Regional Disparities in the Uptake of Differentiated Influenza Vaccines in the United States

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Abstract

Significant racial/ethnic inequities in the uptake of differentiated influenza vaccines (DIVs) have been previously reported, though less is known about regional disparities. We conducted a retrospective longitudinal study (2014/15–2017/18 influenza seasons) among privately insured adults aged 65 + years in the US. The exposure was the beneficiary's area of residence (US Census Bureau division) and the outcome was the type of influenza vaccine: differentiated (high-dose [HDV], adjuvanted, recombinant, and cell-based) versus conventional standard-dose egg-based. Multilevel logistic regression modeling, guided by a causal diagram, was used to assess the influence of socio-demographics, medical, healthcare utilization, community, and vaccinator characteristics in confounding or mediating regional disparities. Among those vaccinated in physician offices, beneficiaries in the East North Central region were twice as likely to receive a DIV vs those in the South Atlantic, whereas those in the East and West South Central were least likely. Disparities became more pronounced in models adjusted for individual and community characteristics, suggesting that crude uptake estimates understate the true magnitude of disparities. A vaccinator's previous HDV use was most influential in explaining regional differences. Similar but less pronounced patterns emerged for vaccinations in pharmacies/facilities. Regional disparities remained even in fully adjusted models, pointing to currently poorly understood factors that may include quality of healthcare, client health literacy and engagement, and other political and cultural factors.

Keywords Influenza · Seasonal influenza vaccine · High-dose influenza vaccine · Inequities · Disparities · Enhanced influenza vaccines

Introduction

We have previously reported significant racial and ethnic inequities in the uptake of differentiated influenza vaccines (DIVs) among vaccinated beneficiaries of Medicare Plan A and B [1, 2] and Medicare Advantage (MA) and similar commercial plans in the United States [3]. In this paper, we explore whether regional inequities in DIVs' uptake exist and attempt to use multilevel models to understand the role of socio-economic, medical, community, and vaccinator

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characteristics in mediating these disparities among MA beneficiaries using data from the Optum Research Database (ORD) covering four influenza seasons (2014/15–2017/18).

Methods

We conducted a retrospective longitudinal study using the ORD, which contains deidentified physician, hospital, and pharmacy claims data on ≥ 60 million MA and commercial health plan beneficiaries nationally [4]. We included all ≥ 65-year-old community-dwelling beneficiaries (not residing in a long-term care facility) who had ≥ 1 year of insurance coverage during the study period (July 2014–June 2018) and who received ≥ 1 influenza vaccine during this period ($N = 1,561,638$). We excluded those with unknown age, gender, race, county of residence, or vaccine type ($N = 231,878$; see ref [3] for details).

The exposure was the beneficiary's US Census Bureau division of residence (Fig. 1) using their address at vaccination as captured in the ORD [5]. The outcome was the type of influenza vaccine received during the study period: differentiated vaccines (DIVs, including high-dose (HDV), adjuvanted, recombinant, and cell-based vaccines) vs conventional standard-dose non-adjuvanted egg-based influenza vaccines. In all analyses, we used a multilevel logistic regression model, using MlwiN3 [6], to account for the clustering of vaccination episodes (level 1) by beneficiaries

(level 2), who were in turn clustered by county of residence (level 3). We stratified by vaccination site (physician office vs pharmacy/facility, e.g., hospital, emergency room) based on our previous findings in significant patterns in differential vaccine use between pharmacies and physician offices [3], and used an expert-developed causal diagram [3] to better understand the role of socio-demographics, medical history, health-care utilization and community, and vaccinator characteristics in confounding or mediating regional disparities.

Results

During the study period, 60% of 2.8 million distinct vaccination claims were for DIVs (Table 1; see ref [3] for a detailed description of population characteristics). Among those vaccinated in physician offices, we observed substantial regional differences in DIV uptake with estimates ranging from > 60% in the Mountain and West North Central regions to < 40% in the South and Pacific regions. The differences were smaller among those vaccinated in pharmacies with estimates ranging from 76% in the West South Central to 67% in the Pacific region.

