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A Population-based Study for 30-Day Hospital Readmissions after Acute Ischemic Stroke

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Abstract

Objective—To determine post-stroke 30-day readmission rate, its predictors, its impact on mortality, and to identify potentially preventable causes of post-stroke 30-day readmission in a population-based study.

Patients and Methods—We identified all acute ischemic strokes (AIS) using the ICD-9 codes (433.x1, 434.xx, and 436) via the Rochester Epidemiology Project (REP) between January 2007 and December 2011. Acute stroke care in Olmsted County is provided by two medical centers, Saint Marys Hospital (SMH), and Olmsted Medical Center Hospital (OMCH). All readmissions to these two hospitals were accounted for this study. Thirty-day readmission data was abstracted through manual chart review. The REP linkage database was used to identify the status (living/dead) of all patients at last follow up.

Results—Forty one (7.6%, 95% CI 5.7%-10.2%) of total 537 AIS patients were readmitted 30 days post-stroke. In a multivariable logistic regression model, discharge to nursing home following index stroke (OR: 0.29, 95% CI 0.08-0.84) was an independent negative predictor of unplanned 30-day readmission. In a subgroup of patients with dementia, being married at time of index stroke was found to be a negative predictor of readmission (OR 0.10, 95% CI 0.005-0.58). Only 2.8% of the patients had potentially preventable readmissions. Hospital readmission had no significant impact on patient's short (3 months) or long term (1 or 2 years) mortality ($p > 0.05$).

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Conclusion—Post-stroke 30-days readmission rate is low in AIS patients from Olmsted County. Further research is needed in regarding discharge checklists, protocols, and stroke transitional programs to reduce potentially preventable readmissions.

Search Terms

Ischemic stroke; readmissions; tissue plasminogen activator; mortality; cohort; and population-based

Background

Thirty day readmission after hospitalization with ischemic stroke has been found in up to 6.5-15% patients, with two-thirds of the patients readmitted due to non-neurological causes.¹⁻⁸ The most common causes for readmission are infection, electrolyte abnormalities, falls, recurrent stroke, and cardiovascular events.³ Predictors for readmission have been identified as patient characteristics (older age⁴, Black race in age group of 65 to 74 years⁹, lower medium/low income, unemployed/disability pensioners,⁵ prior stroke, cardiac disease, patient living in the same county as hospital location, complications at the index hospitalization, and longer hospitalization), discharge/insurance issues (HMO insurance, discharge to a skilled-nursing facility or long-term care, and discharge planning), and process of care characteristics (physician specialty type or Joint Commission-certified primary stroke center certification).^{3,6,10}

Previous published studies have used administrative databases or hospital based registries¹⁰ to understand post-stroke hospital readmission rate, causes, and predictors. A population-based study could provide detailed patient level data which may help with better understanding of underlying causes of the readmission. This information is vital to make policy decisions at a hospital or community level to implement strategies to reduce readmission rates.

Thirty-day readmissions have been associated with increased mortality at 1 year in a dose-dependent manner (higher mortality with more readmissions).^{11,12} Impact of 30-day readmission on long term mortality has not been studied in a population-based study.

The goal of our study was to determine the rate and causes of post-stroke 30-day hospital readmissions, and to study its predictors, and the impact of hospital readmission on 1 year mortality in a population cohort study from Olmsted County, MN. Our underlying hypothesis was that the rate and causes of 30-day hospital readmissions in our population based study would be similar to that reported in administrative databases. We also intended to identify potentially preventable causes of readmission as they are critical for patient safety and quality care.

Methods

The study was conducted at Mayo Clinic in Rochester, Minnesota, USA using the Rochester Epidemiology Project (REP). The REP is a unique research tool that links together nearly all of the medical records of the residents of Olmsted County, Minnesota for approved medical

research.¹³ This allowed us to capture all patients who were admitted in any of hospitals in the Olmsted County. Most patients in Olmsted county are admitted to one of the two medical centers, the Mayo Clinic hospital-Saint Marys Hospital (SMH), and a non-Mayo related facility-Olmsted Medical Center Hospital (OMCH). All readmissions in either of these two hospitals were accounted for this study.

