Published in final edited form as:

Med Care. 2013 January ; 51(1): 4–10. doi:10.1097/MLR.0b013e31826528a7.

Effectiveness of long-term acute care hospitalization in elderly patients with chronic critical illness

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Abstract

Background—For patients recovering from severe acute illness, admission to a long-term acute care hospital (LTAC) is an increasingly common alternative to continued management in an intensive care unit.

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Objective—To examine the effectiveness of LTAC transfer in patients with chronic critical illness.

Research Design—Retrospective cohort study in United States hospitals from 2002 to 2006.

Subjects—Medicare beneficiaries with chronic critical illness, defined as mechanical ventilation and at least 14 days of intensive care.

Measures—Survival, costs and hospital readmissions. We used multivariate analyses and instrumental variables to account for differences in patient characteristics, the timing of LTAC transfer and selection bias.

Results—A total of 234,799 patients met our definition of chronic critical illness. Of these, 48,416 (20.6%) were transferred to an LTAC. In the instrumental variable analysis, patients transferred to an LTAC experienced similar survival compared to patients who remained in an intensive care unit (adjusted hazard ratio = 0.99, 95% CI: 0.96 to 1.01, $p=0.27$). Total hospital-related costs in the 180 days following admission were lower among patients transferred to LTACs (adjusted cost difference = -\$13,422, 95% CI: -26,662 to -223, $p=0.046$). This difference was attributable to a reduction in skilled nursing facility admissions (adjusted admission rate difference = -0.591 (95% CI: -0.728 to -0.454, $p<0.001$). Total Medicare payments were higher (adjusted cost difference = \$15,592, 95% CI: 6,343 to 24,842, $p=0.001$).

Conclusions—Patients with chronic critical illness transferred to LTACs experience similar survival compared with patients who remain in intensive care units, incur fewer health care costs driven by a reduction in post-acute care utilization, but invoke higher overall Medicare payments.

Keywords

mechanical ventilation; costs; Medicare; patient readmission; intensive care

INTRODUCTION

Long-term acute care hospitals (LTACs) provide complex inpatient services for patients in the recovery phase of severe acute illness.¹ Defined by the Centers for Medicare and Medicaid (CMS) as acute care hospitals with average lengths of stay exceeding 25 days, LTACs are among the fastest growing segments of acute care in the United States. Prior to the 2007 moratorium on the certification of new LTACs, the number of LTACs in the US grew at a rate of 8.8% per year, with over 400 LTACs currently in operation.² LTAC spending has grown at a comparable rate—Medicare reimbursement for LTACs was \$4.6 billion in 2008, up from \$398 million in 1993.³

Among other roles, LTACs act as specialized centers for patients with chronic critical illness and those receiving prolonged mechanical ventilation.⁴ These patients comprise a minority of intensive care unit (ICU) patients but account for a disproportionate amount of resource use, with frequent care transitions and poor long-term outcomes.⁵⁻⁸ Studies show that patients with chronic critical illness transferred to LTACs have poor survival.⁹ Yet relatively little is known about how these outcomes differ from patients who remain in ICUs.^{10, 11} LTACs might improve outcomes by offering specialized rehabilitation services and dedicated respiratory care,^{12, 13} or might worsen outcomes by providing less intense nurse and physician staffing^{14, 15} and by disrupting the episode of acute care.¹⁶ To address this issue, we examined the survival and health care costs of fee-for-service Medicare beneficiaries with chronic critical illness transferred to LTACs compared to patients who remain in an acute care ICU.

