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Variation in influenza vaccine assessment, receipt, and refusal by the concentration of Medicare Advantage enrollees in U.S. nursing homes



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ABSTRACT

Background: More older adults enrolled in Medicare Advantage (MA) are entering nursing homes (NHs), and MA concentration could affect vaccination rates through shifts in resident characteristics and/or payer-related influences on preventive services use. We investigated whether rates of influenza vaccination and refusal differ across NHs with varying concentrations of MA-enrolled residents.

Methods: We analyzed 2014–2015 Medicare enrollment data and Minimum Data Set clinical assessments linked to NH-level characteristics, star ratings, and county-level MA penetration rates. The independent variable was the percentage of residents enrolled in MA at admission and categorized into three equally-sized groups. We examined three NH-level outcomes including the percentages of residents assessed and appropriately considered for influenza vaccination, received influenza vaccination, and refused influenza vaccination.

Results: There were 936,513 long-stay residents in 12,384 NHs. Categories for the prevalence of MA enrollment in NHs were low (0% to 3.3%; n = 4131 NHs), moderate (3.4% to 18.6%; n = 4127 NHs) and high (>18.6%; n = 4126 NHs). Overall, 81.3% of long-stay residents received influenza vaccination and 14.3% refused the vaccine when offered. Adjusting for covariates, influenza vaccination rates among long-stay residents were higher in NHs with moderate (1.70 percentage points [pp], 95% confidence limits [CL]: 1.15 pp, 2.24 pp), or high (3.05 pp, 95% CL: 2.45 pp, 3.66 pp) MA versus the lowest prevalence of MA. Influenza vaccine refusal was lower in NHs with moderate (-3.10 pp, 95% CL: -3.53 pp, -2.68 pp), or high (-4.63 pp, 95% CL: -5.11 pp, -4.15 pp) MA compared with NHs with the lowest prevalence of MA.

Conclusion: A higher concentration of long-stay NH residents enrolled in MA was associated with greater influenza vaccine receipt and lower vaccine refusal. As MA becomes a larger share of the Medicare program, and more MA beneficiaries enter NHs, decisionmakers need to consider how managed care can be leveraged to improve the delivery of preventive services like influenza vaccinations in NH settings.

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1. Background

Despite Medicare coverage with no out-of-pocket cost to the beneficiary, and CMS vaccination requirements for nursing homes (NHs), influenza vaccination coverage in NHs remains suboptimal

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[1,2]. At 73.1%, during the 2018–2019 influenza season, vaccination coverage among adults living in NHs fell short of the Healthy People 2020 goal of 90% [3]. The coronavirus disease 2019 (COVID-19) pandemic has not only placed a spotlight on the vulnerability of NH residents to morbidity and mortality from respiratory infections, but it also has emphasized racial and socioeconomic inequities in patient care and outcomes [4,5]. Influenza vaccination can reduce influenza severity and prevent hospitalizations to help avoid the compounded effects of influenza and COVID-19 co-

circulation on the healthcare system and society [6,7]. The widespread provision and acceptance of influenza vaccines is central to any effective strategy to mitigate the spread of influenza infection in NHs. Thus, efforts to promote vaccine uptake in NHs require careful consideration of several factors, including resident profiles, facility attributes, and type of health insurance coverage.

Enrollment in Medicare Advantage (MA) is growing and is projected to increase to 51% of all Medicare beneficiaries in 2030 from 34% in 2019 [8]. Simultaneously, there is rising enrollment of racial and ethnic minorities in MA, and the health profiles of MA and Traditional Medicare (TM) enrollees are increasingly similar over time [9–14]. The historical selection of healthier beneficiaries into MA has diminished (if not reversed) because Medicare implemented changes reducing incentives for MA plans to select enrollees with more favorable risk profiles [15]. MA is distinct from TM in that the Centers for Medicare and Medicaid Services (CMS) pay private health insurance plans on a fixed capitated fee to provide health benefits for Medicare beneficiaries. Features of MA plans such as their payment models, coordinated care, and outreach programs urging high-risk members to get vaccinated may encourage screening and preventive care use to prevent costly medical services [16].