In multilevel models limited to those vaccinated in physician offices (Table 2, top panel), those vaccinated in the East North Central region were twice (95% CI 1.65–2.62) as likely to receive a DIV compared to those vaccinated in the South Atlantic region (the reference group and largest
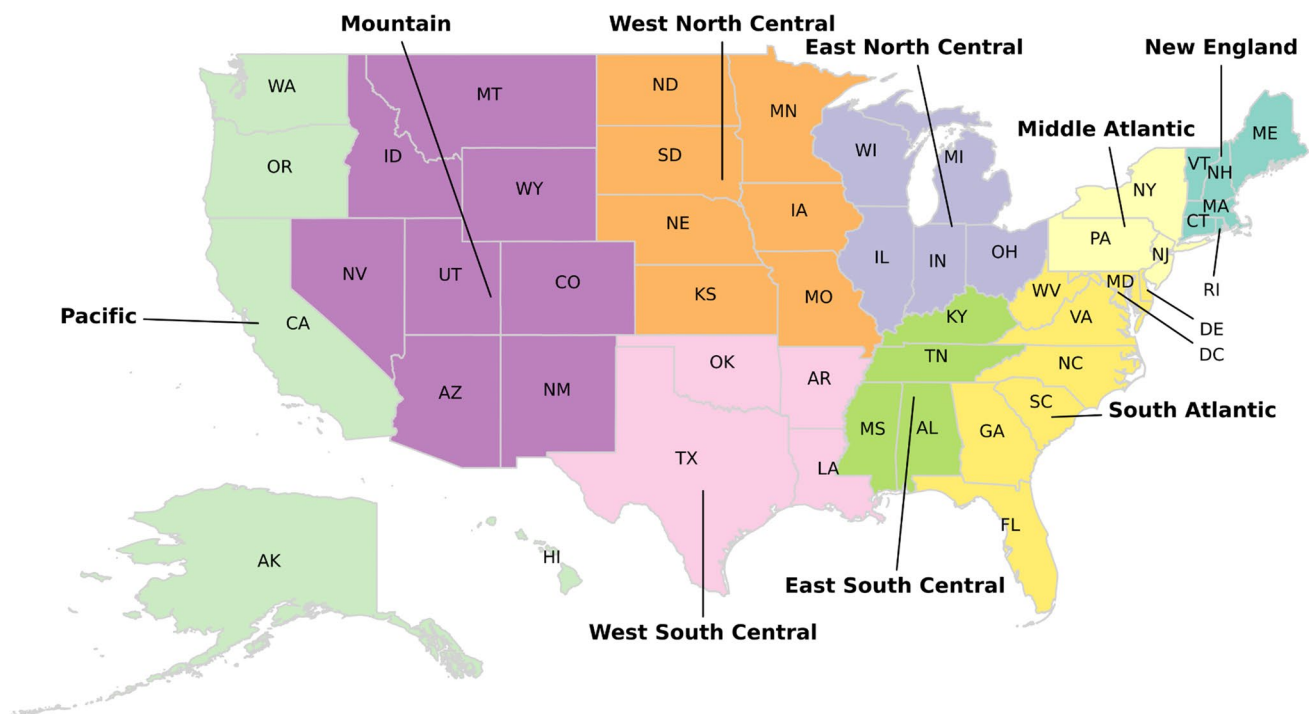

Fig. 1 US Census Bureau regions used in the analysis

Table 1 Percentage of differentiated influenza vaccine (DIV) administrations of all influenza vaccinations by vaccination site and certain person, community, and vaccinator characteristics (2014/15–2017/18)

	DIV vaccination site			All influenza vaccinations
	All sites	Physician office	Pharmacy/facility	
All influenza vaccinations	2,801,685	1,529,656	1,272,029	2,801,685
N (%) differentiated vaccine	1,685,120 (60%)	748,647 (49%)	936,473 (74%)	
Urban/rural				
Urban	1,613,790 (60%)	717,738 (49%)	896,052 (74%)	2,671,391
Rural	71,330 (55%)	30,909 (44%)	40,421 (68%)	130,294
US census divisions				
New England	111,986 (58%)	42,877 (45%)	69,109 (70%)	193,353
Middle Atlantic	241,966 (53%)	119,081 (41%)	122,885 (72%)	459,003
East North Central	303,088 (63%)	142,201 (57%)	160,887 (70%)	480,906
West North Central	212,875 (67%)	110,762 (61%)	102,113 (74%)	318,316
South Atlantic	500,519 (63%)	202,737 (49%)	297,782 (78%)	789,462
East South Central	52,555 (51%)	24,926 (39%)	27,629 (71%)	102,891
West South Central	88,364 (50%)	34,303 (33%)	54,061 (76%)	176,227
Mountain	123,504 (67%)	52,910 (62%)	70,594 (72%)	183,198
Pacific	50,263 (51%)	18,850 (37%)	31,413 (67%)	98,329
Region				
Midwest	515,963 (65%)	252,963 (59%)	263,000 (72%)	799,222
Northeast	353,952 (54%)	161,958 (42%)	191,994 (71%)	652,356
South	641,438 (60%)	261,966 (45%)	379,472 (78%)	1,068,580
West	173,767 (62%)	71,760 (53%)	102,007 (70%)	281,527