METHODS

Design overview

We performed a retrospective cohort study of Medicare beneficiaries with chronic critical illness, comparing survival and health care utilization between patients transferred to an LTAC and patients who remained in an acute care ICU. We used an instrumental variable approach to account for possible unmeasured differences between patient groups. Instrumental variables are a well-developed econometric technique for addressing selection bias and unmeasured confounding in observational studies.¹⁷

Setting and Participants

We used the Medicare Provider Analysis and Review (MedPAR) Files from 2002 to 2006, which contains demographic and administrative data on all fee-for-service Medicare beneficiaries. MedPAR is the only national source of data on LTAC admissions, and Medicare is the primary payer for approximately 75% of LTAC discharges.¹ We linked MedPAR to patient-level survival data from the Medicare Denominator File, ZIP-code level population data from the United States Census, and year-specific hospital characteristics from the CMS Healthcare Cost Report Information System (HCRIS).

We included patients hospitalized in traditional acute care hospitals with chronic critical illness. We defined chronic critical illness as both having received mechanical ventilation, identified using International Classification of Diseases, version 9.0—Clinical Modification (ICD-9-CM) procedure codes 96.7X, and having been admitted to an ICU for at least 14 days, identified using ICU-specific revenue codes. This previously validated definition has 87.6% sensitivity and 88.5% specificity for prolonged mechanical ventilation and identifies a subset of ICU patients with high costs and poor outcomes.¹⁸ We excluded patients <66 years of age to ensure a homogenous elderly population, and patients with less than one year of Medicare enrollment at the time of eligibility to enable complete co-morbidity assessments. We also excluded patients admitted to hospitals in Alaska and Hawaii, since the unique geography of these states limits access to LTACs.

Variables

The primary exposure variable was transfer from an acute care hospital to an LTAC. We defined LTACs using hospital identifiers in MedPAR and HCRIS, as previously described.² We considered a patient to have been transferred to an LTAC if they were discharged from an acute care hospital on day n and admitted to an LTAC on day n or $n + 1$.¹⁹ This method is superior to using the discharge location field in MedPAR, which may be inaccurate.²⁰ The primary outcome variable was survival within one year of admission to the acute care hospital, defined using death dates from the Medicare Denominator File.

Secondary outcome variables were costs from the hospital perspective and spending from Medicare's perspective. We evaluated three types of costs and spending: costs and spending for the entire initial acute care episode including the acute care and LTAC hospitalizations; costs and spending for post-acute care hospitalizations include skilled nursing facility (SNF) admissions, rehabilitation hospital admissions, subsequent short stay hospital admissions, and subsequent LTAC admissions after the first episode of acute care but within 180 days of the initial hospitalization; and total 180 day hospitalization-related costs and spending including both the initial acute care episode and the post-acute care periods. We chose a 180-day cut off these health care utilization measures in order to increase the chance that the utilization was related to the initial episode of critical illness. We did not analyze outpatient or home health costs in order to maximize the likelihood that the costs were attributable to

the events of the initial acute care episode. Although we truncated our assessments of costs, other variables such as length of stay were not truncated.

Costs were determined by multiplying department-specific charges in MedPAR by department-specific cost-to-charge ratios in HCRIS.²¹ Medicare spending was calculated directly from MedPAR. All costs were adjusted for inflation using the consumer price index and are presented in 2006 US dollars. To understand the mechanism of any observed differences in costs and spending, we also evaluated the number of hospitalizations within 180 days after the initial episode of acute care, including readmissions to acute care hospitals and admissions to SNFs.

Covariates in the analysis included age, gender, race (categorized as black, white and other), socio-economic status as measured by the median income of each patient's ZIP code of residence, admission source, primary diagnosis (categorized using the Agency for Healthcare Research and Quality's Healthcare Costs and Utilization Project Clinical Classification Software), and co-morbidities defined in the manner of Elixhauser using ICD-9-CM codes for the initial hospitalization and all hospitalizations within the one year prior.²² We also included hospital-level covariates including ownership (categorized as for-profit, non-profit and government), and academic status (defined using resident-to-bed ratios), derived from the HCRIS files.

