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Impact of Diabetes, Hypertension and Heart Failure on Stroke Rehabilitation Care

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Abstract

Background: Stroke patients who have multiple comorbidities at inpatient rehabilitation admission might experience poorer outcomes than those without comorbidities. Some differences in outcomes between these two groups may be based on age and type of comorbidity. **Materials and Methods:** Retrospective administrative data from an inpatient stroke rehabilitation unit in a Southwestern Ontario hospital were examined to determine the independent associations between diabetes, hypertension, and heart failure in stroke patients and rehabilitation length of stay (LOS), functional gains in rehabilitation, and discharge destination. We also examined the associations between $CHADS_2$ score and rehabilitation LOS, functional gains in rehabilitation, and discharge destination. **Results:** Seven hundred and seven cases of stroke subcategorized as experiencing mild (n = 193), moderate (n = 454), and severe (n = 60) stroke were included in the study. Of these patients, 16.4% (n = 116) had type 2 diabetes, 58.7% (n = 415) had hypertension, and 5.8% (n = 41) had congestive heart failure (CHF) prior to stroke. CHF patients were significantly (p = 0.02) older, had significantly (p = 0.014) lower mean FIM gains and were discharged to residential care facilities compared to non-CHF cases. A higher $CHADS_2$ score was significantly associated with Lower FIM gains and discharge to longer term settings. **Conclusion:** Significant differences exist in the functional gains and discharge disposition of stroke patients based on age of patient, type of comorbidity in stroke, and $CHADS_2$ score.

Keywords

Stroke, Comorbidities, Inpatient Rehabilitation, Functional Outcomes, $CHADS_2$ Score

1. Introduction

The presence of certain comorbidities (e.g., diabetes, hypertension, and heart

failure) prior to stroke may increase the risk of stroke and limit patients' participation and improvement in rehabilitation [1] [2] [3] [4]. When stroke patients have multiple comorbidities, they are at increased risk for developing medical complications [5], having limitations in functional improvement, longer length of stay (LOS) in rehabilitation [6] [7], and increased mortality [8] [9] [10]. Several factors may explain how comorbidities in stroke patients lead to poorer functional outcomes during rehabilitation. Medical complications (e.g., urinary tract infection, pneumonia, renal failure, and symptomatic coronary artery disease) in stroke patients who have comorbidities often need more treatment time in acute care, thus prolonging the length of stay in acute care [11] [12]. Stroke patients with three medical tubes (*i.e.*, indwelling catheter, enteral feeding tube, and tracheostomy) have been found to stay 28 days longer in acute care and 20 days longer in rehabilitation compared to those without the medical tubes [11]. Medical complications in stroke have also been associated with increased stroke severity, delays in transfer to rehabilitation, and a likelihood of transfer back to acute care [13].

Stroke patients with comorbidities reportedly have difficulties performing daily living activities, recover more slowly, and experience further deterioration over time [14]. The presence of cardiac comorbidities (e.g., arterial hypertension, coronary artery disease, congestive heart failure, atrial fibrillation, and myocardial infarction) in stroke has been associated with an increased dependency on daily living activities and frequent institutionalization [15] [16]. Uncontrolled hypertension is known to cause delays in physiotherapy, and physiotherapy is contraindicated for patients with blood pressures higher than 200/100 mmHg [17] [18]. Predicting functional outcomes of stroke patients who have multiple comorbidities and evaluating the potential effects of specific comorbidities on rehabilitation outcomes may enable clinicians to adjust the rehabilitation plan for stroke patients to improve functional outcomes following rehabilitation.

In this study we focused on the potential impact of diabetes, hypertension, and heart failure on inpatient stroke rehabilitation outcomes. We chose these comorbidities because a recent Canadian survey (n = 2067) showed an increase in prevalence of stroke among Canadians with pre-existing diabetes, hypertension, or heart failure, relative to patients without these comorbidities [19]. The highest prevalence was noted among patients with pre-existing heart failure [19]. We examined the independent associations between type 2 diabetes, hypertension, or congestive heart failure in stroke patients and the patients' functional outcomes (LOS, functional gains, and discharge destination) as many patients with these comorbidities often require rehabilitation to promote their physical, functional, and cognitive recovery [7] [20].

Further, we examined whether having a $CHADS_2$ score was related to LOS, FIM gain, and post discharge living setting of stroke patients undergoing inpatient rehabilitation. The acronym $CHADS_2$ refers to congestive heart failure, hypertension, age ≥ 75 years, diabetes mellitus, and history of stroke or TIA. We hypothesized that: 1) diabetes, hypertension, and heart failure in stroke will be

independently associated with longer LOS, lower FIM gains, and higher discharge rates to longer term settings, and 2) increased $CHADS_2$ score will be associated with lower FIM gain, longer LOS, and discharge to longer term settings.

2. Materials and Methods

2.1. Research Design

We conducted a retrospective cohort study using health administrative data on patients who were discharged from an inpatient stroke rehabilitation unit in a post-acute hospital setting in Southwestern Ontario. Specifically, patient-level data on sociodemographic, clinical, and outcome characteristics were extracted from the National Rehabilitation Reporting System (NRS) for individuals admitted and discharged from inpatient rehabilitation between April 1, 2014, and March 31, 2018 with diagnosis of stroke (Rehabilitation Client Groups (RCG): 1160, 1150, 1140, 1130, 1120, 1110 and 1100). The study was approved by the University of Windsor Research Ethics Board (REB# 21-102).

2.2. Study Sample and Setting

Included in the study were adult stroke patients with a clinical diagnosis of ischemic or hemorrhagic stroke. These were patients with documented type of comorbidity and LOS in inpatient rehabilitation. We used the G*Power software to estimate a sample size with ample statistical power to detect a statistically significant difference if one exists [21]. Based on power analysis, a minimum sample size of 144 (alpha = 0.05, power = 0.80, and effect size = 0.5) was determined to be sufficient to detect a difference in mean between two independent groups, using t-test. However, we obtained a much larger sample from the hospital. We excluded a total of 58 cases from the cohort (707 cases remaining) due to missing data (n = 41); non-specific pre-admission and post-discharge living situation (n = 16) or a pre-admission or post-discharge living situation documented as boarding house (n = 1). Boarding house was considered a temporal living setting that could change, and consequently hinder the follow-up of post discharge patients.

