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Effect of Age and Sex on Hospital Readmission in Traumatic Brain Injury

Chih-Ying Li, PhD[1], **Amol Karmarkar, PhD**[1], **Deepak Adhikari, MS**[2], **Kenneth Ottenbacher, PhD**[1], and **Yong-Fang Kuo, PhD**[2]

[1]Division of Rehabilitation Sciences, School of Health Professions, University of Texas Medical Branch

[2]Department of Preventive Medicine and Community Health, University of Texas Medical Branch

Abstract

Objective—To investigate the impact of age and sex on 30-, 60- and 90-day hospital readmission after acute hospital discharge for individuals with traumatic brain injury (TBI).

Design—Retrospective cohort study.

Setting—Acute hospitals and post-acute discharge settings

Participants—From the 2013 Nationwide Readmissions Database, we retrieved information on 52,877 individuals with diagnosis-related group codes of TBI. We included only those alive at index acute discharge and excluded those discharged with same-day readmission. We divided our sample into four age groups: 18-40, 41-65, 66-75 and 76+ years old.

Interventions—NA.

Main Outcome Measure(s)—All-cause hospital readmission.

Results—Sex differences in 30-, 60- and 90-day hospital readmission were found for all age groups (all p<.05). The largest sex differences in hospital readmission were in the two oldest groups (66-75, 76+). For both sexes, the oldest group (76+) had the highest adjusted 90-day readmission risk [e.g., 90-day readmission: Odds Ratio (OR) = 2.32 (2.01-2.69) for males; OR=1.96 (1.59-2.43) for females]. Among those readmitted within 90 days, the youngest group (18-40 years) had the highest cumulative readmission percent (35% for both sexes) within the first week post-hospital discharge.

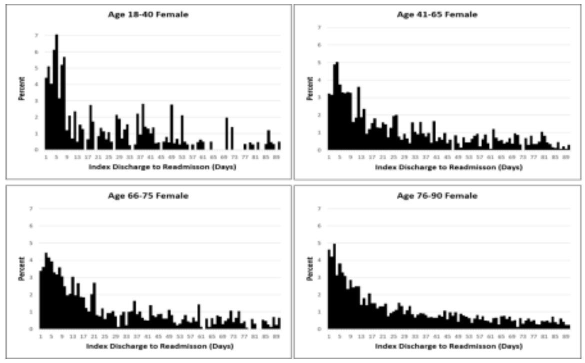
Conclusion—Age and sex were significantly associated with hospital readmission during the first 90 days post-discharge in our TBI sample. Specifically, those aged 66-75 or 76+ had the highest readmission risk over 90 days for both sexes. The findings suggest that clinicians should consider age and sex in discharge planning and for the entire episode of care for the TBI population.

Corresponding Author: Chih-Ying Li, 301 University Blvd. Galveston, TX 77555-0177; Phone: (617) 834-2611. chili@utmb.edu. Fax: 409-747-1638.

Reprints are not available

Conflict of Interest Disclaimer: All authors declare that they have no potential conflicts of interest with respect to publish this paper.

Graphical abstract



Key words (MeSH terms)

brain injuries; hospital readmission; patient age groups; long-term care

Introduction

Worldwide, nearly 10 million individuals experience traumatic brain injury (TBI) each year[1,2]. Brain injury can cause complex and chronic health conditions with high mortality and prolonged morbidity[3,4]. Furthermore, brain injury can lead to chronic physical, cognitive and psychological impairments that further worsen patients' health and quality of life[5]. TBI is among the leading causes of emergency department visits and hospital admissions[6,7]. Patients with severe TBI or more underlying comorbidities have higher rates of hospital readmissions than those with less severe injury or fewer comorbidities[8,9].

Since hospital readmissions are highly prevalent and costly[10,11], identifying factors influencing hospital readmission could serve as a crucial first step to improving care outcomes in the TBI population[10,11]. Studies show that patients leaving hospitals against medical advice after TBI had higher rates of readmission[12,13]. Corrigan and colleagues (2014)[14] pointed out that age-specific interventions are needed to reduce post-acute inpatient rehabilitation mortality in TBI. For patients with stroke, Slocum and colleagues (2006)[15] found that age and functional status were better predictors of hospital readmission across nine years compared to medical comorbidities; however, such age-specific association remains unclear for the TBI population. In addition to age, recent studies have pointed out that sex-specific research in TBI is sparse and needed, to help improve emergency care and health outcomes for the TBI population[16,17].

Most studies in the brain injury field include relatively small samples of patients (<100)[18]. In addition, most of the work related to hospital readmission has been conducted using a 30-day follow-up period. Only one recent Canadian population-based study examined the predictors of rehospitalization in a 3-year period post-TBI and identified the following significant predictors: male, older age, falls, greater injury severity, rural residence, greater comorbidity and psychiatric comorbidity[19]. To our knowledge, this study is the first to analyze the U.S. nationally representative TBI data for adults at all ages, covering all insurance plans across a 90-day follow-up period. Since patients with TBI often have underlying chronic conditions, continuous follow up after hospital discharge can help with continuous care planning and disease monitoring. Thus, this study aims to examine the impact of age and sex on 30-, 60- and 90-day all-cause hospital readmissions post-hospital discharge for the adult TBI population.