Statistical Analysis

We described hospital and patient characteristics using standard summary statistics. To better understand the role of LTAC availability in the selection of patients for transfer, we examined patient characteristics separately for Dartmouth Atlas hospital referral regions (HRRs) that contained an LTAC and HRRs that did not contain an LTAC. For these analyses we judged differences using clinical rather than statistical significance, since due to our large sample size all comparisons would likely be statistically significant.

We examined the relationship between LTAC transfer and our outcomes of interest by fitting a series of regression models. For survival we used proportional hazards regression in which we treated transfer to LTAC as a time-varying covariate in order to avoid immortal time bias---a form of bias that occurs when a patient cannot meet the outcome prior to a time-varying exposure.²³ In this case, patients who are transferred to an LTAC cannot die prior to transfer. For costs and payments we used linear regression in which the dependent variables were untransformed costs and payments.²⁴ For hospital readmissions and skilled nursing facility admissions we used Poisson regression in which the dependent variables was a count of readmissions or admissions. We treated readmissions and skilled nursing facility admissions as counts in which each patient could experience multiple events, rather than as a binary covariate in which each patient could experience only one event, in order to more fully capture any downstream effects of LTACs on outcome.

We performed each analysis in a sequential three step process. First, we estimated the effect of LTAC transfer with no other covariates in the model. Next, we estimated the effect of LTAC transfer in multivariate regression model controlling for patient and hospital characteristics, as defined above. Finally, we used an instrumental variable approach to attempt to account for the selection bias and unmeasured confounding inherent in our observational study design.

Valid instruments are causally related to the exposure of interest but unrelated to the outcome of interest except through the pathway of the exposure itself. We used two instruments: the distance from the admitting hospital to the nearest LTAC obtained as the linear arc distance through geo-coding software (ArcGIS, ESRI, Redlands, CA) and the

number of LTACs in the admitting hospitals' Dartmouth Atlas HRR, which we created using year-specific ZIP-code-to-HRR crosswalks available from the Dartmouth Atlas. These instruments are based on a conceptual model of LTAC transfer in which clinicians and LTACs determine transfers based on proximity and availability. This model is more consistent with LTAC admission than traditional models of patient choice, since patients and their surrogates are typically unaware of LTACs as a treatment option.

We explored the validity of our instruments by examining the multivariate relationship between the instruments and our exposure, the multivariate relationship between the instruments and our outcomes, and the relationship between our instruments and other factors that might be acting as proxies for hospital quality. These analyses are shown in the supplemental digital content and suggest that our instruments are sufficiently correlated with our exposure and uncorrelated with outcome to act as valid instruments (see Supplemental Digital Content, Methods and Tables 1-3).

We implemented our instrumental variable approach using either two-stage prediction inclusion or two-stage residual inclusion.²⁵ In the first stage models we regressed transfer to an LTAC on our instruments and the complete set of covariates. In the second-stage models we regressed our outcome on either the predicted value of the dependent variable from the first-stage model and the complete set of covariates (in the case of prediction inclusion); or the actual exposure, the complete set of covariates, and the residuals from the first-stage models (in the case of residual inclusion).

For the survival models, the first-stage model used linear regression predicting time to LTAC transfer and the second-stage model used proportional hazards regression on predicted time to transfer. In these models patients who died prior to their predicted LTAC time were considered to have not been transferred to an LTAC—this approach avoids biasing the results by attributing mortal time to the LTAC and avoids the exposure post-dating the outcome. For the cost and spending models, the first stage-model used logistic regression predicting LTAC transfer and the second-stage model used linear regression on actual LTAC transfer and the residuals from the first-stage model. For the hospital readmission and SNF admission models, the first stage model used logistic regression predicting LTAC transfer and the second stage model used Poisson regression on actual LTAC transfer and the residuals from the first-stage model. In all models we accounted for hospital-level clustering with generalized estimating equations, specifying robust Huber-White confidence intervals and an exchangeable correlation matrix.²⁶