2.3. Data Collection and Instruments

Functional outcomes were assessed using the Functional Independence Measure (FIM) instrument, administered during admission and at discharge from a rehabilitation program. Physiotherapy staff completed the FIM within the first 72 hours following stroke rehabilitation admission. FIM scores were used to classify stroke severity. Mild stroke patients were those with a FIM score > 80, moderate stroke with a FIM score of 40 - 80, and severe stroke with a FIM score of <40 [22] [23]. When used by well trained and tested professionals, the FIM instrument has been proven to be valid, reliable, feasible for use, responsive to change, and meaningful in clinical settings [24]. FIM change was calculated by subtracting patient's admission total FIM scores from discharge total FIM scores, and FIM effi-

ciency was calculated by dividing the mean FIM change by the mean LOS in rehabilitation [25] [26]. The FIM instrument also captures other information including age, sex, marital status, pre-existing comorbidities, pre-admission living setting (acute care, residential care, home with no health services, assisted living, and home with paid health services), LOS (in days) in the rehabilitation units, and post-discharge living setting (acute care, residential care, home with no health services, assisted living, and home with paid health services) [25] [26].

We calculated a $CHADS_2$ index to identify whether the $CHADS_2$ score is useful in predicting functional outcomes following inpatient rehabilitation. The $CHADS_2$ score is computed by assigning 2 points for a history of stroke or TIA and one point each for any of the above-mentioned risk factors. The total score is calculated by adding the scores for all the risk factors. The sum of the item scores indicates the risk of stroke, and higher total scores represent greater risk of stroke. Using the $CHADS_2$ index, we independently identified the risk of stroke (based on the number of comorbidities, type of additional comorbidity, and total $CHADS_2$ score) in patients with multiple comorbidities [27] [28].

2.4. Data Analysis

A descriptive summary of the data was created using percentages and frequencies for discrete variables and means (standard deviation) and medians (IQR) for continuous quantitative variables. Differences in FIM change and rehabilitation LOS between stroke patients with and without diabetes; stroke patients with and without hypertension; and stroke patients with and without congestive heart failure were examined using independent samples t-test. Relationships between discharge destination and the presence or absence of type 2 diabetes; discharge destination and the presence or absence of hypertension; and discharge destination and the presence or absence of congestive heart failure in patients with stroke were examined using Chi-square tests. Spearman's rho was used to determine the correlation coefficients for the relationships between continuous and categorical variables. A 2-way between groups ANOVA was computed to examine the main effect for the independent variable on the dependent variable and the interaction effect of the independent variables on the dependent variable.

3. Results

A total of 707 patients (314 females and 393 males) who participated in an inpatient rehabilitation program for stroke between April 1, 2014 and March 31, 2018 were included in the study. The rehabilitation unit was a post-acute centre located in Southwestern Ontario. Patients were adults with a clinical diagnosis of hemorrhagic or ischemic stroke, classified as having mild, moderate, or severe stroke based on the patient's individual FIM scores during admission to inpatient rehabilitation (see **Table 1**). For all stroke patients in inpatient rehabilitation, the mean LOS was 34.96 days (27 Mdn; 28.68 SD), and the mean FIM change was 24.24 (24 Mdn; 14.15 SD). We examined the association between the

Table 1. Demographic Characteristics of Participants by stroke severity.

Characteristic	Total	Mild stroke	Moderate stroke	Severe stroke
Age at inpatient rehabilitation (years)				
Mean (SD)	70.86 (14.08)	68.23 (13.63)	72.32 (14.06)	68.25 (14.27)
Median (IQR)	72 (62 - 82)	70 (60 - 78)	74 (65 - 83)	70 (58 - 81)
Sex, %				
Male	55.6	66.3	52.2	46.7
Female	44.4	33.7	47.8	53.3
Etiology of stroke, %				
Ischemic stroke	81.3	82.9	80.8	80
Hemorrhagic stroke	18.7	17.1	19.2	20
Type 2 Diabetes, %				
Type 2 Diabetes	16.4	15.5	16.7	16.7
No Type 2 Diabetes	83.6	84.5	83.3	83.3
Hypertension, %				
Hypertension	58.7	57.0	61.2	45
No Hypertension	41.3	43.0	38.8	55
Congestive heart failure, %				
Congestive heart failure	5.8	1.6	7.3	8.3
No Congestive heart failure	94.2	98.4	92.7	91.7

presence or absence of individual comorbidity prior to stroke and age of the patient at inpatient rehabilitation admission (see **Figures 1-3**). Of the 707 patients, 16.4% (n = 116) had type 2 diabetes, 58.7% (n = 415) had hypertension, and 5.8% (n = 41) had congestive heart failure. Some patients had multiple comorbidities in addition to stroke, and others did not have any of the comorbidities. The mean age was 71 years (11.5 SD) for stroke patients with type 2 diabetes (71 years M; 14.5 SD non-type 2 diabetes), 72.6 years (12.3 SD) for stroke patients with hypertension (68.5 years M; 16 SD no-hypertension), and 75.8 years (9.9 SD) for stroke patients with congestive heart failure (70.5 years M; 14.3 SD no congestive heart failure), with overall mean age of 70.9 years (14.1 SD) at rehabilitation admission for the presence or absence of both type 2 diabetes, hypertension, and congestive heart failure in stroke.

To uncover any age differences between stroke patients with/without diabetes, hypertension, and congestive heart failure at admission to rehabilitation, we conducted an independent-samples t-test. Patient's age differed significantly between stroke patients with and without hypertension ($t(705) = -3.86$, $p = 1.2 \times 10^{-4}$, two-tailed), and stroke patients with and without congestive heart failure ($t(705) = -2.33$, $p = 0.02$, two-tailed). The mean difference (mean difference = −4.11, 95% CI: −6.20 to −2.02) for stroke patients with and without hypertension (Cohen's d = −0.30) and differences in mean (mean difference = −5.25, 95% CI: −9.67 to −0.82) for stroke patients with and without congestive heart failure (Co-

hen's d = −0.37) were both medium [28]. This result suggests that at the onset of rehabilitation care for stroke, there was a slight difference in age of patients with and without hypertension and patients with and without congestive heart failure, with hypertensive patients being younger than congestive heart failure patients.

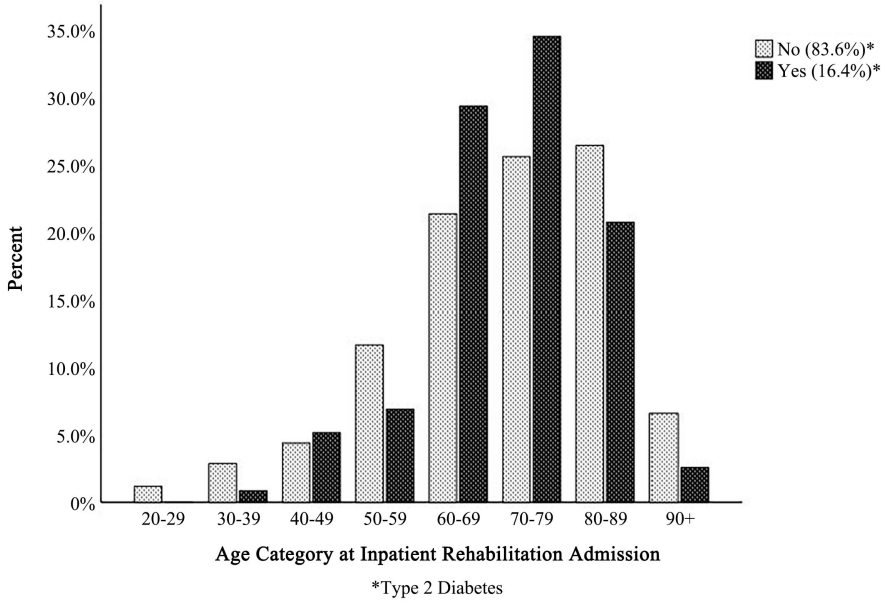

Figure 1. Bars graph of category of age at inpatient rehabilitation admission by dichotomized type 2 diabetes. The presence or absence of type 2 diabetes in patients with stroke is represented by color of the bars, and percentages of cases for each category of age is represented by height of the bars.

