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Long-term Care Facility Variation in the Incidence of Pneumonia and Influenza

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Background. Pneumonia and influenza (P&I) increase morbidity and mortality among older adults, especially those residing in long-term care facilities (LTCFs). Facility-level characteristics may affect the risk of P&I beyond resident-level risk factors. However, the relationship between facility characteristics and P&I is poorly understood. To address this, we identified potentially modifiable facility-level characteristics that influence the incidence of P&I across LTCFs.

Methods. We conducted a retrospective cohort study using 2013–2015 Medicare claims linked to Minimum Data Set and LTCF-level data. Short-stay (<100 days) and long-stay (100+ days) LTCF residents were followed for the first occurrence of hospitalization, LTCF discharge, Medicare disenrollment, or death. We calculated LTCF risk-standardized incidence rates (RSIRs) per 100 person-years for P&I hospitalizations by adjusting for over 30 resident-level demographic and clinical covariates using hierarchical logistic regression.

Results. We included 1 767 241 short-stay (13 683 LTCFs) and 922 863 long-stay residents (14 495 LTCFs). LTCFs with lower RSIRs had more licensed independent practitioners (nurse practitioners or physician assistants) among short-stay (44.9% vs 41.6%, $P < .001$) and long-stay residents (47.4% vs 37.9%, $P < .001$), higher registered nurse hours/resident/day among short-stay and long-stay residents (mean [SD], 0.5 [0.7] vs 0.4 [0.4], $P < .001$), and fewer residents for whom antipsychotics were prescribed among short-stay (21.4% [11.6%] vs 23.6% [13.2%], $P < .001$) and long-stay residents (22.2% [14.3%] vs 25.5% [15.0%], $P < .001$).

Conclusions. LTCF characteristics may play an important role in preventing P&I hospitalizations. Hiring more registered nurses and licensed independent practitioners, increasing staffing hours, and higher-quality care practices may be modifiable means of reducing P&I in LTCFs.

Keywords.: influenza; long-term care; Medicare; nursing homes; pneumonia.

Pneumonia and influenza (P&I) are responsible for substantial morbidity and mortality among older adults [1, 2]. Approximately 90% of all P&I deaths occur among individuals aged 65 or older [3]. The risk of P&I infection is particularly high for older adults residing in long-term care facilities (LTCFs), a population totaling 1.3 million across approximately 16 000 LTCFs nationwide [4]. In 2017, the Centers for Medicare and Medicaid Services (CMS) required all LTCFs to implement Infection Prevention and Control Programs to reduce P&I incidence [5, 6]. Although this policy requires LTCFs to develop procedures for infection control and treatment, the most important risk factors for P&I incidence in LTCFs remain unknown. Facility-level characteristics such as staffing, structure, and care practices may be important modifiable determinants of P&I risk. Prior data suggest that these factors influence all-cause hospitalization rates, resident hip fracture rates, and prescribing of antipsychotics [7–10]. Additionally, it has been shown that overall staffing hours among LTCFs are frequently below recommended levels [11]. Meaningful reductions in the burden of P&I in LTCFs are likely impossible if modifiable facility-level determinants remain unidentified.

Few studies have examined LTCF-level P&I hospitalization rates or their determinants, and existing ones were limited in scope and design. For example, prior studies did not use national data and evaluated a relatively small subset of facilities, producing imprecise estimates that do not generalize well to all LTCFs [12–14]. Second, previous studies ignored the amount of time residents spent in LTCFs when reporting incidence rates, which may lead to biased estimates [15–17]. Third, existing evidence does not differentiate between short-stay and long-stay LTCF populations or focuses primarily on long-stay residents.

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Making this distinction is important as the short-stay (ie, post–acute care) population is larger, costlier, and distinct from the long-stay population [18]. Additionally, short- and long-stay residents are often cared for in the same LTCF, with >90% of LTCFs certified to care for both populations [19]. Altogether, these limitations have prevented an understanding of how facility-level characteristics and practices affect P&I hospitalization across LTCFs.

Therefore, the objectives of our study were (1) to determine whether P&I rates vary across US LTCFs after adjusting for resident characteristics and (2) to identify modifiable facility-level characteristics associated with lower P&I rates. We hypothesized that employment of a variety of health care providers, increased staffing hours, and high-quality care practices (such as decreased antipsychotic prescribing) would be associated with a lower rate of P&I hospitalizations across LTCFs.

