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Long-Term Acute Care Hospital Use of Non-Mechanically Ventilated Hospitalized Older Adults

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OBJECTIVES: To determine why non-mechanically ventilated hospitalized older adults are transferred to long-term acute care (LTAC) hospitals rather than remaining in the hospital.

DESIGN: Observational cohort.

SETTING: National Medicare data.

PARTICIPANTS: Non-mechanically ventilated hospitalized adults aged 65 and older with fee-for-service Medicare in 2012 who were transferred to an LTAC hospital (n=1,831) or had a prolonged hospitalization without transfer (average hospital length of stay or longer of those transferred to an LTAC hospital) and had one of the 50 most common hospital diagnoses leading to LTAC transfer (N=12,875).

MEASUREMENTS: We assessed predictors of transfer using a multilevel model, adjusting for patient-, hospital-, and hospital referral region (HRR)-level factors. We estimated proportions of variance at each level and adjusted hospital- and HRR-specific LTAC transfer rates using sequential models.

RESULTS: The strongest predictor of transfer was being hospitalized near an LTAC hospital (<1.4 vs > 33.6 miles, adjusted odds ratio=6.2, 95% confidence interval (CI) =4.2–9.1). After adjusting for case mix, differences between hospitals explained 15.4% of the variation in LTAC use and differences between regions explained 27.8%. Case mix–adjusted LTAC use was high in the South, where many HRRs had rates between 20.3% and 53.1%, whereas many HRRs were less than 5.4% in the Pacific Northwest, North, and New England. From our fully adjusted model, the median adjusted hospital LTAC transfer rate was 7.2% (interquartile range 2.8–17.5%), with substantial within-region variation (intraclass coefficient=0.25, 95% CI=0.21–0.30).

CONCLUSIONS: Nearly half of the variation in LTAC use is independent of illness severity and is explained by which hospital and what region the individual was hospitalized in. Because of the greater fragmentation of care and Medicare spending with LTAC transfers (because LTAC hospitals generate a separate bundled payment from the hospital), greater attention is needed to define the optimal role of LTAC hospitals in caring for older adults. **J Am Geriatr Soc 00:1–8, 2018.**

Key words: postacute care; long-term acute care hospital; Medicare; variation; health policy

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One in 7 hospitalized older adults is transferred to a postacute care facility rather than going home after hospitalization.[1] Long-term acute care (LTAC) hospitals have become a major part of postacute care, accounting for more than 130,000 stays and $5.3 billion in Medicare spending annually, which is approximately one-fifth of the spending on skilled nursing facilities (SNFs).[2] Although LTAC hospitals were initially designed to care for individuals requiring prolonged mechanical ventilation, over the past few decades, they have cared for an expanded population of nonventilated older adults with other complex and prolonged illness and a range of ongoing long-term inpatient care needs, such as antibiotic infusions or complex wound care.[3,4] Given the uncertainty of the clinical and cost effectiveness of LTAC hospitals for caring for these patients, as opposed to acute care hospitals, it is unclear what factors influence the decision to transfer older adults to LTAC hospitals.

Although SNFs are the principal alternative postacute care setting for many individuals in LTAC hospitals who require subacute care,[3,5] on average, patients in LTAC hospitals are more similar to patients in hospital step-down units than SNFs with respect to clinical severity, cognitive and functional status, and treatments received.[3] Nevertheless, despite the overlap in levels of care between LTAC and

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acute care hospitals, we know little about why nonventilated older adults are transferred to an LTAC rather than remaining in an acute care hospital. This transfer decision has important implications not only for recovery and outcomes of older adults, but also for Medicare spending because a LTAC transfer generates a separate bundled payment.

Therefore, we sought to examine the patient-, hospital-, and regional-level factors associated with LTAC transfer (vs remaining in the hospital) and to quantify the amount of variation explained at each level. We hypothesized that many nonpatient factors would be strongly predictive of LTAC transfer and that differences between hospitals and between regions, rather than solely between patients, would explain a sizeable proportion of the variation.

