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Stroke Secondary Medication Persistence and Risk for Hospital Readmission within 90 Days after Discharge

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Abstract

Purpose: In stroke patients, a group at high risk for readmission, there is limited information on medication persistence and its impact on readmission. Utilizing data from a quality improvement program for post-acute processes of care, we investigated the relationship between secondary prevention medication persistence and risk for 90-day readmission in acute stroke patients.

Methods: Patients were eligible for the study if they were age 18 years or older and hospitalized with a primary diagnosis of acute ischemic or hemorrhagic stroke, or transient ischemic attack (TIA). A total of 142 patients who had been enrolled in the Transition Coaching for Stroke (TRACS) program were included in the analysis.

Results: The mean age was 63.6 ± 13.13 years and 52.8% were women. History of a prior stroke was significantly associated with medication non-persistence ($p=0.013$, odds ratio [OR], 4.85; 95% confidence interval [CI] 1.39-16.96). History of a prior stroke was also significantly associated with readmission for recurrent stroke or TIA within 30 days of discharge ($p=0.029$, OR 7.00; 95% CI 1.22-40.23). Logistic regression modeling with stroke/TIA readmission at 90 days showed that only prior stroke was significant ($p=0.012$, OR 5.54; 95% CI 1.45-21.10). A trend toward lower medication persistence was observed in patients readmitted with a stroke/TIA within 90 days (60.0% vs. 81.8%, $p=0.095$).

Conclusions: In patients discharged with stroke, history of a prior stroke was significantly associated with stroke/TIA readmission at 30 and 90 days after discharge. Poor secondary prevention medication persistence may be a potential risk factor for stroke/TIA readmission. Quality improvement programs focused on improving medication persistence may be essential, especially in patients with a history of recurrent strokes.

Keywords: Medication persistence; Re-admission; Secondary prevention; Stroke

Introduction

Stroke is a leading cause of disability and healthcare expenditure in the United States. An estimated 6.8 million Americans ≥ 20 years of age have had a stroke. Overall stroke prevalence is approximately 2.8% [1]. Each year, about 795,000 people experience a new or recurrent stroke. Approximately 610,000 of these are first attacks, and 185,000 are recurrent attacks [1]. About one-third of strokes are estimated to be preventable if appropriate medications and lifestyle changes occur at 100% compliance [2]. One could postulate that secondary prevention after the first stroke could be even higher because providers can identify risk factors and optimize prevention medications prior to discharge.

Effective prevention, however, relies on patients' persistent use of medications long term for optimizing risk factors, such as hypertension, diabetes, hyperlipidemia, and antithrombotic use for atherothrombotic strokes. Medication persistence is defined as "the duration of time from initiation to discontinuation of therapy" [3]. Medication persistence with prescribed drug regimens is a pervasive medical problem since medication non-persistence is a major risk factor for recurring vascular events or death. In patients with coronary heart disease, non-persistence with secondary prevention therapies is associated with a 2-fold increase in cardiovascular disease events, including stroke [4].

Stroke is the second leading cause of hospital admission among the elderly [5]. Among those who survive a stroke or a transient ischemic attack (TIA), readmission is common, with estimates ranging from 20% to 27% in the first year [5-7]. Besides the readmissions due to recurrent stroke, most of the other etiologies are related to medical conditions identified during hospitalization [6]. Several population based studies from administrative databases have identified different risk factors for readmission in stroke patients [8,9]. Depending on the research methods, predictors of readmission at 30 days include older age, black race, discharge destination, comorbidities such as prior stroke, heart disease, peripheral vascular disease, fluid and electrolyte imbalance, anemia, dementia, percutaneous endoscopic gastrostomy placement, stroke severity, need for nursing care, discharge planning, length of stay, prior hospitalizations, and treatment by specialists during initial admission [10-14]. Although there is a higher risk of recurrent stroke in patients who do not continue

to take prevention medications, there is limited information on medication persistence and the impact on readmission in this population [12,15,16]. We developed a quality improvement program (Transition Coaching for Stroke or TRACS) for patients going home after stroke in order to understand the reasons for readmission. In this study, we investigated the relationship between secondary prevention medication persistence and risk for 90-day readmission in acute stroke patients enrolled in this program.