METHODS

Data Source

Medicare Part A claims were linked to Minimum Data Set (MDS), version 3.0, Online Survey, Certification and Reporting and Certification And Survey Provider Enhanced Reports (OSCAR/CASPER) and LTCFocus data using unique identifiers for all LTCF residents enrolled in Medicare fee-for-service. The MDS is a government-mandated assessment for LTCFs that documents health information of LTCF residents including demographics, clinical conditions, functional status, psychological, and cognitive status for treatment planning. OSCAR/CASPER are facility data collected by state survey agencies during annual LTCF certification inspections. OSCAR/CASPER data were used to assess facility-level factors such as primary payer, number of facility beds, and staffing [20]. LTCFocus data from Brown University provide additional facility information, including facility all-cause rehospitalization rates and admissions per bed [21]. The validated residential history file algorithm was applied to the data sets to characterize residents' timing and location of health services utilization [22]. The institutional review board at Brown University approved the study protocol.

Study Design and Population

This was a retrospective cohort study derived from a national source population of >7.2 million Medicare beneficiaries residing in 15 887 LTCFs between January 1, 2013, and December 31, 2015. Eligible LTCF residents were classified as short-stay with a total stay of <100 days in the same LTCF or long-stay with a total stay of ≥100 consecutive days and no more than 10 days outside of the facility. Index dates were assigned as the date of LTCF entry for short-stay residents and the 100th day of a stay for long-stay residents. Follow-up occurred from each resident's index date until hospitalization, discharge from the LTCF, disenrollment from Medicare, death, or the end of the study period, whichever occurred first. The residents' first LTCF stay was identified, and subsequent stays were excluded. Those included in the study population had 6 months of continuous enrollment in Medicare Part A before index, were age 65 years or older at index, and had at least 1 MDS assessment within the 100 days before the index date for long-stay residents and upon entry to the facility for short-stay residents for use in resident characteristic ascertainment. We excluded residents on a health maintenance organization (HMO; ie, Medicare Advantage) plan at any time during the study period and individuals with missing data on any covariate used in modeling. We also excluded LTCFs that were hospital-based because they differ markedly from most LTCFs in their structure, access to physicians, and hospital resources. Finally, we excluded LTCFs with <180 total person-days contributed during the study window. Based on empirical analyses, we found that 180 person-days was sufficient to estimate stable facility-level rates for both short- and long-stay populations while also maximizing the study sample to ensure generalizability of the findings.

Resident Characteristics

Demographic variables such as age, sex, and date of death were obtained from the Medicare Enrollment file. All other resident characteristics (eg, race/ethnicity) were derived from MDS assessments. Functional status was assessed by calculating the 28-point Morris Activities of Daily Living (ADL) Scale [23]. The Cognitive Function Scale (CFS) was used to assess cognitive status [24]. The Changes in Health, End-Stage Disease and Symptoms and Signs (CHESS) score was calculated as a measure of health instability and likelihood of future mortality [25]. Resident comorbidities, including asthma, chronic obstructive pulmonary disease, heart disease, and cancer, were identified from the Active Diagnoses section of the MDS. Receipt of pneumococcal and influenza vaccinations was assessed through a previously published algorithm [26].

Facility Characteristics

Facility-level variables were obtained from OSCAR/CASPER and LTCFocus data. We selected characteristics a priori based on prior literature [11, 27] and subject matter knowledge. Both potentially modifiable and likely nonmodifiable facility characteristics were ascertained because (1) modifiability is subjective and may vary by facility and (2) understanding the contribution of nonmodifiable characteristics is important for health care system planning and policy development. We considered likely nonmodifiable LTCF characteristics, such as number of beds, occupancy rate, resident primary payer (Medicare, Medicaid, or other), facility Acuity Index [28], if the facility was located in an urban center, if the facility was for-profit, location based on Census region, and admissions per bed.

Modifiable characteristics focused on four primary components of LTCF care: (1) specific types of health care providers on staff at the LTCF, (2) the staffing hours of registered nurses (RNs) and

certified nursing assistants (CNAs), (3) quality measures related to care processes, and (4) the relationship between short-stay and long-stay care provided in an LTCF. Variables reflecting staffing in the LTCF included the ratio of registered nurses (RNs) to total nurses (RNs and licensed practical nurses), the on-site presence of a licensed independent practitioner (LIP; either a physician assistant [PA] or an advanced practice RN [APRN]), and speech language pathologist (SLP) on-staff hours per 100 beds. We captured staffing hours of RNs and CNAs by analyzing the total nursing hours/resident/day, CNA hours/resident/day, and RN hours/resident/day. Quality measures included the percentage of residents receiving antipsychotics, percentage of residents restrained, percentage of residents with a pressure ulcer, and overall LTCF hospitalizations per resident-year. Although there are many CMS quality measures, we chose to evaluate those that have been previously studied in relation to P&I [15]. LTCFs often care for both short- and long-stay residents within the same facility; thus we calculated the LTCF's short-stay proportion of person-time to assess the relationship between these populations and their associated needs within each LTCF. We calculated this by dividing the LTCF's short-stay resident person-time by the total person-time (sum of short- and long-stay person-time).