Research among community-dwelling beneficiaries has found higher rates of preventive services use (e.g., mammography screening, annual influenza vaccinations, and cholesterol testing) in MA compared with TM [17–19]. However, these studies did not consider NH populations and rely on data from more than a decade ago. MA plans and the characteristics of their enrollees have changed over time, as has the population of individuals receiving care in NHs [20,21]. The composition of MA beneficiaries in a NH and its relationship with the proportion of residents vaccinated has not been characterized. Yet, this is an important lens through which to examine and address gaps in influenza vaccination coverage in NHs, especially as MA plans may be selectively contracting with NHs, such as those that are larger and are part of a chain [22].

Furthermore, the direction of relationship between MA concentration and NH vaccination rates is uncertain. The shifts in the composition of MA enrollees and the payment model that incentivizes preventive services potentially present opposing possibilities for vaccination rates in NHs. A ‘financial incentives’ hypothesis may suggest that an increased proportion of NH residents enrolled in MA produces higher influenza vaccination rates; participating plans that promote the health of their enrollees in NHs may emphasize preventive services such as influenza vaccinations [23,24]. Another hypothesis informed by previous research proposes that the racial composition of NHs, based on the percentage of Black residents, contributes to individual- and facility-level variation in vaccination coverage [2,25,26]. Then, the proportion of non-White beneficiaries would increase in NHs with more MA enrollees lowering vaccination rates owing to disparities in care. In this context, we aimed to determine how measures of influenza vaccination offer, receipt and refusal differ among NHs with varying concentrations of residents enrolled in MA.

2. Methods

2.1. Study design and data sources

We conducted a national retrospective cohort study of 100% older adult Medicare beneficiaries residing in NHs during the 2014–2015 influenza season (October 1, 2014–March 31, 2015). We selected this period to identify the study population because it overlaps with the period over which influenza vaccination is entered on the Minimum Data Set (MDS) when received from

October 1– March 31. To maximize generalizability, we included all free-standing NHs in the 50 U.S. states, District of Columbia, and Puerto Rico, excluding hospital-based facilities because of significant case-mix and structural differences [27]. We analyzed long-stay (≥ 100 days) NH residents who were ≥ 65 years of age. The 100-day cutoff is informed by Medicare reimbursement policy covering up to 100 days of post-acute skilled nursing facility (SNF) care during each benefit period [28]. We used Medicare enrollment data combined with MDS version 3.0 clinical assessments, and facility level data. We obtained NH organizational and aggregate resident characteristics from Certification and Survey Provider Enhanced Reports (CASPER) and LTCFocus.org (LTCFocus: Long-Term Care: Facts on Care in the US) data. We used CMS’s Nursing Home Compare for overall and domain-specific (staffing, quality, inspections) star rating data.

2.2. NH MA concentration

We determined a beneficiary’s status of MA coverage at the time of NH admission using Medicare enrollment data. We calculated the percentage of residents in each NH who were enrolled in MA. We used the rank procedure to create a dummy variable categorizing NHs into tertiles (low, moderate, high) based on their percentage of MA enrollees.

2.3. Outcomes

We used the MDS to ascertain influenza vaccination status and reasons for vaccine nonreceipt. Although the study population included residents in a NH between October 1st – March 31st, MDS assessments can be submitted with influenza vaccination during those dates through June 30. Therefore, in line with the Nursing Home Compare influenza vaccination quality measures, we assessed all MDS assessments for eligible residents from October 1, 2014 to June 30, 2015 [29]. To reduce misclassification of vaccination status we counted beneficiaries who received an influenza vaccine outside the NH during the current influenza season as vaccinated. This consideration is particularly relevant for short-stay residents who are more likely to be vaccinated in the hospital or elsewhere compared with long-stay NH residents. We examined three vaccination measures at the NH level: 1) percentage of residents assessed and appropriately provided the seasonal influenza vaccine; 2) percentage of receipt of influenza vaccine; and 3) percentage of refusal of influenza vaccine. The percent of residents appropriately assessed and provided influenza vaccination was defined as the sum of the percent vaccinated (i.e., appropriately provided), percent offered and refused, and the percent not eligible/contraindicated (i.e., appropriately assessed). Other possible reasons for non-vaccination that we do not report due to small cell sizes are “inability to obtain influenza vaccine due to a declared shortage” if vaccine is unavailable at the NH and “none of the above.”

