Community Use of Physical and Occupational Therapy After Stroke and Risk of Hospital Readmission

Janet K. Freburger, PT, PhD,[a,b] Dongmei Li, MS,[c] Erin P. Fraher, PhD[b,d]

From the [a]Department of Physical Therapy, University of Pittsburgh, Pittsburgh, PA; [b]Cecil G. Sheps Center for Health Services Research, University of North Carolina, Chapel Hill, NC; [c]Department of Epidemiology, University of North Carolina, Chapel Hill, NC; and [d]Department of Family Medicine, University of North Carolina, Chapel Hill, NC.

Abstract

Objectives: To determine whether receipt of therapy and number and timing of therapy visits decreased hospital readmission risk in stroke survivors discharged home.

Design: Retrospective cohort analysis of Medicare claims (2010−2013).

Setting: Acute care hospital and community.

Participants: Patients hospitalized for stroke who were discharged home and survived the first 30 days (N = 23,413; mean age ± SD, 77.6±7.5y).

Interventions: Physical and occupational therapist use in the home and/or outpatient setting in the first 30 days after discharge (any use, number of visits, and days to first visit).

Main Outcome Measures: Hospital readmission 30 to 60 days after discharge. Covariates included demographic characteristics, proxy variables for functional status, hospitalization characteristics, comorbidities, and prior health care use. Multivariate logistic regression analyses were conducted to examine the relation between therapist use and readmission.

Results: During the first 30 days after discharge, 31% of patients saw a therapist in the home, 11% saw a therapist in an outpatient setting, and 59% did not see a therapist. Relative to patients who had no therapist contact, those who saw an outpatient therapist were less likely to be readmitted to the hospital (odds ratio, 0.73; 95% confidence interval, 0.59−0.90). Although the point estimates did not reach statistical significance, there was some suggestion that the greater the number of therapist visits in the home and the sooner the visits started, the lower the risk of hospital readmission.

Conclusions: After controlling for observable demographic-, clinical-, and health-related differences, we found that individuals who received outpatient therapy in the first 30 days after discharge home after stroke were less likely to be readmitted to the hospital in the subsequent 30 days, relative to those who received no therapy.

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Advances in the acute care of stroke have reduced stroke mortality by approximately 40% in recent decades,[1] but the incidence of residual impairments in stroke survivors remains high, making stroke a major cause of long-term disability in adults.[2-5] Motor impairment is the most common and widely recognized impairment after stroke,[5] affecting 80% of stroke survivors to varying degrees.[3] Poststroke cognitive impairments are also fairly common, affecting up to one-third of survivors.[6,7] Motor and cognitive impairments after stroke affect quality of life, interfering with daily activities, function, and social roles. These impairments also increase the risk of inactivity, falls, and hospital readmission.[8-12]

Physical and occupational therapists play key roles in rehabilitating stroke survivors with motor and cognitive impairments.[5]

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Clinical practice guidelines recommend rehabilitation evaluation and treatment as soon as possible after hospital admission,[13-17] but decreasing lengths of stay shift much of the rehabilitation to postacute settings (ie, inpatient rehabilitation facility [IRF], skilled nursing facility [SNF], the patient's home, the outpatient setting). Stroke survivors with more severe limitations and/or the lack of family support are more likely to be discharged to an IRF or SNF, but most (approximately 60%) are discharged directly home.[18,19]

Literature on the comparative effectiveness and cost of postacute rehabilitation care for patients with stroke and other diagnoses has primarily focused on care in delivered IRFs and SNFs.[19-33] Less is known for patients who transition from acute care to the community. Although a few studies have examined the use of postacute care in the home,[28,34] the use of rehabilitation in outpatient settings after hospitalization has largely been ignored.

Understanding all possible postacute care pathways is important because evidence suggests early contact with a therapist and more intense therapy (eg, greater number of visits/time) may promote better recovery after stroke.[14,27,35] Physical and occupational therapists also play a role in educating patients about stroke recovery, secondary prevention, safe mobility, and self-management of physical activity and exercise.[8] Such activities promote better health and well-being of stroke survivors and may decrease the risk of hospital readmission, falls, and other adverse health care events.[36-38] Understanding postacute care pathways for stroke also has implications for models of care delivery and payment that promote care coordination (eg, Accountable Care Organizations, Patient-Centered Medical Homes) and the sharing of financial risk across settings and/or providers (eg, bundled payment).

We examined the group of stroke survivors discharged directly home after stroke to determine whether receipt of physical therapist and/or occupational therapist care in the first 30 days postdischarge (delivered in the home or outpatient setting), the number of therapist visits in the first 30 days, and the timing of the first therapist visit (ie, days from discharge to start of care) were associated with hospital readmission. We hypothesized that receipt of care, more intense care (ie, greater number of visits), and timelier care would be associated with a decreased risk of readmission.

Methods

Data sources

Our primary data source was a 20% random sample of Medicare claims (2010−2013). We extracted data from the Beneficiary Summary, Medicare Provider and Analysis Review, Home Health, Outpatient, Carrier, and Durable Medical Equipment files. The claims data were merged with Area Health Resource file data to obtain information on socioeconomic factors in the county where the stroke survivor resided.

Study design and cohort

We used a retrospective, cohort design to identify Medicare beneficiaries admitted to short-term, acute care hospitals for stroke.

List of abbreviations:

IRF **inpatient rehabilitation facility**
SNF **skilled nursing facility**

We established a 6-month baseline period prior to admission to assess comorbidities and health care use; the hospitalization period to assess comorbidities and clinical characteristics and therapist use; and a 30-day exposure period after discharge home to assess the use, number, and timing of in-home and outpatient therapist visits. We then assessed the 30-day period after the exposure period (ie, our follow-up period) to identify hospital readmissions (supplemental fig S1, available online only at http://www.archives-pmr.org/). Our motivation for this design was to have an exposure period distinct from the outcome assessment period to improve causal inference.

We limited our sample to Medicare beneficiaries who were ≥66 years at admission (to ensure cases were Medicare eligible during the 6-mo baseline period), survived the hospital stay and were discharged directly home, remained at home and survived the first 30 days after discharge, and were continuously enrolled in Medicare Parts A and B (traditional, fee-for-service). We excluded individuals hospitalized for stroke during the 6-month baseline period. We identified stroke based on primary and secondary *International Classification of Diseases−9th Revision−Clinical Modifications* discharge diagnoses codes[39-43] and excluded individuals with transient ischemic attack diagnoses (supplemental table S1).