Methods

Data Source

The Nationwide Readmissions Database (NRD) 2013 is a population-based database managed by the Healthcare Cost and Utilization Project (HCUP) of the Agency for Healthcare Research and Quality (AHRQ)[20]. The NRD is drawn from the HCUP State Inpatient Databases (SID) and includes national readmission data from all types of payers (government, private and uninsured patients), across all ages. The NRD accounts for 49.3% of the US population and 49.1% of US hospitalizations as reported in the American Hospital Association (AHA) Annual Survey Database with more than 100 clinical and nonclinical variables. As the first database that includes hospitalizations in specialty and federal hospitals and community from 21 states, the NRD has data on approximately 15 million unweighted and 36 million weighted discharges annually[20]. Hospital readmission rates, readmission reasons and hospital costs for each hospital stay are the main outcomes in the NRD[20]. For this study, we used three files from the NRD: core file (clinical and nonclinical variables that support readmission analyses), severity file (diagnosis and procedure classifications variables) and hospital file (hospital-level variables). We obtained university Institutional Review Board approval (IRB# 16-0286) and an HCUP Data Use Agreement (DUA) prior to conducting this study.

Cohort Selection

We used our conservative operational definition to identify patients with TBI based on the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)[22] codes (800.XX, 802.XX, 803.XX, 804.XX and 851.XX-854.XX). In this study, we did not include 850.XX (concussion), as this code represents a wide spectrum of symptoms (from none, mild, to severe). Only individuals older than 18 years were included and we excluded those who died during the index hospitalization. Figure 1 provides the detailed cohort selection process. The final cohort of this study is 52,877 individuals with TBI. To examine the timing of readmission by age, we selected a sub-set of cases readmitted within 90 days.

Study Outcome

The primary outcome was any readmission that occurred within 90 days after hospital discharge. We used the Centers for Medicare and Medicaid Services (CMS) methodology to identify hospital-wide all-cause readmission[22]. We examined readmission at three time points: 30-, 60- and 90-days and included only the first (index) readmission at each time point. During the study period, 0.3% of the total NRD population had TB (using 15 million as the denominator), which was less than half the TBI prevalence of 0.7% reported by the CDC (numerator: 2.5 million, denominator: 323.1 million)[22].

Primary Variable

We classified the sample into four age groups: 18-40, 41-65, 66-75 and 76+ years. The four age groups were determined based on (a) the data representation in the NRD (young, middle-aged, old and very old) and (b) the epidemiology literature report: adults with TBI aged 65 and older are responsible for more than 80,000 annual emergency department visits and those 76+ years have the highest rates of TBI-related hospitalization and death[17,23].

Secondary Variables

Three secondary variables, severity of injury, discharge setting and hospital teaching status, were chosen because these three variables differed significantly by group readmission rate across time (Table 1). Based on all-patient-refined Diagnosis Related Group (AP-DRG) defined by the HCUP, we categorized severity of injury into four groups: minor, moderate, major and extreme severity, using the summed number of DRGs[21]. We also classified patients into three discharge-setting categories: home, Skilled Nursing Facility (SNF)/ Intermediate Care Facility (ICF) and Home Health (HH). In addition, teaching status of the hospital was categorized as teaching-metropolitan, non-teaching-metropolitan and non-teaching-rural.

Covariates

We adjusted for the following covariates in all analytical models: sex (male/female), admission type (elective/non-elective), emergency room services (yes/no), primary payer (Medicare, Medicaid, private, self and other), Elixhauser comorbidity score[24], county of residence by urban status (central, fringe, county population 250,000-1,000,000, population 50,000-250,000, population <50,000), income (zip-code level quartile), hospital ownership (e.g., government, private and non-profit), hospital bed size (small, medium and large) and hospital volume (quartile).

Primary 30-day Readmission Reasons

We identified the primary reasons for 30-day readmission by age, based on the ranked prevalence of each primary diagnosis assigned to each patient at 30-day readmission.

Statistical Analyses

We examined the time to first readmission using time-to-event analysis. Unadjusted readmission rates from day 1 to day 90 post-discharge were estimated using the Kaplan-Meier method, stratified by age groups. The follow-up period was censored at 12/31/2013 due to non-availability of 2014 data. Multivariate logistic regression was used to adjust for all the above-listed covariates to estimate the risk of 30-, 60-, or 90-day readmission associated with the primary variable (age), as well as the secondary variables (severity of injury and discharge setting). The denominators for 'readmission rate' were based on the total sample size of the specific readmission timeframe, age group and sex (e.g., 30-day readmission: the overall denominator is 52,877; for males, it is 31,363). All analyses were adjusted for NRD survey design (cluster, strata and weights) to allow for generalization of estimates. Analyses were conducted at three time points (30-, 60- and 90-day) on outcome (readmission) and also by sex (male vs. female) to examine the effect of time and sex on readmission. We also examined the interactions between sex/age and secondary variables. We used SAS 9.4 to perform all analyses[25].

Results

Demographics

The largest cohorts of patients were 76+ years (37.0%), male (59.1%), discharged to home (59.3%), in the lowest quartile of income (28.2%) at baseline; had non-elective admissions (96.7%), an emergency department visit prior to the index hospitalization (87.3%), Medicare as the primary payer (52.2%), moderate severity of injury (42.3%) and resided in fringe counties (24.0%) (N=52,877) (Table 1).

Age and Sex Associated with Hospital Readmission

Unadjusted Hospital Readmission—Table 1 shows significant sex differences in 30-, 60- and 90-day unadjusted hospital readmission among all age groups (all p< .05). Figure 2 presents the unadjusted hospital readmission trajectory by sex for all age groups across 90 days. Females 66-75 years had a very similar readmission pattern to females 76+ years. The youngest group (18-40 years) had the most distinct readmission pattern over 90 days compared to the other age groups, regardless of sex (Figure 2).

Cumulative Daily Unadjusted Readmission Percent—Figure 3 shows the daily readmission rate for all age groups by sex, among those with any readmission within 90 days from January 1st through September 30th. Table 2 summarizes the cumulative unadjusted readmission rate by sex weekly for the first five weeks. Overall, the youngest group (18-40 years) had the highest cumulative readmission rate during the first week post-discharge, regardless of sex (34.92% for males and 35.15% for females) (Table 2).