Patient Selection

Rochester Epidemiology Project database (REP) was used to identify all hospitalized ischemic stroke patients from Olmsted County, Minnesota. The electronic medical records of all patients seen between January 1, 2007 to December 31, 2011 at the SMH and OMCH were reviewed.

Inclusion Criteria

1. People living in Olmsted County, Minnesota from January 1, 2007 to December 31, 2011 with Olmsted County residency for at least 12 months.
2. Patients who were discharged with AIS as the primary discharge diagnosis.
3. Age greater than equal to 18 years.
4. Research authorization available to review a patient's medical records.

Cohort identification

We identified all acute ischemic strokes (primary or recurrent) using discharge principal diagnosis (International Classification of Diseases 9th revision (ICD-9) codes (433.x1, 434.xx, and 436)¹⁴ from the REP linkage system. A previous study has shown that the combined sensitivity of 0.81, specificity of 0.90, and positive predictive value of 0.79 for these ICD-9 codes.¹⁴ Only the first patient admission during the study period was included. IV rt-PA use was determined via detailed medical record review.

Cohort validation

- a. We validated this cohort of stroke patients by cross checking it with the hospital stroke registry- used for the “Get with the Guidelines” database which has been maintained prospectively since 2006. A clinical nurse specialist obtains a list of stroke patients using discharge ICD-9 codes (433.x1, 434.xx, and 436) and then verifies these patients via review of the medical record, and enters any cases that were missed by the ICD-9 codes.
- b. A random sample of 10% patients was taken to identify 59 patients whose medical records were reviewed by a board certified neurologist to check the accuracy of ICD-9 codes for ischemic stroke. The positive predictive value of a combination of ICD-9 codes (433.x1, 434.xx, and 436) to identify acute ischemic strokes was 93%.

Outcome measurement

Readmission within 30 days—All admissions to any hospital in Olmsted County within 30 days of index hospitalization for acute ischemic stroke were defined as a readmission. Rochester epidemiology project provided us information about the mortality data for all patients irrespective of their location at the time of death. Admissions for acute rehabilitation were excluded. We then reviewed comprehensive medical record to obtain detailed information regarding the initial admission and the readmission. Only the first readmission within 30 days was included.

Causes for readmission—The principal discharge diagnosis at readmission was considered as the main reason for hospital readmission. This data was collected from the billing data and was further validated by a detailed medical record review.

Planned versus unplanned readmission—A readmission for a surgical procedure (cerebral angiogram (1), carotid endarterectomy (2), patent foramen ovale closure (2), and aortic valve papillary fibroelastoma surgery (1)), which was planned during the index hospitalization was classified as a planned readmission. An unplanned readmission was defined as a readmission from any unforeseen cause.

Potentially Preventable readmission—All hospital acquired conditions tied to non-payment to hospitals as defined by centers for Medicare and Medicaid services were included in this group.¹⁵ Further, a potentially preventable 30-day readmission was defined as any readmission from any cause which potentially could have been prevented by an intervention during the index hospitalization as agreed upon by two study neurologists (Manoj Mittal and Alejandro Rabinstein). A third neurologist (Kelly Flemming) was available for any disagreement.

Mortality—REP linkage database was used to identify all patients who have died since their stroke during the study period.

Other data points

The REP database and manual chart review was used to collect data on the patient's demographics (age, sex, educational level, race, ethnicity, occupation, employment status, marital status, and living arrangement), smoking status, co-morbidities, use of intravenous thrombolysis, last follow up date, survival at various time points (30 days, 3 months, 1 year, 2 year and last available follow up), and date of death.

Statistical Analysis

Group statistics are presented as mean $\pm$ standard deviation for continuous variables and number (%) for categorical variables. Precision was measured using 95% confidence interval. We presented various reasons for 30-day readmission as number and percentages with 95% confidence interval. Patients with planned readmissions were excluded from further analysis. Demographic factors, co-morbidities, use of IV rt-PA, index stroke length of hospitalization, and discharge disposition were studied to identify predictors of post-

stroke 30-day readmission using the χ^2 and Fisher exact tests to compare categorical variables and the two sample *t* test was for continuous variables.