Pneumonia and Influenza Hospitalizations

P&I hospitalizations that occurred while an individual was a resident in an LTCF were identified using Medicare Part A claims data. As is common in previous studies, P&I hospitalizations were identified by the presence of an International Classification of Diseases, 9th Revision (ICD-9) or 10th Revision (ICD-10), diagnosis code for pneumonia or influenza-like-illness (480–488.XX, J09–J18) in the principal position on the claim [29, 30].

Statistical Methods

Resident demographic and clinical characteristics vary greatly across LTCFs. Thus, to better understand the LTCF-level drivers of P&I hospitalization, we calculated crude P&I hospitalization incidence rates (IRs) and risk-standardized incidence rates (RSIRs) to adjust for resident-level differences across LTCFs. First, crude IRs were calculated as the total number of P&I hospitalizations occurring in the LTCF divided by residents' cumulative person-time, then scaled to 100 person-years. Next, to adjust for LTCF resident characteristics that may influence facility-level IRs, we used risk standardization via hierarchical logistic modeling adapted from the CMS methodology for publicly reporting hospital readmission rates [31]. Risk standardization is a form of indirect standardization that accounts for within-LTCF clustering of residents, removing bias in the assessment of the relation between LTCF characteristics and P&I hospitalizations [31]. To estimate facility RSIRs, we adjusted for 39 resident-level demographic and clinical covariates from the MDS and each facility's hospitalization rate per resident year from LTCFocus using facility-specific and facility-average hierarchical models (Supplementary Data, Supplementary Table 1). We included each LTCF's overall hospitalization rate in the models to reduce measurement bias in the estimates of P&I. Each LTCF has a different probability of hospitalizing residents, and thus ascertainment of P&I will differ by LTCF. Inclusion of this allows for a less biased comparison of P&I rates across facilities. We calculated 95% confidence intervals (CIs) for each LTCF's RSIR using the bootstrap percentile method with 500 replications of the resident-level data set and random selection by LTCF with replacement.

Facilities were ranked from lowest to highest RSIR and subdivided into 2 groups at the 50th percentile. We then examined differences in resident and facility characteristics between the 2 groups using *t* tests and chi-square tests. All analyses were 2-tailed with an α set at 0.05. We performed all analyses separately for the short-stay and long-stay populations. Data were analyzed using SAS, version 9.4 (SAS Institute, Inc., Cary, NC), and R, version 3.4 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Study Cohort

The final study cohort consisted of 1 767 241 short-stay residents in 13 683 LTCFs and 922 863 long-stay residents in 14 495 LTCFs (Supplementary Figure 1). The median number of residents per facility (interquartile range [IQR]) was 77 (35–165) and 57 (36–84) for short- and long-stay residents, respectively. The short-stay population was younger, more Caucasian and male, less vaccinated for P&I, and carried fewer diagnoses than the long-stay population (Tables 1 and 2; Supplementary Tables 2 and 3).

Crude and Risk-Standardized Facility-Level Pneumonia and Influenza Incidence Rates

During the study period, 52.6% of LTCFs (7198/13683) had at least one P&I hospitalization in the short-stay population, and 87.6% of LTCFs (12 692/14 495) had at least one P&I hospitalization in the long-stay population. The crude IR per 100 person-years among LTCFs ranged from 0 to 320.18 with a median (IQR) of 4.73 (0–17.87) for short-stay residents, whereas the crude IR ranged from 0 to 193.63 with a median of 7.58 (3.79–12.61) for long-stay residents. The RSIR per 100 person-years across LTCFs ranged from 5.14 to 39.79 with a median (IQR) of 10.16 (9.37–11.82) for short-stay residents (Supplementary Figure 2A), and from 2.96 to 51.96 with a median of 8.51 (6.87–10.92) for long-stay residents (Supplementary Figure 2B). The difference between the LTCF crude IR and RSIR was greater for short-stay residents than long-stay residents (Supplementary Figure 3).