Adjusted Hospital Readmission—Table 3 presents the adjusted Odds Ratio (OR) of readmission. The interactions between age/sex and injury severity level/discharge setting were not significant (p> .05). The main difference at three time-point in readmission rates was between the oldest group and the youngest group (for both males and females) [e.g., 90-day readmission: OR= 2.32 (95% CI: 2.01-2.69) for males vs. OR: 1.96 (95% CI: 1.59 – 2.43) for females] (Table 3). Using the 18-40 year group as a reference, the 76+ group had the highest risk of 30-, 60-, and 90-day readmission for both sexes (Table 3).

We also collapsed the four groups into two (18-40 vs. 41+ years) to conduct two-group comparisons. This categorical simplification was based on the unadjusted results in Figure 2 (i.e., the 18-40 group showed a distinct readmission pattern, regardless of sex). Using 18-40 as a reference, those 41 and above had significantly higher risk of 30-, 60- and 90-day readmission for both males and females (Table 3).

Characteristics of Multiple Readmissions—Among readmitted patients, about 68% (n=8,420) had only one readmission. For those with multiple readmissions (n=3,962), the average number of readmission was 2.7 (SD=1.3), total diagnoses was 9.9 (SD=5.8), total number of care procedures was 2.0 (SD=2.8) and the mean Elixhauser comorbidity score was 2.8 (SD=5.9). The majority of patients with multiple readmissions were female (63.6%), intracranially injured (69.1%), non-elective admitted (97.1%), Medicare covered (46.1%) and had emergency department visits (87.6%).

Primary 30-day Readmission Reasons by Age—We also examined the primary reason for 30-day readmission by age based on DRG. This study only reported the primary readmission reasons by age for study clarity. Poisoning/bodily injury was the most common reason for 30-day readmission across all ages, but other reasons varied by age. For those aged 18-40 and 41-65, the top three reasons included mental disorder; disease of the nervous system; and sense organs and disease of the circulatory/digestive system(s). For those aged 66-75 and older, the top three 30-day readmission reasons included disease of the circulatory system; disease of the respiratory system, infectious and parasitic disease; and disease of the genitourinary system (Appendix Table).

Secondary Variables and Hospital Readmission

Age group and sex showed no significant interaction with all three secondary variables. Individuals with the three most severe levels of injury (moderate, major and extreme) had significantly higher 30-, 60- and 90-day readmission risk than those with minor injury (Table 3). Those with major injury had the highest ORs of 30-. 60- and 90-day readmission. Using SNF/ICF as a reference, patients discharged to home had significantly lower readmission risk at 30-, 60- and 90-days (Table 3). Using teaching-metropolitan hospital as a reference, non-teaching rural hospital had significantly lower 60- and 90-day readmission risk (Table 3).

Discussion

This study examined the impact of age and sex on 30-day, 60-day and 90-day all-cause readmission for adults with TBI using a national representative dataset (NRD). Age and sex were significantly associated with readmission at three time points, severity of injury and types of post-acute discharge settings. The oldest group (76+ years) of males and females had the highest adjusted readmission risk of all age groups. Sex differences in readmission risk were significant across age groups. These findings suggest that early preventive strategies for readmission in patients with TBI should differ by age and sex.

Another significant finding is the timing of hospital readmission. Among those admitted within 90 days, the youngest group (18-40 years) had the highest cumulative readmission rate within the first week post-discharge, but the lowest readmission rate over 90 days, for both males and females. This study finding suggests that care continuity/monitoring during the first week after discharge is of utmost importance for younger and middle-aged patients with TBI. Providing early follow up may alleviate the risk of readmission in TBI[26–28]. Early intervention such as symptom management prior to discharge could also reduce the readmission risk for patients with TBI[3].

Contradictorily, the Canadian population-based TBI study[19] found no sex differences in the number of rehospitalizations for the first year, even though women between 15 and 49 years old had 15% more rehospitalizations than men at the 3-year follow-up. Such inconsistency may be due to the variety in study timeframe and national healthcare policies between this study and ours. However, our study agreed with Saverino et al.[19] that those who were male, older, had more severe injury and more comorbidities had significantly higher readmission rates over time.

The primary causes of 30-day readmission in our sample were ‘poisoning/body injury’ and ‘circulatory system disease’ for those aged 41 or older. One study found self-poisoning to be the primary cause of suicidal deaths and attempts in a TBI sample[29]. Individuals with TBI tend to be in risky conditions that could lead to toxic or overdosing substance consumption and subsequent readmission. However, readmissions caused by poisoning/body injury are potentially preventable. Providing suicidal prevention, home care education, safety or environmental modification to remove unsafe triggers (e.g., drugs) may address such concerns. For ‘circulatory system disease,’ cardiac dysfunction in the first two weeks after TBI was found associated with higher rates of in-hospital mortality[30]. Consistently, our findings suggest that timely intervention in symptoms management and improved compliance with medication for cardiac disease may facilitate the hemodynamic management of TBI and further avoid follow up readmissions[15].

We also suggest that younger and older patients with TBI (using 65 years as a cutoff) may require different protective mechanisms to maximize health outcomes. For example, psychosocial support may be more important for middle-aged patients with TBI, as Corrigan and colleagues[13] found that individuals with TBI aged 30-59 years had poorer mental and emotional outcomes compared to older patients with TBI. Patients older than 65 years may benefit more than younger patients from medical management of chronic and comorbid conditions.