METHODS

Study Design and Cohort

We conducted a retrospective cohort study using national 5% Medicare data from 2010 to 2012. We included non-mechanically ventilated, hospitalized, fee-for-service Medicare beneficiaries aged 65 and older who were transferred to a LTAC hospital or remained in an acute care hospital (henceforth referred to as hospital). To ensure adequate claims history to characterize baseline health, we excluded older adults without continuous Medicare Parts A and B or having any Part C coverage in the year before hospitalization. For the LTAC group, we included hospitalized older adults transferred to an LTAC hospital on the same or next day using a temporally adjacent algorithm.[6,7] LTAC hospitals were identified using the Centers for Medicare and Medicaid Services (CMS) provider number and verified by reviewing the facility name and conducting an Internet search if the facility type was uncertain.

Because most hospitalized older adults are not transferred to LTAC, we restricted the cohort to older adults with a greater likelihood of LTAC transfer (Supplementary Figure S1, Supplementary Table S1 for details on cohort assembly). First, we included only patients who had one of the 50 most common hospital Diagnosis-Related Groups (DRGs) as observed in our data in patients transferred to LTAC. Second, we excluded patients in the hospital cohort with a short length of stay (LOS), defined as less than the DRG-specific mean LOS for patients transferred to LTAC. Third, because our goal was to compare hospitalized older adults transferred to an LTAC versus remaining in the hospital, we excluded patients transferred to alternative inpatient postacute care facilities within a comparable amount of time that a patient would have otherwise spent in LTAC, which we defined as the sum of the DRG-specific mean time to LTAC transfer and the LTAC DRG-specific short-stay outlier (SSO) threshold. CMS uses the SSO threshold to adjust reimbursement for LTAC stays that are considerably shorter than the average LTAC LOS for that diagnosis.

To illustrate how the hospital group was constructed, we will use a hypothetical patient with DRG 592 (skin ulcers). Of LTAC patients with DRG 592, mean time to transfer was 6 days, and the LTAC SSO threshold was 21 days. Thus, patients with DRG 592 who were not transferred to LTAC were included in the hospital group if their hospital LOS was 6 days or longer and were not transferred to an alternative postacute care facility before Day 27, which is the sum of the mean time to transfer and the SSO threshold for DRG 592.

Predictors

We obtained patient-level characteristics from the Medicare data. We used durable medical equipment claims to identify incident wheelchair use as a proxy for advanced debility.[8,9] We used DRGs and major diagnostic categories to characterize the primary reason for hospitalization. DRG weights are assigned multipliers that reflect the average resources used to treat patients in that DRG. Hospital characteristics were obtained from CMS provider of services and impact files. Regions were defined at the hospital-referral region (HRR) level.[10] Regional population and healthcare intensity were ascertained from the Dartmouth Atlas.[10] Linear arc distance from the hospital to the nearest LTAC hospital was calculated using addresses in the provider of services file. Information on state certificate of need laws restricting the opening or expansion of hospitals was obtained from the National Conference of State Legislatures.[11]

Statistical Analyses

Predictors of LTAC Transfer

To ascertain independent predictors of LTAC transfer, we developed a multilevel mixed-effects logistic regression model. We chose candidate predictors based on prior literature and our expertise.[5,12–15] Fixed effects included significant patient-, hospital-, and region-level predictors in univariate analyses with $p<.05$. We retained all predictors in our final model with $p<.05$ using backward stepwise selection. We specified random effects at the hospital and HRR level to account for clustering of patients within hospitals and hospitals within HRRs. We graphically evaluated functional forms of continuous variables with restricted cubic splines. We group-mean centered patient- and hospital-level continuous predictors. Model diagnostics suggested excellent fit (C-statistic=0.91; < 1.6% absolute difference between observed and predicted LTAC transfer rates for the lowest 8 deciles of predicted risk; Supplementary Table S2).

Variation of LTAC Transfer

To estimate the variation that each level explained, we used variance partition coefficients (VPCs) from sequential multilevel models.[16,17] VPCs indicate the residual variation in LTAC transfer that unobserved differences at each level that remain after adjustment explain.[16] From the case-mix model, which included the patient-level predictors from our final model, we created a heat map to illustrate variation in adjusted HRR LTAC transfer rates. From the full model, we created a variation profile graph showing adjusted hospital LTAC transfer rates and a scatterplot of hospital variation within HRRs. We restricted hospital variation analyses to hospitals with 5 or more eligible patients in our cohort to enable more-stable estimates. Lastly, we estimated the intraclass correlation coefficient to examine hospital variation in LTAC use within the same HRR.

