (0.41, 0.71)
50–64	376	86.0 (75.8, 93.1)	94.8 (75.1, 99.8)	95.3 (77.2, 99.9)	84.6 (75.1, 91.5)	0.80 (0.68, 0.92)
≥65	265	90.4 (83.0, 95.3)	100.0 (NA)	100.0 (NA)	73.6 (58.1, 85.7)	0.80 (0.68, 0.92)
Race and ethnicity[e]						
Non-Hispanic White	676	84.1 (76.3, 90.2)	99.8 (98.6, 100.0)	99.9 (98.0, 100.0)	80.3 (72.2, 86.9)	0.81 (0.74, 0.87)
Non-Hispanic Black	259	83.6 (69.5, 93.0)	99.9 (96.5, 100.0)	99.9 (96.7, 100.0)	85.2 (76.0, 92.0)	0.83 (0.72, 0.94)
Hispanic	158	43.2 (23.5, 64.7)	100.0 (95.7, 100.0)	99.9 (86.0, 100.0)	67.3 (54.0, 78.8)	0.45 (0.25, 0.65)
Non-Hispanic Asian	60	74.5 (53.7, 89.4)	100.0 (NA)	100.0 (NA)	51.2 (28.8, 73.3)	0.55 (0.31, 0.79)
Non-Hispanic other	36	96.1 (75.9, 100.0)	100.0 (NA)	100.0 (NA)	92.8 (75.0, 99.2)	0.94 (0.85, 1.00)
Missing	93	60.8 (33.8, 83.6)	85.2 (49.3, 99.0)	75.1 (31.6, 97.6)	74.8 (54.9, 89.2)	0.47 (0.14, 0.80)
Chronic health condition[f]						
Yes	484	85.0 (76.9, 91.1)	95.2 (77.7, 99.8)	97.8 (88.9, 99.9)	71.8 (60.2, 81.5)	0.73 (0.62, 0.84)
No	798	63.6 (52.6, 73.6)	99.7 (98.7, 100.0)	99.5 (97.2, 100.0)	74.9 (67.6, 81.2)	0.64 (0.54, 0.75)
Vaccinated for influenza in prior season (per EHR)						
Yes	466	85.3 (78.1, 90.9)	100.0 (NA)	100.0 (NA)	44.7 (30.6, 59.4)	0.55 (0.40, 0.70)
No	816	52.5 (38.8, 66.0)	98.2 (92.0, 99.9)	93.3 (73.8, 99.6)	80.8 (74.7, 86.0)	0.57 (0.45, 0.69)

Abbreviations: CI, confidence interval; EHR, electronic health records; n, number; NA, not applicable; yrs, years.

[a]Self-reported vaccination status treated as the criterion standard.

[b] Measured point estimates and confidence intervals account for sample design strata, sample and response weights, and finite population correction.

[c] Confidence intervals estimated by Clopper-Pearson methods.

[d] Kappa and associated confidence intervals estimated with bootstrap replication variance estimation.

[e] Data regarding race and ethnicity were obtained from EHR.

[f] Chronic health conditions not related to pregnancy which increased risk of influenza-related morbidity and mortality were identified from EHR encounters using International Classification of Diseases, 10th Revision diagnoses codes.