We also conducted a series of sensitivity analyses to examine the robustness of our analyses to model assumptions. In these analyses we shortened the ICU length of stay required to meet our definition of chronic critical illness in order to account for patients transferred to LTACs prior to meeting the criteria. We also excluded hospitals in which an LTAC is co-located with the hospital and hospitals in HRRs without LTACs, since the decision to transfer a patient to an LTAC may be fundamentally different in these hospitals than others. Finally, we performed a sensitivity analysis on costs and payments in which we modeled these variables using the gamma distribution rather than the normal distribution.²⁷

Data management and analysis was performed in SAS 9.2 (SAS Institute, Cary NC). A p-value of 0.05 was considered significant. All work was reviewed and approved by the University of Pennsylvania and University of Pittsburgh Institutional Review Boards.

RESULTS

There were 9,093,159 hospitalizations during the study period. We excluded 434,650 patients less than or equal to 66 years of age, 85,982 patients from hospitals in Alaska and

Hawaii, 8,328,171 patients not meeting our definition of chronic critical illness, and 9,557 hospitalizations that occurred subsequent to the first. After exclusions, a total of 234,799 patients met eligibility criteria. Of these, 48,416 (20.6%) were transferred to an LTAC. In HRRs with at least one LTAC, 43,540 of 167,596 patients were transferred (26.0%), while in HRRs with no LTACs, 4,876 of 66,843 patients were transferred (7.3%). Eligible patients came from 2,609 hospitals (Table 1). Hospitals were diverse in academic status, the number of patients with chronic critical illness, the number of LTACs and LTAC beds in the HRR, and the percent of patients transferred to an LTAC.

A total of 356 LTACs received patients in transfer. Of these 173 (50%) were co-located in an acute care hospital and 173 (50%) were free-standing LTACs; 248 (71.7%) were for-profit facilities, with the rest being nonprofit (78, 22.5%) and government owned (20, 5.8%).

Patient characteristics and unadjusted outcomes are shown in Table 2. Measured demographic and clinical characteristics were similar between patients transferred to LTACs and patients who remained in ICUs. Patients transferred to LTACs experienced slightly shorter lengths of stay in the initial hospital but longer total length of stay when LTAC length of stay was included. Unadjusted hospital readmission, SNF admission and 1-year mortality were similar across patient groups.

Unadjusted and adjusted survival estimates are shown in Table 3. In the base analysis, the unadjusted hazard ratio for transfer to an LTAC was 1.21 (95% CI: 1.19 – 1.22, $p < 0.001$). This estimate did not appreciably change after adjusting for patient level covariates. In our instrumental variable analysis, however, there was no association with LTAC transfer and survival (adjusted hazard ratio = 0.99, 95% CI: 0.96 – 1.01, $p = 0.27$). In our sensitivity analysis, the results did not change when we excluded hospitals with co-located LTACs or in HRRs without LTACs. LTACs appeared moderately beneficial when our definition of chronic critical illness was broadened to include patients with shorter ICU lengths of stay.

In analyses of our secondary outcomes, adjusting for patient characteristics and utilizing our instrumental variables demonstrated that transfer to an LTAC was associated with lower post-acute care costs (\$9,463 lower; 95% CI: \$6,465 – \$12,450), lower total costs (\$13,442 lower; 95% CI: \$223 - \$26,662), but higher Medicare payments (\$15,592 higher; 95% CI: \$6,343 - \$24,842) compared to patients who were not transferred to an LTAC (Table 4). Reductions in costs were primarily due to reductions in post-acute care hospitalizations. The cost and payment results did not substantively change when we modeled costs and payments using the gamma distribution instead of the normal distribution (see Supplemental Digital Content, Table 4).