Exposure, outcome, and covariates

We created several variables to describe therapist exposure in the 30 days after discharge home. We created a categorical variable indicating whether the patient received care from a physical therapist and/or occupational therapist in the home (home health claims), in the outpatient setting (outpatient and carrier claims), or not at all. For patients who had contact with a physical or occupational therapist, we created variables to indicate the number of therapist visits and time to first visit for both settings (home or outpatient). We identified therapist use based on revenue center codes and Healthcare Common Procedure Coding System/Current Procedural Terminology codes for therapy-related procedures (supplemental appendix S1 and supplemental table S2) using an algorithm developed by RTI International.[43] We combined physical therapist and occupational therapist visits because of the low number of occupational therapist visits overall.

We created a dichotomous outcome variable indicating whether the patient was hospitalized in a short-term, acute care hospital in the subsequent 30 days after the exposure for any reason (data from MedPAR claims, supplemental table S3). We also created several covariates (ie, control variables) to characterize the sociodemographic characteristics of patients (eg, age, race, dual eligibility), the hospitalization (eg, length of stay, intensive care unit use), and comorbidities during baseline and hospitalization. Specifically, we identified Elixhauser[44] comorbidities during baseline and hospitalization, stroke-related comorbidities (eg, aphasia, dementia) during hospitalization, and frailty comorbidities during baseline. The latter were developed based on the work of Faurot et al.[45] Finally, we created variables to indicate baseline health care use. Covariate definitions are shown in supplemental table S3.

Analysis

We conducted descriptive analyses to identify therapist use in the home and outpatient settings. We then conducted several multivariate logistic regression analyses to examine the association

between therapist use, visits, and timing and the risk of hospital readmission controlling for all covariates previously described. Analyses were conducted in Stata 14[a] using the robust SE option and clustering on hospital to account for the nonindependence of measures within hospital.[46]

Effect of therapist use in home or outpatient setting

We used a propensity score technique with inverse probability of treatment weighting with stabilization and trimming (for stabilized weights>10)[45-47] to estimate treatment effects. Briefly, for each patient, we calculated the conditional probably (propensity score) of receiving care from a physical therapist and/or occupational therapist (in the home and/or outpatient setting) given our defined covariates (see supplemental table S3). We then generated inverse probability of treatment weights for each patient using the propensity scores (ie, patients who had a higher propensity to receive physical therapy and/or occupational therapy were assigned larger weights). The propensity score essentially balances the characteristics (covariates) of treated and untreated subjects mimicking some aspects of a randomized controlled trial.[47] Once the weights were calculated, we used them in multivariate logistic regression models to examine the effects of therapist use in the home or outpatient setting (relative to no use) on risk of hospital readmission. We conducted analyses on the overall sample and on the following subgroups to assess heterogeneity of treatment effects: men, women, black, white, dual eligible, ischemic stroke, and hemorrhagic stroke.

Effect of number and timing of visits

These analyses were limited to individuals who received therapist care in the first 30 days after discharge. Because there was variability in the number and timing of visits by setting and because of differences in case mix for patients seen in the home versus outpatient setting, we conducted analyses separately by setting. We created categorical variables for the total number of therapist visits in the first 30 days after discharge based on the quartile distribution of the data for each setting. Patients who received both home health and outpatient care (n=291) were grouped with the home health setting because these individuals received home health first, most of the visits in the 30-day exposure period were for home health, and the number of subjects overall was small (1% of the sample). We also created categorical variables to represent the number of days from discharge to the first therapist visit based on the distribution of the data and with a particular focus on the first 2 weeks of the exposure period (ie, we created more granular categories for the time period from 1 to 14d). Because of smaller sample sizes we did not conduct subgroup analyses for the effects of therapist visits and timing.

Our study protocol was reviewed and approved by the University of North Carolina's Institutional Review Board.

Results

Our sample consisted of 23,413 patients discharged home after stroke (fig 1). In the first 30 days after discharge, 40.8% of patients (n=9546) had contact with a physical therapist and/or occupational therapist. Thirty-one percent of the sample had contact with a therapist in their home, 11% had contact with a therapist in an outpatient setting, and 1% had contact with therapists in both settings. Figure 2 provides detailed information on therapist use.

For patients who had contact with a therapist in the home, the mean and median number of days to the first visit was 5.2±4.6 and 4, respectively, and the mean number of visits was 7.5±4.5. For patients who received outpatient therapy, the mean and median number of days to the first visit was 10.3±7.6 and 8, with a mean of 5.7±4.6 visits. Physical therapist use was much more frequent than occupational therapist use and occupational therapist use was most often in combination with physical therapist use.

Table 1 presents select sample characteristics stratified by therapist use. Patients who received care in the home were older, more likely to be black and dual eligible, and generally had greater comorbid illness and baseline health care use than patients who received care in the outpatient setting. Although patients who received no postacute care generally had lower rates of comorbidities and physical impairments relative to those who received postacute care, in several instances these rates were only slightly lower.

Overall, 6.3% of the sample was readmitted to the hospital 31 to 60 days after discharge home. The unadjusted rate of readmission was highest for patients who received home health (7.4%), followed by patients who received no therapy (5.9%) and patients who received outpatient therapy (5.0%).

Effect of therapist use on readmission

Table 2 presents adjusted odds ratios for the effect of therapist use in the first 30 days postdischarge and readmission in the subsequent 30 days. Patients who received outpatient care in the first 30 days of discharge were less likely to be readmitted in the subsequent 30 days relative to patients who had no contact with a therapist (odds ratio, 0.73; 95% confidence interval, 0.59−0.90; $P=.003$). This effect was present in all subgroups; however, estimates were not statistically significant for the 2 smallest subgroups (ie, black, hemorrhagic stroke). The treatment effect was greatest in the dual eligible subgroup (odds ratio, 0.53; 95% confidence interval, 0.30−0.95; $P=.03$) Patients who received home health therapy and were a woman or white had a higher risk of hospital readmission (odds ratios, 1.16 and 1.19, respectively) relative to those who received no therapy.