Methods

Transition Coaching for Stroke (TRACS) is a hospital-supported, quality improvement program developed at Wake Forest Baptist Medical Center focused on improving the transition for stroke patients going home and reducing readmissions [17,18]. The TRACS Program is modeled after Hospital to Home (H2H), a quality initiative program of the American College of Cardiology with the goal of reducing readmission rates among those admitted with heart failure or acute myocardial infarction (MI). H2H focuses on three domains: medication management post-discharge, early follow-up, and symptom management [17]. The TRACS program also addresses these three areas by providing one-on-one transition coaching prior to discharge following admission for stroke. The hospital-based TRACS educator or nurse meets individually with patients and provides a take-home packet that includes a personalized review of the patient's risk factors, medication information, instructions for stroke awareness, action with new symptoms, and post-hospital follow-up care. These materials are given in large font for a 7-8th grade reading level with a one page summary. The coach explains new medications that had been added to the patient's regimen and behavioral changes that are necessary for a successful transition and also answers any questions the patient may have. The coach also collects information regarding health status and discharge medications. After discharge, enrolled patients are contacted with reminders about follow-up appointments, inquiries regarding medication changes or problems with the transition home. Patients are scheduled in the Stroke Nurse Practitioner (NP) clinic within 2 to 4 weeks of discharge for a standardized assessment that includes functional status, medication-taking, depression screen, and progress with rehabilitation. If needed, referrals for therapy or home health are performed and medications are adjusted during this visit. Patients are referred to primary care (if not already established) and follow-up with the stroke faculty clinic is scheduled, depending on the patient's needs for long-term follow-up.

For this study, patients who had been enrolled in TRACS from October 2012 to February 2014 were included in the analysis. Patients were eligible for the study if they were age 18 years or older and hospitalization for a primary diagnosis of acute ischemic or hemorrhagic stroke, or TIA. Patients who had been discharged to a skilled nursing facility or outside

inpatient rehabilitation facility were excluded. Medication persistence was ascertained by comparing the discharge medication list with the medication list at the first neurology follow-up visit (stroke NP or faculty visit). Patients prescribed an individual medication at discharge but were not taking that medication at follow-up were defined as "non-persistent." Persistence for the specified medication classes (i.e., antiplatelet, warfarin, antihypertensive, lipid-lowering, or diabetic agent) was defined in the same way [19]. For patients who discontinued a medication at follow-up, discontinuation by the patient or a physician was ascertained from the clinic note. If discontinuation was self-initiated, then subjects were asked to select from a list the response that most closely represented their reason for discontinuation. Data collection forms were programmed for online data entry of baseline variables (education, prior hospitalizations, health literacy) using Research Electronic Data Capture (REDCap). All causes of readmissions at 30 days and 90 days were obtained from medical records and hospital reports. The study protocol was approved by the Wake Forest School of Medicine Institutional Review Board. All data were de-identified for analysis. Because of the quality improvement focus of this project, informed consent was waived.

Statistical Analysis

Data are expressed as means (standard deviations) or numbers (percentages). Categorical data were examined by χ^2 analysis. The Mann-Whitney U test was used to compare the non-normally distributed data, and Student's t-test was used to compare normally distributed data. The baseline characteristics were compared among the groups using a one-way ANOVA. Simple and multivariate logistic regression models were used to analyze the association of univariate significant variables. A two-sided P-value of $<.05$ was considered statistically significant. SPSS version 20.0 for Windows was used for the statistical analysis.

Results

Of the 171 patients, 15 patients (8.8%) were discharged to a skilled nursing facility or outside inpatient rehabilitation facility and 14 patients (8.2%) were lost to follow-up. A total of 142 patients were included in the analysis for this study. The baseline characteristics of the analysis cohort are shown in **Table 1**. The mean age was 63.6 ± 13.13 years and 52.8% were women. The majority of patients (89.4%) had a history of hypertension, 35.9% diabetes, 53.5% hypercholesterolemia, and 28.2% were currently cigarette smokers. The most frequent stroke subtype was ischemic stroke (IS) ($n=108$, 76.1%), followed by TIA ($n=21$, 14.7%), and hemorrhagic stroke (HS) ($n=13$, 9.2%). Systolic blood pressure (SBP), diastolic blood pressure (DBP), and baseline National Institutes of Health stroke scale (NIHSS) score were significantly higher in the HS than IS and TIA groups. High-density lipoprotein (HDL)

cholesterol was significantly lower in the HS than the TIA group.