Patients with greater severity of injury had higher readmission risk within 90 days. Intiso and colleagues[8] observed that readmitted patients with TBI were more disabled than those not readmitted. In addition, Hammond and colleagues[31] found that TBI patients with higher motor functional status at admission were less likely to be readmitted to hospitals. While our study found that major loss of function (instead of extreme) was associated with a higher risk of readmission, we hypothesized that our result could be skewed due to a higher mortality rate for those with extreme severity of injury. However, additional data is not available to validate this assumption.

Selecting appropriate discharge setting could be crucial to optimize health outcomes. Patients discharged to SNF/ICF may be at greater risk of readmission than those discharged to home care. Hammond and colleagues[30] also found discharge to institutional settings was associated with higher hospital readmission rates compared to discharge to home. Discharge to SNF also significantly increased the risk of depression in both men and women post-TBI[31]. Our and previous studies have shown the importance of monitoring quality of care and supporting psychosocial function across discharge settings in those with TBI.

Patients receiving services at non-teaching rural hospitals tend to have lower risk of hospital readmission at 60- and 90-day follow-up than those receiving services at teaching-metropolitan hospitals. In metropolitan areas, readmission rates were similar for teaching and non-teaching hospitals. Rural hospitals are less likely to treat patients with complex medical conditions due to limited capabilities, and rural hospitals have higher unplanned readmission rates when multiple-hospital patients are excluded from analysis[32].

Brain injury often requires extensive rehabilitation and follow-up care. Understanding the factors associated with readmission risk thus helps guide strategies for effective care planning. We suggest future studies link the NRD with clinical data to provide additional clinical information and practical implementation.

Study Limitations

This study had several limitations. First, we did not address variations in brain injury types, levels of cognitive impairment or severity measures, as these data (e.g., the Glasgow Coma Scale) were not available. Second, varied diagnostic codes for brain injury may inherently have varied readmission risks. Future studies should investigate whether analyzing different ICD-9 diagnostic codes (e.g., bone fracture, intracranial nerve injury) affects the estimated readmission risk. Also, our conservative operational definition may underestimate hospital readmission rates and the results may not be comparable to other TBI studies. In addition, the NRD had a lower prevalence of TBI compared to the CDC report, which may under-represent the real TBI population. Lastly, this study utilized only one-year data, potentially limiting the implications and generalizability of the findings. For instance, we could not construct a look-back window or identify any previous brain injuries prior to the TBI diagnosis at the index date. NRD also lacks information on whether patients were readmitted to acute medical wards or mental health institutions.

Conclusion

We found that age and sex were significantly associated with 30-, 60- and 90-day hospital all-cause readmission in patients with TBI. Specifically, males were more at risk than females of 90-day readmission if they were 76+ years old. Females aged 66-75 and 76+ had similar readmission risk over 90 days. Recognizing age- and sex-related readmission patterns is the first step to developing strategies for preventive care for the TBI population. The rational next steps are to align resources and improve communication between all healthcare stakeholders. We also suggest early management of self-poisoning and cardiovascular diseases, and provision of psychosocial support to prevent subsequent readmission. This study provides evidence that adjusting treatment for those with TBI according to age and sex could optimize patients' follow-up health outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

AHRQ	Agency for Healthcare Research and Quality
AHA	American Hospital Association
CMS	Centers for Medicare and Medicaid Services
DUA	Data Use Agreement
DRG	Diagnosis Related Group
HCUP	Healthcare Cost and Utilization Project
HH	Home Health
ICF	Intermediate Care Facility
ICD-9-CM	International Classification of Diseases, Ninth Revision, Clinical Modification
NRD	Nationwide Readmissions Database
OR	Odds Ratio
SNF	Skilled Nursing Facility
SID	State Inpatient Databases
TBI	Traumatic Brain Injury

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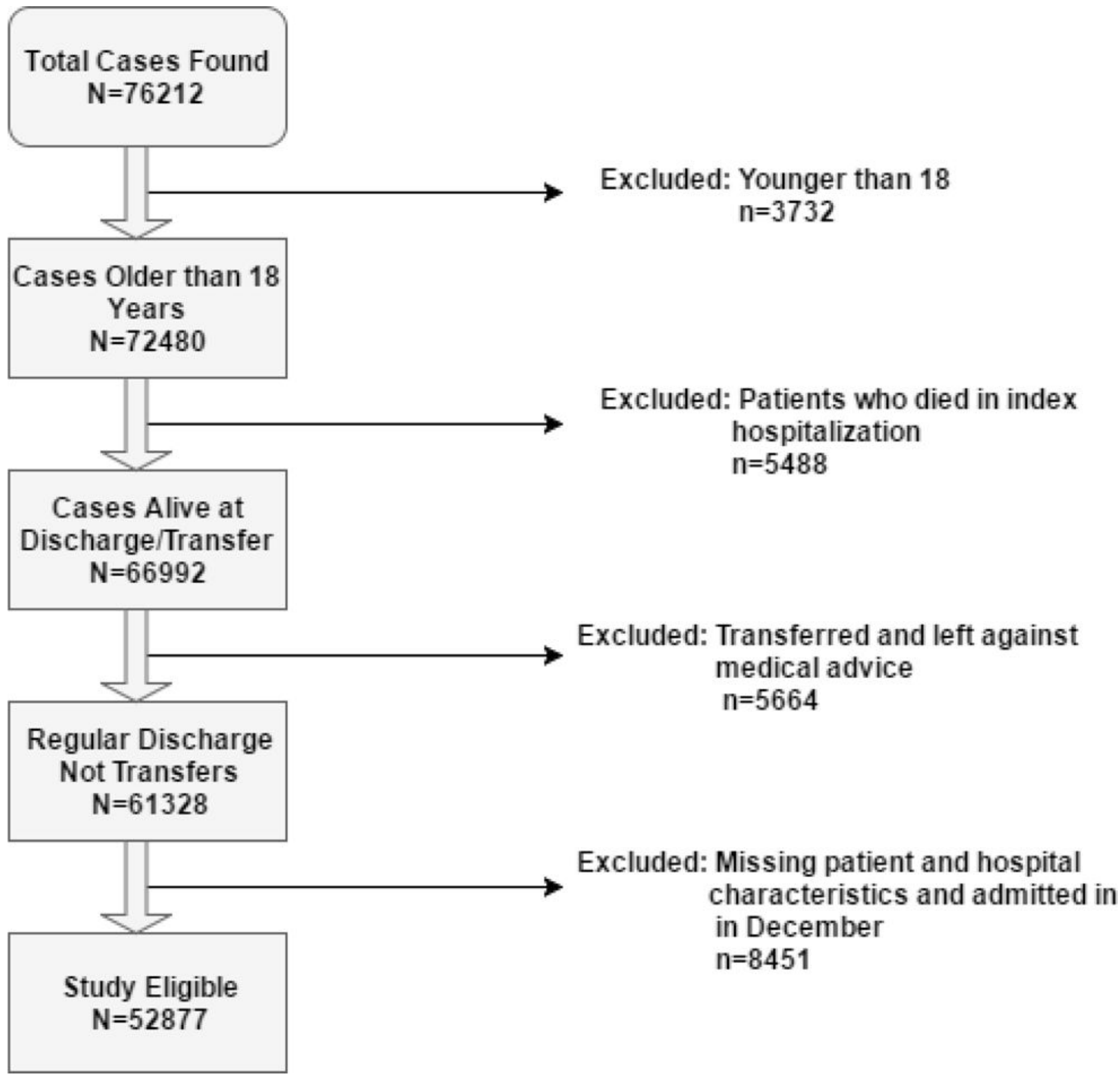