Sensitivity Analyses

We conducted 3 sensitivity analyses to examine the policy relevance and robustness of our estimates. (See Supplementary Table S3 for subcohort details.) First, we restricted our cohort by excluding patients who had an intensive care unit stay of less than 3 days during the index hospitalization or if they had a psychiatric or rehabilitation diagnosis. Beginning in fiscal year 2020, the CMS site-neutral payment policy will substantially decrease LTAC reimbursement for these patients, making LTAC transfer less likely in the future given the lower financial incentives. Second, we restricted our original cohort to patients hospitalized in HRRs with 1 or more LTAC hospitals. Third, because the group of patients who remained in the hospital had shorter inpatient stays (10 days) for the entire episode of care than those transferred to LTAC (32 days), we restricted the hospital cohort to patients with an index hospital LOS greater than or equal to the LTAC DRG-specific SSO threshold.

The University of Texas Southwestern institutional review board approved this study. We conducted analyses using Stata version 14.2 (Stata Corp., College Station, TX), SAS version 9.4 (SAS Institute, Inc., Cary, NC)), and ArcGIS version 10.3 (Esri, Inc., Redlands, CA).

RESULTS

We included 12,875 patients from 2,448 hospitals in 301 HRRs (Supplementary Table S1), 1,831 of whom (14.2%) were transferred to LTAC. Patients with one of the most common 50 diagnoses leading to LTAC transfer comprised 63.2% of the eligible nonventilated LTAC population and 34.4% of the nonventilated hospital population. The most common diagnoses for patients included in our cohort were sepsis, heart failure, chronic obstructive pulmonary disease, and pneumonia (Supplementary Table S4). Overall, patients transferred to LTAC were younger, more likely to be non-white, and sicker than those who remained in the hospital (Table 1). Patients transferred to LTAC hospitals were more likely to have a surgical diagnosis, sepsis, soft skin tissue or joint infection, and chronic wounds.

Predictors of LTAC Transfer

Table 2 shows the independent predictors of LTAC transfer. Measures of greater illness severity and complexity were typically associated with greater odds of LTAC transfer, including previous postacute care use and presence of delirium or dementia, although patients hospitalized with respiratory or circulatory conditions were more likely to stay in the hospital. Placement of a central venous line and excisional debridement were also strongly associated with LTAC transfer. We identified only 2 independent hospital-level predictors of transfer. For-profit hospitals had higher rates of LTAC transfer. Hospitals located in urban areas were less likely to send patients to LTAC. Lastly, we identified many important region-level predictors of LTAC transfer. The strongest predictor of LTAC transfer was whether a patient was hospitalized in close proximity to the nearest LTAC (adjusted odds ratio=6.2, 95% confidence interval (CI)=4.2–9.1, for distance ≤ 1.4 vs > 33.6 miles).

Regional Variation

After adjusting for case mix, unmeasured differences between regions explained 27.8% of the variation (Table 3), with LTAC transfer rates 11 times as high in HRRs with transfer rates in the 90th percentile as in those in the 10th percentile (Figure 1). There was far greater LTAC use in the South, particularly in Texas, Oklahoma, and Louisiana, with transfer rates between 20.3% and 53.1% for several HRRs, than New England, the North, and the Pacific Northwest, where many HRRs had transfer rates between 1.1% and 5.4%. The 5 region-level predictors included in our full model explained three-quarters of the regional variation identified in the case-mix model (proportion of variation explained=(region case-mix VPC-region full model VPC)/ region case-mix VPC) = (27.8%–7.1%)/27.8% = 74.5%).

Hospital Variation

From our fully adjusted model, unobserved differences between hospitals explained 18.4% of the variation in LTAC use. The average adjusted transfer rate for individual hospitals varied widely (Figure 2A). The median adjusted hospital LTAC transfer rate was 7.2% (interquartile range 2.8–17.5%). Even within a specific region, the adjusted hospital LTAC transfer rates varied substantially (intraclass correlation coefficient=0.25, 95% CI=0.21–0.30; Figure 2B). In low-use regions, there were hospitals with high adjusted transfer rates, and in high-use regions there were many hospitals with low LTAC use.