Table 1 Baseline characteristics of enrolled patients

| | Total (n=142) | IS(n=108) | HS (n=13) | TIA (n=21) | P value |
|--|---------------|----------------|----------------|----------------|---------|
| Demographics | | | | | |
| Age, years | 63.6 (13.13) | 62.8 (13.43) | 62.1 (8.98) | 68.8 (12.96) | 0.146 |
| Female | 75 (52.8) | 55 (50.9) | 7 (53.8) | 13 (61.9) | 0.652 |
| Medical history | | | | | |
| Hypertension | 127 (89.4) | 96 (88.9) | 12 (92.3) | 19 (90.5) | 0.918 |
| Diabetes mellitus | 51 (35.9) | 37 (34.3) | 5 (38.5) | 9 (42.9) | 0.739 |
| Hypercholesterolemia | 76 (53.5) | 57 (52.8) | 5 (38.5) | 14 (66.7) | 0.263 |
| Coronary artery disease | 35 (24.6) | 29 (26.9) | 2 (15.4) | 4 (19.0) | 0.539 |
| Stroke | 35 (24.6) | 25 (23.1) | 2 (15.4) | 8 (38.1) | 0.250 |
| Congestive heart failure | 18 (12.7) | 12 (11.1) | 3 (23.1) | 3 (14.3) | 0.459 |
| Smoking | 40 (28.2) | 36 (33.3) | 3 (23.1) | 1 (4.8) | 0.026* |
| Alcohol abuse | 15 (10.6) | 12 (11.1) | 1 (7.7) | 2 (9.5) | 0.918 |
| Depression | 18 (12.7) | 16 (14.8) | 0 (0) | 2 (9.5) | 0.283 |
| Prior Hospitalization | 27 (19.0) | 17 (15.7) | 1 (7.7) | 9 (42.9) | 0.008* |
| Clinical presentation | | | | | |
| SBP, mmHg | 158.1 (27.03) | 156.2 (25.61) | 181.9 (39.78) | 153.0 (16.70) | 0.003* |
| DBP, mmHg | 85.5 (18.43) | 85.1 (16.29) | 101.1 (30.08) | 77.9 (14.61) | 0.001* |
| HbA1c, % | 6.7 (2.07) | 6.8 (2.16) | 5.9 (1.29) | 6.6 (1.68) | 0.655 |
| Total cholesterol, mg/dL | 181.4 (46.08) | 182.4 (43.62) | 176.1 (44.77) | 177.9 (61.06) | 0.881 |
| LDL-cholesterol, mg/dL | 109.8 (35.88) | 111.9 (34.34) | 102.3 (48.65) | 100.2 (39.78) | 0.397 |
| HDL-cholesterol, mg/dL | 40.0 (12.47) | 40.2 (11.97) | 34.6 (5.76) | 47.3 (15.03) | 0.024* |
| Triglyceride, mg/dL | 156.0 (119.6) | 155.3 (108.35) | 212.3 (147.08) | 134.9 (162.77) | 0.314 |
| Neurological scale score, median (range) | | | | | |
| Baseline NIHSS score | 2.0 (0-32) | 3.0 (0-32) | 6.0 (0-27) | 0.0 (0-9) | 0.004* |
| mRS at discharge | 3.0 (0-5) | 3.0 (0-5) | 3.0 (1-4) | 0.0 (0-0) | 0.019* |
| IS, Ischemic Stroke; HS, Hemorrhagic Stroke; TIA, Transient Ischemic Attack; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; LDL, Low-Density Lipoprotein; HDL, High-Density Lipoprotein; NIHSS, National Institutes Of Health Stroke Scale; mRS, Modified Rankin Score. Data are means (SD) Or numbers (%). Significant p is marked with*. | | | | | |

The percentage of patients prescribed medications by class and by type at discharge, post-discharge persistence, and discontinuation rates (physician’s recommendation or self-discontinued) are shown in **Table 2**. Persistence at 3 months was greatest for antithrombotic (96.7%) and diabetes mellitus (95.8%) medications. Of those treated, 114 patients (80.3%) were persistent with all the secondary prevention medications prescribed by their physicians at discharge. Medication non-persistence was significantly associated with the history of a prior stroke (p=0.045) and index cerebrovascular event (IS, p=0.04) (**Table 3**).

The reasons for hospital readmission are shown in **Table 4**. The most common reason for readmission at 30 days after discharge was recurrent stroke/TIA, followed by worsening stroke symptoms, and congestive heart failure. The factors associated with readmission at 30 days are shown in **Tables 5** and **6**. Twelve patients (8.5%) were readmitted at 30 days after discharge. Of these, 6 patients (50.0%) were readmitted due to stroke/TIA. Prior hospitalization was significantly associated with all cause readmission at 30 days (p=0.037). However, demographic, medical history, clinical presentation, and stroke severity were not associated with all cause readmission at 30 days (**Table 5**). History of a prior stroke was higher in patients readmitted within 30 days for stroke/TIA (66.7% vs. 22.8%;

p=0.033; **Table 6**). There was no significant relationship between medication persistence and all cause or stroke/TIA readmission at 30 days (p=0.704 and p=0.328, respectively). Multiple logistic regression analysis revealed that prior

hospitalization was significantly associated with all cause readmission at 30 days (p= 0.034, OR 3.97; 95% CI 1.11-14.23) and history of a prior stroke was associated with stroke/TIA readmission at 30 days (p= 0.029, OR 7.00; 95% CI 1.22-40.23).