2.4. Covariates

Our analysis adjusted for NH-level variables that capture the demographic (age, sex, race/ethnicity) composition of residents and their physical and clinical attributes (e.g., acuity index, activities of daily living scale, cognitive function scale, and comorbidities including serious mental illness and heart failure) as well as facility structural (e.g., for-profit ownership, bed count, occupancy rates, rurality, payer mix) and quality (overall star rating) characteristics. These were selected based on prior literature and substantive knowledge. The overall star rating is a composite score (ranging from 1 to 5) that takes into account a NH’s performance on staffing, health inspections, and care quality measures. We included the

Herfindahl-Hirschman index, which measures the concentration of NH beds in a county, as a covariate to account for variation in NH availability. Additionally, we controlled for the county-level MA penetration rate since MA markets vary substantially. MA penetration is defined as the share of Medicare beneficiaries enrolled in MA plans per county. We used MA penetration data from September 2014 which is the month prior to the start of our observation period [30]. We imputed the state average MA penetration rate for counties with missing or suppressed penetration values due to small sample sizes.

2.5. Statistical analysis

We compare the characteristics of NHs with different concentrations of residents with MA coverage. To assess the relationship between MA concentration and influenza vaccination rates, we conducted a linear regression analysis specified to account for clustering of residents within facilities and facilities within counties using the Huber-White sandwich estimator via generalized estimating equations. We specified an unstructured working correlation structure. In the model we included the dummy variable for the NH's MA concentration and the above-described covariates. Variables with a p -value < 0.05 were considered associated with the outcome.

2.6. Stability analysis

We carried out a stability analysis to determine the robustness of the results by applying an alternate and stricter definition for MA enrollment that required MA coverage during the entire observation period instead of only at admission. This analysis provides information on the extent to which switching from MA to FFS after admission affects the results.

2.7. Analysis of Short-Stay

We additionally analyzed short-stay (<100 days) residents as they can be co-located with long-stay residents in NHs and account for an increasing share of NH residents [31]. Therefore, influenza vaccination for short-stay residents has implications for NH-wide efforts to prevent and control the spread of influenza infection. Several reasons warrant the separate analysis of long-stay and short-stay residents. First, prior research found differences in risk factors for influenza infection and outcomes between these groups [32–34]. Second, there are distinct care goals between short- and long-stay residents [35,36]. Short-stay residents receive recuperative and rehabilitative skilled nursing care immediately following hospitalization prior to returning home. Whereas, long-stay residents predominantly receive custodial care including assistance with activities of daily living. Finally, there are potential differences in how reliably influenza vaccination status is captured in the MDS depending on the duration of a resident's NH stay. A short-stay resident is more likely to be vaccinated outside the NH and there is a possibility of undercounting if influenza vaccination status is not communicated to the NH upon admission. We present the short-stay results in the online [supplementary materials](#).

2.8. Software, data use Agreement, and ethics approval

Data preparation and analyses were conducted using SAS version 9.4 (SAS Institute, Inc., Cary, NC). The Brown University Institutional Review Board approved this study.

3. Results

3.1. Long-Stay cohort

From a national total cohort of 1,690,642 Medicare beneficiaries ≥ 65 years of age, we identified 936,513 long-stay residents living in 12,384 unique Medicare-certified NHs between October 1, 2014 and March 31, 2015 (Table 1). At the resident level, the overall prevalence of MA enrollment at the time of NH admission was 21.4% among long-stay residents. When NHs were classified into three groups by their prevalence of residents enrolled in MA, the groups were classified at the following thresholds: low MA concentration (0% to 3.3%), moderate MA concentration (3.4% to 18.6%), and high MA concentration ($>18.6\%$). The range for the prevalence of MA in NHs within the highest MA concentration category was 18.64% to 100%. There were 13 NHs, representing 0.3% of 4126 NHs in the highest concentration category, with an MA prevalence more than 90%.