stratum in our study) who in turn were twice (95% CI 0.39–0.61) as likely to receive a DIV compared to those vaccinated in the East and West South Central regions. Generally, regional disparities became more pronounced in models adjusted for socio-demographic factors (including race/ethnicity, education, and income), medical history and patterns of healthcare utilization, and for community characteristics (rurality, age and sex composition, proportion of migrants, and mean household income) especially in the New England, Mountain, and Pacific regions. After controlling for "having a primary healthcare provider" (model " + measures of healthcare utilizations" in Table 2), further adjustment for the type of provider did not change the estimates. Healthcare access factors (e.g., availability of physicians) seemed to narrow the gap somewhat but the county's Gini index and the overall Social Vulnerability Index (SVI) ranking had little effect. Vaccinator characteristics, especially a vaccinator's use of the HDV in previous seasons were the most influential factors in explaining the regional differences as evidenced by all odds ratio estimates getting closer to 1.0 after adjusting for these variables. A similar pattern emerged for vaccinations in pharmacies/facilities although disparities were generally smaller and vaccinators' characteristics were not as influential (Table 2, bottom panel).

Discussion

We found significant regional disparities in the receipt of DIV especially among those vaccinated in physician offices. Frequently cited explanations for inequality such as lack of insurance and negative attitudes towards vaccines cannot explain the observed gaps because everyone in this analysis was fully insured and vaccinated. Furthermore, the disparities were generally more pronounced after adjusting for personal and community-level characteristics suggesting that not controlling for these variables underestimates the significance of regional disparities. Only controlling for the vaccinators' prior use of HDV lessened the observed disparities suggesting that issues of access to DIVs especially by physicians might be at play. However, significant levels of regional disparities were still observed even in the fully adjusted models pointing to currently poorly understood factors that may include the overall quality of healthcare services, client health literacy and engagement, and other political and cultural factors. Research into these factors is warranted.

At the national level, programmatic changes and recommendations can play a key role in reducing vaccination disparities, as evident by the federally funded Vaccines for Children (VFC) program initiated in 1994 to ensure free

Table 2 Odds ratio (95% confidence interval) of the association between US census divisions and differentiated vaccine uptake among influenza-vaccinated persons according to vaccination site (2014/15–2017/18), ref South Atlantic