Sensitivity Analyses

Findings were similar for the sicker patients who would be exempt from reduced site-neutral payment (Supplementary Tables S5 and S6). For patients hospitalized in HRRs with 1 or more LTAC hospitals, the magnitude of the effect size for distance to the nearest LTAC was attenuated, and differences between regions explained less of the variation in LTAC transfer (18.6%) than in the full cohort (27.8%). Otherwise findings were comparable. Lastly, when restricting the cohort of patients who remained in the hospital to those with a longer stay, the effect sizes for patient illness severity measures were greatly attenuated or no longer associated with LTAC transfer, and the region-level predictors were more strongly associated with transfer. Furthermore, unobserved differences between regions (VPC=41.0%) and between hospitals (VPC=20.0%) explained much more of the variation in LTAC transfer after adjusting for differences in case mix than in our original cohort.

DISCUSSION

In this national Medicare study, we found marked variation in LTAC transfer among non-mechanically ventilated hospitalized older adults compared to remaining in the acute care hospital for the duration of their inpatient care. Differences between hospitals and between regions explained nearly half of the variation, independent of patient illness complexity and severity. By far the strongest predictor of LTAC transfer was how close patients were hospitalized to the nearest LTAC facility. Our analyses were robust when

Table 1. Cohort Characteristics

Characteristic	Transferred to LTAC (n=1,831)	Remained in Hospital (n=11,044)
Patient factors before hospitalization, n (%)		
Age		
65–69	265 (14.5)	1653 (15.0)
70–74	359 (19.6)	1983 (18.0)
75–79	356 (19.4)	2159 (19.6)
80–84	409 (22.3)	2107 (19.1)
≥85	442 (24.1)	3142 (28.5)
Female	1006 (54.9)	6224 (56.4)
White	1374 (75.0)	8931 (80.9)
Prior LTAC use	189 (10.3)	218 (2.0)
Prior skilled nursing facility use	738 (40.3)	2889 (26.2)
Wheelchair use	357 (19.5)	1564 (14.2)
Patient index hospitalization factors		
Length of hospital stay, days, median (IQR)	8 (5–13)	10 (8–14)
Intensive care unit stay ≥ 3 days, n (%)	911 (49.8)	4619 (41.8)
Primary diagnosis		
DRG resource intensity weight, median (IQR)	1.91 (1.47–2.59)	1.17 (1.00–1.84)
DRG with major complication or comorbidity designation, n (%)	1,378 (75.3)	5,614 (50.8)
Medical diagnosis (vs surgical), n (%)	1,322 (72.2)	10,155 (92.0)
Respiratory MDC, n (%)	386 (21.1)	3,572 (32.3)
Circulatory MDC, n (%)	296 (16.2)	2,260 (20.5)
Urinary MDC, n (%)	148 (8.1)	1,309 (11.9)
Secondary diagnoses, n (%)[1]		
Respiratory failure	612 (33.4)	2,792 (25.3)
Sepsis	681 (37.2)	2,410 (21.8)
Skin, soft tissue, or joint infection	322 (17.6)	874 (7.9)
Chronic skin ulcer	493 (26.9)	1,484 (13.4)
Delirium or dementia	488 (26.7)	2,295 (20.8)
Select intensive treatments and procedures, n (%)		
Transient mechanical ventilation (<96 hours)	127 (6.9)	449 (4.1)
Central venous line	498 (27.2)	1,614 (14.6)
Excisional debridement	76 (4.2)	89 (0.8)
Hospital factors, n (%)		
For-profit ownership	466 (25.5)	1,688 (15.3)
Urban	1662 (90.8)	9,546 (86.4)
Region factors		
Linear arc distance to nearest LTAC, miles, n (%)		
>33.6	90 (4.9)	2,486 (22.5)
11.5–33.6	204 (11.1)	2,399 (21.7)
5.2–11.4	400 (21.9)	2,161 (19.6)
1.5–5.1	553 (30.2)	1,995 (18.1)
≤1.4	584 (31.9)	2,003 (18.1)
No state Certificate of Need law, n (%)	685 (37.4)	7,380 (66.8)
HRR LTAC supply, beds per 100,000 persons, median (IQR)	11.1 (7.6–23)	7 (2.7–11.5)
HRR Medicare spending per person, $, median (IQR)	10,579 (10,003–11,646)	10,091 (9,207–10,731)
HRR median household income, $, median (IQR)[2]	51,761 (45,409–60,501)	52,864 (45,948–61,250)