DISCUSSION

In our national study of elderly Medicare beneficiaries, patients with chronic critical illness transferred to LTACs experienced similar one-year survival and lower 180-day hospitalization-related costs compared to patients who remained in acute care ICUs. These results were robust to varying assumptions about patients and hospitals eligible for the analysis, with some sensitivity analyses suggesting that LTACs might improve survival for patients when the population of eligible patients is expanded to include those earlier in their ICU course. Our study provides important conceptual support both for the LTAC model in chronic critical illness and for the utility of comparative effectiveness research in evaluating the organization of care for the critically ill.

Prior to performing our analyses we had several hypotheses as to why LTACs might either improve or worsen survival. LTACs might improve survival by providing greater clinical

experience in the care of patients with prolonged-mechanical ventilation²⁸ or by providing specialized weaning and rehabilitation services for the chronically critically ill.⁷ At the same time LTACs might worsen survival by offering less-intense nurse and physician staffing, which are known to be strongly associated with outcomes.^{14, 15} Our analysis demonstrates that these effects either do not strongly affect survival or counteract in way that makes overall survival similar.

We also show that hospitalization-related costs are lower for patients transferred to LTACs, primarily driven by a reduction in SNF admissions. Post-acute care utilization is an increasingly important driver of health care costs.²⁹ Our findings suggest that more intense post-acute care early in the form of LTAC admission may ultimately prevent additional post-acute care use later in the form of SNF admissions, at least in the subset of hospitalized patients with chronic critical illness. Importantly, despite finding reduced costs for these patients, we found LTAC use increased Medicare payments. These results suggest a potential disconnect between payment and cost for Medicare patients transferred to LTACs. Ideally, services that are cost-saving from a societal perspective should also save money for health care payers, so long as those services are appropriately incentivized. However, were hospital care to be overvalued by payers, hospitalizations may be reimbursed out of proportion to their value. Innovative payment strategies such as bundled payments for episodes of care³⁰ and accountable care organizations³¹ may make LTACs more attractive for Medicare in the future.

The results of our instrumental analyses differ markedly from the results of the other analyses. In the multivariate model adjusting for observed confounders, admission to an LTAC was associated with shorter survival and higher costs, while in the instrumental variable analyses admission to an LTAC was associated with no difference in survival and lower costs. These results underscore the importance of addressing unmeasured confounding and selection in cases when treatment assignment is chosen by physicians. Given that LTACs entirely select their patients for admission, it is not surprising that selection bias was so large. The fact that our instrumental variable analyses were specified a priori helps support the validity of these findings. That being said, instrumental variable analyses do require assumptions that cannot be proven, and these results should be interpreted accordingly.

Our study has several limitations. First, we studied only patients with chronic critical illness, which represent only a portion of the patients eligible for transfer to LTACs. Patients with lower acuity and fewer care needs may not experience similar outcomes. Second, although we used a validated administrative definition of chronic critical illness, the performance characteristics of our definition may vary among patient groups. In particular, our definition would exclude patients transferred to LTACs very early in their hospital course. Our approach represents a balance between including the most eligible patients and restricting the analysis to patients most likely to benefit. Third, our study examined only one type of specialized care for chronic critical illness—we could not examine the role of step-down units or intermediate care units within acute care hospitals. Fourth, we employed a macro-costing method, that, while internally valid, may overstate cost differences when a large proportion of costs are variable, such as nursing costs. This issue may limit inference as to cost differences between LTAC and non-LTAC patients, since nursing costs are subsumed in the daily bed charges for each patient. Unfortunately, more granular methods of measuring costs are not available in MedPAR. Nor are home health or outpatient costs available in MedPAR, although these costs are likely small compared to inpatient costs. Finally, we used an instrumental variable approach to address selection and unmeasured confounding. Although we undertook extensive steps to identify a valid instrument, our results could be sensitive to instrument choice, and are only applicable to the marginal

patient, i.e. a patient with a definable probability of being either transferred or not transferred to an LTAC.³²

In identifying a subset of patients for which LTAC care is equally effective and potentially less costly, we demonstrate how the tools of comparative effectiveness research can be used to examine the role of novel health delivery approaches in our health care system.