Figure 1.
Cohort Selection
Figure 1 represents each step used in the cohort selection process. The final sample is 52,877.

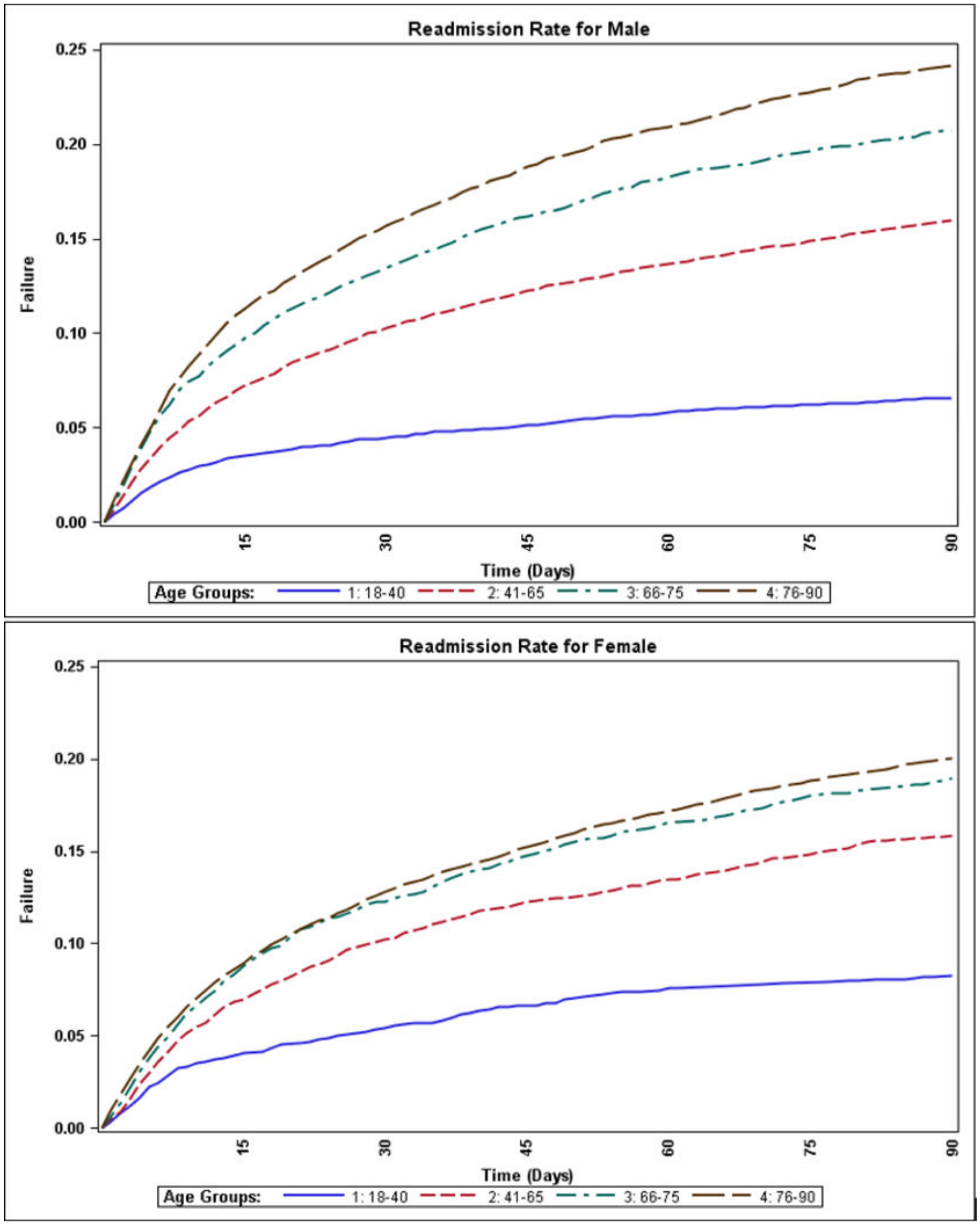

Figure 2.