Effect of therapist visits on readmission

Table 3 presents adjusted odds ratios for the effect of therapist visits and hospital readmission. Although findings were not significant, the effect of receiving 8 to 9 home health visits in the first 30 days (relative to 1−4 home health visits) on hospital readmission approached significance (odds ratio, 0.78; 95% confidence interval, 0.58−1.03; $P=.08$). The number of outpatient therapist visits was not associated with hospital readmission.

Effect of therapist timing on readmission

Table 4 presents adjusted odds ratios for the effect of timing of the first therapist visit and hospital readmission. Although the point estimates for time to first home health visit or first outpatient visit suggest that patients seen in the first 2 weeks after discharge have a decreased risk of readmission, these estimates were imprecise (ie, wide confidence intervals) and did not reach statistical significance.

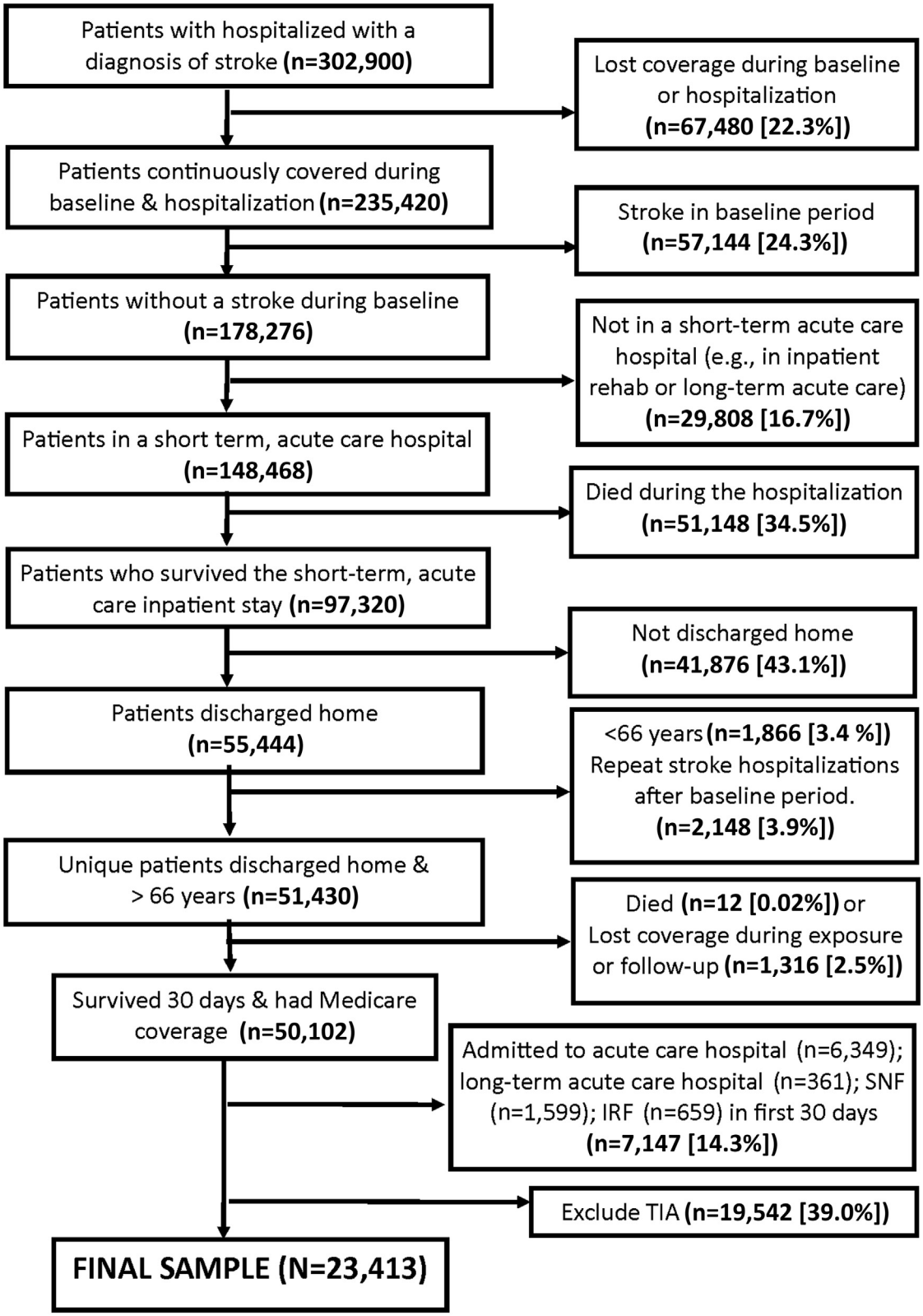

Fig 1 Cohort diagram.