All significant predictors from univariable analysis defined as *p* value less than 0.10 were further studied in a multivariable logistic model. Age was also included in the final model as it is a known predictor of readmission.¹⁶ Nominal logistic regression analysis was performed to identify the independent predictors of 30-day readmission. A subgroup analysis was done to 30-day readmissions in patients with prior history of dementia using univariable and multivariable analysis. Interaction was checked and was adjusted for in the final model. *P* value less than 0.05 was considered significant.

Results

The final study cohort included 537 patients with 41 readmissions within 30-days (7.6%, 95% CI 5.7%-10.2%) (Figure-1, Table-1).

Six (1%, 95% CI 0.5% - 2.4%) patients had planned readmission and 35 (6.5%, 95% CI 4.7% - 8.9%) had unplanned readmission. Table-2 shows the baseline demographic data, co-morbidities, and index stroke hospitalization data for all patients, patients with unplanned readmission, and those without readmission in 30 days. Readmitted patients were admitted after median of 10 days (Q1-Q3 4.3-17.5) after stroke discharge. The most common (81%, 95% CI 66%-90%) reasons for readmission were non-neurological (cardiovascular (37%), infectious (34%), and musculoskeletal (15%)) as shown in Table-1. There was no significant trend over the study period in the number of readmissions per year (*p*=0.34).

Post-stroke unplanned 30-day readmission risk factors

Univariable analysis showed living in assisted living facility at the time of index stroke, prior diagnosis of hypertension, and prior diagnosis of dementia as positive predictors whereas education level of high school graduation or higher, being married, and discharge to a nursing home following index stroke as negative predictors of unplanned 30-day readmission (Table-1).

In a multivariable logistic regression model (using age, sex, marital status, education level more than high school, living in assisted living, discharge to nursing home after index stroke, prior history of hypertension, and prior history of dementia, dementia* discharge to nursing home after index stroke), discharge to nursing home after index stroke (OR: 0.29, 95% CI 0.08-0.84) was an independent negative predictor of unplanned 30-day readmission (Table-3).

Lower readmissions in married patients with previous diagnosis of dementia

—On univariable analysis variables associated with 30-day unplanned readmission (*n*=12) in stroke patients with prior diagnosis of dementia (*n*=97), were being married at presentation (readmitted versus non-readmitted, 8% versus 42%, *p* value=0.02), coronary artery disease as a co-morbidity (50% versus 81%, *p* value=0.02), and discharge to a nursing home after index stroke (17% versus 44%, *p* value=0.08). In a multivariable logistic model (using age, marital status, history of coronary artery disease, and discharge to a nursing home after

index stroke), being married at time of index stroke was found to be a negative predictor of readmission (OR 0.10, 95% CI 0.005-0.58).

Potentially Preventable 30-day readmissions

Fifteen of 35 unplanned readmissions (43%) readmissions were considered potentially preventable. The reasons for these readmissions were fall with or without fracture (4), infection (urinary tract infection in 4 and pneumonia in 1), adverse drug reaction (hypoglycemia (2) and hypotension (1)), deep venous thrombosis and pulmonary embolism (1), contrast-induced nephropathy (1), and stroke due to missed opportunity for early carotid endarterectomy (1).

Post-stroke 30-day readmission and mortality (short and long term)

Median length of stay after readmission was 1 day (Q1-Q3=1-5 days). Overall, post-stroke mortality was 12%, 15%, 21%, 26% and 37% at 30 days, 3 months, 1 year, 2 years, and last available follow up (mean follow up of 28 months) respectively with no significant difference between readmitted and non-readmitted groups (Table-4).

Discussion

Our population-based study shows that the rate of post-stroke 30-day readmission in our cohort was 7.6% (95% CI 5.7%-10.1%) was similar to the 6.5-15% reported range in literature.¹⁻⁸ The most common reasons for unplanned readmission in our cohort were cardiovascular, infectious, neurological, and musculoskeletal similar to previous studies.^{2,3,6}

Predictors of readmissions

Nursing home discharge after index stroke have been reported as a positive predictor for stroke readmission³; however, it was noted to be a negative predictor in our study. The underlying mechanism may be closer supervisions in nursing homes leading to less medication errors, less aspiration, and fewer falls. Education less than high school has been previously reported to play a role in 30-day readmissions after percutaneous coronary intervention.¹⁷ We found similar effect of education in our cohort but it did not have an independent association when adjusted for other confounders.