[1]Categorized using Agency for Healthcare Research and Quality Clinical Classification Software.
[2]Obtained from the U.S. Census Bureau and aggregated at (HRR) level.[35]
LTAC = long-term acute care; IQR = interquartile range; DRG = Diagnosis-Related Group; MDC = major diagnostic category.

we focused on the population of patients who will be exempt from reduced LTAC reimbursement beginning in 2020, making these findings relevant to the current and future postacute care policy environment. Furthermore, when we limited our comparison group to older adults with considerably longer hospital stays, who may have a greater likelihood of LTAC transfer, we found that patient-level predictors were much less important and that unmeasured differences between hospitals and regions were much stronger drivers of LTAC use. Taken together, the large amount of variation in LTAC transfer that is unrelated to differences between patients suggests great uncertainty about the optimal role of LTAC hospitals for non-mechanically ventilated individuals.

Transferring nonventilated, hospitalized, older Medicare beneficiaries to LTAC hospitals, rather than continuing to care for them in traditional acute care hospitals has several important clinical and economic implications. LTAC hospitals may facilitate quicker recovery given their greater focus on interdisciplinary rehabilitation.[18] Furthermore, given their focus on the sickest patients, LTAC hospitals have unique expertise in caring for patients with complex care needs (e.g., wound care), which may lead to better outcomes and lower costs.[18] Conversely, LTAC transfer could

Table 2. Predictors of Long-Term Acute Care Hospital (LTAC) Transfer Versus Staying in the Hospital

Factor	Odds Ratio (95% Confidence Interval)	
	Unadjusted	Adjusted
Patient factors before hospitalization		
Age (reference 65–69)		
70–74	1.11 (0.91–1.35)	1.11 (0.89–1.39)
75–79	0.99 (0.81–1.21)	1.08 (0.87–1.35)
80–84	1.25 (1.03–1.53)	1.37 (1.10–1.70)
≥ 85	0.83 (0.69–1.01)	0.94 (0.76–1.16)
Prior LTAC use	3.34 (2.62–4.26)	1.77 (1.36–2.31)
Prior SNF use	2.17 (1.92–2.46)	1.73 (1.50–1.99)
Wheelchair	1.49 (1.28–1.73)	1.30 (1.10–1.53)
Patient index hospitalization factors		
Primary diagnosis		
DRG resource intensity weight, per unit	1.82 (1.73–1.91)	1.16 (1.04–1.29)
DRG with major complication or comorbidity designation	3.52 (3.08–4.02)	2.16 (1.82–2.57)
Medical diagnosis (vs surgical)	0.16 (0.14–0.19)	0.41 (0.29–0.58)
Respiratory MDC	0.50 (0.44–0.58)	0.71 (0.60–0.85)
Circulatory MDC	0.77 (0.66–0.90)	0.65 (0.54–0.78)
Urinary MDC	0.61 (0.50–0.75)	0.71 (0.56–0.90)
Secondary diagnoses		
Respiratory failure	1.67 (1.47–1.90)	1.37 (1.17–1.60)
Skin, soft tissue, or joint infection	3.18 (2.68–3.78)	2.02 (1.65–2.46)
Chronic skin ulcer	3.18 (2.75–3.68)	1.73 (1.46–2.04)
Delirium or dementia	1.36 (1.19–1.56)	1.19 (1.01–1.39)
Select intensive treatments and procedures		
Transient mechanical ventilation (vs none)	2.06 (1.61–2.62)	0.66 (0.50–0.88)
Central venous line	2.61 (2.27–3.01)	1.57 (1.34–1.83)
Excisional debridement	10.4 (6.95–15.5)	2.05 (1.31–3.22)
Hospital factors		
For-profit ownership	1.39 (1.14–1.71)	1.58 (1.27–1.95)
Urban	1.77 (1.37–2.27)	0.54 (0.39–0.73)
Region factors		
Linear arc distance to nearest LTAC, miles (reference > 33.6)		
11.5–33.6	2.04 (1.47–2.82)	2.24 (1.56–3.21)
5.2–11.4	4.41 (3.18–6.10)	4.83 (3.27–7.14)
1.5–5.1	5.69 (4.13–7.84)	6.14 (4.18–9.04)
≤1.4	6.49 (4.71–8.93)	6.18 (4.21–9.09)
No state Certificate of Need law	2.63 (1.98–3.49)	2.31 (1.81–2.94)
LTAC supply, per 5 beds/100,000 persons	1.47 (1.37–1.58)	1.23 (1.16–1.32)
Median household income, per $10,000	0.81 (0.71–0.93)	0.88 (0.79–0.97)
Medicare spending per person, per $3,000	4.97 (3.37–7.33)	1.48 (1.06–2.06)