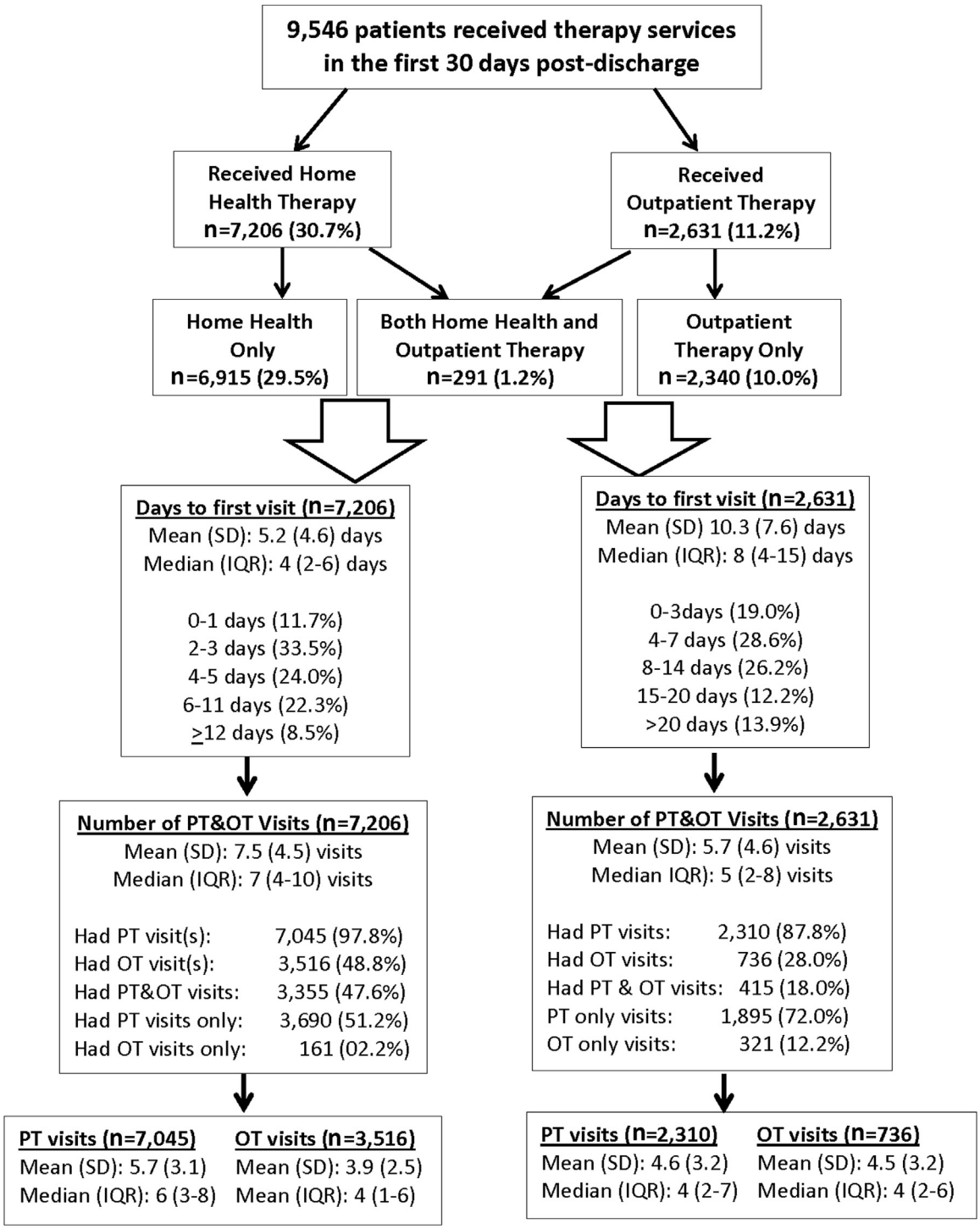

Fig 2 Therapy use during 30-day exposure period. Abbreviations: IQR, interquartile range; OT, occupational therapist; PT, physical therapist.

Discussion

We examined the effect of therapist use, therapist visits, and timing of first visit in the first 30 days after discharge home on subsequent hospital readmission in a sample of Medicare beneficiaries hospitalized for stroke. Our most compelling finding was that patients who had contact with an outpatient therapist in the first 30 days after discharge home were less likely to be readmitted to the hospital in the subsequent 30 days, relative to patients who did not have any therapist contact. This effect was consistently observed in the various subgroup analyses and may be because of factors such as improved physical function, engagement with the health care system, and/or patient education on physical activity, falls prevention, stroke risk factors, and so forth.

Table 1 Sample characteristics by therapist use (N = 23,413)

Characteristic	Postacute Therapist Use		
	In Home (30.8%)	Outpatient* (10.0%)	None (59.2%)
Demographic characteristics			
Male	34.0	50.0	46.0
Mean age ± SD, y	79.8±7.7	75.8±6.7	76.7±7.3
Race White	76.4	87.8	82.5
Black	15.0	7.0	10.2
Hispanic	3.8	1.6	2.7
Other	4.8	3.6	4.6
Dual eligibility	33.6	14.1	25.3
Hospitalization characteristics			
Stroke Hemorrhagic	12.4	10.5	12.0
Ischemic	87.6	89.5	88.0
Intensive care unit use	37.8	36.7	36.6
Coronary care unit use	15.6	13.2	14.5
Mean length of stay ± SD (d)	4.6±4.1	3.3±2.9	3.4±2.9
Received care from PT and/or OT	69.6	91.7	89.9
Stroke-related comorbidities			
Aphasia	11.4	10.3	10.8
Dysphagia	5.8	3.9	2.5
Movement abnormalities	8.0	10.8	5.8
Hemiparesis/hemiplegia	18.2	21.9	13.4
Fall	1.1	0.6	0.5
Elixhauser comorbidities			
Comorbidity count			
0—1	7.2	12.2	11.9
2—4	34.2	41.2	38.9
5—7	30.8	26.6	26.6
8—10	19.6	12.2	13.2
>10	18.3	7.8	9.5
Paralysis	18.3	15.9	8.6
Other neurologic	53.3	34.3	37.2
Obesity	6.4	4.4	4.7
Depression	16.6	9.7	9.4
Baseline frailty comorbidities and health care use			
Use of wheelchair	3.2	0.8	1.3
Parkinson disease	1.3	0.7	0.6
Weakness	0.6	0.2	0.3
Vertigo	6.8	6.8	6.7
History of a fall	8.0	5.3	3.3
Use of oxygen	6.6	2.3	4.0
Use of hospital bed	2.1	0.3	0.8
Use of assistive devices	2.8	1.2	1.4
≥2 hospitalizations	11.1	5.5	5.4
≥1 SNF admissions	4.8	1.7	1.7
Use of inpatient PT or OT	16.1	9.2	7.3
Use of PT or OT in home	21.4	3.8	5.5
Use of outpatient PT or OT	10.8	20.3	7.8

NOTE. Values are percentages or as otherwise indicated.
Abbreviations: OT, occupational therapist; PT, physical therapist.
* Restricted to patients who saw an outpatient therapist only.