Being married at the time of index stroke was a negative predictor of readmission in dementia patients probably due to availability of a spouse as a caregiver. Presence of a spouse may have led to better medication compliance, aspiration precautions, and fall prevention. Previously, marriage has been associated with reduced readmissions in psychiatric and cardiac patients.^{18,19}

Potentially Preventable readmissions

Overall 2.8% (95% CI 1.7% - 4.6%) of the patients had potentially preventable readmissions in 30 days similar to the 1.7% reported by Lichtman et al.⁴ Reasons for readmissions in these 2.8% (n=15) patients were varied, but medication reconciliation errors and infection were most noticeable.

We found that medication reconciliation and education at discharge contributed to at least 3 cases of readmission. Other studies have also found drug related errors in up to 68% hospitalized stroke patients taking more than 2 medications, reinforcing the importance of medication reconciliation by a pharmacist at the time of admission and discharge for all stroke patients.²⁰ Pre-discharge (medication reconciliation at admission and discharge by a pharmacist, patient and caregiver education, and discharge planning by case managers) and post-discharge (follow up on any pending test results, communication and partnership with primary physician and nursing homes, and post-discharge contact with patient) strategies may help reduce medication errors and 30-days readmissions.²¹⁻²⁵

The most common infections facing stroke patients include urinary tract infection and aspiration pneumonia. Post-stroke urinary retention and use of indwelling urinary catheters can contribute to the risk of urinary tract infection. Inpatient automated reminders to reassess need for urinary catheter and urinary retention protocols focused on early catheter removal and use of intermittent straight catheterization may help reduce the risk of urinary tract infection. In addition, information technology system alerts and post hospitalization follow up (by phone or in person) may help recognize post hospitalization positive culture results that may impact patient care.

Post-stroke dysphagia is seen in one-third stroke patients.²⁶ Stroke patients at high risk for aspiration should be identified using clinical indicators and video fluoroscopic swallowing study; and diet modification and percutaneous endoscopic gastrostomy should be used when appropriate to prevent aspiration pneumonia and stroke readmissions in these patients. Score like acute ischemic stroke-associated pneumonia score [AISAPS] may be used to identify high risk patients.²⁷ Clear instructions to patients, their families or as part of discharge instructions to care facilities must be provided to prevent this complication.

The critical time between discharge and first 30 days, the transition period, deserves special attention in stroke patients. Discharge checklists, protocols, and post hospitalization follow up may help reduce preventable readmissions and improve quality of care.^{28,29} In particular focusing on high risk groups such as patients with dementia and providing additional resources and support to reduce 30-day readmission may be useful. Expanded adult day programs were found to reduce 30-day readmissions in a pilot retrospective study.³⁰ Post-discharge home visits by a physician and physical therapist has shown to decrease 6 month readmission rates in a randomized study.²⁵ Transitional programs specifically dedicated to stroke patients are lacking though potentially beneficial in other areas of medicine.

Hospital readmissions and mortality

Hospital readmission had no significant impact on patient's short or long term mortality in our cohort. This is probably secondary to the relatively small number of readmissions in our cohort. Patient with 30-day readmissions had a trend towards higher short and long term mortality, which needs to be explored in larger populations. Data from 422 hospitals showed increased 1 year mortality in patients with post-stroke 30-days readmissions.¹²

Strengths and Limitations

The strength of our study is that it is a population-based study with no referral or selection biases, which commonly affect registry-based studies. We did a detailed chart review and had individual level data, which is not available in registry based studies. Measurement bias was reduced in our study via validation of acute stroke patients by crosschecking with a stroke registry and chart review of a random sample of cases. We have identified areas for further research and quality improvement in acute and subacute stroke care. The main limitation of our study is sample size, we had total of only 41 readmissions with only 15 potentially preventable readmissions, which limits our statistical significance for studying the effect of readmissions on patient outcome. However, we included all possible patients who could be investigated for our study questions in Olmsted County over 5 year time period. Another limitation is that we did not capture data about hospital readmissions outside Olmsted County. It is possible, but quite unlikely because of the characteristics of our cohort, that Olmsted County residents were readmitted to another hospital outside the county after their index hospitalization. Most of the patients in Olmsted County are readmitted to the study hospitals limiting the measurement bias for the rate of readmissions. Another limitation could be lack of generalizability of our finding to US population; however previous studies have found similar results between Olmsted County and US national population for incidence of hip fracture^{31,32} and heart disease mortality trends³³. Also, population characteristics of Olmsted County population are similar to those of state of Minnesota and the Upper Midwest.³⁴