Likely Unmodifiable Facility-Level Characteristics

Considering characteristics that are likely nonmodifiable or difficult to modify, LTCFs with lower RSIRs in both short- and

Table 1. Characteristics of Short-Stay and Long-Stay Residents

Characteristic	Short-Stay Residents (n = 1 767 241)	Long-Stay Residents (n = 922 836)
Demographics		
Age	81.0 (8.3)	82.9 (8.4)
Female	1 094 475 (61.9%)	613 549 (66.5%)
Race/ethnicity:		
White non-Hispanic	1 500 769 (84.9%)	747 156 (81.0%)
Black non-Hispanic	127 408 (7.2%)	100 300 (10.9%)
Hispanic	49 189 (2.8%)	36 534 (4.0%)
Other	90 207 (5.1%)	39 031 (4.2%)
Region:		
Northeast	333 838 (19.5%)	172 443 (19.3%)
Midwest	457 593 (26.7%)	265 493 (29.7%)
West	280 022 (16.3%)	98 867 (11.1%)
South	641 632 (37.5%)	357 425 (40.0%)
Other	188 (<0.1%)	0 (0.0%)
Marital status	649 249 (37.4%)	219 838 (24.1%)
BMI, kg/m^2	26.5 (6.9)	26.2 (6.8)
Tobacco use	39 490 (2.2%)	31 574 (3.4%)
Influenza vaccination	953 052 (53.9%)	597 544 (64.8%)
Pneumococcal vaccination	1 123 309 (63.6%)	644 314 (69.8%)
Clinical characteristics		
Charlson Comorbidity Index–MDS	2.8 (2.0)	3.0 (2.1)
ADL status[a]		
Independent to limited assistance required	849 839 (48.1%)	284 736 (30.9%)
Extensive assistance required	596 412 (33.7%)	350 555 (38.0%)
Extensive dependency	320 990 (18.2%)	287 545 (31.2%)
Health instability[b]		
No instability	973 621 (55.1%)	486 899 (52.8%)
Minimal health instability	505 739 (28.6%)	282 974 (30.7%)
Low health instability	241 683 (13.7%)	122 489 (13.3%)
Moderate to very high instability	46 198 (2.6%)	30 474 (3.3%)
Cognitive function[c]		
Cognitively intact	1 142 086 (64.6%)	307 544 (33.3%)
Mildly impaired	327 841 (18.6%)	233 705 (25.3%)
Moderately impaired	230 440 (13.0%)	305 969 (33.2%)
Severely impaired	66 874 (3.8%)	75 618 (8.2%)

The data are presented as either mean (standard deviation) or count (%).

Abbreviations: ADL, activities of daily living; BMI, body mass index; MDS, Minimum Data Set; P&I, pneumonia and influenza; RSIR, risk-standardized incidence rate.

[a]Measured using the Morris 28-point scale of Independence in ADLs and categorized as 0 to 14 (independent to limited assistance required), 15 to 19 (extensive assistance required), or 20 or higher (extensive dependency).

[b]Measured using CHESS, a 6-point scale of health instability, ranging from 0 = not at all unstable to 5 = highly unstable, categorized as 0 (no instability), 1 (minimal health instability), 2 (low health instability), and 3 or higher (moderate to very high health instability).

[c]Measured using CFS, a 4-point scale of cognitive function categorized as 0 (cognitively intact), 1 (mildly impaired), 2 (moderately impaired), and 3 (severely impaired).

long-stay populations tended to have more beds and care for more residents (Table 3; Supplementary Tables 4 and 5). They were also located in urban centers, had more residents with Medicare as a primary payer, had a higher Acuity Index, and had more admissions per bed. Profit status and chain ownership of LTCFs did not differ between high and low LTCF RSIR for the short-stay population.

Potentially Modifiable Facility-Level Characteristics

Lower RSIR LTCFs employed a greater variety of health care providers and had more staffing hours. LTCFs with lower RSIRs had more LIPs in both the short-stay (44.9% vs 41.6%, $P < .001$) and long-stay populations (47.4% vs 37.9%, $P < .001$). LTCFs with lower RSIRs also had higher RN/total nursing ratios in the short-stay (mean [SD], 0.4 [0.2] vs 0.3 [0.2], $P < .001$) and long-stay populations (0.4 [0.2] vs 0.3 [0.2], $P < .001$). Of note, SLP on-staff hours per 100 beds was not significantly different between low and high RSIR LTCFs in the short-stay population (0.4 [0.8] vs 0.3 [2.1], $P = .306$) but was significantly different in the long-stay population (0.4 [0.8] vs 0.3 [2.0], $P < .001$). The RN hours/resident/day was also higher in LTCFs with fewer hospitalizations among short- and long-stay residents (0.5 [0.7] vs 0.4 [0.4], $P < .001$). LTCFs with lower RSIRs had a lower percentage