3.2. Resident and NH characteristics by MA concentration

Resident and facility characteristics varied by the prevalence of MA beneficiaries in NHs. As the prevalence of MA-enrolled residents increased, the beneficiaries tended to be older in age, and more racially and ethnically diverse. NHs with the highest prevalence of MA enrollees were more often larger, part of a chain system, and located in urban settings. The resident acuity index varied minimally across categories of MA prevalence. However, NHs with increasing MA prevalence had residents with more limitations in activities of daily living, greater cognitive impairment, but lower levels of serious mental illness than NHs with lower MA prevalence. The majority (89.2%) of NHs with low MA prevalence had a high overall star rating of 4 or 5 compared with about half of NHs in the other MA categories who met the same ratings. The prevalence of MA in NHs was higher for facilities located in counties with greater MA penetration rates.

3.3. Influenza vaccination rates by MA concentration

On average, 96.9% of long-stay residents in NHs with a low prevalence of MA-enrolled residents were assessed and appropriately considered for influenza vaccination compared with 94.7% of residents in NHs with the highest prevalence of MA. While the unadjusted rates of influenza vaccine receipt were similar, vaccine refusal decreased as the prevalence of MA enrollees in a NH increased (Fig. 1).

Table 2 presents the unadjusted and adjusted results from multivariable regression models. The adjusted association between MA concentration and influenza vaccine assessment and provision was minimal in magnitude but statistically significant: low MA (reference) versus high MA (prevalence difference -0.82% , 95% confidence limits [-1.22% , -0.42%]).

Influenza vaccination rates among long-stay residents were higher in NHs with moderate (1.70%, [1.15%, 2.24%]), or high (3.05%, [2.45%, 3.66%]) MA compared with NHs with the lowest prevalence of MA (Table 2). Influenza vaccine refusal was lower in NHs with moderate (-3.10% [-3.53% , -2.68%]), or high (-4.63% [-5.11% , -4.15%]) MA compared with NHs with the lowest prevalence of MA. All P values were < 0.0001 .

NH variables that were positively associated with higher rates of appropriate assessment and provision and influenza vaccination included mean age, occupancy rate, high NH quality star rating, percent with serious mental illness, percent paying with Medicaid, and the Herfindahl-Hirschman index. In contrast, for profit and chain ownership and increasing percent of Black residents were

Table 1
Resident and nursing home characteristics by category of Medicare Advantage concentration, long-stay residents, 2014–2015.