Hospital Readmission Trajectory of Four Age Groups over 90 Days by Sex (Unadjusted Kaplan-Meier Censoring Method) (Sample size for male: 33,282; for female: 19,595). X-axis represents time (days). Y-axis represents readmission rate.

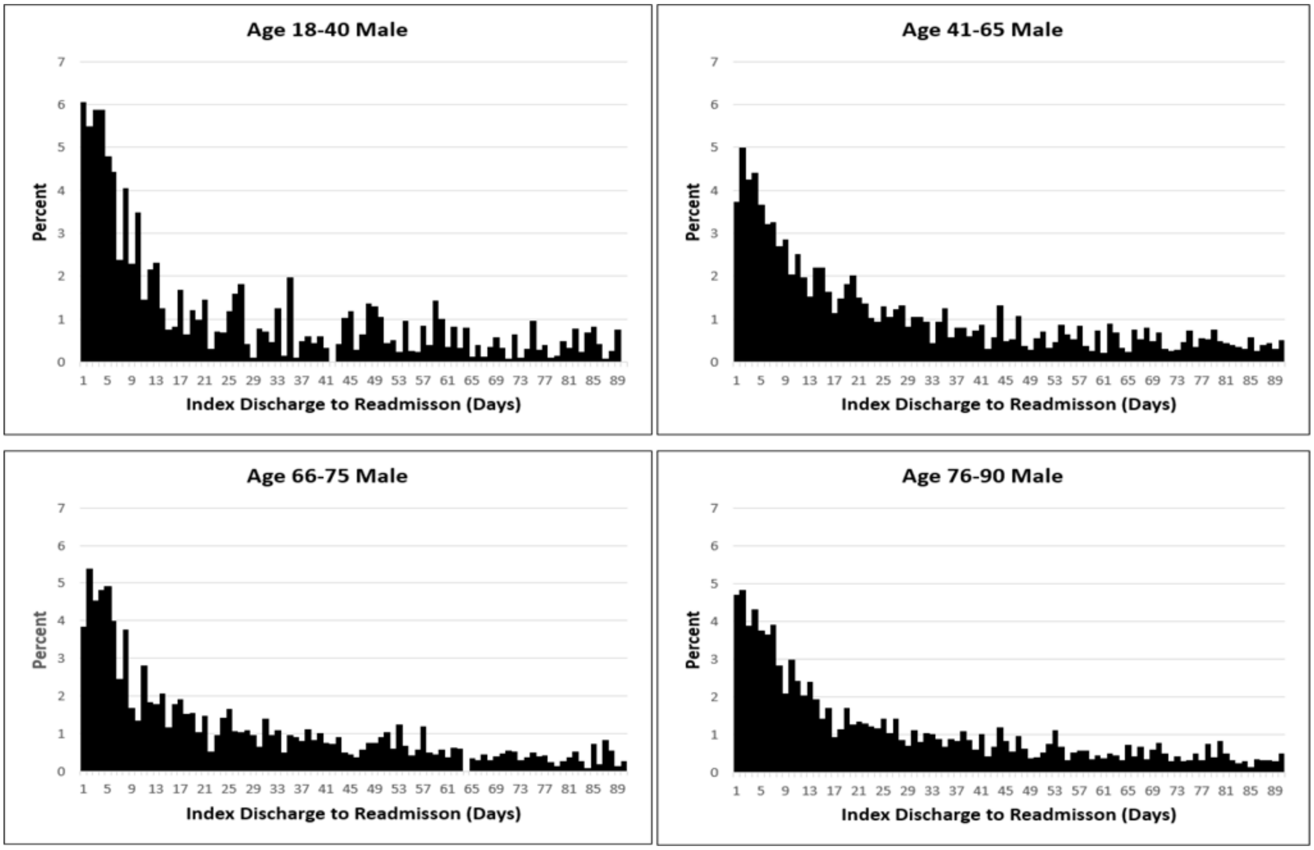

Figure 3.

Daily Rate of Hospital Readmission Percentage for Four Age Groups by Sex.

X-axis represents time (days) from index discharge to readmission. Y-axis represents the readmission percent of each time point (day).

Table 1

Person-level and Hospital-level Characteristics of Patients with Observed 30-, 60- and 90-Day Readmission.