DRG = Diagnosis-Related Group; MDC = major diagnostic category.

lengthen recovery through fragmentation of the initial episode of acute care, which has been shown to lead to unfavorable outcomes in other clinical scenarios.[19–21] Problems during the hospital-to-LTAC transition may arise from non-interoperable information technology systems, as well as from personnel changes, with a new team of nurses, ancillary staff, and physicians. Additionally, LTAC hospitals have financial incentive to delay discharges until after

Table 3. Proportion of Variation in Long-Term Acute Care Hospital LTAC Transfer That Patients, Hospitals, and Regions Explain

VPC level	Case mix only	Case mix + hospital	Case mix, hospital + region (full model)
	VPC, % (95% Confidence Interval)		
Between patients	56.9 (51.7–62.1)	57.8 (52.4–62.8)	74.5 (70.0–79.0)
Between hospitals	15.4 (11.7–19.0)	15.4 (11.7–19.1)	18.4 (14.1–22.7)
Between regions	27.8 (22.1–33.5)	27.0 (21.3–32.7)	7.1 (3.9–10.2)

Variance partition coefficients (VPC) describe the proportion of variation that unobserved differences between patients, hospitals, and hospital referral regions explain. We conducted sequential multilevel mixed-effects logistic regression models to estimate the effect of adjusting for each successive level of predictors shown in Table 2.