Table 2. Characteristics of Short-Stay and Long-Stay Residents Stratified by Risk-Standardized Pneumonia and Influenza Incidence Rate

Characteristic	Short-Stay <50th Percentile P&I RSIR (n = 1 006 809)	Short-Stay ≥50th Percentile P&I RSIR (n = 760 432)	Long-Stay <50th Percentile P&I RSIR (n = 472 515)	Long-Stay ≥50th Percentile P&I RSIR (n = 450 231)
Demographics				
Age, y	81.0 (8.4)	80.9 (8.3)	83.1 (8.4)	82.7 (8.4)
Female	625 384 (62.1%)	469 091 (61.7%)	313 082 (66.3%)	300 467 (66.7%)
Race/ethnicity				
White, non-Hispanic	852 724 (84.7%)	648 045 (85.2%)	385 080 (81.5%)	362 076 (80.4%)
Black, non-Hispanic	72 076 (7.2%)	55 332 (7.3%)	50 127 (10.6%)	50 173 (11.1%)
Hispanic	27 024 (2.7%)	22 165 (2.9%)	16 219 (3.4%)	20 315 (4.5%)
Other	55 176 (5.5%)	35 031 (4.6%)	21 196 (4.5%)	17 835 (4.0%)
Clinical characteristics				
BMI, kg/m^2	26.5 (6.8)	26.5 (7.0)	26.1 (6.8)	26.4 (6.8)
Charlson Comorbidity Index–MDS	2.7 (2.0)	2.8 (2.0)	3.1 (2.1)	3.0 (2.0)
ADL status[a]				
Independent to limited assistance required	474 785 (47.2%)	375 054 (49.3%)	132 053 (27.9%)	152 683 (33.9%)
Extensive assistance required	349 082 (34.7%)	247 330 (32.5%)	189 680 (40.1%)	160 875 (35.7%)
Extensive dependency	182 942 (18.2%)	138 048 (18.2%)	150 782 (31.9%)	136 763 (30.4%)
Health instability[b]				
No instability	559 575 (55.6%)	414 046 (54.4%)	249 825 (52.9%)	237 074 (52.6%)
Minimal health instability	285 420 (28.3%)	220 319 (29.0%)	145 148 (30.7%)	137 826 (30.6%)
Low health instability	136 307 (13.5%)	105 376 (13.9%)	62 439 (13.2%)	60 050 (13.3%)
Moderate to very high instability	25 507 (2.5%)	20 691 (2.7%)	15 103 (3.2%)	15 371 (3.4%)
Cognitive function[c]				
Cognitively intact	660 481 (65.6%)	481 605 (63.3%)	162 172 (34.3%)	145 372 (32.3%)
Mildly impaired	183 399 (18.2%)	144 442 (19.0%)	118 559 (25.1%)	115 146 (25.6%)
Moderately impaired	126 471 (12.6%)	103 969 (13.7%)	153 885 (32.6%)	152 084 (33.8%)
Severely impaired	36 458 (3.6%)	30 416 (4.0%)	37 899 (8.0%)	37 719 (8.4%)
Influenza vaccination	552 311 (54.9%)	400 741 (52.7%)	305 509 (64.7%)	292 035 (64.9%)
Pneumococcal vaccination	651 130 (64.7%)	472 179 (62.1%)	330 631 (70.0%)	313 683 (69.7%)

The data are presented as either mean (standard deviation) or count (%).

Abbreviations: ADL, activities of daily living; BMI, body mass index; MDS, Minimum Data Set; P&I, pneumonia and influenza; RSIR, risk-standardized incidence rate.

[a]Measured using the Morris 28-point scale of Independence in ADLs and categorized as 0 to 14 (independent to limited assistance required), 15 to 19 (extensive assistance required), or 20 or higher (extensive dependency).

[b]Measured using CHESS, a 6-point scale of health instability, ranging from 0 = not at all unstable to 5 = highly unstable, categorized as 0 (no instability), 1 (minimal health instability), 2 (low health instability), and 3 or higher (moderate to very high health instability).

[c]Measured using CFS, a 4-point scale of cognitive function categorized as 0 (cognitively intact), 1 (mildly impaired), 2 (moderately impaired), and 3 (severely impaired).

of residents prescribed antipsychotics in both the short-stay (21.4% [11.6%] vs 23.6% [13.2%], $P < .001$) and long-stay populations (22.2% [14.3%] vs 25.5% [15.0%], $P < .001$). For both populations, the RSIR tended to decrease with increasing LTCF proportion of short-stay person-time (Table 2 and Figure 1; Supplementary Tables 4 and 5).