CONCLUSION

In identifying a subset of patients for which LTAC care is equally effective and potentially less costly, we demonstrate how the tools of comparative effectiveness research can be used to examine the role of novel health delivery approaches in our health care system. LTACs are a prime example of how financial incentives can radically change health care delivery. The expansion of the LTAC model was driven by payment structures that create incentives for early hospital discharge for severely ill patients, rather than clear evidence of clinical or financial benefit.¹⁰ Nonetheless it is possible to critically examine these changes in ways that can inform policy decisions. Policy makers can use these results to reevaluate payment models for LTACs in ways that result in costs-savings from the societal and payer perspectives, while at the same time improving the quality of care for hospitalized patients. Bundled payments, use of accountable care organizations, and other financial incentives to optimize LTAC utilization have the potential to better integrate episodes of acute care while maximizing value of LTACs to the health system.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This work was supported by a research grant from the National Institutes of health (R01HL096651).

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Table 1

Acute care hospital characteristics

Variable	Value (n = 2,609)
Hospital beds	175 [110 - 294]
ICU beds	16 [10 - 31]
Academic status *	
Non-teaching	1,615 (61.9)
Small teaching	698 (26.8)
Large teaching	296 (11.3)
Annual volume of patients with chronic critical illness	11 [4 - 26]
LTAC in HRR	
Zero	691 (26.5)
One	590 (22.6)
Two	483 (18.5)
Three	258 (9.9)
4	587 (22.5)
LTAC beds in HRR	
Zero	691 (26.5)
1 – 200	1,164 (44.6)
201 – 400	396 (15.2)
>400	358 (13.7)
Percent transferred to LTAC	
Median [IQR]	17.6 [0 - 38.1]
Range	[0 - 1]

Values are median [IQR] or N (percent.)

ICU = intensive care unit; LTAC = long-term acute care hospital; HRR = hospital referral region; IQR = interquartile range

* Academic status defined using the resident to bed ratio and categorized as non-teaching (ratio=0), small teaching (ratio >0 and <0.25) and large teaching (ratio ≥ 0.25).