	30-day readmission (N=52,877)			60-day readmission (N=48,300)			90-day readmission (N=43,408)		
	Actual (n, %#)	Admitted (%**, SE)^	p-value	Actual (n, %*)	Admitted (%**, SE)	p-value	Actual (n, %*)	Admitted (%**, SE)	p-value
Patient Characteristics									
Age group (yr)			<.0001*			<.0001*			<.0001*
18–40	11,305(21.5)	4.6(0.2)		10,396(21.6)	6.2(0.2)		9,382(21.7)	7.2(0.3)	
41–65	14,495(27.5)	10.9(0.3)		13,247(27.5)	14.8(0.4)		11,953(27.7)	17.6(0.5)	
66–75	7,485(14.1)	13.4(0.4)		6,810(14.0)	18.6(0.5)		6,086(14.0)	21.5(0.6)	
76+	19,592(37.0)	14.6(0.3)		17,847(36.8)	20.1(0.4)		15,987(36.7)	24.0(0.4)	
Sex			.0171*			.0009*			.0008*
Male	31,363(59.1)	11.7(0.2)		28,743(59.3)	14.9(0.3)		25,830(59.3)	17.6(0.3)	
Female	21,514(40.9)	10.9(0.3)		19,557(40.7)	16.3(0.3)		17,578(40.7)	19.2(0.3)	
Admission type			.0765			.1516			0.2171
Elective	1,637(3.3)	9.7(0.9)		1,507(3.4)	14.1(0.9)		1,372(3.4)	16.9(1.1)	
Non Elective	51,025(96.7)	11.3(0.2)		46,590(96.6)	15.5(0.2)		41,847(96.6)	18.3(0.2)	
ED Service			.0732			.1599			.0757
No	6,665(12.7)	12.2(0.6)		6,034(12.5)	16.4(0.7)		5,410(12.5)	19.5(0.8)	
Yes	46,212(87.3)	11.1(0.2)		42,266(87.5)	15.3(0.2)		37,998(87.5)	18.1(0.2)	
Primary payer			<.0001*			<.0001*			.0001*
Medicare	27,438(52.2)	14.7(0.2)		25,000(52.0)	20.3(0.3)		22,397(51.8)	24.1(0.3)	
Medicaid	4,741(8.6)	11.2(0.5)		4,356(8.7)	15.2(0.7)		3,932(8.7)	17.8(0.7)	
Private	11,229(21.6)	6.9(0.3)		10,265(21.6)	9.4(0.3)		9,276(21.8)	11.0(0.4)	
Self	4,952(9.6)	5.8(0.4)		4,532(9.6)	7.6(0.5)		4,078(9.6)	9.1(0.4)	
Other	4,517(8.1)	7.0(0.4)		4,147(8.1)	10.0(0.6)		3,725(8.1)	11.6(0.6)	
Severity			<.0001*			<.0001*			<.0001*
Minor	14,401(26.9)	7.3(0.3)		13,181(27.0)	9.7(0.3)		11,909(27.2)	11.4(0.4)	
Moderate	22,362(42.3)	10.6(0.3)		20,446(42.3)	14.9(0.3)		18,324(42.1)	17.8(0.3)	
Major	12,367(23.5)	15.4(0.4)		11,272(23.5)	20.8(0.5)		10,121(23.5)	24.2(0.6)	
Extreme	3,747(7.3)	16.7(0.6)		3,401(7.3)	22.7(0.7)		3,054(7.2)	27.3(0.9)	

	30-day readmission (N=52,877)			60-day readmission (N=48,300)			90-day readmission (N=43,408)		
	Actual (n, %#)	Admitted (%**, SE)^	p-value	Actual (n, %*)	Admitted (%**, SE)	p-value	Actual (n, %*)	Admitted (%**, SE)	p-value
Comorbidity	**Mean (95% CI)**		<.0001*	**Mean (95% CI)**		<.0001*	**Mean (95% CI)**		<.0001*
For admitted	4.6(4.3, 2.8)			4.6(4.4, 4.8)			4.6(4.4,4.8)		
Not admitted	2.5(2.3, 2.6)			2.5(2.4, 2.6)			2.5(2.2,2.5)		
Discharge destination		<.0001*			<.0001*			<.0001*	
Home	31,676(59.3)	8.1(0.2)		28,978(59.4)	11.0(0.2)		26,148(59.7)	13.1(0.3)	
SNF, ICF	14,911(29.2)	16.0(0.4)		13,572(29.1)	22.6(0.4)		12,082(28.8)	26.8(0.5)	
Home Health	6,290(11.4)	15.5(0.6)		5,750(11.4)	20.3(0.6)		5,178(11.4)	23.7(0.7)	
Residence			.0578			.0011*			<.0001*
Central	18,141(29.1)	11.7(0.3)		16,571(29.1)	16.0(0.4)		14,884(29.1)	18.9(0.5)	
Fringe	11,980(24.0)	11.6(0.4)		10,936(24.0)	16.3(0.4)		9,819(24.0)	19.2(0.5)	
Counties (250K-1M)	10,635(20.2)	10.7(0.4)		9,732(20.2)	14.5(0.4)		8,795(20.3)	17.4(0.5)	
Counties (50K-250K)	4,744(9.8)	11.9(0.8)		4,339(9.8)	16.5(0.9)		3,899(9.9)	19.4(0.9)	
Counties (<50K)	7,163(16.9)	10.3(0.4)		6,531(16.9)	13.8(0.6)		5,833(16.7)	16.0(0.6)	
Income(quartile)			.1826			.5740			0.7473
1	14,388(28.2)	10.9(0.3)		13,182(28.3)	15.2(0.4)		11,872(28.3)	18.1(0.3)	
2	13,342(26.4)	11.8(0.3)		12,140(26.3)	15.9(0.4)		10,872(26.2)	18.6(0.4)	
3	12,908(24.1)	11.1(0.3)		11,814(24.1)	15.3(0.4)		10,609(24.1)	18.0(0.4)	
4	12,239(21.3)	11.2(0.3)		11,164(21.3)	15.4(0.3)		10,055(21.4)	18.4(0.4)	
Hospital characteristics									
Hospital control			.3045			.0293*			.0057*
Government	9,821(16.3)	10.6(0.5)		9,000(16.3)	14.1(0.5)		8,116(16.4)	16.7(0.5)	
Private	7,641(12.8)	11.6(0.6)		6,992(12.8)	16.2(0.7)		6,264(12.8)	19.4(0.7)	
Not-profit	35,415(70.9)	11.4(0.2)		32,308(70.8)	15.6(0.3)		29,028(70.8)	18.4(0.3)	
Teaching status			.0180*			.0002*			.0004*
Teaching-metropolitan	34,736(68.1)	11.1(0.2)		31,746(68.1)	15.2(0.3)		28,518(68.1)	18.0(0.3)	
Non-teach metropolitan	16,811(28.4)	11.9(0.3)		15,343(28.4)	16.5(0.4)		13,806(28.4)	19.3(0.4)	
Non-teach rural	1,330(3.5)	9.2(0.9)		1,211(3.5)	12.0(1.0)		1,084(3.4)	14.5(1.1)	
Hospital size			0.1022			.1209			.2238