	New England	Middle Atlantic	East North Central	West North Central	East South Central	West South Central	Mountain	Pacific
Physician office								
Baseline	1.01 (0.84–1.20)	1.12 (1.02–1.23)	2.08 (1.65–2.62)	1.65 (1.51–1.81)	0.57 (0.48–0.69)	0.49 (0.39–0.61)	1.00 (0.87–1.14)	1.09 (0.79–1.51)
+Personal characteristics[1]	0.57 (0.49–0.67)	1.15 (0.92–1.43)	1.95 (1.78–2.14)	1.53 (1.40–1.68)	0.52 (0.40–0.66)	0.51 (0.42–0.61)	0.61 (0.49–0.76)	0.71 (0.55–0.90)
+Measures of healthcare utilizations[2]	0.62 (0.48–0.80)	1.10 (0.93–1.30)	2.19 (1.84–2.60)	1.61 (1.38–1.88)	0.55 (0.45–0.67)	0.62 (0.54–0.70)	0.65 (0.54–0.79)	1.02 (0.82–1.26)
+Community characteristics[3]	0.40 (0.35–0.46)	0.97 (0.79–1.20)	1.66 (1.45–1.92)	1.72 (1.44–2.06)	0.52 (0.39–0.69)	0.52 (0.42–0.65)	0.64 (0.53–0.77)	0.78 (0.56–1.07)
+Community mean HH income	0.80 (0.56–1.14)	0.88 (0.77–1.01)	1.75 (1.32–2.34)	1.77 (1.41–2.22)	0.46 (0.31–0.67)	0.60 (0.49–0.72)	0.54 (0.42–0.70)	0.77 (0.58–1.02)
+Community education and marital status percent	0.62 (0.43–0.89)	0.88 (0.70–1.10)	1.98 (1.58–2.48)	1.85 (1.61–2.12)	0.48 (0.35–0.65)	0.60 (0.52–0.70)	0.84 (0.66–1.08)	0.91 (0.66–1.26)
+Community nativity	0.69 (0.51–0.94)	0.81 (0.62–1.07)	1.57 (1.34–1.84)	1.40 (1.11–1.76)	0.39 (0.30–0.50)	0.47 (0.38–0.58)	0.53 (0.38–0.75)	0.58 (0.44–0.76)
+Physician and health insurance coverage[4]	0.70 (0.52–0.93)	1.05 (0.89–1.24)	1.83 (1.48–2.25)	1.93 (1.68–2.23)	0.56 (0.43–0.73)	0.67 (0.47–0.95)	0.70 (0.58–0.86)	0.73 (0.51–1.07)
+Gini index	0.61 (0.51–0.73)	0.87 (0.78–0.97)	1.56 (1.28–1.90)	1.53 (1.21–1.94)	0.53 (0.41–0.67)	0.55 (0.45–0.67)	0.55 (0.38–0.77)	0.61 (0.45–0.81)
+Overall SVI ranking	0.58 (0.48–0.71)	0.99 (0.91–1.08)	1.57 (1.21–2.05)	1.62 (1.32–1.97)	0.66 (0.54–0.81)	0.58 (0.46–0.73)	0.55 (0.47–0.65)	0.64 (0.41–1.00)
+Vaccination month	0.56 (0.36–0.87)	0.95 (0.79–1.14)	1.63 (1.42–1.86)	1.38 (1.22–1.57)	0.63 (0.53–0.75)	0.64 (0.52–0.77)	0.65 (0.46–0.91)	0.74 (0.58–0.96)
+Vaccinator's characteristics[5]	0.75 (0.56–1.01)	1.08 (0.86–1.35)	1.90 (1.68–2.15)	1.87 (1.64–2.12)	0.68 (0.49–0.93)	0.81 (0.71–0.93)	0.56 (0.47–0.66)	0.74 (0.55–1.00)
+Vaccinator's flu vaccination (%)[6]	0.61 (0.46–0.81)	0.81 (0.59–1.11)	1.59 (1.34–1.88)	1.61 (1.34–1.94)	0.67 (0.53–0.84)	0.57 (0.46–0.71)	0.57 (0.42–0.77)	0.77 (0.60–0.99)
+Vaccinator's HD flu vaccination (%)[6]	0.85 (0.71–1.02)	1.03 (0.83–1.27)	1.45 (1.23–1.70)	1.41 (1.24–1.62)	1.01 (0.81–1.25)	1.15 (0.98–1.35)	0.88 (0.77–1.00)	0.97 (0.71–1.31)
Pharmacy/facility								
Baseline	1.03 (0.85–1.24)	0.64 (0.53–0.77)	1.25 (1.12–1.39)	0.86 (0.73–1.01)	0.80 (0.63–1.02)	1.60 (1.34–1.91)	0.52 (0.45–0.60)	0.59 (0.46–0.76)
+Personal characteristics[1]	0.84 (0.73–0.97)	0.73 (0.61–0.88)	1.09 (0.91–1.31)	0.75 (0.67–0.84)	0.72 (0.58–0.89)	1.70 (1.50–1.92)	0.51 (0.44–0.60)	0.62 (0.46–0.85)
+Measures of healthcare utilizations[2]	0.82 (0.66–1.03)	0.74 (0.58–0.95)	1.05 (0.82–1.35)	0.73 (0.63–0.84)	0.68 (0.55–0.84)	1.66 (1.41–1.96)	0.53 (0.44–0.65)	0.58 (0.43–0.78)
+Community characteristics[3]	0.99 (0.80–1.23)	0.77 (0.63–0.94)	0.99 (0.85–1.16)	0.70 (0.58–0.85)	0.71 (0.56–0.90)	1.71 (1.36–2.14)	0.52 (0.43–0.63)	0.44 (0.31–0.63)
+Community mean HH income	0.84 (0.67–1.05)	0.70 (0.59–0.83)	0.98 (0.88–1.09)	0.72 (0.58–0.89)	0.69 (0.54–0.88)	1.49 (1.29–1.72)	0.43 (0.35–0.51)	0.73 (0.56–0.95)
+Community education and marital status percent	0.93 (0.74–1.17)	0.74 (0.62–0.89)	0.95 (0.86–1.06)	0.75 (0.65–0.87)	0.73 (0.65–0.82)	1.58 (1.37–1.83)	0.51 (0.44–0.59)	0.74 (0.52–1.04)
+Community nativity	1.09 (0.91–1.31)	0.77 (0.65–0.92)	1.18 (1.04–1.33)	0.81 (0.69–0.95)	0.87 (0.69–1.09)	1.62 (1.40–1.88)	0.47 (0.40–0.55)	0.66 (0.48–0.91)
+Physician and health insurance coverage[4]	1.03 (0.85–1.26)	0.83 (0.68–1.02)	1.06 (0.93–1.21)	0.83 (0.74–0.94)	0.77 (0.65–0.91)	1.46 (1.25–1.70)	0.55 (0.47–0.65)	0.61 (0.51–0.73)
+Gini index	1.04 (0.88–1.23)	0.58 (0.50–0.67)	1.05 (0.93–1.20)	0.75 (0.62–0.90)	0.72 (0.49–1.06)	1.22 (0.99–1.51)	0.39 (0.27–0.54)	0.65 (0.46–0.91)