	Overall	Nursing Home Prevalence of Residents with Medicare Advantage		
		0%–3.3%	3.4%–18.6%	>18.6%
Resident-level Characteristics				
Number of individuals	936,513	267,924	326,106	342,483
Age in years, mean (sd)	84.0 (8.7)	83.8 (8.7)	84.0 (8.7)	84.2 (8.6)
Age category, %				
65–74	18.1	18.6	18.1	17.6
75–84	13.5	13.7	13.5	13.3
85+	68.5	67.8	68.3	69.1
Female sex, %	70.6	69.8	70.7	71.1
Race/ethnicity, %				
White	82.8	83.4	83.8	81.5
Black	12.3	12.4	11.8	12.6
Hispanic	2.0	2.0	2.0	2.1
Asian	1.5	0.8	1.2	2.2
Enrolled in MA at NH admission	21.4	10.9	10.4	40.0
Enrolled in MA during entire study period	18.2	9.4	8.7	34.3
Nursing Home Characteristics from CASPER and LTCFocus				
Number of facilities	12,384	4,131	4,127	4,126
MA enrollment at admission, mean (sd) %	16.8 (19.5)	0.4 (0.9)	10.4 (4.3)	39.6 (17.0)
median (Q1, Q3)	10.2 (0, 25.0)	0 (0, 0)	10.2 (6.7, 13.8)	71.4 (64.7, 77.3)
Rural setting, %	26.9	38.4	29.3	13.1
For profit, %	73.0	70.4	75.6	73.0
Multifacility/chain, %	57.8	51.4	60.4	61.7
Total beds, mean (sd) %	113 (61)	82 (8)	116 (56)	124 (69)
Occupancy rate, mean (sd) %	83.1 (13.8)	81.4 (14.8)	83.2 (13.6)	84.7 (12.6)
Black resident composition including non-Medicare, mean (sd) %	11.6 (18.0)	11.9 (18.8)	11.3 (17.6)	11.6 (17.6)
Percent paying with Medicaid, mean (sd) %	60.1 (22.2)	62.0 (22.4)	59.3 (22.6)	58.9 (21.3)
Resident acuity index	12.2 (1.3)	11.9 (1.5)	12.3 (1.2)	12.3 (1.3)
Mean ADL score for residents in facility	16.6 (2.7)	15.7 (3.2)	16.8 (2.4)	17.1 (2.3)
Residents with heart failure, mean (sd) %	20.1 (9.6)	19.8 (10.4)	20.2 (9.1)	20.3 (9.2)
Residents with schizophrenia and/or bipolar disorder, mean (sd) %	9.9 (12.4)	11.9 (16.1)	9.0 (10.1)	8.8 (9.8)
Residents with low cognitive function score, mean (sd) %	33.1 (13.6)	31.8 (14.8)	33.0 (13.0)	34.4 (12.7)
Low resource facility based on payer mix, %	6.66	9.1	5.7	5.2
Herfindal index of nursing home beds in county, mean (sd)	0.19 (0.23)	0.24 (0.26)	0.21 (0.25)	0.12 (0.17)
MA penetration in NH county, mean (sd) %	28.9 (14.1)	23.0 (13.2)	25.2 (11.2)	38.5 (12.4)
Above average MA penetration in county, %	48.1	31.9	34.1	78.1
Nursing Home Quality Characteristics				
High overall Nursing Home Compare rating, 4–5 stars, %	64.9	89.2	52.9	52.6
Overall star rating (range 1–5 stars), mean (sd)	3.8 (1.3)	4.6 (0.9)	3.4 (1.3)	3.4 (1.3)
Staffing rating, mean (sd)	3.7 (1.2)	4.6 (0.9)	3.3 (1.1)	3.3 (1.1)
Quality rating, mean (sd)	4.4 (0.9)	4.8 (0.6)	4.2 (0.9)	4.3 (0.9)
Inspection/survey rating, mean (sd)	3.1 (1.2)	3.7 (0.8)	2.8 (1.3)	2.7 (1.3)

NH: nursing home, SD: standard deviation, MA: Medicare Advantage, CASPER: Certification and Survey Provider Enhanced Reporting, LTCFocus: Long-Term Care: Facts on Care in the US, ADL: Activities of Daily Living – on a scale of 0 to 28, higher scores indicate more limitations in these activities, CFS: cognitive function score – lower scores indicate less cognitive impairment.

*The Herfindal index is a measure of the size of any entity in relation to the industry in which those entities operate (i.e., market concentration). It ranges from 0 to 1 with higher values indicating greater concentration.

associated with decreased assessment and appropriate provision, and influenza vaccination. See [Table 3](#) for the covariate estimates and the corresponding 95% confidence limits.

3.4. Stability Analysis: Alternate MA enrollment definition

Changing the definition of MA enrollment yielded substantively similar results to the main analysis. There appeared to be a clearer dose response relationship when MA was defined on the basis of enrollment throughout the entire observation period rather than at the time of admission. See supplementary Table S1.

3.5. Short-stay analysis

See [supplementary materials](#) (Tables S2–S4 and [Figure S1](#)) for a summary of the short-stay results.