Table 2

Patient Characteristics

	LTAC in HRR		No LTAC in HRR	
	LTAC transfer (n=43,540)	No LTAC transfer (n= 124,416)	LTAC transfer (n= 4,876)	No LTAC transfer (n= 61,967)
Demographics				
Age	76.5 ± 6.6	77.1 ± 7.0	76.5 ± 6.3	77.0 ± 6.7
Female gender (%)	21,772 (50.0)	60,774 (48.8)	2,398 (49.2)	29,653 (47.9)
Race (%)				
White	34,676 (79.6)	99,240 (79.8)	4,170 (85.5)	54,138 (87.4)
Black	6,974 (16.0)	18,682 (15.0)	538 (11.0)	5,584 (9.0)
Other	1,890 (4.3)	6,494 (5.2)	168 (3.4)	2,245 (3.6)
Socioeconomic status by ZIP code				
Median income	41,270 ± 15,140	42,271 ± 16,403	42,396 ± 16,596	45,295 ± 18,099
Percent owning own home	66.7 ± 16.8	64.9 ± 19.2	71.4 ± 13.9	69.2 ± 16.2
Percent below poverty line	13.6 ± 9.2	13.7 ± 9.5	12.0 ± 8.0	11.5 ± 7.9
Percent with college degree	25.8 ± 16.4	27.0 ± 17.2	25.4 ± 15.0	27.8 ± 15.5
Clinical characteristics				
Admission source (%)*				
Emergency department	11,308 (27.6)	31,180 (26.3)	1,320 (28.5)	14,892 (25.0)
Outside hospital	4,410 (10.8)	12,006 (10.1)	436 (9.4)	6,503 (10.9)
SNF Transfer	1,435 (3.5)	4,514 (3.8)	120 (2.6)	2,132 (3.6)
Direct	23,777 (58.1)	70,919 (59.8)	2,751 (59.5)	35,993 (60.5)
Primary diagnosis (%)				
Respiratory	12,634 (29.0)	41,532 (33.4)	1,396(28.6)	19,672 (31.7)
Neurological	5,231 (12.0)	11,331 (9.1)	529 (10.8)	5,533 (8.9)
Cardiac surgery	6,678 (15.3)	12,487 (10.0)	932 (19.1)	7,662 (12.4)
Cardiac - non surgery	4,444 (10.2)	14,484 (11.6)	450 (9.2)	7,109 (11.5)
Other	14,553 (33.4)	44,582 (35.8)	1,569 (32.2)	21,991 (35.5)
Co-morbidities - #, Median [IQR]	5 [4 - 7]	5 [4 - 7]	5 [3 - 7]	5 [3 - 7]
Comorbidities - type (%)				
Congestive heart failure	21,716 (49.9)	61,710 (49.6)	2,453 (50.3)	30,333 (49.0)
Chronic lung disease	22,725 (52.2)	62,790 (50.5)	2,551 (52.3)	31,297 (50.5)
Diabetes	13,400 (30.8)	38,107 (30.6)	1,385 (28.4)	17,926 (28.9)
Cancer	5,823 (13.4)	19,841 (15.9)	606 (12.4)	9,331 (15.1)
Outcomes of acute care				
Acute care length of stay (mean ± SD)				
Hospital	31.3 ± 15.7	33.5 ± 22.7	35.3 ± 18.4	38.8 ± 27.6
LTAC	35.3 ± 25.9	-	40.1 ± 29.4	-
Total	66.6 ± 31.0	33.5 ± 22.7	75.4 ± 34.9	38.8 ± 27.6
Acute care length of stay (median, IQR)				
Hospital	28 [21 - 37]	26 [20 - 38]	29 [22 - 39]	27 [20 - 40]

	LTAC in HRR		No LTAC in HRR	
	LTAC transfer (n=43,540)	No LTAC transfer (n= 124,416)	LTAC transfer (n= 4,876)	No LTAC transfer (n= 61,967)
LTAC	31 [18 – 46]	-	35 [20 – 56]	-
Total	62 [46 – 81]	26 [20 – 38]	67 [50 – 92]	27 [20 – 40]
Acute care outcomes (%)				
Home	6,700 (15.4)	32,559 (26.2)	543 (11.1)	15,747 (25.4)
SNF/rehab	15,573 (35.8)	41,523 (33.3)	1,684 (34.6)	20,500 (33.5)
Acute care	8,048 (18.5)	18,506 (14.9)	883 (18.1)	9,173 (14.8)
Dead	13,208 (30.3)	31,781 (25.5)	1,766 (36.2)	16,270 (26.3)
Unknown	11 (0)	46 (0.0)	0(0.0)	10 (0.0)
Hospital readmissions in 180 days	1.3 ± 0.7	1.3 ± 0.7	1.3 ± 0.7	1.3 ± 0.7
Skilled nursing facilitation admission in 180 days	0.4 ± 0.7	0.4 ± 0.7	0.4 ± 0.7	0.4 ± 0.8
1-year mortality	25,955 (59.6)	79,820 (64.2)	3,045 (62.4)	37,200 (60.0)
Costs and payments				
Acute care costs (thousands \$)				
Hospital	71.9 ± 48.4	74.1 ± 64.1	81.3 ± 56.2	80.7 ± 68.1
LTAC	43.1 ± 43.5	-	52.8 ± 48.3	-
Total	114.0 ± 67.3	74.1 ± 64.1	134.0 ± 75.7	80.7 ± 68.1
Acute care Medicare payments (thousands \$)				
Hospital	76.5 ± 46.1	68.4 ± 60.1	84.3 ± 49.7	74.1 ± 60.7
LTAC	43.9 ± 32.2	-	44.5 ± 32.8	-
Total	120.3 ± 57.9	68.4 ± 60.1	128.8 ± 59.4	74.1 ± 60.7
Total 180-day inpatient costs	127.5 ± 73.5	85.4 ± 73.8	147.1 ± 83.0	93.9 ± 79.5
Total 180-day inpatient payments	131.6 ± 61.7	77.9 ± 65.1	139.5 ± 63.2	83.5 ± 64.8