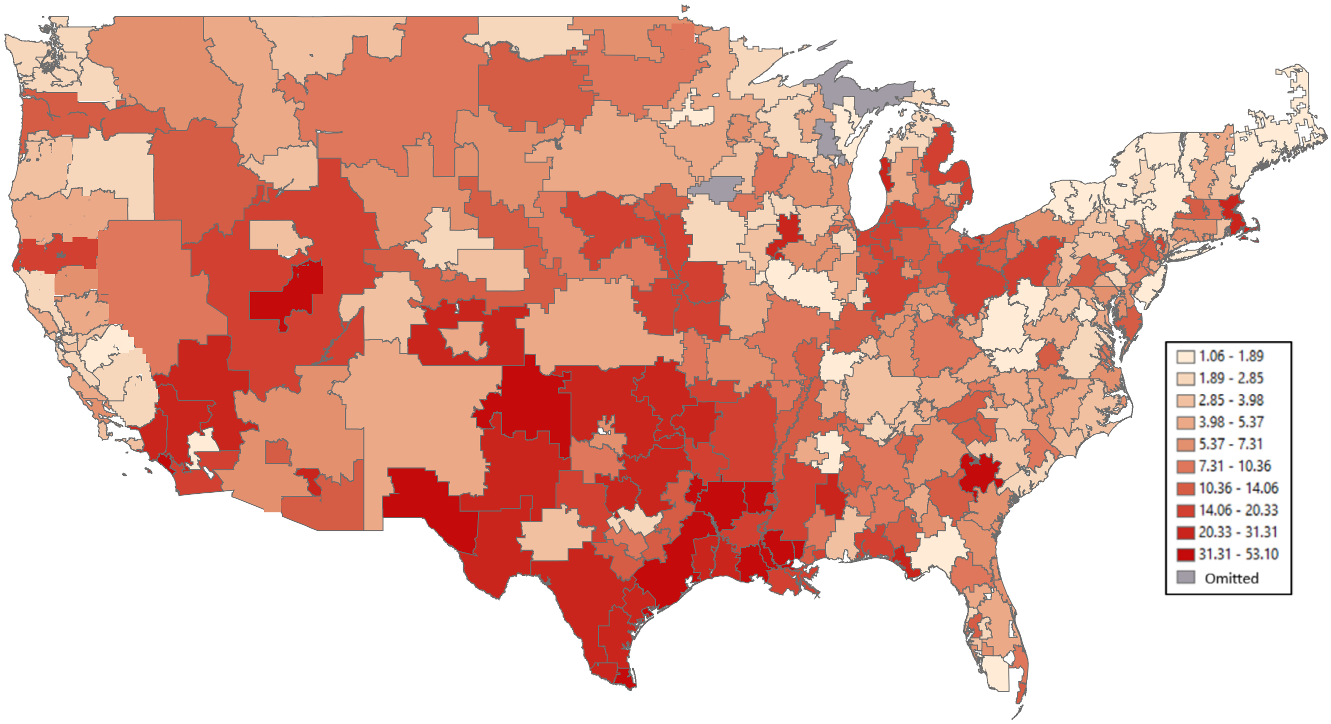

Figure 1. Adjusted long-term acute care hospital (LTAC) transfer rate by region. Mean adjusted LTAC transfer rate (vs remaining in hospital) according to hospital referral region of non-mechanically ventilated hospitalized older adults estimated from case mix–only multilevel model adjusted for all individual-level predictors shown in Table 2. Hospital referral regions (n=304) are defined as regional healthcare markets for tertiary medical care.[10]

patients reach their diagnosis-specific SSO threshold to qualify for full reimbursement, potentially leading to unnecessarily long LTAC stays.[22] Unnecessary LTAC days expose frail, vulnerable older adults to hazards of hospitalization, including hospital-acquired infections from multidrug-resistant organisms, which are more prevalent in LTAC hospitals than acute care hospitals.[23–26] Furthermore, despite having a high burden of palliative care needs,[27,28] older adults in LTAC hospitals may have less access to geriatrics and palliative care clinicians than in the hospital, which may worsen quality of life.[29] With respect to financial implications for CMS, a LTAC transfer generates a separate payment from the bundled payment hospitals receive under the CMS Inpatient Prospective Payment System (PPS). Although transferring certain patients to an LTAC may result in lower costs of care than providing continued care in a traditional hospital, Medicare spending is greater because of the dual PPS reimbursement structure.[30] This would also have implications for Medicare Accountable Care Organizations, because participants are benchmarked to spending targets and not costs of care. Conversely, from a hospital's perspective, transferring patients to an LTAC is a financially sensible decision because LTAC hospitals can substitute for a prolonged hospitalization and thus decrease LOS and costs of care.[31,32]

Additional comparative effectiveness research is needed to provide greater clarity as to which older adults would benefit from LTAC transfer. LTAC hospitals are thought to be most effective in caring for chronically critically ill patients who require prolonged mechanical ventilation.[12,30] For nonventilated patients, existing evidence suggests lower mortality in those transferred to LTAC after surviving a critical illness or having multiorgan failure, but differences in severity of illness between patients in the comparison group limited this comparison because LTAC transfer was compared with all other alternative disposition options combined, including discharge to home and to a SNF.[33] Furthermore, these studies examined only mortality and did not examine other person-centered outcomes, including cognitive and functional recovery, important outcomes relevant to older adults with advanced illnesses.

Although this study compared patients transferred to LTAC hospitals with those remaining in the hospital, SNFs are also a major alternative to LTAC hospitals for postacute care. Although hospitals and SNFs care for patients with different illness severities and care needs, we found remarkable similarity in the variation of LTAC use with our previous study comparing LTAC hospitals with SNFs.[5] Regions with high case mix–adjusted LTAC use in this study were also identified as high LTAC-use regions when the alternative was transfer to a SNF. Additionally, hospitals' adjusted LTAC transfer rates are highly correlated, such that the same hospitals that preferably transfer patients to LTAC hospitals instead of keeping them hospitalized also send more patients to LTAC hospitals than SNFs (Pearson correlation coefficient=0.74, p<0.01; Supplementary Figure S2). The consistency of our findings further suggests that regional and hospital use of LTAC hospitals is related more to availability and practice culture than illness severity.

Our study has certain limitations. First, though our findings may not be generalizable to privately insured,