Table 2 Three-month persistence by drug class and drug type

| Drug Class/Drug | Prescription at Discharge (n=142) | Hospital | Persistence | Discontinued by Provider | Discontinued by Patient |
|---------------------------------------|-----------------------------------|----------|-------------------|--------------------------|-------------------------|
| Antithrombotic, n (%) | 121 (85.2) | | 117 (96.7) | 2 (1.7) | 2 (1.7) |
| Antiplatelet | 117 (82.4) | | 112 (95.7) | 2 (1.7) | 2(1.7) |
| Anticoagulant | 7 (4.9) | | 7 (100) | 0 (0) | 0 (0) |
| Antihypertensive, n (%) | 124 (87.3) | | 107 (86.3) | 8 (6.5) | 5 (4.0) |
| Diuretics | 40 (28.2) | | 35 (87.5) | 1 (2.5) | 1 (2.5) |
| ACEI | 39 (27.5) | | 37 (94.9) | 0 (0) | 1 (2.6) |
| ARB | 11 (7.7) | | 10 (91.1) | 0 (0) | 0 (0) |
| CCB | 32 (22.5) | | 25 (78.1) | 3 (9.4) | 3 (9.4) |
| Beta blockers | 54 (38.0) | | 52 (96.3) | 0 (0) | 0 (0) |
| Alpha antagonist | 3 (2.1) | | 2 (66.7) | 1 (33.3) | 0 (0) |
| Vasodilators | 16 (11.3) | | 11 (68.8) | 3 (18.8) | 0 (0) |
| Lipid-lowering drugs, n (%) | 112 (78.9) | | 97 (86.7) | 6 (5.4) | 4 (3.6) |
| Diabetes mellitus drugs, n (%) | 48 (33.8) | | 46 (95.8) | 2 (4.2) | 0 (0) |

ACEI, Angiotensin Converting Enzyme Inhibitor; ARB, Angiotensin II Receptor Blocker; CCB, Calcium Channel Blocker. The denominator for persistence and non-persistence for each drug or drug class is use at discharge; missing persistence data and unknown reason for non-persistence account for the difference from the total prescribed at discharge.

At 90 days, 18.3% (n=26) of patients were readmitted when all causes were considered (**Table 5**). Of all of the candidate factors, only prior CAD was significantly higher in all cause readmitted patients (42.3% vs. 20.7%, p=0.021). Of these 26 readmitted patients, 10 (38.5%) patients were readmitted due to recurrent stroke/TIA (**Table 6**). History of a prior stroke was significantly higher in stroke/TIA readmitted patients (60.0% vs. 22.0%, p=0.015). Multiple logistic regression modeling revealed that prior CAD (p= 0.03, OR 2.90; 95% CI 1.11-7.60) and female gender (p= 0.037, OR 2.85; 95% CI 1.07-7.61) were significantly associated with all cause readmission at 90 days. Logistic regression modeling with stroke/TIA readmission at 90 days as the outcome showed that only prior stroke was significant (p= 0.012, OR 5.54; 95% CI 1.45-21.10). Though there was no significant relationship between medication persistence and all cause readmission at 90 days (p=0.945), a trend toward lower medication persistence was observed in stroke/TIA readmission at 90 days (60.0% vs. 81.8%, p=0.095).

Discussion

Readmission after hospital discharge is an important indicator for the quality of healthcare services. Readmissions may indicate unresolved issues during the initial admission, or poor resources allocated for post-hospital care [20]. Reducing

the rate of readmission after stroke is an important focus for quality improvement. This requires detecting and treating modifiable risks for re-admission prior to and after discharge in the early post-acute stroke period and developing strategies to improve patient persistence with medication regimens [21]. Besides the re-admissions due to recurrent stroke, most of the other etiologies are related to medical management during hospitalization and may be preventable [11]. In this study, we found that, although there was no significant relationship between medication persistence and all cause readmission at 90 days, a trend toward lower medication persistence was observed in stroke/TIA re-admission at 90 days (60.0% vs. 81.8%, p=0.095).