DISCUSSION

In this large, retrospective cohort study of US LTCFs caring for residents nationwide from 2013 to 2015, there was notable variation in the incidence of P&I hospitalization after adjusting for a wide array of resident-level characteristics. LTCF RSIRs were higher in the short-stay resident population than the long-stay population. We found that potentially modifiable characteristics like employment of a greater variety and more educated health care providers (eg, RNs, LIPs) were associated with lower RSIRs. Additionally, both short- and long-stay resident populations had fewer hospitalizations in LTCFs with increased staffing hours, higher-quality care practices, and a larger proportion of short-stay person-time. These findings are important because they provide the first evidence of national P&I rates in LTCFs. Furthermore, these LTCF-level rates are stratified for short-stay and long-stay residents, two populations with distinct care goals and needs. These findings suggest that LTCF staffing and care practices may be modifiable determinants of P&I risk in both populations.

The lack of available P&I data in LTCFs has prevented an evaluation of the association between LTCF characteristics and P&I. Most literature focuses on how LTCF characteristics affect overall resident hospitalization and care quality without differentiating between modifiable and nonmodifiable factors. Prior studies describe LTCFs receiving primarily Medicaid reimbursement as delivering a lower level of care, staffing with fewer nurses, and having lower occupancy rates compared with other

Table 3. Characteristics of Long-term Care Facilities by Risk-Standardized Pneumonia and Influenza Incidence Rate Among Short-Stay and Long-Stay Residents

Characteristic	Short-Stay <50th Percentile P&I RSIR (n = 6841)	Short-Stay ≥50th Percentile P&I RSIR (n = 6842)	Long-Stay <50th Percentile P&I RSIR (n = 7247)	Long-Stay ≥50th Percentile P&I RSIR (n = 7248)
P&I hospitalizations				
Crude IR of P&I, per 100 person-years	1.7 (3.3)	25.1 (28.5)	3.9 (3.1)	14.8 (9.2)
RSIR of P&I, per 100 person-years	9.1 (0.9)	12.4 (2.4)	6.8 (1.1)	12.0 (3.7)
Structural characteristics				
No. of beds	115.3 (62.6)	108.1 (56.0)	113.7 (63.6)	106.0 (54.9)
Urban	5143 (75.2%)	4448 (65.0%)	5888 (81.2%)	4295 (59.3%)
For-profit	4951 (72.4%)	5015 (73.3%)	5102 (70.4%)	5469 (75.5%)
Chain	3965 (58.0%)	3898 (57.0%)	4206 (58.0%)	3950 (54.5%)
Operational characteristics				
Facility proportion short-stay PT	0.2 (0.1)	0.1 (0.1)	0.2 (0.2)	0.1 (0.1)
Volume	147.2 (171.7)	111.1 (132.5)	65.2 (40.3)	62.1 (37.1)
Acuity Index[a]	12.0 (1.8)	11.8 (1.8)	11.9 (1.9)	11.8 (1.8)
Admissions/bed	2.3 (2.5)	1.8 (1.5)	2.3 (2.5)	1.6 (1.3)
Staffing hours				
Total nursing hours/resident/day	4.3 (7.2)	3.9 (2.7)	4.3 (5.6)	3.8 (2.0)
CNA hours/resident/day	2.4 (0.8)	2.3 (0.8)	2.4 (0.9)	2.3 (0.7)
RN hours/resident/day	0.5 (0.7)	0.4 (0.4)	0.5 (0.7)	0.4 (0.4)
Staffing type				
Ratio of CNA to RN+LPN	2.0 (0.7)	2.0 (0.6)	2.0 (0.7)	2.1 (0.7)
Ratio of RN to RN+LPN	0.4 (0.2)	0.3 (0.2)	0.4 (0.2)	0.3 (0.2)
SLP on-staff hours/100 beds	0.4 (0.8)	0.3 (2.1)	0.4 (0.8)	0.3 (2.0)
LIP on-site	3069 (44.9%)	2846 (41.6%)	3433 (47.4%)	2746 (37.9%)
Care quality				
Hospitalizations/resident year	1.2 (1.4)	1.1 (0.8)	1.1 (1.4)	1.1 (0.7)
Antipsychotic use, % of residents	21.4 (11.6)	23.6 (13.2)	22.2 (14.3)	25.5 (15.0)
Restraint use, % of residents	2.3 (4.6)	2.6 (5.3)	2.2 (4.5)	2.9 (5.8)
Pressure ulcers, % of residents	6.2 (4.2)	5.9 (4.4)	6.1 (4.5)	5.8 (4.2)

The data are presented as either mean (SD) or count (%).