4. Discussion

This study investigated influenza vaccination receipt and non-receipt among older adults in NHs, and their variation on the basis

of the concentration of residents enrolled in MA. We found that although nearly all long-stay residents were assessed and appropriately considered for influenza vaccination (95.5%), influenza vaccine receipt was lower (81.3%) largely due to high refusal rates (13.4%) when the vaccine was offered. Additionally, although crude estimates were similar, in adjusted models we found that as the concentration of MA enrollees increased so did receipt of influenza vaccination among long-stay residents.

Our finding that NHs with a greater share of MA enrollees have higher influenza vaccination coverage rates among long-stay residents are consistent with perspectives that MA plans promote preventive care use. Given that nearly all the attention on MA efforts to improve preventive care use has targeted community-dwelling beneficiaries, the extent to which MA plans conduct health promotion efforts in NHs is unknown. Individual MA plans conduct care coordination and health promotion efforts for their beneficiaries with varying rigor and success. As such, MA beneficiaries may not experience these benefits uniformly as MA plans are not created equal [24]. The processes that MA plans have in place for outreach and education for providers and patients in NH settings deserve attention in efforts to increase vaccination rates. The

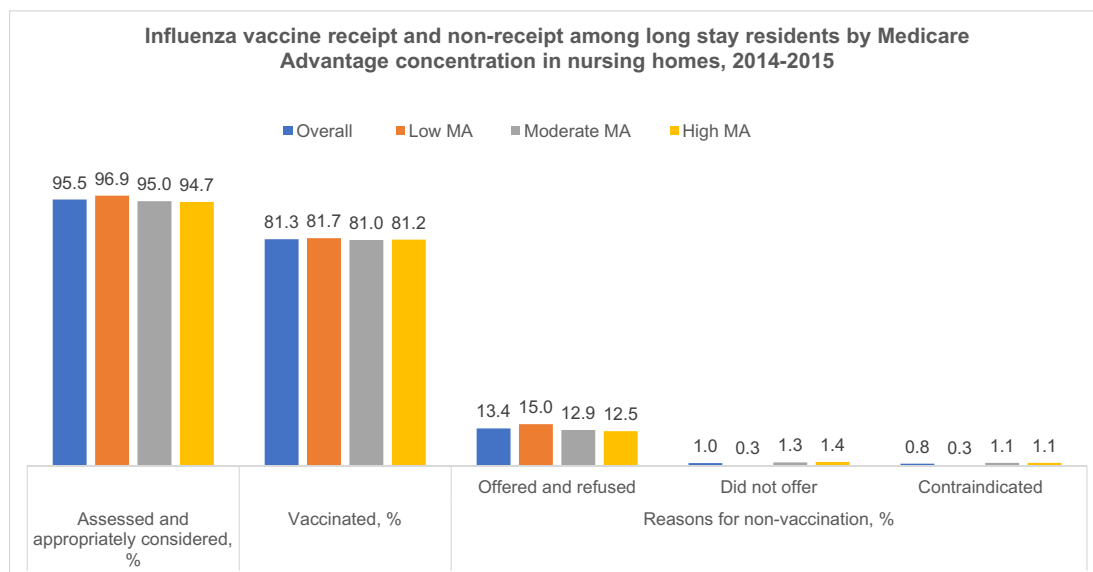


Fig. 1. Unadjusted vaccination receipt and non-receipt by Medicare Advantage concentration among long-stay residents, 2014–2015.

Table 2

Association between the nursing home Medicare Advantage concentration and influenza vaccination rates among long-stay residents, 2014–2015.

	Assessed and appropriately considered		Vaccinated		Offered and refused vaccine	
	Prevalence difference		Prevalence difference		Prevalence difference	
	Unadjusted, % (95% CL)	Adjusted, % (95% CL)	Unadjusted, % (95% CL)	Adjusted, % (95% CL)	Unadjusted, % (95% CL)	Adjusted, % (95% CL)
Low MA Prevalence (n = 4,131 NHs; 267,924 people)	reference	reference	reference	reference	reference	reference
Moderate MA Prevalence (n = 4,127 NHs; 326,106 people)	–1.97 (–2.23, –1.71)	–0.70 (–1.06, –0.34)	–0.66 (–1.12, –0.21)	1.70 (1.15, 2.24)	–2.11 (–2.47, –1.75)	–3.10 (–3.53, –2.68)
High MA Prevalence (n = 4,126 NHs; 236,782 people)	–2.25 (–2.52, –1.98)	–0.82 (–1.22, –0.42)	–0.54 (–0.99, –0.08)	3.05 (2.45, 3.66)	–2.51 (–2.87, –2.16)	–4.63 (–5.11, –4.15)