Conclusions

Our population-based study shows that the rate of post-stroke 30-day readmission in our cohort was 7.6%, with cardiovascular, infectious, neurological, and musculoskeletal diseases being the most common causes for readmissions. Discharge to nursing home after index stroke was a negative predictor of post-stroke 30-day readmission. In a subgroup of patient with dementia, being married at the time of stroke was a negative predictor of readmission. Hospital readmission had no significant impact on patient's short or long term mortality in our cohort. These results should be confirmed in other populations.

Annually, 795,000 people have stroke (ischemic and hemorrhagic) in United States. Since, 80% of strokes are ischemic strokes around 636,000 people have ischemic strokes.³⁵ If we consider 7.6% (our study) to 15% (reported in literature) as the readmission rate then 48,336 to 95,400 patients will have post-stroke 30-days readmissions annually. Thus, measures to prevent these readmissions can have substantial impact on the patient safety and reduction of health care costs to the society. More research is urgently needed to study strategies that may reduce patient readmissions and improve patient safety.

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Abbreviations

AIS	acute ischemic stroke
CI	confidence interval

ICD	International Classification of Diseases
OMCH	Olmsted Medical Center Hospital
OR	odds ratio
REP	Rochester Epidemiology Project
rt-PA	recombinant tissue plasminogen activator
SMH	Saint Marys Hospital

Figure-1.

Study flow chart, Abbreviations: IV rt-PA= intravenous recombinant tissue plasminogen activator, OMCH= Olmsted Medical Center Hospital, and REP= Rochester Epidemiology Project

Table-1

Univariable analysis of predictors of unplanned 30-day readmission after acute ischemic stroke patients in Olmsted County, Minnesota

	Total (N=537) Number (%)	Patients with unplanned 30-day readmission (N=35) Number (%)	Patients without 30-day readmission (N=496) Number (%)	P value
Age in years (mean±SD)	76±14	77±12	76±14	0.81
Sex (Men: Women)	234:303	29%:71%	45%:55%	0.06
Educational level	N=506	N=33	N=473	
High school graduation or higher ¹	415 (82)	22 (67)	393 (83)	0.02
Marital status				
Married at presentation	273 (51)	10 (29)	263 (52)	0.006
Living arrangement	N=463	N=30	N=433	
Apartment/House	388 (84)	21 (70)	367 (85)	0.31
Assisted living	31 (7)	5 (17)	26 (6)	0.04
Nursing home	16 (4)	0	16 (4)	0.62
Other ²	28 (6)	4 (13)	24 (6)	0.07
Smoking	N=504	N=34	N=470	
Current smokers	64 (13)	6 (18)	58 (12)	0.55
Past smokers	215 (43)	12 (35)	203 (43)	
Never smoked	225 (45)	16 (45)	209 (44)	
Co-morbidities				
Previous ischemic stroke	199 (37)	12 (34)	187 (37)	0.73
TIA	129 (24)	7 (20)	122 (24)	0.57
Intracranial hemorrhage	13 (2)	1 (3)	12 (2)	0.59
Coronary artery disease	370 (69)	23 (66)	347 (69)	0.67
Atrial fibrillation	170 (32)	11 (31)	159 (32)	0.98
Heart failure	133 (25)	10 (29)	123 (25)	0.59
Hyperlipidemia	402 (75)	27 (77)	375 (75)	0.75
Hypertension	462 (86)	34 (97)	428 (85)	0.046
Diabetes	171 (32)	13 (37)	158 (32)	0.49
Dementia	97 (18)	12 (34)	85 (17)	0.01
Intravenous thrombolysis	61 (11.4)	3 (9)	58 (12)	0.59
Median length of stay (days)	4 (Q1-Q3=2-6)	5 (Q1-Q3=3-6)	4 (Q1-Q3=2-6)	0.15
Discharge disposition after index stroke³	N=507	N=35	N=472	
Home	254 (50)	21 (60)	233 (49)	0.23
Rehabilitation	122 (24)	10 (29)	112 (24)	0.52