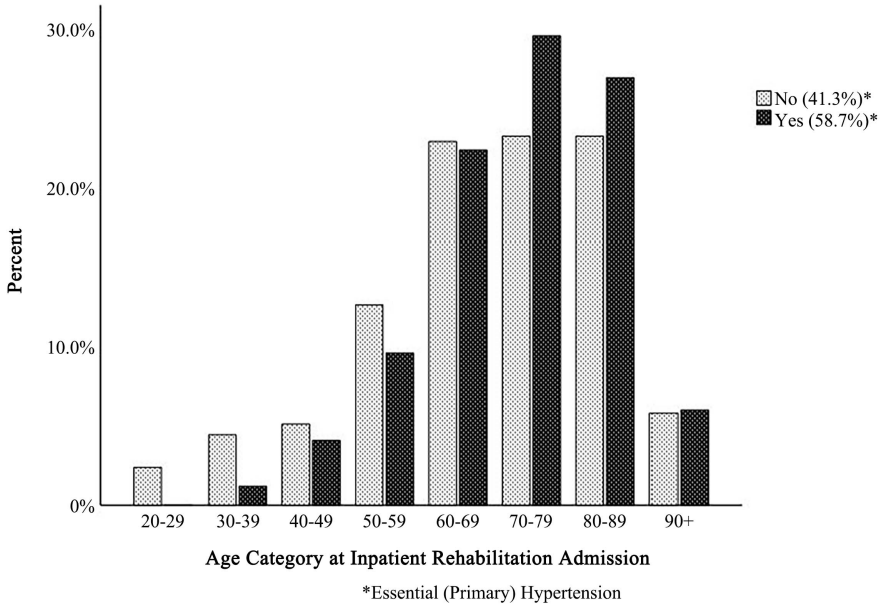

Figure 2. Bars graph of category of age at inpatient rehabilitation admission by dichotomized hypertension. The presence or absence of hypertension in patients with stroke is represented by color of the bars, and percentages of cases for each category of age is represented by height of the bars.

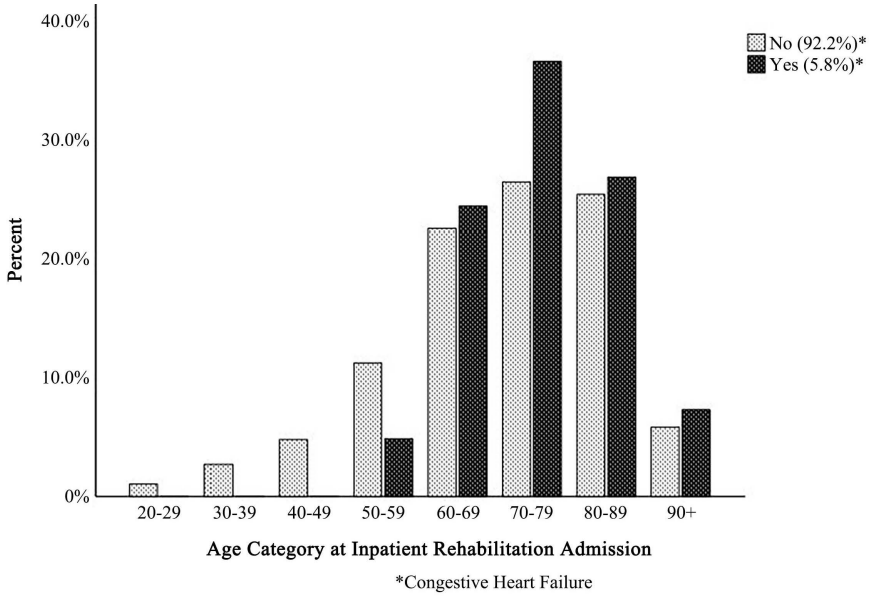

Figure 3. Bars graph of category of age at inpatient rehabilitation admission by dichotomized congestive heart failure. The presence or absence of congestive heart failure in patients with stroke is represented by color of the bars, and percentages of cases for each category of age is represented by height of the bars.

The age difference between stroke patients with/without type 2 diabetes was not statistically significant $t(705) = -0.09$, $p = 0.929$, two-tailed).

3.1. Are Diabetes, Hypertension, and Heart Failure Independently Related to Stroke Severity at Inpatient Rehabilitation Admission

First, we examined the association between the presence or absence of type 2 diabetes and severity of stroke based on patient's FIM score at rehabilitation admission. For diabetic stroke patients, the mean FIM score at rehabilitation admission was 66.74 points (66.50 Mdn; 18.59 SD) and 67.68 points for non-diabetic stroke patients (69 Mdn; 19.99 SD), with a total mean FIM score of 67.52 (19.76 SD). Percentages of diabetic stroke patients and their corresponding stroke severities are displayed in Table 1. To determine whether the proportions of diabetic and non-diabetic stroke patients were significantly different, a Chi-square test for independence was conducted. The associations between type 2 diabetes and severity of stroke were not statistically significant χ^2 (2, n = 707) = 0.14, p = 0.93, Cramer's v = 0.01.

Next, we examined the relationship between the presence or absence of hypertension and stroke severity based on patient's FIM score at rehabilitation admission. At rehabilitation admission, hypertensive stroke patients had a mean FIM score 67.24 points (69 Mdn; 18.92 SD) and non-hypertensive stroke patients had a mean FIM score of 67.93 points (68.50 Mdn; 20.91 SD), with a total mean FIM score of 67.52 (19.76 SD). Percentages of hypertensive stroke patients and their corresponding stroke severities are displayed in Table 1. We also conducted a Chi-square test for independence to examine the proportions of hyper-

tensive and non-hypertensive stroke patients for differences. Results showed that the associations between hypertension and severity of stroke were not statistically significant χ^2 (2, n = 707) = 6.08, p = 0.05, Cramer's v = 0.09.