Although we had a large sample size, we were generally underpowered to assess the effects of the number and timing of therapist visits on hospital readmission because of the low prevalence of our outcome and the fact that less than half of our sample had contact with a therapist after discharge home. Future work should use 100% Medicare claims data. Much more work is also needed in understanding what combinations of postacute care provide the greatest value. Although some work has been done comparing IRF versus SNF care after acute care hospitalizations, even this area lacks strong evidence to guide decisions about the most appropriate site for postacute care. Factors other than need often explain whether patients receive IRF or SNF care.[23]

Only 11% of our sample had contact with an outpatient therapist. Although therapist use in the home was higher (31%), more

Table 2 Adjusted* odds ratios for the effect of therapist use on hospital readmission

Sample	Therapist Use†	Hospitalized 31—60d After Discharge			
		Odds Ratio	95% Confidence Interval		*P*
Overall sample (N=23,413)	Home health	1.10	0.97	1.25	.13
	Outpatient	0.73	0.59	0.90	.003
White (n=19,003)	Home health	1.16	1.01	1.33	.04
	Outpatient	0.74	0.59	0.92	.008
Black (n=2652)	Home health	0.89	0.63	1.25	.50
	Outpatient	0.67	0.30	1.49	.33
Dual eligible (n=6263)	Home health	0.88	0.70	1.10	.26
	Outpatient	0.53	0.30	0.95	.03
Male (n=9995)	Home health	0.99	0.81	1.21	.94
	Outpatient	0.73	0.55	0.97	.03
Female (n=13,418)	Home health	1.19	1.01	1.40	.04
	Outpatient	0.70	0.51	0.96	.03
Ischemic stroke (n=20,613)	Home health	1.09	0.96	1.25	.19
	Outpatient	0.75	0.60	0.94	.01
Hemorrhagic stroke (n=2800)	Home health	1.15	0.84	1.57	.38
	Outpatient	0.51	0.23	1.12	.09

* Adjusted via inverse probability of treatment weights for demographic characteristics, hospitalization characteristics, comorbidities, and baseline health care use.

† Referent is no therapist use.

than half of our sample had no therapist contact. This is in contrast with most of our sample having contact with a therapist in the acute care setting (see table 1). These findings suggest there may be underutilization of therapists in the community after stroke considering current evidence that suggests rehabilitation begin as soon as possible and be as intensive as possible[5,8,13-15,17] and on prevalence estimates of 80% to 90% for motor impairment after stroke.[2,3,5] The low use of outpatient therapists, in particular, suggests a potential area to target as health care systems and insurers move to episode-based models of care delivery and payment.

Current Medicare payment policy for home health and outpatient therapy may be one explanation for our findings regarding greater therapist use in the home versus the outpatient setting. Therapist care in the home, is covered completely under Medicare Part A if a doctor certifies the patient is homebound and in need of therapy. Outpatient therapist care, however, is covered under Medicare Part B and the patient is responsible for 20% of the costs either through supplemental insurance or paying out-of-pocket. Another potential reason for this finding may be related to the processes in place at patient discharge. Unlike home health, which is sometimes arranged as part of the discharge process, patients are usually just given a written referral for outpatient therapy without assistance in locating a provider in their area. Other potential barriers include transportation issues, lack of family support, scarcity of outpatient therapists, and lack of physician support for therapist use and advocacy for physical activity/exercise after stroke.

Table 3 Adjusted* odds ratios for the effect of therapist visits on hospital readmission by setting

Visit Type	No. of Visits	Hospitalized 31—60d After Discharge Home		
		Odds Ratio	95% Confidence Interval	*P*
Home health visits (n=7206)	1—4	1.00	NA	NA
	5—7	0.94	0.73—1.20	.60
	8—9	0.78	0.58—1.03	.08
	≥10	1.08	0.84—1.39	.55
Outpatient visits (n=2340)	1—2	1.00	NA	NA
	3—5	1.06	0.60—1.85	.84
	6—7	1.10	0.62—1.96	.75
	≥8	1.17	0.66—2.09	.60

Abbreviation: NA, not applicable.

* Adjusted for demographic characteristics, hospitalization characteristics, comorbidities, and baseline health care use.

As the population ages and advances in medicine continue to improve the acute care of stroke, the prevalence of strokes survivors is likely to increase. Our findings provide some support for better efforts and policies to promote access to and continuity in the use of therapists in the acute to postacute transition after stroke, particularly for patients discharged home. One area to target is educating nurses, physicians, and other providers in the acute and postacute settings about the roles of therapists and the importance of early and continued care after discharge home. Facilitating the transition of patients across rehabilitation settings (eg, home to outpatient) with the objective of maximizing value by sending patients to the least expensive and safest setting to achieve the best possible outcomes is also important. Finally, the health care team needs to recognize and support the ultimate goal of rehabilitation, which is having the patient self-manage their physical activity and exercise to maintain cardiovascular health and general well-being. Needless to say, seamless communication and information exchange among providers in acute and postacute settings are necessary for effective care coordination and continuity for patients who transition from acute to postacute care. Electronic health records and other electronic forms of information exchange (eg, e-care plans) can potentially begin to address

Table 4 Adjusted* odds ratios for the effect of timing of first therapist visit on hospital readmission by setting

		Hospitalized 31—60d After Discharge		
Setting	Days to First Visit	Odds Ratio	95% Confidence Interval	*P*
Home health visits (n=7206)	1—6	0.82	0.56—1.19	.29
	7—14	0.85	0.56—1.29	.45
	>14	1.00	NA	NA
Outpatient visits (n=2340)	1—7	0.85	0.45—1.58	.60
	8—13	0.88	0.55—1.40	.59
	>13	1.00	NA	NA

Abbreviation: NA, not applicable.

* Adjusted for demographic characteristics, hospitalization characteristics, comorbidities, and baseline health care use.

issues around care transitions and continuity of care. As hospitals move toward alternative payment models that include both acute and postacute care, strengthening continuity of therapist care across settings may be particularly useful in preventing downstream health care costs.

Study limitations

This study has several limitations. First, findings are limited to Medicare beneficiaries discharged home after stroke who survived the first 30 days at home. Second, we did not have direct measures of need for therapy based on therapist/physician assessment, but rather relied on proxy measures available in our data. Related to this limitation is the observational design of our study, which raises the possibility of unmeasured confounding. A third limitation is our measures of therapist utilization were very general (ie, number, timing of visits) and did not reflect the content or patient adherence. Because of sample size issues and the low use of occupational therapists, we chose to combine the physical therapist and occupational therapist data. Future studies should examine the effects of care delivered by each discipline, further explore the content of the therapy sessions, and include the use of other providers (eg, primary care physician, skilled nursing in the home, social worker). Because contact with other providers could also affect readmission risk, understanding the order and timing of all health care provider contacts is important to fully understand predictors of readmission. One strength of our study was that we had distinct exposure and follow-up periods that did not overlap. This design allowed for more confidence in causal inference, but eliminated individuals readmitted in the first 30 days after discharge home (fig 1). Although 30-day readmissions have been the focus of some alternative payment models (eg, Medicare's Readmissions Reduction Program), these models are evolving and including longer periods of risk sharing. In Medicare's Comprehensive Joint Replacement model, hospitals assume risk for their patients for the first 90 days after discharge. A final limitation is that we examined all-cause hospitalization and did not attempt to identify potentially preventable hospitalizations.