CL: confidence limits.

importance of addressing this knowledge gap is magnified by the growing enrollment in MA [8], expensive costs of post-acute and long-term care [37], and high risk of morbidity and mortality due to respiratory infections in NH residents and older adults generally [38,39]. The COVID-19 pandemic adds further imperative to explore levers (e.g., care coordination and initiatives to promote preventive care) at the MA plan level to improve NH influenza vaccination coverage. While improving uptake of the annual influenza vaccine is a perennial challenge [2], the availability of a vaccine for COVID-19 means that it will be even more critical to ensure high vaccination rates among NH residents – a population that has experienced disproportionately high rates of COVID-19 cases and deaths [40].

Since the composition of residents in a NH often includes a mix of post-acute short-stay and long-stay residents [41], effective influenza mitigation strategies should also target improving the assessment and appropriate provision of the vaccine to short-stay residents [34]. This may require NHs to maintain vaccine supplies over a longer period during influenza season. Doing so could create a low-barrier opportunity for NHs to improve their influenza vaccination performance by extending their efforts to offer and vaccinate short-stay residents. Such targeted efforts could be especially beneficial for NHs with large proportions of short-stay residents. In addition, our results suggest actions to improve overall NH Compare star ratings (targeting 4 or 5 stars) could contribute

to better vaccination rates. While the quality domain of star ratings includes NH vaccination coverage, this is unlikely to fully explain the strong independent associations of the overall star rating with vaccination rates in multivariable analyses.

This study has limitations. First, this is a cohort study focusing on a single influenza season (2014–2015). Nonetheless, the findings provide foundational evidence that point to the relevance of further investigation through longitudinal and more recent data. Second, we relied on facility-level resident acuity and comorbidity measures from the CASPER database rather than resident-level MDS clinical assessments. However, by using CASPER variables we avoided making assumptions that would be required to handle missing data particularly for short-stay residents who more frequently have missing information on MDS-derived variables. In addition, our findings may not generalize to beneficiaries younger than 65 years, residing in the community, or with insurance coverage other than Medicare.

In conclusion, this study found that higher concentration of MA beneficiaries in NHs is associated with increased rates of influenza vaccination receipt among long-stay residents after adjusting for covariates. Vaccine refusal when offered was lower as the prevalence of long-stay MA beneficiaries increased. As the MA program continues to grow and more MA-enrolled beneficiaries enter NHs, concerted efforts by MA plans and NHs will be essential to improve influenza vaccination rates and reduce vaccine refusals. This

Table 3
Estimates from multivariable regression models of vaccination rates among long-stay nursing home residents, 2014–2015.