Further, we examined the relationship between the presence or absence of congestive heart failure and severity of stroke based on patient's FIM score at rehabilitation admission. At rehabilitation admission, congestive heart failure stroke patients had a mean FIM score of 60.41 points (61 Mdn; 16.84 SD) and non-congestive heart failure patients had a mean FIM score of 67.96 points (69 Mdn; 19.84 SD), with a total mean FIM score of 67.52 (19.76 SD). Percentages of congestive heart failure stroke patients with their stroke severities are displayed in Table 1. The proportions of congestive heart failure and non-congestive heart failure stroke patients were examined for differences using a Chi-square test for independence. Congestive heart failure and severity of stroke demonstrated a statistically significant association χ^2 (2, n = 707) = 8.87, p = 0.01, Cramer's v = 0.01, but the effect size was small.

3.2. Is Diabetes in Stroke Associated with Functional Gains during Inpatient Rehabilitation?

The relationship between the presence or absence of type 2 diabetes in stroke and patient's FIM change during inpatient rehabilitation were examined. For diabetic stroke patients, the mean FIM change was 26.05 points (26 Mdn; 16.27 SD) and 23.85 points for non-diabetic stroke patients (24 Mdn; 13.69 SD), with a total mean FIM change of 24.95 (14.98 SD). Differences in mean FIM change between diabetic and non-diabetic stroke patients were determined using independent samples t-test. FIM change did not differ significantly between type 2 diabetes and no type 2 diabetes (t(705) = −1.532, p = 0.126, two-tailed). The mean difference between the two groups (mean difference = −2.20, 95% CI: −5.02 - −0.62) was very small (Cohen's d = −0.16).

3.3. Is Diabetes Associated with Length of Stay in Rehabilitation?

Potential associations between diabetes in stroke and inpatient rehabilitation LOS were examined. Diabetic stroke patients had a mean LOS of 31.15 (23 Mdn; 28.36 SD) and 35.71 (28 Mdn; 28.71 SD) for non-diabetic stroke patients, with a total mean LOS of 33.43 (26 Mdn; 28.54 SD). We used independent samples t-test to determine the differences in rehabilitation LOS between diabetic and non-diabetic patients. Mean LOS in rehabilitation did not differ significantly for diabetes (M = 31.15, 28.36 SD) and no diabetes (M = 35.71, 28.71 SD); t(705) = 1.581, p = 0.12, two-tailed). The mean difference between the two groups (mean difference = 4.56, 95% CI: −1.15 to −10.28) was very small (Cohen's d = −0.12). When we used spearman's rho to determine whether the presence or absence of type 2 diabetes was related to inpatient rehabilitation LOS, we observed a weak negative correlation between type 2 diabetes and LOS (spearman's rho = −0.092, p = 0.014), suggesting that the absence of type 2 diabetes is associated with longer inpatient rehabilitation LOS.

3.4. Is Diabetes in Stroke Associated with Patient's Discharge Destination?

To establish whether the presence or absence of type 2 diabetes in stroke patients influenced their discharge disposition, the association between type 2 diabetes and patient's post hospital living setting was examined. As shown on **Figure 4**, 79.3% of diabetic stroke (64% non-diabetic stroke) patients went home with paid health services following discharge from rehabilitation unit. Regarding other dispositions, 7.6% of non-type 2 diabetes stroke patients (4.3% type 2 diabetes) went home with no health services, 10.2% (4.3% type 2 diabetes) went to assisted living facilities, and 16.6% (8.6% type 2 diabetes) went to residential care facilities. As demonstrated by the Chi-square test for independence, type 2 diabetes is significantly associated with living setting post discharge from inpatient rehabilitation, χ^2 (4, n = 707) = 14.07, p = 0.007, Cramer's v = 0.14, but the effect size was small. The finding suggests that stroke patient who have type 2 diabetes have a tendency of being discharged to home with homecare and those who do not have type 2 diabetes have a tendency of being discharged to other settings and without home care

3.5. Is There an Association between Hypertension in Stroke and Functional Gains during Inpatient Rehabilitation?

Potential relationship between the presence or absence of hypertension in stroke and FIM change during inpatient rehabilitation were examined. For hypertensive stroke patients, the mean FIM change was 24.21 points (24 Mdn; 14.24 SD), and for non-hypertensive patients, the mean FIM change was 24.21 points (24 Mdn; 14.05 SD), with a total mean FIM change of 24.21 (14.15 SD). Differences in FIM change between hypertensive and non-hypertensive patients were determine using independent samples t-test. FIM change did not differ significantly between hypertension in stroke and no hypertension in stroke (t(705) = −0.002, p = 0.998, two-tailed). The mean difference (mean difference = −0.002, 95% CI: −2.126 - −2.122) between hypertension in stroke and no hypertension in stroke was very small (Cohen's d = −0.00015).

3.6. Is Hypertension Associated with Length of Stay in Rehabilitation?

The associations between hypertension in stroke and inpatient rehabilitation LOS were examined. Hypertensive stroke patients had a mean LOS of 35.27 (28 Mdn; 28.87 SD) and 34.52 (27 Mdn; 28.46 SD) for non-hypertensive patients, with a total LOS of 34.90 (28 Mdn; 28.67 SD). The mean rehabilitation LOS did not differ significantly for patients with hypertension (M = 35.27, 28.87 SD) and those with no hypertension in stroke (M = 34.52, 28.46 SD); t(705) = −0.339, p = 0.735, two-tailed). The mean difference (mean difference = −0.743, 95% CI: −5.05 - 3.56) between hypertension in stroke and no hypertension in stroke was very small (Cohen's d = −0.026).

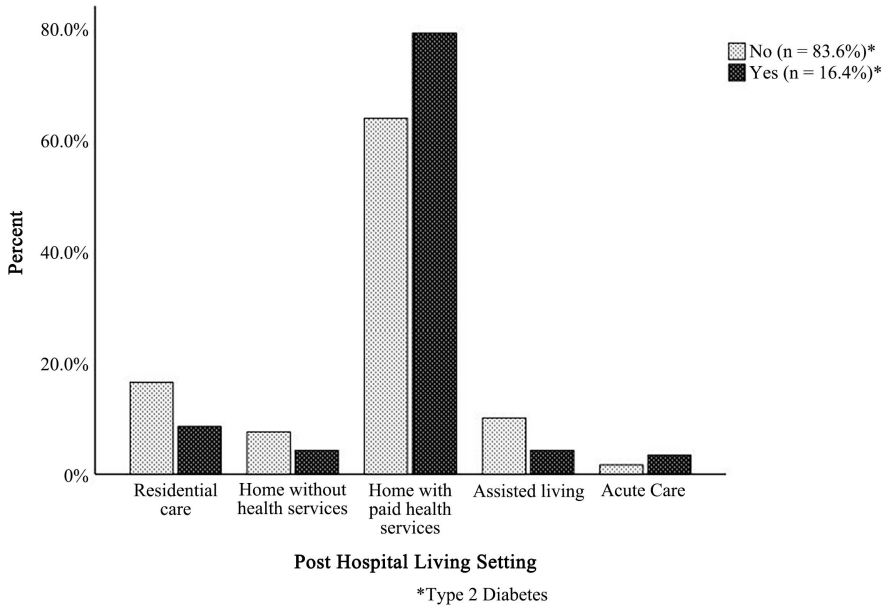

Figure 4. Bars graph of living setting post discharge from inpatient rehabilitation by dichotomized type 2 diabetes. The presence or absence of type 2 diabetes in patients with stroke is represented by color of the bars, and percentages of cases with a likelihood of being discharged to the corresponding living setting is represented by height of the bars.