Conclusions

After controlling for observable demographic, clinical, and health-related differences, we found that individuals who received outpatient therapy in the first 30 days after discharge home after stroke were less likely to be readmitted to the hospital in the subsequent 30 days, relative to those who received no therapy.

Supplier

a. Stata 14; StataCorp.

Keywords

Occupational therapists; Patient readmission; Physical therapists; Rehabilitation; Stroke

Corresponding author

Janet K. Freburger, PT, PhD, Department of Physical Therapy, School of Health and Rehabilitation Science, Bridgeside Point 1, Ste 201, 100 Technology Dr, Pittsburgh, PA 15219-3130. *E-mail address:* janet_freburger@pitt.edu.

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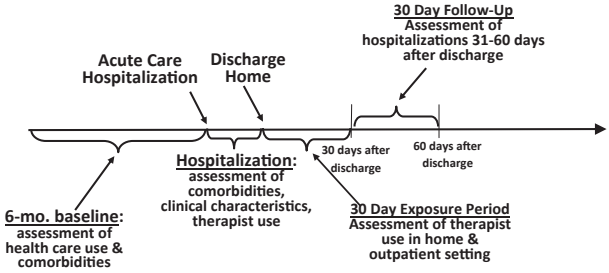

Supplemental fig S1 Study design.

Supplemental Appendix S1 Revenue center codes for therapy

Revenue Center Codes
0420 = Physical therapy—general classification
0421 = Physical therapy—visit charge
0422 = Physical therapy—hourly charge
0423 = Physical therapy—group rate
0424 = Physical therapy—evaluation or reevaluation
0429 = Physical therapy—other
0430 = Occupational therapy—general classification
0431 = Occupational therapy—visit charge
0432 = Occupational therapy—hourly charge
0433 = Occupational therapy—group rate
0434 = Occupational therapy—evaluation or reevaluation
0439 = Occupational therapy—other (may include restorative therapy)
0977 = Professional fees—physical therapy
0978 = Professional fees—occupational therapy

Supplemental Table S1 ICD-9-CM diagnosis codes to identify stroke and exclude TIA

ICD-9-CM Code	Description	Type of Stroke
430	Subarachnoid hemorrhage	Hemorrhagic
431	Intracerebral hemorrhage	Hemorrhagic
432	Other unspecified hemorrhage	Hemorrhagic
433.01	Basilar artery; with cerebral infarction	Ischemic
433.11	Carotid artery; with cerebral infarction	Ischemic
433.21	Vertebral artery; with cerebral infarction	Ischemic
433.31	Multiple and bilateral; with cerebral infarction	Ischemic
433.81	Other specified precerebral artery; with cerebral infarction	Ischemic
433.91	Unspecified precerebral artery; with cerebral infarction	Ischemic
434.01	Cerebral thrombosis; with cerebral infarction	Ischemic
434.11	Cerebral embolism; with cerebral infarction	Ischemic
434.91	Cerebral artery occlusion, unspecified; with cerebral infarction	Ischemic
436	Acute, but ill-defined, cerebrovascular disease	Ischemic
437.1	Other generalized ischemic cerebrovascular disease	Ischemic
435	Transient cerebral ischemia	TIA
435.0	Basilar artery syndrome	TIA
435.1	Vertebral artery syndrome	TIA
435.2	Subclavian steal syndrome	TIA
435.3	Vertebrobasilar artery syndrome	TIA
435.8	Other specified transient cerebral ischemia	TIA
435.9	Unspecified transient cerebral ischemia	TIA

Abbreviations: ICD-9-CM, *International Classification of Diseases—9th Revision—Clinical Modifications*; TIA, transient ischemic attack.

Supplemental Table S2 Therapy CPT/HCPCS codes*

Code Type	Code	Description	Code Type	Code	Description
Proc CPT	64550	Apply neurostimulator	Proc CPT	97032	Electrical stimulation
Proc CPT	90901	Biofeedback train, any meth	Proc CPT	97033	Electric current therapy
Proc CPT	90911	Biofeedback peri/uro/rectal	Proc CPT	97034	Contrast bath therapy
Proc CPT	92506	Speech/hearing evaluation	Proc CPT	97035	Ultrasound therapy
Proc CPT	92507	Speech/hearing therapy	Proc CPT	97036	Hydrotherapy
Proc CPT	92508	Speech/hearing therapy	Proc CPT	97039	Physical therapy treatment
Proc CPT	92520	Laryngeal function studies	Proc CPT	97110	Therapeutic exercises
Proc CPT	92526	Oral function therapy	Proc CPT	97112	Neuromuscular reeducation
Proc CPT	92597	Oral speech device eval	Proc CPT	97113	Aquatic therapy/exercises
Proc CPT	92605	Ex for nonspeech device rx	Proc CPT	97116	Gait training therapy
Proc CPT	92606	Nonspeech device service	Proc CPT	97124	Massage therapy
Proc CPT	92607	Ex for speech device rx, 1h	Proc CPT	97139	Physical medicine procedure
Proc CPT	92608	Ex for speech device rx addl	Proc CPT	97140	Manual therapy
Proc CPT	92609	Use of speech device service	Proc CPT	97150	Group therapeutic procedures
Proc CPT	92610	Evaluate swallowing function	Proc CPT	97530	Therapeutic activities
Proc CPT	92611	Motion fluoroscopy/swallow	Proc CPT	97532	Cognitive skills development
Proc CPT	92612	Endoscopy swallow tst (fees)	Proc CPT	97533	Sensory integration
Proc CPT	92614	Laryngoscopic sensory test	Proc CPT	97535	Self-care management training
Proc CPT	92616	Fees w/laryngeal sense test	Proc CPT	97537	Community/work reintegration
Proc CPT	92618	Ex for nonspeech dev rx add	Proc CPT	97542	Wheelchair management training
Proc CPT	95831	Limb muscle testing, manual	Proc CPT	97597	Rmvl devital tis 20cm or less
Proc CPT	95832	Hand muscle testing, manual	Proc CPT	97598	Rmvl devital tis addl 20cm or less
Proc CPT	95833	Body muscle testing, manual	Proc CPT	97602	Wound(s) care nonselective
Proc CPT	95834	Body muscle testing, manual	Proc CPT	97605	Neg press wound tx, <50cm
Proc CPT	95851	Range of motion measurements	Proc CPT	97606	Neg press wound tx, >50cm
Proc CPT	95852	Range of motion measurements	Proc CPT	97750	Physical performance test
Proc CPT	95992	Canalith repositioning Proc	Proc CPT	97755	Assistive technology assessment
Proc CPT	96105	Assessment of aphasia	Proc CPT	97760	Orthotic management and training
Proc CPT	96110	Developmental test, lim	Proc CPT	97761	Prosthetic training
Proc CPT	96111	Developmental test, extend	Proc CPT	97762	C/O for orthotic/prosth use
Proc CPT	96125	Cognitive test by HC pro	Proc CPT	97799	Physical medicine procedure
Proc CPT	97001	PT evaluation	Proc CPT	0019T	Extracorp shock wv tx ms NOS
Proc CPT	97002	PT reevaluation	Proc CPT	0183T	Wound ultrasound
Proc CPT	97003	OT evaluation	Proc HCPCS	G0281	Electrical stimulation unattend for press
Proc CPT	97004	OT reevaluation	Proc HCPCS	G0283	Electrical stimulation other than wound
Proc CPT	97010	Hot or cold packs therapy	Proc HCPCS	G0329	Electromagnetic tx for ulcers
Proc CPT	97012	Mechanical traction therapy			
Proc CPT	97016	Vasopneumatic device therapy			
Proc CPT	97018	Paraffin bath therapy			
Proc CPT	97022	Whirlpool therapy			
Proc CPT	97024	Diathermy (eg, microwave)			
Proc CPT	97026	Infrared therapy			
Proc CPT	97028	Ultraviolet therapy			