From a therapeutic point of view, our study had two interesting points related to all-cause and stroke/TIA readmissions. First, history of a prior stroke was significantly associated with medication non-persistence (p=0.045). Even though there was no significant relationship between medication non-persistence and stroke/TIA readmission, prior stroke was significantly associated with these readmissions at 30 and 90 days (p=0.033 and p=0.015, respectively). Among those who survive after stroke, the risk of further stroke is high, ranging from 15% to 42% over 5 years [5,22]. Recurrent stroke accounts for up to 40% of all strokes and is associated

with higher mortality than first stroke and functional recovery is often poorer [9,23].

Table 3 Factors associated with medication persistence

| Variable | Persistence (n=114) | Non-persistence (n=28) | P Value |
|--|---------------------|------------------------|---------|
| Age, years | 63.4 (12.95) | 64.29 (14.05) | 0.756 |
| Female | 59 (51.8) | 16 (57.1) | 0.609 |
| Race | | | 0.087 |
| White | 67 (76.1) | 21 (23.9) | |
| African American | 23 (79.3) | 6 (20.7) | |
| Not reported | 24 (96.0) | 1 (4.0) | |
| Education level | | | |
| ≥college | 19 (16.7) | 7 (25.0) | 0.250 |
| Work status | | | 0.249 |
| Working | 32 (28.1) | 4 (14.3) | |
| Retired | 35 (30.7) | 13 (46.4) | |
| Disabled | 10 (8.8) | 7 (25.0) | |
| Not reported | 37 (32.4) | 4 (14.3) | |
| Medical history | | | |
| Hypertension | 102 (89.5) | 25 (89.3) | 0.977 |
| Diabetes mellitus | 42 (36.8) | 9 (32.1) | 0.642 |
| Hypercholesterolemia | 60 (52.6) | 16 (57.1) | 0.668 |
| Coronary artery disease | 29 (25.4) | 6 (21.4) | 0.659 |
| Stroke | 23 (21.1) | 11 (39.3) | 0.045* |
| Index cerebrovascular event | | | 0.040* |
| Ischemic stroke | 89 (82.4) | 19 (17.6) | |
| Hemorrhagic stroke | 7 (53.8) | 6 (46.2) | |
| TIA | 18 (85.7) | 3 (14.3) | |
| Insurance | | | |
| Have insurance or help to pay for meds | 94 (82.5) | 22 (78.6) | 0.577 |
| Prior Hospitalization | 24 (21.1) | 3 (14.3) | 0.212 |
| Length of admission, days | 3.2 (3.53) | 3.7 (2.87) | 0.509 |
| Office visits after discharge | 93 (81.6) | 22 (78.6) | 0.716 |
| Neurological Index at discharge | | | |
| mRS score ≥3 | 65 (57.0) | 9 (32.1) | 0.286 |
| SPPB score | 4.7 (4.16) | 7.2 (5.67) | 0.252 |
| MoCA score | 21.0 (5.64) | 25.0 (3.61) | 0.241 |

TIA, Transient Ischemic Attack; mRS, Modified Rankin Score; SPPB, Short Physical Performance Battery; MoCA, Montreal Cognitive Assessment. Data are means (SD) or numbers (%). Significant p is marked with*.

The available data on stroke patients suggest that medication persistence is often sub-optimal, and that many patients are consequently at a significantly increased risk of a

further stroke [6,13,16]. Although early initiation of prevention strategies has shown sustained persistence and good outcomes in some stroke patients, other evidence suggests

that use of these secondary prevention therapies may not persist long-term [19]. In a study of over 3,000 stroke patients, 84% are taking aspirin at one year post stroke, 77% oral anticoagulants, but only 61% who are prescribed Clopidogrel at discharge are still taking it one year later [24]. It has been also known that only 70% of patients are still taking cholesterol reducing treatment one year after stroke [25]. Data from the Netherlands reveal that by one year after ischemic

stroke, 22% of patients who had been taking oral anticoagulation had stopped, half of whom did so “for non-medical reasons” such as perceived adverse effects or patient request [26]. Our study provides further evidence that continuing prescribed stroke prevention medications is essential to prevent stroke recurrence especially in patients with prior stroke.