3.7. Is Hypertension in Stroke Related to Discharge Destination?

To establish whether the presence or absence of hypertension in stroke patients influenced their discharge disposition, the relationship between hypertension and living setting post discharge from inpatient rehabilitation was examined. Following discharge from the rehabilitation unit, 66.7% of hypertensive stroke patients (66.1% non-hypertensive stroke) went home with paid health services, while 16.4% (13.7% non-hypertensive) were discharged to residential care. With regards to other dispositions, 8.6% of non-hypertensive stroke patients (6.0% hypertensive) were discharged home with no home care, and 9.6% (8.9% hypertensive) went to assisted living facilities. As revealed by the Chi-square test for independence, hypertension was not significantly associated with living setting post discharge from inpatient rehabilitation, χ^2 (4, n = 707) = 2.48, p = 0.648, Cramer's v = 0.06, and the effect size was small.

3.8. Is Congestive Heart Failure in Stroke Associated with Functional Gains during Inpatient Rehabilitation?

Potential relationship between the presence or absence of congestive heart failure in stroke and FIM change during inpatient rehabilitation were examined (see Figure 5). For congestive heart failure stroke patients, the mean FIM change was 18.95 points (16 Mdn; 12.90 SD) and 24.51 points for non-congestive heart failure stroke patients (25 Mdn; 14.17 SD), with a total mean FIM change of 21.75 (13.54 SD). Differences in mean FIM change between congestive heart failure and non-congestive heart failure stroke patients were determined using independent samples t-test. Mean FIM change between congestive heart failure and

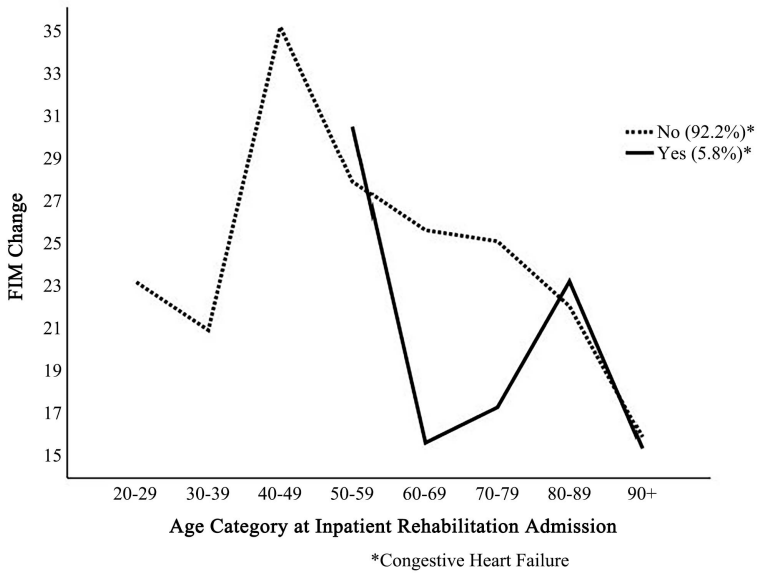

Figure 5. Lines graph of category of age at inpatient rehabilitation admission by FIM change and dichotomized congestive heart failure. The presence or absence of congestive heart failure in patients with stroke is represented by color of the bars, and functional gains for each category of age is represented by height of the lines.

no congestive heart failure differed significantly (t(705) = 2.462, p = 0.014, two-tailed), suggesting that stroke patients with comorbid congestive heart failure achieve lower functional gains during inpatient rehabilitation. The mean difference (mean difference = 5.59, 95% CI: 1.13 - 10.04) between congestive heart failure in stroke and no congestive heart failure in stroke was small to medium (Cohen's d = 0.40).

3.9. Is Congestive Heart Failure Associated with Length of Stay in Rehabilitation?

Potential associations between congestive heart failure in stroke and inpatient rehabilitation LOS were examined. Congestive heart failure stroke patients had a mean LOS of 38.20 (29 Mdn; 27.58 SD) and 34.76 (27 Mdn; 28.76 SD) for non-congestive heart failure stroke patients, with a total LOS of 36.48 (28 Mdn; 28.17 SD). The mean rehabilitation LOS did not differ significantly for patients with congestive heart failure (M = 38.20, 27.58 SD) and no congestive heart failure (M = 34.76, 28.76 SD); t(705) = −0.744, p = 0.457, two-tailed). The mean difference (mean difference = −3.43, 95% CI: −12.50 to 5.63) between congestive heart failure in stroke and no congestive heart failure in stroke was very small (Cohen's d = −0.12).

3.10. Is Congestive Heart Failure in Stroke Related to Discharge Destination?

To ascertain whether the presence or absence of congestive heart failure in stroke patients influenced their discharge disposition, the association between congestive heart failure and living setting post discharge from inpatient rehabil-

itation was examined as shown on Figure 6. Following discharge from the rehabilitation unit, 67.3% of non-congestive heart failure stroke patients (53.7% congestive heart failure in stroke patients) went home with home care, while 9.5% (4.9% congestive heart failure) were discharged to assisted living. With regards to other discharge dispositions, 7.3% of congestive heart failure stroke patients (7.1% no congestive heart failure) were sent home with no home care, while 26.8 (14.6% no congestive heart failure) were discharged to residential care, 7.3% congestive heart failure stroke patients (1.7% non-congestive heart failure) were sent to acute care units. As shown by the Chi-square test for independence, congestive heart failure was significantly associated with living setting post discharge from inpatient rehabilitation, χ^2 (4, n = 707) = 12.03, p = 0.017, Cramer's v = 0.13, but the effect size was small. This finding suggests that congestive heart failure stroke patients have tendency of being discharged to home with home care, residential care, or readmitted to acute care following inpatient rehabilitation.