Abbreviations: addl, additional; C/O, care of; CPT, Current Procedural Terminology; dev, device; devital, devitalized; Elec, electric; eval, evaluation; Electromagntic, electromagnetic; Ex, exercise; Extracorp, extracorporeal; HC, healthcare; HCPCS, Healthcare Common Procedure Coding System; lim, limited; meth, method; ms, musculoskeletal system; Neg, negative; NOS, not otherwise specified; OT, occupational therapy; peri, perineal muscles; press, pressure; pro, professional; Proc, procedure; prosth, prosthetic; PT, physical therapy; Rmvl, removal; rx, prescription; stim, stimulation; tis, tissue; tst, test; tx, treatment; uro, urethral sphincter; w/, with; wv, wave.

* For this analysis, speech-related codes and wound therapy codes were excluded.

Supplemental Table S3 Definitions of outcome and explanatory variables

Variable	Definition	Data Source
Outcome		
Hospital readmission	Hospitalization in a short-term, acute care hospital (excluded long-term acute care, psychiatric, SNF, etc) for any reason in the first 30d after the exposure period.	Medicare MedPAR file
Sociodemographic variables		
Sex	Male = 1, female = 0	Medicare Beneficiary Summary File
Age	Age at hospital admission, categorized: 66—70, 71—75, 76—80, 81—85, 86—90, >90y	
Race	Categorized as white, black, Hispanic, other (patient's race categorized as other if missing, <1% missing)	
Dual eligibility	Medicare and Medicaid, coded as 1 = yes, 0 = no	
Hospitalization characteristics		
Patient admitted through emergency department	1 = yes, 0 = no, based on type of admission variable	Medicare MedPAR file
Patient transferred from another hospital	1 = yes, 0 = no, based on source of admission variable	
Type of stroke	Ischemic, hemorrhagic, or transient ischemic attack; coded 0 or 1 based on ICD-9-CM codes (see supplemental table S1)	
Stroke code in principal discharge diagnosis	Coded as 1 if principal discharge diagnosis is for stroke, 0 if stroke diagnosis in a secondary position	
Length of stay	Categorized as 1, 2, 3—4, 5—7, 8—10, >10d	
Use of intensive care	Based on revenue codes for ICU use, coded 1 if yes, 0 if no	
Use of coronary care	Based on revenue codes for ICU use, coded 1 if yes, 0 if no	
Physical therapist use	Based on revenue codes for use, coded as 1 if yes, 0 if no (see supplemental appendix S1)	
Occupational therapist use	Based on revenue codes for use, coded as 1 if yes, 0 if no (see supplemental appendix S1)	
Speech therapist use	Based on revenue codes for use, coded as 1 if yes, 0 if no	
Stroke-related and other relevant comorbidities		
Altered consciousness	ICD-9-CM diagnosis codes 780, 780.0, 780.02, 780.03	Medicare MedPAR file
Aphasia	ICD-9-CM diagnosis codes 438.1, 438.11, 784.3, 784.6	
Dysphagia	ICD-9-CM diagnosis codes 438.82, 787.2, 787.20, 787.21, 787.22, 787.23, 787.24, 787.29	
Aspiration pneumonia	ICD-9-CM diagnosis codes 507, 507.0, 507.1, 507.8	
Decubitus	ICD-9-CM diagnosis codes 707,707.0, 707.1, 707.10, 707.11, 707.12, 707.13, 707.14, 707.15, 707.19, 707.2, 707.20, 707.21, 707.22, 707.23,707.24, 707.25, 707.8, 707.9	
Dementia	ICD-9-CM diagnosis codes 290, 290.1, 290.11, 290.3, 290.4, 290.41, 291.0, 292.81, 293.0, 293.1	
Movement abnormalities	ICD-9-CM diagnosis codes 781.0, 781.2, 781.3	
Hemiparesis	ICD-9-CM diagnosis codes 782, 342.ss, 368.46, 781.8, 438.2, 432.12, 438.22, 438.3, 438.31, 438.32, 438.4, 438.41, 438.42, 438.5, 438.51, 438.52, 438.53, 438.6, 438.7, 438.84	
Falls	ICD-9-CM diagnosis codes E880, E880.9, E884.2, E884.3, E884.4, E884.5, E884.6, E884.9, E885, E886.9, E888, E888.0, E888.1, E888.8, E888.9, E9293, 719.7, 719.70, 719.75, 719.76, 719.77, 719.78, 719.79	
Incontinence	ICD-9-CM diagnosis codes 596.5, 596.51—596.55, 596.59, 788.2, 788.20, 788.21, 788.29, 788.3, 788.30—788.39	
Malnutrition	ICD-9-CM diagnosis codes 260, 262, 262, 263, 263.1 263.2, 26.8, 253.9	
Atrial fibrillation	ICD-9-CM diagnosis codes 427.3, 427.31, 427.32	
Hypertensive heart disease	ICD-9-CM diagnosis codes 402.xx	
Ischemic heart disease	ICD-9-CM diagnosis codes 410.xx—414.xx	