Table 4 Etiology of re-admission

| Reason for readmission | At 30 days (n=12, 8.5%) | At 90 days (n=26, 18.3%) |
|---------------------------|-------------------------|--------------------------|
| Recurrent Stroke | 6 (4.3%) | 10 (7.0%) |
| Worsening stroke symptoms | 2 (1.4%) | 3 (2.2%) |
| Congestive heart failure | 2 (1.4%) | 2 (1.4%) |
| Carotid procedure | 1 (0.7%) | 1 (0.7%) |
| Dysphagia | 1 (0.7%) | 1 (0.7%) |
| Arrhythmias | 0 | 1 (0.7%) |
| Anorexia | 0 | 1 (0.7%) |
| Shoulder fracture | 0 | 1 (0.7%) |
| Gangrene on toes | 0 | 1 (0.7%) |
| Intra-abdominal abscess | 0 | 1 (0.7%) |
| Urinary tract infection | 0 | 1 (0.7%) |
| Iron deficiency anemia | 0 | 1 (0.7%) |
| Vertigo | 0 | 1 (0.7%) |
| Ureter stone | 0 | 1 (0.7%) |

The second important finding from our study is that the frequency of all-cause readmission in this study was 8.5% at 30 days and 18.5% at 90 days after discharge. Several studies have been undertaken to examine the frequency of readmissions within 30 days of discharge after stroke [13,27]. Evidence from these studies show that the frequency of hospital readmissions may vary from 6.5% to 24.3% [27]. The readmission rate in our study was comparable to what has been reported using Medicare data (12-14%) or single center studies (10%) [11]. Patients with strokes, who are readmitted within 30 days, are at a higher risk of mortality in the long term and incur greater healthcare costs [10,28]. The potential factors that may be associated with being readmitted after an initial hospitalization for stroke can be grouped into 5 broad categories: patient characteristics, social circumstances, health system, clinical care, and health outcome [27]. In this study, prior hospitalization was significantly associated with all-cause readmission at 30 days ($p= 0.034$). Using our own hospital data to determine the risks for readmission in stroke patients discharged to all locations (and not just to home), we found a 2.2-fold higher risk of 30-day readmission with each prior hospitalization before the stroke [13]. The current analysis also confirmed the importance of the prior hospitalization as a predictor of early readmission.

Although the most common 90-day readmission diagnosis in our study was stroke or TIA, 61.5% of patients in this study were readmitted for an indication unrelated to the index admission. It also may be that factors associated with a more severe incident admission may place these patients at an even higher risk of subsequent readmission. In our study, prior CAD ($p= 0.03$) and female gender ($p= 0.037$) were significantly associated with 90-day all-cause readmission. Among the factors ascribed to the risk of rehospitalization in stroke patients, older age, atrial fibrillation, prior CAD, and prior stroke are generally recognized as risk factors for vascular events, and consequently increase the risk of rehospitalization [29]. Readmissions related to cardiac diseases maybe due to alteration of medications during the admission [11]. Therefore, careful review of medications at discharge and early outpatient follow-up may aid in lowering this risk.

This study had limitations. This was a single-center study performed at a tertiary, academic medical center with relatively small numbers of patients readmitted. Only patients discharged home and enrolled in our quality improvement program that focused on providing personalized stroke and medication education were included in this analysis. One could postulate that this might be the best case scenario for outcomes related to persistence and readmission. For these reasons, the results may not be generalizable to other settings.

In addition, although we collected a large amount of data in this study, including both clinical and nonclinical characteristics, we cannot discount unmeasured confounders, such as social support and other socioeconomic factors that could affect the readmission. The strengths of this study were that the TRACS program includes comprehensive patient-, provider-, and system-level data useful for quality

improvement purposes. In addition, TRACS included information not generally found in the electronic medical record, such as education and working status. Measures reflecting physical (short physical performance battery or SPPB) and cognitive function (Montreal Cognitive Assessment or MoCA) were also obtained at discharge, which could impact medication persistence [30].