3.11. Is Stroke Severity Related to Length of Stay and $CHADS_2$ Score during Inpatient Rehabilitation

Although the impact of severity on outcomes was not the focus of this study, we chose to determine whether LOS in rehabilitation differed across stroke severities. Using a two-way between groups ANOVA, we found no main effect for $CHADS_2$ score (F (4, 706) = 1.90, p = 0.11). Stroke severity and $CHADS_2$ score

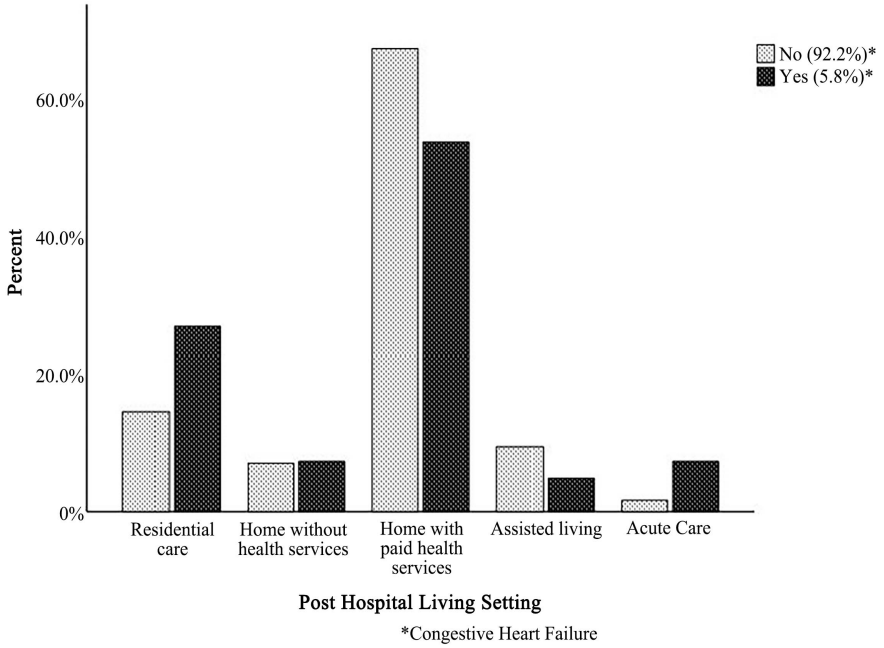

Figure 6. Bars graph of living setting post discharge from inpatient rehabilitation by dichotomized congestive heart failure. The presence or absence of congestive heart failure in patients with stroke is represented by color of the bars, and percentages of cases with a likelihood of being discharged to the corresponding living setting is represented by height of the bars.

showed no interaction with rehabilitation LOS (F (7, 706) = 1.25, p = 0.27). However, stroke severity demonstrated a significant mean effect (F (2, 706) = 18.30, p = 1.8×10^{-8}), but the effect size observed was small (partial $\eta^2 = 0.05$). Post hoc comparison using the Tukey HSD test indicated that the mean LOS for mild stroke was significantly (p = 5.1×10^{-9}) different from the mean LOS for moderate and severe stroke patients. See Table 2 for LOS by stroke severities. To determine whether stroke severity is related to a patient's $CHADS_2$ score, we calculated the frequencies of $CHADS_2$ scores by stroke severity (see Table 2), then performed Chi-square test for independence to examine the proportions of $CHADS_2$ scores for differences. Findings showed that patient's $CHADS_2$ score was significantly associated with severity of stroke, χ^2 (8, n = 707) = 15.98, p = 0.04, Cramer's v = 0.11, but the effect size was medium. The result suggests that severity of stroke has an impact on the patient's $CHADS_2$ score and that moderate stroke patients have a larger proportion of $CHADS_2$ scores of one or greater compared to mild and severe stroke patients.

Table 2. Demographic and clinical characteristics of subjects by type of comorbidity.

Characteristic	Total	Type 2 Diabetes	No Type 2 Diabetes	Hypertension	No Hypertension	Congestive Heart Failure	No Congestive Heart Failure
Age at inpatient rehabilitation (years)							
Mean (SD)	70.86 (14.08)	70.97 (11.53)	70.84 (14.54)	72.56 (12.34)	68.45 (15.95)	75.80 (9.87)	70.55 (14.25)
Median (IQR)	73 (62 - 82)	72 (64 - 79)	73 (62 - 82)	74 (64 - 82)	71 (60 - 81)	76 (68.5 - 83.5)	72 (62 - 82)
Sex, %							
Male	55.6	62.1	54.3	55.7	55.5	53.7	55.7
Female	44.4	37.9	45.7	44.3	44.5	46.3	44.3
Etiology of stroke, %							
Ischemic stroke	81.3	84.5	80.7	81.7	19.2	7.3	19.4
Hemorrhagic stroke	18.7	15.5	19.3	18.3	80.8	92.7	80.6
Days between ready for admission and admission date							
Mean (SD)	2.28 (4.24)	1.85 (5.54)	2.37 (3.93)	2.59 (4.61)	1.85 (3.61)	3.24 (8.10)	2.23 (3.88)
Median (IQR)	0.00 (0.00 - 3)	0.00 (0.00 - 1)	0.00 (0.00 - 3)	0.00 (0.00 - 4)	0.00 (0.00 - 2)	0.00 (0.00 - 3)	0.00 (0.00 - 3)
Total Admission FIM							
Mean (SD)	67.52 (19.76)	66.74 (18.59)	66.68 (19.99)	67.24 (18.92)	67.93 (20.91)	60.41 (16.86)	67.96 (19.85)
Median (IQR)	69 (54 - 82)	66.50 (55 - 81)	69 (54 - 82)	69 (54 - 82)	68.50 (54 - 82)	61 (50.50 - 74)	69 (54 - 82)

Continued

Total Discharge FIM							
Mean (SD)	91.74 (22.64)	92.79 (20.89)	91.53 (22.97)	91.45 (22.11)	92.14 (23.39)	79.37 (21.43)	92.50 (22.50)
Median (IQR)	96 (77 - 110)	98.00 (78.5 - 108)	96 (77 - 111)	96 (77 - 109)	97 (77 - 112)	83 (67 - 95.5)	98 (77 - 111)
Length of Stay in rehabilitation (days)							
Mean (SD)	35.0 (28.68)	31.15 (28.36)	35.71 (28.71)	35.27 (28.87)	34.52 (28.46)	38.2 (27.58)	34.76 (28.76)
Median (IQR)	27 (17 - 44)	22.5 (15 - 40)	28 (18 - 45)	28 (18 - 44)	26.5 (16 - 44.75)	29 (21.50 - 48)	27 (17 - 44)
Functional (FIM) Change							
Mean (Median; SD)	24.21 (14.15)	26.05 (16.27)	23.85 (13.68)	24.21 (14.24)	24.21 (14.05)	18.95 (12.90)	24.54 (14.17)
Median (IQR)	24 (15 - 33)	26 (14 - 37)	24 (15 - 33)	24 (15 - 33)	24 (15 - 33)	16 (10 - 28.5)	25 (15 - 33)
$CHADS_2$ Score %							
0	20.9	0.0	25.0	0.0	50.7	0.0	22.2
1	39.2	19.8	43.0	37.1	42.1	7.3	41.1
2	33.1	51.7	29.4	51.3	7.2	36.6	32.9
3	6.1	24.1	2.5	10.4	0.0	43.9	3.8
4	0.7	4.3	0.0	1.2	0.0	12.2	0.0
Pre-hospital living setting							
Home without Health Services	81.3	86.2	80.4	78.6	85.3	68.3	82.1
Home with health services	13.3	11.2	13.7	16.9	8.2	24.4	12.6
Assisted Living	4.8	2.6	5.2	4.3	5.5	7.3	4.7
Residential Care	0.6	0.0	0.7	0.2	1.0	0.0	0.6
Post-hospital living Setting							
Home without Health Services	7.1	4.3	7.6	6.0	8.6	7.3	7.1
Home with health services	66.5	79.3	64.0	66.7	66.1	53.7	67.3
Assisted Living	9.2	4.3	10.2	8.9	9.6	4.9	9.5
Residential Care	15.3	8.6	16.6	16.4	13.7	26.8	14.6
Acute care.	2.0	3.4	1.7	1.9	2.1	7.3	1.7