Abbreviations: CNA, certified nursing assistant; HPRD, hours/resident/day; IR, incidence rate; LIP, licensed independent practitioner; LPN, licensed practical nurse; PT, person-time; RN, registered nurse; RSIR, risk-standardized incidence rate; SLP, speech language pathologist.

[a]Acuity Index is a measure of the care needed by long-term care facility residents derived from the Minimum Data Set, with a higher value indicating a greater need for care. It is calculated based on the number of residents needing various levels of activities of daily living assistance and the number of residents receiving special treatment (eg, respiratory care, intravenous therapy, etc.) [28].

payment sources [32]. Similarly, it was found that increased receipt of Medicaid reimbursements translates to a higher risk of rehospitalization [33]. Additional findings included a lower risk of hospitalization among LTCFs that were nonprofit, nonchain, and had more beds [33]. These findings are consistent with our results, although we found no effect of profit status and chain ownership on LTCF P&I hospitalization of short-stay residents.

Regarding staffing, prior studies suggest that LIPs decrease the risk of hospitalization, as was found in our study [7, 8]. Studies have also linked increased RN staffing to higher care quality and decreased adverse outcomes such as urinary tract infections and pressure ulcers [34, 35]. It has also been shown that increased CNA hours/resident/day correlates with improved care quality [36]. Our findings show that slightly higher CNA hours/resident/day was seen in LTCFs with lower RSIRs, but that a higher CNA-to-nurse ratio coincided with higher RSIRs in the long-stay population. Quality-related LTCF events, such as hip fractures and antipsychotic use, were shown to decrease with more total nurse hours/resident/day and greater CNA employment, respectively, similar to our findings [9, 37].

Our finding that lower P&I hospitalization rates occur in LTCFs with a greater proportion of short-stay person-time is supported by an increasing focus on post–acute care among LTCFs [38]. Skilled professionals are common in the provision of post–acute care (short-stay population) as residents' care plans are oriented around rehabilitation and return to the community, as opposed to the custodial care provided for the long-stay population. Employment of RNs and LIPs may allow for more effective management of complex residents in LTCFs, reducing the need for hospitalization. Specialized and more skilled providers, including SLPs, may reduce infection risk by recognizing and intervening in aspiration risk in residents with dysphagia, thus preventing aspiration pneumonia. Although additional research is needed, the greater presence of skilled health care providers for post–acute