Table 5 Factors associated with all cause readmission

| | 30 days | | | 90 days | | |
|--------------------------------------|-------------------|------------------------|--------|-------------------|------------------------|--------|
| | Readmitted (n=12) | Not readmitted (n=130) | P | Readmitted (n=26) | Not readmitted (n=116) | P |
| Age, years | 64.5 (15.26) | 63.5 (12.98) | 0.803 | 65.1 (13.43) | 63.3 (13.09) | 0.514 |
| Female | 4 (33.3) | 63 (48.5) | 0.376 | 18 (69.2) | 57 (49.1) | 0.064 |
| Hypertension | 12 (100) | 115 (88.5) | 0.364 | 23 (88.5) | 104 (89.7) | 0.858 |
| Diabetes mellitus | 7 (58.3) | 44 (33.8) | 0.091 | 12 (46.2) | 39 (33.6) | 0.262 |
| Hypercholesterolemia | 8 (66.7) | 68 (52.3) | 0.382 | 15 (61.5) | 60 (51.7) | 0.364 |
| Coronary artery disease | 5 (41.7) | 30 (23.1) | 0.153 | 11 (42.3) | 24 (20.7) | 0.021* |
| Stroke | 5 (41.7) | 30 (23.1) | 0.153 | 9 (34.6) | 26 (22.4) | 0.192 |
| Congestive heart failure | 3 (25.0) | 15 (11.5) | 0.180 | 6 (23.1) | 12 (10.3) | 0.079 |
| Smoking | 2 (16.7) | 38 (29.2) | 0.510 | 9 (34.6) | 31 (26.7) | 0.419 |
| Alcohol abuse | 3 (25.0) | 12 (9.2) | 0.117 | 5 (19.2) | 10 (8.6) | 0.112 |
| Depression | 2 (16.7) | 16 (12.3) | 0.650 | 4 (15.4) | 14 (12.1) | 0.744 |
| Prior Hospitalization | 5 (41.7) | 22 (16.9) | 0.037* | 8 (30.8) | 19 (16.4) | 0.091 |
| Medication persistence | 9 (75.0) | 105 (80.8) | 0.704 | 21 (80.8) | 93 (80.2) | 0.945 |
| Length of admission, days | 2.0 (1.48) | 3.42 (3.51) | 0.169 | 2.5 (2.23) | 3.5 (3.6) | 0.211 |
| Office visits after discharge | 8 (66.7) | 107 (82.3) | 0.186 | 19 (73.1) | 96 (82.8) | 0.256 |
| SBP, mmHg | 160.4 (21.12) | 157.9 (27.56) | 0.755 | 160.2 (24.00) | 157.6 (27.73) | 0.659 |
| DBP, mmHg | 80.3 (13.59) | 86.0 (18.78) | 0.309 | 82.2 (20.95) | 86.3 (17.83) | 0.303 |
| HbA1c, % | 7.5 (3.34) | 6.6 (1.89) | 0.150 | 7.1 (2.70) | 6.6 (1.90) | 0.296 |
| Total cholesterol, mg/dL | 177.6 (33.59) | 181.8 (47.26) | 0.764 | 183.6 (33.84) | 180.9 (48.54) | 0.799 |
| LDL-cholesterol, mg/dL | 105.1 (27.66) | 110.3 (36.69) | 0.634 | 110.9 (33.48) | 109.5 (36.57) | 0.871 |
| HDL-cholesterol, mg/dL | 45.8 (13.56) | 40.4 (12.30) | 0.152 | 40.9 (13.05) | 40.9 (12.40) | 0.985 |
| Triglyceride, mg/dL | 120.9 (66.52) | 159.6 (123.33) | 0.288 | 84.7 (17.30) | 126.5 (12.28) | 0.926 |
| Baseline NIHSS score, median (range) | 3.0 (0-10) | 2.0 (0-32) | 0.638 | 3.0 (0-10) | 2.0 (0-32) | 0.457 |
| mRS at discharge, median (range) | 1.0 (0-4) | 3.0 (0-5) | 0.474 | 2.0 (0-5) | 3.0 (0-5) | 0.767 |

TIA, Transient Ischemic Attack; BP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; LDL, Low-Density Lipoprotein; HDL, High-Density Lipoprotein; NIHSS, National Institutes Of Health Stroke Scale; mRS, modified Rankin score. Data are means (SD) or numbers (%). Significant p is marked with *.

In conclusion, our study identified that in patients discharged with stroke, the most common reason for readmission at 90 days after discharge was recurrent stroke/TIA, followed by worsening stroke symptoms, and congestive heart failure. Prior hospitalization was significantly associated with all cause readmission at 30 days. Prior CAD and female gender were significantly associated with all cause readmission

at 90 days. Prior stroke was significantly associated with stroke/TIA readmission at 30 and 90 days after discharge, and the importance of optimal secondary prevention medication persistence is an obvious target for reducing the risk of recurrent stroke. Though there was no significant relationship between medication persistence and all cause readmission at 90 days, a trend toward lower medication persistence was

observed in stroke/TIA readmission at 90 days (Table 7). Quality improvement programs that provide additional counseling and contact with stroke patients to improve

medication persistence may be essential, especially in those who have already had a recurrent stroke.