3.12. Is the $CHADS_2$ Score Associated with Functional Gains during Rehabilitation?

Potential relationship between stroke patient's $CHADS_2$ score at admission to inpatient rehabilitation and FIM change during the rehabilitation process were examined. To determine the correlation coefficients for the relationships between the stroke patient's $CHADS_2$ score and FIM change, we performed a spearman's correlation between each category of $CHADS_2$ score and FIM change during rehabilitation. We observed a small significantly negative correlation between a $CHADS_2$ score of 2 and FIM change (spearman's rho = −0.09, p = 0.016). There was no significant correlation between $CHADS_2$ score of 1 and FIM change (spearman's rho = 0.07, p = 0.05), $CHADS_2$ score of 3 and FIM change (spearman's rho = −0.01, p = 0.75), and $CHADS_2$ score of 4 and FIM change (spearman's rho = −0.07, p = 0.08). These findings suggest that having a $CHADS_2$ score of 2 at rehabilitation admission is associated with lower FIM gains during inpatient rehabilitation.

3.13. Does Stroke Patient's $CHADS_2$ Score Influence Length of Stay Rehabilitation?

The associations between $CHADS_2$ score and inpatient rehabilitation LOS were examined as shown on Figure 7. Stroke patients with no $CHADS_2$ score had a mean LOS of 35.6 (28 Mdn; 30.6 SD), 34.1 (28 Mdn; 24.6 SD) for $CHADS_2$ score = 1, 36.7 (27 Mdn; 32.4 SD) for $CHADS_2$ score = 2, 29.0 (25 Mdn; 22.3 SD) for $CHADS_2$ score = 3, and 37.0 (18 Mdn; 43.6 SD) for $CHADS_2$ score = 4, with a total LOS of 35.0 (27 Mdn; 28.7 SD). The mean rehabilitation LOS for patients with no $CHADS_2$ score (M = 35.6, 30.6 SD) and patients with a $CHADS_2$ score of 1+ (M = 34.8, 28.2 SD); did not differ significantly t (705) = 0.30, p = 0.76, two-tailed). The difference in means (mean difference = 0.80, 95% CI: −4.41 to 6.01) was very small (Cohen's d = 0.03).

3.14. Is $CHADS_2$ Score Related to Discharge Destination?

To ascertain the relationship that exist between a patient's $CHADS_2$ score and living setting post discharge from inpatient rehabilitation, the associations between $CHADS_2$ scores and living setting post discharge from rehabilitation were examined as shown on Table 3 and Figure 8. At discharge from rehabilitation units, 12.2% of stroke patients with a $CHADS_2$ score of zero were discharged home without homecare compared to 5.8% of patients with a $CHADS_2$ score of 1 (6.4% $CHADS_2$ score of 2, 2.3% $CHADS_2$ score of 3, and 0.0% $CHADS_2$ score of 4). With regards to other dispositions, 80.0% of stroke patients with a $CHADS_2$ score of 4 (72.1% $CHADS_2$ score of 3, 58.1% $CHADS_2$ score of 2, 71.1% $CHADS_2$ score of 1, 68.9% $CHADS_2$ score of 0) were discharged home with home care, 0.0% of patients with $CHADS_2$ score of 4 (7.0% $CHADS_2$ score of 3, 13.7% $CHADS_2$ score of 2, 8.3% $CHADS_2$ score of 1, 4.7% $CHADS_2$ score of 0) were discharged to assisted living facilities, and 20% of stroke patients (14.0% $CHADS_2$

score of 3, 19.7% $CHADS_2$ score of 2, 14.1% $CHADS_2$ score of 1, 10.8% $CHADS_2$ score of 0) went to residential care facilities. When we computed Chi-square test for independence, patient's $CHADS_2$ score was significantly associated with their post discharge living setting, χ^2 (16, n = 707) = 31.64, p = 0.01, Cramer's v = 0.11, but the effect size was small. The results imply that $CHADS_2$ score slightly

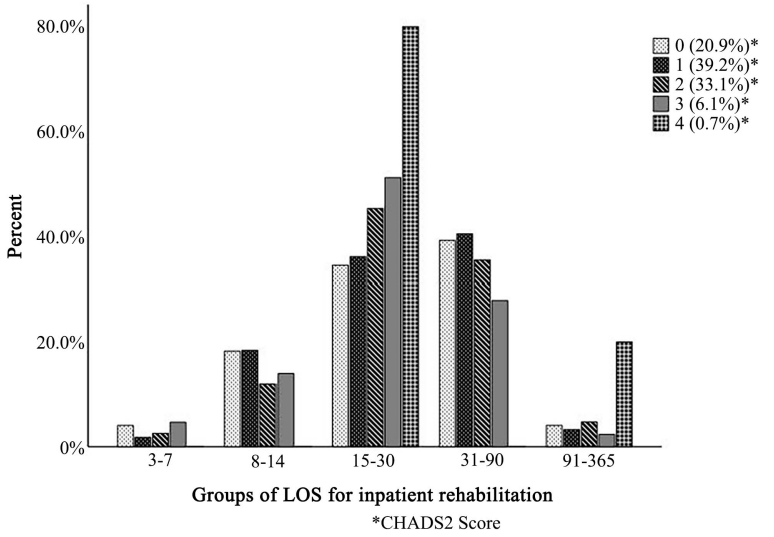

Figure 7. Bars graph of groups of rehabilitation LOS by $CHADS_2$ score. The presence or absence of $CHADS_2$ score in patients with stroke is represented by color of the bars, and percentages of cases with a likelihood of being discharged to the corresponding living setting is represented by height of the bars.