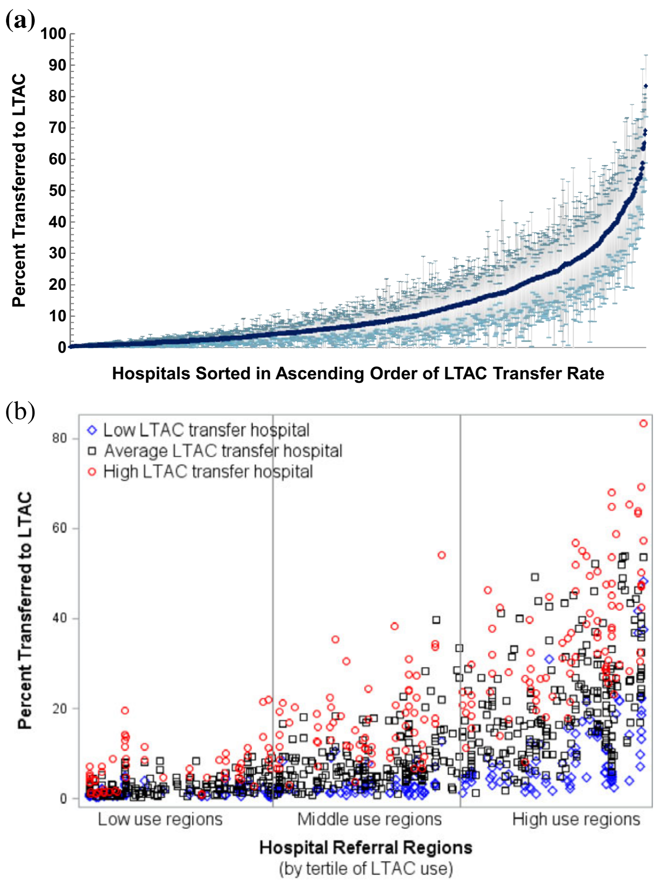

Figure 2. Hospital Variation in long-term acute care hospital (LTAC) use. (A) Distribution of adjusted hospital LTAC transfer rates. Adjusted hospital LTAC transfer rates were estimated from the full multilevel model and shown for hospitals with ≥5 patients (n=1,038). (B) Variation in adjusted hospital LTAC transfer rate within regions. Hospitals are shown as individual markers within hospital referral regions (HRRs). HRRs were sorted in ascending order according to their case mix–adjusted LTAC transfer rates (as per Figure 1) and further categorized according to tertile of use. For each of the HRRs, we estimated the HRR-specific 25th and 75th percentile values for adjusted hospital LTAC transfer rates. A low LTAC transfer hospital (blue diamond) was defined as having an adjusted transfer rate less than its HRR-specific 25th percentile hospital transfer rate. An average LTAC transfer hospital (black square) was defined as having between the 25th and 75th percentile transfer rate. A high LTAC transfer hospital (red circle) was defined as greater than the 75th percentile rate. All hospitals in HRRs with fewer than 4 hospitals were defined as average. This approach compares a hospital's adjusted LTAC transfer rate with that of their peers in the same HRR.

Medicare Advantage, or young populations, fee-for-service Medicare beneficiaries account for the majority of national LTAC use.[2] Second, it is likely that we omitted important patient- and hospital-level predictors owing to data limitations, although the VPCs we estimated for our variation analyses capture unobserved differences at each level beyond what was included in our models.[16] For example, patient-level VPCs include unmeasured differences in cognition, functional status, frailty, and patient preference, plus other domains of illness severity and complexity. Third, our findings may not generalize to patients with a diagnosis not among the most common 50 DRGs leading to LTAC transfer.

In conclusion, differences between hospitals and between regions explain nearly half of the variation in LTAC transferring among nonventilated hospitalized older adults, independent of illness severity and preferences for care. Regional differences account for more than one-quarter of the variation, with far greater use in the South, although there was the considerable hospital variation in LTAC use, even between hospitals with the same potential LTAC access from the same region. A scarcity of evidence of which model of care is most effective in improving outcomes for hospitalized older adults with prolonged illness may in part drive variation in LTAC use. The decision for LTAC transfer has important clinical and economic consequences that will need to be explored further in comparative effectiveness research, especially given that the burden of prolonged acute or chronic critical illness is likely to expand with an aging population and advances in medical care and technologies.[34]

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article.

Supplementary Figure S1. Defining the Cohort

Supplementary Figure S2. Correlation of Hospitals' Adjusted LTAC Transfer Rates

Supplementary Table S1. Study Flow Table

Supplementary Table S2. Model Performance of Full Multilevel Models

Supplementary Table S3. Subcohorts for Sensitivity Analyses

Supplementary Table S4. Fifty Most Common Diagnoses Leading to LTAC Transfer

Supplementary Table S5. Predictors of LTAC Transfer from Sensitivity Analyses

Supplementary Table S6. Variation in LTAC Use from Sensitivity Analyses