Table 2 (continued)

	New England	Middle Atlantic	East North Central	West North Central	West South Central	East South Central	Mountain	Pacific
+ Overall SVI ranking	1.14 (0.93–1.39)	1.00 (0.85–1.19)	1.19 (1.00–1.42)	0.89 (0.76–1.05)	1.38 (1.14–1.67)	0.85 (0.66–1.09)	0.54 (0.45–0.64)	0.85 (0.62–1.15)
+ Vaccination month	1.12 (0.78–1.61)	0.86 (0.71–1.04)	1.22 (1.09–1.36)	0.92 (0.83–1.03)	1.57 (1.29–1.91)	0.79 (0.67–0.94)	0.51 (0.40–0.66)	0.83 (0.63–1.08)
+ Vaccinator's characteristics[5]	1.11 (0.93–1.33)	0.72 (0.62–0.85)	1.00 (0.89–1.12)	0.92 (0.83–1.02)	1.52 (1.27–1.81)	0.59 (0.47–0.75)	0.56 (0.38–0.84)	1.04 (0.80–1.36)
+ Vaccinator's flu vaccination (%)[6]	1.12 (0.94–1.34)	0.85 (0.72–1.01)	1.34 (1.07–1.68)	1.30 (1.14–1.48)	1.80 (1.50–2.17)	0.72 (0.56–0.93)	0.39 (0.34–0.45)	0.49 (0.36–0.65)
+ Vaccinator's HD flu vaccination (%)[6]	0.78 (0.63–0.96)	0.76 (0.62–0.95)	1.01 (0.90–1.14)	1.04 (0.92–1.17)	1.28 (1.09–1.49)	0.95 (0.70–1.28)	0.44 (0.35–0.56)	0.47 (0.38–0.58)

SVI social vulnerability index, *HH* household

[1] Age, gender, race, socio-economic characteristics (education, household income, and receiving low income subsidies), and medical factors (immunocompromised, chronic cardiovascular disease, chronic respiratory disease, other chronic disease, substance use and dementia)

[2] Number of hospitalizations, physician visits, prescriptions and having a primary healthcare provider

[3] County's rurality, sex, and old-age ratios

[4] Number of physicians per 100,000 and percentage with health insurance coverage

[5] Vaccinator's age and gender

[6] In the previous season

access to childhood vaccinations, thereby reducing racial/ethnic disparities in childhood vaccine coverage in the years following its roll-out [7]. As of 2022, the Advisory Committee on Immunization Practices (ACIP) updated its influenza vaccination recommendations, making a preferential recommendation for the use of DIVs among older adults [8]. As with the VFC program, these revised guidelines will hopefully help to reduce disparities and inequities in DIV uptake. Future research will be needed to assess this potential impact.

It was not possible to reliably assess disparities between states due to relatively small numbers in many states, but gaps in vaccine uptake are likely wider in states and smaller geographies. By relying on a large database, we avoided sampling, social desirability, and non-response biases associated with surveys and self-reports of vaccine receipt. We lacked information on other potential mediators, e.g., immigration status, and English proficiency, as well as characteristics of vaccinators, e.g., knowledge and attitudes about vaccines, intentions to discuss available options, and behavioral tendencies. Our findings may not be generalizable to adults who have no or other forms of insurance where inequities are likely starker.

In conclusion, regional disparities in DIV uptake among fully insured older adults could not be fully explained by differences in sociodemographic, clinical, community, and vaccinator characteristics. New legislative, fiscal, educational, and research strategies are warranted to address vaccine uptake inequities.

Code Availability Not applicable.

Declarations

Ethics Approval and Consent to Participate The University of Manitoba Research Ethics Board approved this study.

Consent to Publish Not applicable.

Competing Interests SMM received research funding from Assurex, GSK, Merck, Pfizer, Roche, and Sanofi for unrelated studies and is/was a member of advisory boards for GSK, Merck, Sanofi, and Seqirus. CHR has received an unrestricted research grant from Pfizer for an unrelated study. MML, ET, HK, and AC are employees of Sanofi and may hold shares and/or stock options in the company.

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