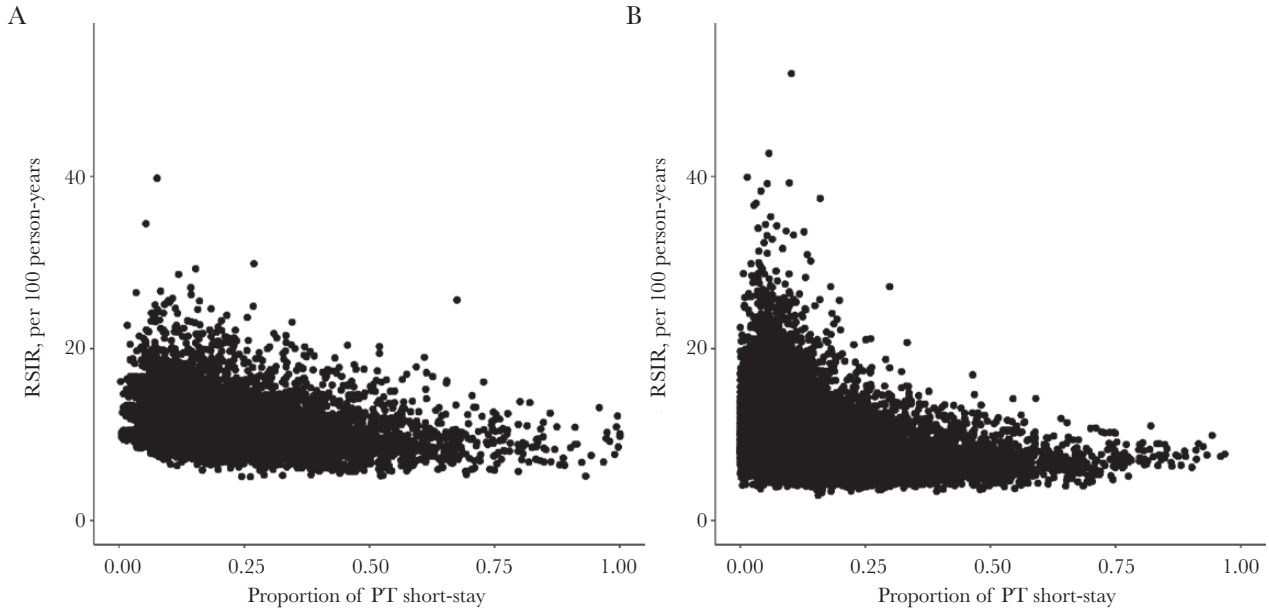

Figure 1. A, Facility risk-standardized incidence rate (RSIR) of pneumonia and influenza hospitalizations per 100 resident person-years among short-stay residents by facility proportion of short-stay person-time (n = 13 683). B, Facility risk-standardized incidence rate of pneumonia and influenza hospitalizations per 100 resident person-years among long-stay residents by facility proportion of short-stay person-time (n = 14 496). Each dot represents a facility. A higher value of facility proportion of short-stay person-time indicates a large proportion of facility time devoted to caring for short-stay residents relative to long-stay residents.

care may help explain the reduced P&I hospitalizations seen in the short- and long-stay populations.

Our study has several potential limitations. First, our study uses P&I hospitalization based on inpatient claims as the measure of P&I. This will miss infections not evaluated by diagnostic testing (eg, the rapid influenza diagnostic test or radiography) or those not resulting in hospitalization. Additionally, inpatient claims prevent the disentanglement of P&I because of coding practices, which may vary by region and are potentially affected by preferential coding for concurrent diagnoses. Conditions such as acute myocardial infarction or heart failure, both exacerbated by P&I, may capture the attention of providers and leave respiratory diagnoses unrecognized. Second, although we adjusted for resident vaccination, LTCFs' overall influenza and pneumococcal vaccination rates may contribute to herd immunity and thus would be an important potentially modifiable risk factor. Additionally, our study window considered multiple years, preventing a precise estimate of LTCF pneumococcal and influenza vaccination rates. Future studies should explore the relationship between LTCF vaccination rates and P&I incidence further. Finally, the covariate information derived from MDS assessments is measured after LTCF admission, after follow-up had begun for short-stay residents, which may result in overadjustment [39]. However, most short-stay residents had the assessment just a few days after LTCF admission, which helps to mitigate this concern. Many short-stay residents were discharged from the LTCF before assessment, which resulted in complete missingness for all MDS-derived covariates. We excluded such individuals from our analysis because multiple imputation and related missing data approaches would have required assumptions that were untenable.

In conclusion, P&I incidence varies markedly between LTCFs even after accounting for differences in resident characteristics. Lower LTCF incidence of P&I hospitalizations was associated with LTCFs that employ a greater variety of health care providers, have increased staffing hours, and have higher-quality care practices. The finding that caring for more short-stay residents is associated with lower RSIRs in both short- and long-stay populations merits future study to better understand the relationship's mechanism. As LTCFs respond to requirements for improved infection prevention and control, our findings may help them to identify modifiable targets for reducing the burden of P&I infection. Devoting additional resources toward hiring more RNs or LIPs and increasing staffing hours should be considered as prime potential targets to reduce P&I incidence in the growing LTCF population.

Supplementary Data

Supplementary materials are available at *Open Forum Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Notes

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quality. V.M.'s research is in an area related to that of several different paid activities. V.M. also periodically serves as a paid speaker at national conferences, where he discusses trends and research findings in long-term and post–acute care. V.M. holds stock of unknown value in PointRight, Inc., an information services company that provides advice and consultation to various components of the long-term care and post–acute care industry, including suppliers and insurers. PointRight sells information on measurement of nursing home (NH) quality to NHs and liability insurers. V.M. was a founder of the company but has divested much of his equity in the company and relinquished his seat on board. V.M. chairs the Independent Quality Committee for HRC Manor Care, Inc., a nursing chain, for which he receives compensation in the $20 000 to $40 000 range. V.M. serves as chair of a scientific advisory committee for NaviHealth, a post–acute care service organization, for which he also receives compensation in the range of $20 000 to $40 000 per year. V.M. serves as a technical expert panel member on several Centers for Medicare and Medicaid quality measurement panels. V.M. is a member of the board of directors of Tufts Health Plan Foundation, Hospice Care of Rhode Island, and The Jewish Alliance of Rhode Island. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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