	Assessed and appropriately considered		Vaccinated		Offered and refused	
	Prevalence difference (%)	95% Confidence Limits	Prevalence difference (%)	95% Confidence Limits	Prevalence difference (%)	95% Confidence Limits
MA Concentration Category						
Low MA	reference	reference	reference	reference	reference	reference
Moderate MA	−0.70	−1.06, −0.34	1.70	1.15, 2.24	−3.10	−3.53, −2.68
High MA	−0.82	−1.22, −0.42	3.05	2.45, 3.66	−4.63	−5.11, −4.15
Mean age	0.29	0.16, 0.42	0.95	0.79, 1.11	−0.63	−0.76, −0.50
Percent female	0.01	−0.02, 0.05	−0.05	−0.09, −0.01	0.06	0.04, 0.09
Urban vs. rural setting	−0.49	−0.75, −0.22	−0.32	−0.76, 0.12	−0.18	−0.53, 0.16
For profit vs. non-profit	−0.49	−0.74, −0.25	−2.84	−3.27, −2.41	2.38	2.04, 2.72
Multifacility/chain vs. non-chain	−0.60	−0.82, −0.39	−1.18	−1.54, −0.81	0.56	0.27, 0.86
Total beds, mean n	0.001	−0.0004, 0.003	−0.002	−0.005, 0.002	0.003	0.0004, 0.005
Occupancy rate, mean %	0.02	0.01, 0.03	0.04	0.03, 0.06	−0.02	−0.03, −0.009
Black resident composition including non-Medicare, mean %	−0.03	−0.04, −0.02	−0.10	−0.11, −0.09	0.07	0.06, 0.08
Percent paying with Medicaid, mean %	0.04	0.03, 0.05	0.07	0.06, 0.09	−0.04	−0.05, −0.02
Resident acuity index	0.20	−0.03, 0.44	0.25	−0.07, 0.58	−0.09	−0.30, 0.13
Mean ADL score for residents in facility	−0.03	−0.13, 0.06	−0.12	−0.25, 0.02	0.09	0.0005, 0.19
Percent of residents with heart failure	0.01	−0.007, 0.02	−0.01	−0.03, 0.02	0.01	−0.01, 0.03
Percent of residents with schizophrenia and/or bipolar disorder	0.03	0.02, 0.05	0.05	0.03, 0.07	−0.01	−0.03, 0.01
Percent of residents with low cognitive function score, mean	−0.005	−0.02, 0.01	−0.07	−0.08, −0.05	0.06	0.04, 0.07
Low resource vs. high resource facility based on payer mix	0.08	−0.42, 0.58	0.39	−0.49, 1.26	−0.32	−1.02, 0.39
Herfindal index for nursing home beds in county, range 0–1	0.88	0.43, 1.33	2.45	1.66, 3.24	−1.76	−2.40, −1.13
Overall Nursing Home Compare rating of 4–5 stars vs. 1–3 stars	1.56	1.26, 1.86	2.03	1.55, 2.51	−0.40	−0.78, −0.02
MA penetration in NH county (above vs. below national average)	−0.02	−0.28, 0.25	−2.04	−2.46, −1.61	2.10	1.77, 2.43

NH: nursing home, MA: Medicare Advantage, CASPER: Certification and Survey Provider Enhanced Reporting, LTCFocus: Long-Term Care: Facts on Care in the US, ADL: Activities of Daily Living – on a scale of 0 to 28, higher scores indicate more limitations in these activities, CFS: cognitive function score – lower scores indicate less cognitive impairment.

*The Herfindal index is a measure of the size of any entity in relation to the industry in which those entities operate (i.e., market concentration). It ranges from 0 to 1 with higher values indicating greater concentration.

importance is magnified in the COVID-19 era when mitigating the transmission of respiratory infections is of critical importance for the health of NH residents and staff.

CRedit authorship contribution statement

Patience Moyo: Conceptualization, Data curation, Formal analysis, Methodology, Writing - original draft, Writing - review & editing. **Elliott Bosco:** Conceptualization, Data curation, Methodology, Writing - review & editing. **Barbara H. Bardenheier:** Conceptualization, Methodology, Writing - review & editing. **Maricruz Rivera-Hernandez:** Conceptualization, Methodology, Writing - review & editing. **Robertus van Aalst:** Conceptualization, Methodology, Writing - review & editing. **Ayman Chit:** Conceptualization, Methodology, Writing - review & editing. **Stefan Gravenstein:** Conceptualization, Funding acquisition, Methodology, Writing - review & editing. **Andrew R. Zullo:** Conceptualization, Data curation, Funding acquisition, Supervision, Methodology, Writing - review & editing.

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: [EB, ARZ, BHB, and PM declare no conflicts of interest. RVA and AC are employed by Sanofi Pasteur. SG reports grants and personal fees from Seqirus, Sanofi; and consulting or speaker fees from Sanofi, Merck, Longe-

veron, and the Gerontological Society of America for research related to vaccines or NH care quality.].

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Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.vaccine.2021.12.069>.

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