Values are mean ± SD, median [IQR] or N (percent.)

LTAC = long-term acute care hospital; HRR = hospital referral region; SNF = skilled nursing facility; IQR = interquartile range

Table 3

Association between long-term acute care hospital transfer and survival

Model	N	HR	95% CI	P Value
Base Analyses				
Unadjusted	232423	1.21	(1.19 - 1.22)	< 0.001
Adjusted [*]	232423	1.24	(1.22 - 1.25)	< 0.001
Adjusted plus instrument [†]	232423	0.99	(0.96 - 1.01)	0.27
Sensitivity Analyses [†]				
ICU length of stay 7 days	404738	0.93	(0.91 - 0.94)	< 0.001
ICU length of stay 10 days	294287	0.93	(0.91 - 0.95)	< 0.001
Excluding hospitals with co-located LTACs	223876	0.99	(0.96 - 1.01)	0.35
Excluding hospitals in HRRs without LTACs	166217	0.98	(0.95 - 1.01)	0.22

HR = hazard ratio; CI = confidence interval; ICU = intensive care unit; HRR = hospital referral region; LTAC = long-term acute care hospital

^{*} Models adjusted for age, gender, race, diagnostic category, comorbidities, socioeconomic status, hospital ownership, and hospital academic status.[†] Models use the instrumental variable approach as well as adjustment for all covariates in adjusted model.

Table 4

Association between long-term acute care hospital transfer and 180-day resource utilization

		Unadjusted	Adjusted	Adjusted plus IV
Costs				
Acute care hospitalization costs	Value	40,645	40,018	-3,980
	95% CI	(38,206 - 43,083)	(38,075 - 41,962)	(-16,484 - 8,525)
	p-value	< 0.001	< 0.001	0.53
Post-acute care hospitalization costs	Value	644	251	-9,463
	95% CI	(125 - 1,163)	(-262 - 763)	(-12,460 - -6,465)
	p-value	0.015	0.34	< 0.0001
Total costs	Value	41,289	40,269	-13,442
	95% CI	(38,679 - 43,898)	(38,217 - 42,321)	(-26,662 - -223)
	p-value	< 0.001	< 0.001	0.046
Payments				
Acute care hospitalization payments	Value	50,908	49,269	12,700
	95% CI	(49,191 - 52,625)	(48,090 - 50,448)	(3880 - 21,519)
	p-value	<0.001	<0.001	<0.001
Post-acute care hospitalization payments	Value	1,676	1,182	2,892
	95% CI	(1,371 - 1,980)	(889 - 1,475)	(1,442 - 4,343)
	p-value	<0.001	<0.001	<0.001
Total payments	Value	52,584	50,451	15,592
	95% CI	(50,758 - 54,409)	(49,210 - 51,693)	(6,343 - 24,842)
	p-value	<0.001	<0.001	0.001
Post-discharge hospitalizations				
Acute care readmissions	Value	0.066	0.052	0.060
	95% CI	(0.056 - 0.076)	(0.042 - 0.061)	(0.014 - 0.107)
	p-value	<0.001	<0.001	0.01
Skilled nursing facility admissions	Value	0.033	-0.008	-0.591
	95% CI	(-0.034 - 0.019)	(-0.034 - 0.019)	(-0.728 - -0.454)
	p-value	0.01	0.57	<0.001

IV = instrumental variable