	Total (N=537) Number (%)	Patients with unplanned 30-day readmission (N=35) Number (%)	Patients without 30-day readmission (N=496) Number (%)	P value
Nursing home	131 (26)	4 (11)	127 (27)	0.046

Abbreviations: Q1-Q3= Quartile 1 to Quartile 3 (Interquartile range), SD= standard deviation, TIA= transient ischemic attack

¹Patients who graduated from high school but did not go to college were excluded

²Other included patients who did not live in any of the other three categories.

³Excluded patients who died at discharge

Table-2

Multivariable analysis of predictors of 30-day readmission after acute ischemic stroke hospitalization

	Odds ratio	95% confidence interval
Overall final model		
Age (per year change)	1.03	0.99-1.07
Men	2.36	0.96-6.46
Married	0.47	0.18-1.14
Education level more than high school	0.43	0.16-1.02
Living in assisted living	2.25	0.63-7.11
Discharge to nursing home after index stroke	0.29	0.08-0.84 *
Prior history of hypertension	4.72	0.79-92.3
Prior history of dementia	2.55	0.76-8.52
Subgroup analysis of patients with dementia		
Age (per year change)	0.995	1.09-1.005
Married at presentation	0.10	0.005-0.58 *
History of coronary artery disease	3.85	0.97-15.74
Discharge to nursing home after index stroke	4.55	0.98-33.07

Confidence intervals marked with

* denotes statistical significance

Table-3

Reasons for 30-day readmission after acute ischemic stroke

Reason	Number of patients N (%)
Total number of readmissions	41
Neurological	8 (20)
Recurrent stroke	4 (10)
Seizure	1 (2)
Angiography (planned)	1 (2)
Carotid endarterectomy (planned)	2 (5)
Cardiovascular	15 (37)
Atrial fibrillation	6 (15)
Coronary artery disease	2 (5)
Patent foramen ovale closure (planned)	2 (5)
Aortic valve fibroelastoma surgery (planned)	1 (2)
Chest pain	1 (2)
Hypertensive urgency	1 (2)
Hypotension	2 (5)
Pulmonary	3 (7)
Pulmonary embolism	2 (5)
Respiratory failure	1 (2)
Infection	14 (34)
Urinary tract infection	7 (17)
Pneumonia	6 (15)
Gastroenteritis	1 (2)
Musculoskeletal	6 (15)
Fall	3 (7)
Fracture	2 (5)
Post-surgical chest pain	1 (2)
Others	7 (17)
Hypoglycemia	2 (5)
Deep venous thrombosis	1 (2)
Gastrointestinal hemorrhage	1 (2)
Unexplained vomiting	1 (2)
Renal failure	1 (2)
Urinary retention	1 (2)

* Some patient had multiple reasons for readmission

Table-4

Impact of 30-day readmission after acute ischemic stroke on patient mortality

	Total (N=537) Number (%)	Patients with unplanned 30-day readmission (N=35) Number (%)	Patients without 30-day readmission (N=496) Number (%)	P value
Follow up period in months (mean±SD)	28±22	28±22	29±22	0.98
Post-stroke mortality at				
30 days (N, %, 95% CI)	64 (12, 10-15)	3 (9, 3-22)	61 (12, 10-15)	0.79
3 months (N, %, 95% CI)	80 (15, 12-18)	7 (20, 10-36)	73 (15, 12-18)	0.38
1 year (N, %, 95% CI)	113 (21, 18-25)	9 (26, 14-42)	104 (21, 17-25)	0.48
2 years (N, %, 95% CI)	139 (26, 22-30)	11 (31, 19-48)	128 (26, 22-30)	0.44
Last follow up (N, %, 95% CI)	199 (37, 33-41)	15 (43, 28-59)	184 (37,33-41)	0.46
Time from stroke to death in months (mean±SD)	16±19	16±22	16±18	0.99

Abbreviations: CI= confidence interval, IV=intravenous, rt-PA= recombinant tissue plasminogen activator

* Two year follow up data not available for all patients as mortality data was checked on 4/26/2013.