	30-day readmission (N=52,877)			60-day readmission (N=48,300)			90-day readmission (N=43,408)		
	Actual (n, %#)	Admitted (%**, SE)^	p-value	Actual (n, %*)	Admitted (%**, SE)	p-value	Actual (n, %*)	Admitted (%**, SE)	p-value
Small	2,172(4.6)	11.3(0.7)		1,970(4.6)	16.5(1.0)		1,795(4.6)	19.9(1.2)	
Medium	9,708(18.3)	10.4(0.5)		8,874(18.4)	14.5(0.6)		8,011(18.5)	17.6(0.6)	
Large	40,997(77.1)	11.5(0.2)		37,456(77.0)	15.6(0.2)		33,602(76.9)	18.3(0.2)	
Hospital volume (quartile)			0.2879			.0054 *			.0021 *
1	13,412(25.5)	11.8(0.3)		12,230(25.5)	16.6(0.3)		10,974(25.5)	19.9(0.5)	
2	13,119(24.5)	11.4(0.3)		11,951(24.4)	15.7(0.4)		10,078(24.5)	18.2(0.5)	
3	13,239(24.5)	11.2(0.4)		12,142(24.5)	15.2(0.5)		10,896(24.5)	18.0(0.5)	
4	13,107(25.5)	10.7(0.5)		11,977(25.5)	14.2(0.6)		10,754(25.5)	16.9(0.7)	

weighted %,

** weighted row % SE=Standard Error,

* significant at p-value of 0.05;

^ denominator of readmission rate was based on the total sample in that specific age group at that admission period.

SE, standard error; CI, confidence interval; ED, emergency department; SNF, skilled nursing facility; ICF, intermediate care facility.

Table 2

Percent of Unadjusted Hospital Readmissions across Age Groups by Sex (Per Week; January through September). (Sample size for males: 33,282; for females: 19,595).

Age Group (years)	1^{st} wk* (1–7 days)	2^{nd} wk (8–14 days)	3^{rd} wk (15–21 days)	4^{th} wk (22–28 days)	5^{th} wk (29–35 days)
Male					
18–40	34.92(%)**	17.01	7.56	6.76	5.45
41–65	27.56	15.78	11.81	8.20	6.53
66–75	29.91	15.29	10.46	7.75	6.49
76+	29.02	16.67	9.48	8.41	6.22
Female					
18–40	35.15 (%)**	14.05	7.22	6.79	5.98
41–65	26.57	17.88	9.59	8.80	7.11
66–75	26.00	18.14	13.35	6.27	4.98
76+	27.12	15.80	10.31	8.16	6.61

* wk=week.

** All numbers are percentages. The denominator is the total sample size of each age group by sex.

Table 3

Age (by Sex), Severity and Discharge Location for Adjusted 30-, 60- and 90-Day Hospital Readmission.

Patient characteristic	30-day readmission OR(95%CI)*	60-day readmission OR(95%CI)	90-day readmission OR(95%CI)
Demographic characteristics			
Age Group (years)			
Male			
Four groups			
18–40	Ref.	Ref.	Ref.
41–65	2.11(1.83, 2.43)	2.15(1.89, 2.46)	2.19(1.94, 2.46)
66–75	2.07(1.73, 2.47)	2.16(1.85, 2.52)	2.09(1.81, 2.42)
76+	2.24(1.90, 2.63)	2.28(1.95, 2.67)	2.32(2.01, 2.69)
Two groups			
18–40	Ref.	Ref.	Ref.
41+	2.17(1.90, 2.48)	2.22(1.97, 2.50)	2.31(2.08, 2.57)
Female			
Four groups			
18–40	Ref.	Ref.	Ref.
41–65	1.48(1.15, 1.90)	1.47(1.15, 1.89)	1.65(1.33, 2.06)
66–75	1.54(1.17, 2.02)	1.59(1.22, 2.08)	1.71(1.36, 2.15)
76+	1.69(1.32, 2.17)	1.76(1.37, 2.26)	1.96(1.59, 2.43)
Two groups			
18–40	Ref.	Ref.	Ref.
41+	1.54(1.22, 1.94)	1.51(1.21, 1.89)	1.68(1.36, 2.08)
Severity of Injury			
Minor	Ref.	Ref.	Ref.
Moderate	1.16(1.07, 1.27)	1.25(1.16, 1.35)	1.30(1.20, 1.40)
Major	1.40(1.25, 1.56)	1.42(1.28, 1.58)	1.43(1.29, 1.59)
Extreme	1.21(1.04, 1.41)	1.22(1.06, 1.40)	1.29(1.11, 1.48)
Discharge Destination			
SNF, ICF	Ref.	Ref.	Ref.
Home Health	1.08(0.96, 1.21)	0.97(0.99, 1.07)	0.95(0.86, 1.06)
Home	0.79(0.71, 0.87)	0.74(0.68, 0.80)	0.74(0.68, 0.80)
Teaching Status			
Teaching-Metropolitan	Ref.	Ref.	Ref.
Non-Teaching-Metropolitan	1.00(0.91, 1.10)	0.99(0.92, 1.07)	0.97(0.90, 1.05)
Non-Teaching-Rural	0.78(0.62, 1.00)	0.71(0.57, 0.88)	0.74(0.61, 0.91)

*Adjusted for all covariates listed in Table 1 (sex, admission type, emergency room use, primary insurance payer, Elixhauser comorbidity score, county of residence, income, hospital ownership, hospital teaching status, hospital bed size, and hospital volume).

OR, odds ratio; CI, confidence interval; SNF, skilled nursing facility; ICF, intermediate care facility.