(*continued on next page*)

Supplemental Table S3 (*continued*)

Variable	Definition	Data Source
Vascular procedures	ICD-9-CM diagnosis codes 38.11, 28.12, 00.61—00.65, 17.53, 17.54, 38.01, 38.02, 38.31, 38.32, 38.41, 38.42, 38.51, 38.52, 38.61, 38.62, 38.81, 38.83, 39.72, 39.75, 39.76, 39.81—39.89	
Other comorbidities (Elixhauser comorbidities)		
Elixhauser Comorbidity Index	29 comorbidity variables (available at: https://www.hcup-us.ahrq.gov/toolssoftware/comorbidity/comorbidity.jsp) Created a dichotomous variable for each comorbidity identified during hospitalization and/or during baseline and a categorical count variable (<2, 2—4, 5—7, 8—10, >10 comorbidities)	Medicare MedPAR file, outpatient file, home health file, carrier file
Baseline frailty comorbidities		
Use of screening tests	HCPCS/CPT codes: G0009, 90669, 90732, 80061, 82465, 83715, 83716, 83717, 83718, 83719, 83720, 83721, 84478, 83700, 83701, 83704, G0101, G0202, 3014F, 76083, 77052, 76092, 77057, 3017F, G0104, G0105, G0106, G0107, G0120, G0121, G0122, G0328, G0102, G0103, 84153, 84154 ICD-9-CM diagnosis codes: V7644, V771, V7791, V761, V7610, V7611, V7612, V7651	Medicare MedPAR file, outpatient file, home health file, carrier file, and durable medical equipment file
Use of wheelchair	CPT/HCPCS codes: 97542, E0950—E0986, E0988, E0990—E1039, E1050, E1060, E1065, E1066, E1069, E1070, E1083-E1093, E1100, E1110, E1130, E1140, E1150, E1160, E1161, E1170—E1172, E1180, E1190, E1195, E1210—E1213, E1220—E1228, E1240, E1250, E1260, E1270, E1280, E1285, E1290, E1295—E1298, E2201—E2228, E2230, E2231, E2300, E2301, E2310—E2313, E2320—E2331, E2340—E2343, E2351, E2358—E2377, E2381—E2397, E2399, E2601—E2633, G9156, K0001—K0109, K0114—K0116, K0195, K0452, K0460, K0461, K0650—K0669, K0733—K0737, K0813—K0816, K0820—K0831, K0835—K0843, K0848—K0864, K0868—K0886, K0890, K0891, K0898, L3964, L3965, L3966 ICD-9-CM diagnosis codes: V463, V538	
Use of other assistive devices	HCPCS: A4635—A4637, E0100, E0105, E0110—E0114, E0116—E0118, E0130, E0135, E0140—E0149, E0153—E0159, E0163—E0172, E0175, E0240—E0248, K0457—K0459, L0978	
Parkinson disease	ICD-9-CM diagnosis codes: 332, 3320, 3321	
Weakness	ICD-9-CM diagnosis codes: 7282, 7283, 7287, 7993, V4984	
Vertigo	ICD-9-CM diagnosis codes: 386, 3860, 38600, 38601, 38602, 38603, 38604, 3861, 38610, 38611, 38612, 38619, 3862, 43885, 7804	
Falls/difficulty walking	ICD-9-CM diagnosis codes: 7197, 71970, 71975, 71976, 71977, 71978, 71979, 7812, V1588, E880, E8800, E8801, E8809, E8842, E8843, E8844, E8845, E8846, E8859, E888, E8880, E8881, E8888, E8889, E9293	
Incontinence	ICD-9-CM diagnosis codes: 5965, 59651, 59652, 59653, 59654, 59655, 59659, 7882, 78820, 78821, 78829, 7883, 78830, 78831, 78832, 78833, 78834, 78835, 78836, 78837, 78838, 78839	
Decubitus	ICD-9-CM diagnosis codes: 7070, 7071, 70710, 70711, 70712, 70713, 70714, 70715, 70719, 7072, 70720, 70721, 70722, 70723, 70724, 70725, 7078, 7079	
Use of oxygen	HCPCS codes: E0431, E0433, E0434, E0435, E0439, E0441, E0442, E0443, E1390, E1393, K0671	
Use of hospital bed	HCPCS codes: E0250, E0251, E0255, E0256, E0260, E0261, E0265, E0266, E0270, E0290, E0291, E0292, E0293, E0294, E0295, E0296, E0297, E0301, E0302, E0303, E0304, E0316, K0456, K0459, K0550	
Use of ambulance	HCPCS codes: A0426, A0427, A0428, A0429, A0999	
Nail care	HCPCS and CPT codes: 11700, 11701, 11710, 11711, 11719, 11720, 11721, G0127, G0247, M0101	

(*continued on next page*)

Supplemental Table S3 (*continued*)

Variable	Definition	Data Source
Baseline health care use		
Hospitalization	Number of hospitalizations during baseline period categorized as 0, 1, 2 or more.	From MedPAR files
SNF admissions	SNF admission during baseline period (yes or no)	From MedPAR files
Use of PTs or OTs during baseline	Indicator for outpatient therapy use, home health therapy use, use in short-stay hospital, use in SNF or long-term care hospital (see supplemental appendix S1 and supplemental table S2)	From MedPAR, outpatient, carrier, home health files
Use of speech therapists during baseline	Indicator for speech therapist use during baseline in an inpatient setting based on revenue center codes	From MedPAR files

Abbreviations: CPT, Current Procedural Terminology; HCPCS, Healthcare Common Procedure Coding System; ICD-9-CM, *International Classification of Diseases—9th Revision—Clinical Modifications*; ICU, intensive care unit; MedPar, Medicare provider and analysis review; OT, occupational therapist; PT, physical therapist.