Table 6 Factors associated with stroke/TIA re-admission

| | 30 days | | | 90 days | | |
|--------------------------------------|------------------|------------------------|--------|-------------------|------------------------|--------|
| | Readmitted (n=6) | Not Readmitted (n=136) | P | Readmitted (n=10) | Not Readmitted (n=132) | P |
| Age, years | 65.3 (13.19) | 63.5 (13.17) | 0.741 | 65.3 (12.66) | 63.5 (13.20) | 0.671 |
| Female | 4 (66.7) | 71 (52.2) | 0.684 | 6 (60.0) | 69 (52.3) | 0.749 |
| Hypertension | 6 (100) | 121 (89.0) | 0.999 | 8 (80.0) | 119 (90.2) | 0.285 |
| Diabetes mellitus | 3 (50.0) | 48 (35.3) | 0.667 | 3 (30.0) | 48 (36.4) | 0.686 |
| Hypercholesterolemia | 3 (50.0) | 73 (53.7) | 0.860 | 5 (50.0) | 71 (53.8) | 0.817 |
| Coronary artery disease | 2 (33.3) | 33 (24.3) | 0.636 | 2 (20.0) | 33 (25.0) | 0.724 |
| Stroke | 4 (66.7) | 31 (22.8) | 0.033* | 6 (60.0) | 29 (22.0) | 0.015* |
| Congestive heart failure | 1 (16.7) | 17 (12.5) | 0.564 | 1 (10.0) | 17 (12.9) | 0.792 |
| Smoking | 1 (16.7) | 39 (28.7) | 0.985 | 3 (30.0) | 37 (28.0) | 0.894 |
| Alcohol abuse | 1 (16.7) | 14 (10.3) | 0.495 | 2 (20.0) | 13 (9.8) | 0.285 |
| Depression | 2 (33.3) | 16 (11.8) | 0.167 | 2 (20.0) | 16 (12.1) | 0.615 |
| Prior Hospitalization | 2 (33.3) | 25 (18.4) | 0.320 | 2 (20.0) | 25 (18.9) | 0.934 |
| Medication persistence | 4 (66.7) | 110 (80.9) | 0.328 | 6 (60.0) | 108 (81.8) | 0.095 |
| Length of admission, days | 1.5 (0.55) | 3.4 (3.46) | 0.188 | 2.8 (3.12) | 3.4 (3.33) | 0.635 |
| Office visits after discharge | 5 (83.3) | 110 (80.9) | 0.881 | 8 (80.0) | 107 (81.1) | 0.934 |
| SBP, mmHg | 165.2 (13.32) | 157.8 (27.46) | 0.513 | 164.9 (19.02) | 157.6 (27.52) | 0.409 |
| DBP, mmHg | 84.3 (14.58) | 85.6 (18.62) | 0.872 | 89.5 (23.34) | 85.2 (18.08) | 0.482 |
| HbA1c, % | 7.0 (2.29) | 6.7 (2.07) | 0.737 | 6.5 (1.95) | 6.7 (2.08) | 0.760 |
| Total cholesterol, mg/dL | 166.2 (18.32) | 182.2 (46.92) | 0.097 | 172.0 (30.05) | 182.1 (47.07) | 0.528 |
| LDL-cholesterol, mg/dL | 93.3 (21.22) | 110.6 (36.31) | 0.251 | 93.8 (37.12) | 111.0 (35.65) | 0.166 |
| HDL-cholesterol, mg/dL | 48.33 (17.12) | 40.56 (12.18) | 0.136 | 44.6 (14.88) | 40.7 (12.30) | 0.366 |
| Triglyceride, mg/dL | 121.3 (66.72) | 157.6 (121.46) | 0.469 | 167.6 (101.59) | 155.1 (121.12) | 0.765 |
| Baseline NIHSS score, median (range) | 2.0 (0-4) | 2.0 (0-32) | 0.054 | 2.0 (0-7) | 2.0 (0-32) | 0.447 |
| mRS at discharge, median (range) | 1.0 (0-4) | 3.0 (0-5) | 0.429 | 1.0 (0-4) | 3.0 (0-5) | 0.091 |

TIA, Transient Ischemic Attack; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; LDL, Low-Density Lipoprotein; HDL, High-Density Lipoprotein; NIHSS, National Institutes Of Health Stroke Scale; mRS, modified Rankin score. Data are means (SD) or numbers (%). Significant p is marked with *.

Table 7 Key issues

| |
|---|
| The most common reason for readmission at 90 days after discharge was recurrent stroke/transient ischemic attack (TIA), followed by worsening stroke symptoms, and congestive heart failure. |
| Prior hospitalization was significantly associated with all cause readmission at 30 days. |
| Prior coronary artery disease and female gender were significantly associated with all cause readmission at 90 days. |
| Prior stroke was significantly associated with stroke/TIA readmission at 30 and 90 days after discharge, |
| Though there was no significant relationship between medication persistence and all cause readmission at 90 days, a trend toward lower medication persistence was observed in stroke/TIA readmission at 90 days |

Conflict of Interest

All authors have no conflicts of interest.

Ethical Adherence

The study protocol was approved by the Wake Forest School of Medicine Institutional Review Board.

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