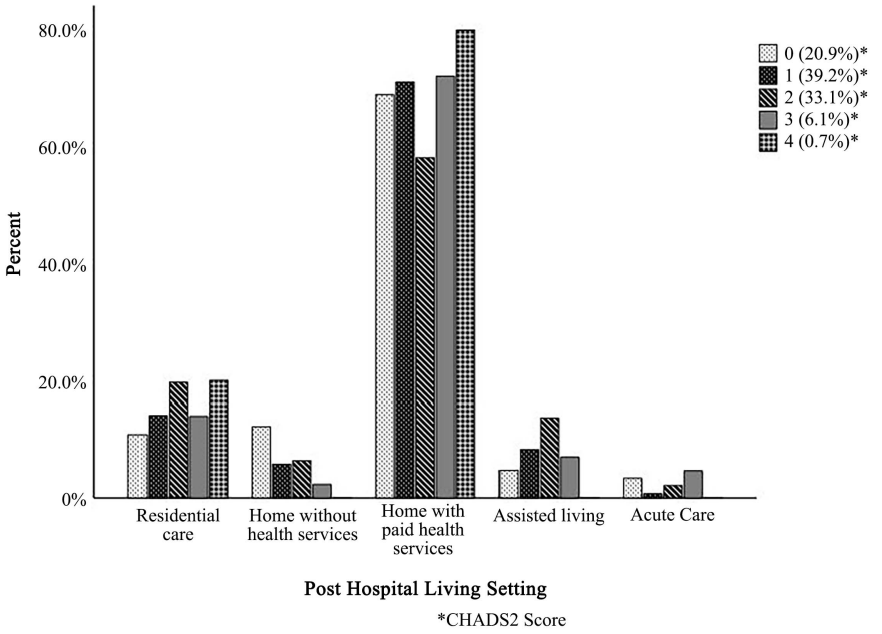

Figure 8. Bars graph of living setting post discharge from inpatient rehabilitation by $CHADS_2$ score. The presence or absence of $CHADS_2$ score in patients with stroke is represented by color of the bars, and percentages of cases with a likelihood of being discharged to the corresponding living setting is represented by height of the bars.

Table 3. Frequencies of $CHADS_2$ scores by pre and post-hospital living setting.

Pre-hospital living Setting	$CHADS_2$ Score %				
	0	1	2	3	4
Home with paid health services	7.4	9.7	20.1	16.3	40
Home with no paid health services	91.2	84.1	72.6	79.1	60
Assisted Living	0.7	5.1	7.3	4.7	0
Residential care	0.7	1	0	0	0
Post-hospital living setting					
Home with paid health services	68.9	71.1	58.1	72.1	80.0
Home with no paid health services	12.2	5.8	6.4	2.3	0.0
Assisted living	4.7	8.3	13.7	7.0	0.0
Residential care	10.8	14.1	19.7	14.0	20.0
Acute care	3.4	0.7	2.1	4.7	0.0

influenced discharge destination of patients with stroke. The findings suggest that majority of patients are discharged home with homecare and that patients with a higher $CHADS_2$ score are discharged to longer term care settings including assisted living and residential care.

When the associations between $CHADS_2$ scores and pre-admission living settings were examined using chi-square test for independence, patient's $CHADS_2$ score and pre-admission living setting were significantly associated, χ^2 (12, n = 707) = 33.46, p = 8.2×10^{-4}, Cramer's v = 0.13, but the effect size was medium. During inpatient rehabilitation admission, 91.2% of stroke patients with a $CHADS_2$ score of zero were living at home with no home care compared to 84.1% of patients with a $CHADS_2$ score of 1 (72.6% $CHADS_2$ score of 2, 79.1% $CHADS_2$ score of 3, and 60.0% $CHADS_2$ score of 4). Percentages of cases for other preadmission living settings are displayed on Table 3. From these findings, stroke patients with no $CHADS_2$ score at rehabilitation admission were likely living at home with no home care compared to those with a $CHADS_2$ score of one or more points. On the contrary, stroke patients with a $CHADS_2$ score of 4 were likely living at home with home care.

4. Discussion

4.1. Important Highlights

This study was a retrospective analysis of health administrative data from a cohort of stroke patients who participated in an inpatient rehabilitation program in a post-acute Southwestern Ontario hospital between April 1, 2014, and March 31, 2018. Stroke patients with congestive heart failure tended to be older and have lower functional gains in rehabilitation than non-congestive heart failure stroke patients. Stroke patients with a $CHADS_2$ score of 4 tended to have lower functional gains and a likelihood of being discharged to longer term settings

compared to those with a lower $CHADS_2$ score. No significant differences in FIM change were found between patients with/without type 2 diabetes in stroke, and patients with and without hypertension in stroke. Similarly, LOS in rehabilitation did not differ between stroke patients with and without type 2 diabetes, stroke patients with and without hypertension, stroke patients with and without congestive heart failure, and stroke patients with and without a $CHADS_2$ score.

4.2. Impact of Comorbidities in Stroke on Functional Outcomes

Congestive heart failure stroke patients and patients with multiple comorbidities in the Southwestern Ontario Hospital were older, had lower FIM gains during rehabilitation and tended to be discharged home with homecare compared to non-congestive heart failure patients or patients with no comorbidities in addition to stroke. This finding for congestive heart failure was similar to the findings from a large United States Study [29] and may be attributed to several factors including cardiovascular deconditioning prior to stroke (or resulting from delayed initiation of therapy), limited ability to endure sustained physical activity, and alteration in hemodynamic response to exercise [30]. Factors that may reduced the patient's likelihood of being discharged to home include fluid and electrolyte imbalance, serious nutritional deficiency, and family's inability to provide additional care at home [29]. The difference between stroke patients with congestive heart failure and those with no congestive heart failure seems to suggest the need to refine programs designed to support stroke patients who have certain comorbidities. Factors that influence discharge destination of stroke patients with congestive heart failure should be examined, and strategies that enable clinicians to make more definite prediction of rehabilitation outcomes should be employed.

4.3. Influence of $CHADS_2$ Score on Stroke Rehabilitation Outcomes

During inpatient stroke rehabilitation, patients with higher $CHADS_2$ scores (multiple comorbidities) had lower FIM change and a likelihood of being discharged to longer term settings or to home with home care. This finding may be explained by the perspective that stroke patients who have multiple comorbidities have increased risk for developing medical complications [5], having limitations in functional improvement, longer length of stay in rehabilitation [6] [7], and mortality [8]. Factors (e.g., specific comorbidities) that influence discharge destination of stroke patients with $CHADS_2$ score should be identified and examined and programs that provide support to stroke patients with certain comorbidities should be explored.

4.4. Prospects for Change

This study has demonstrated that functional gains in rehabilitation are lower in older stroke patients who have congestive heart failure and in patients with a higher $CHADS_2$ score. Stroke patients with congestive heart failure and patients with a higher $CHADS_2$ are discharged to living environments (assisted living,

residential care, acute care, and home with paid health services) that provide additional levels of care for stroke patients. We hope that our study will provide a better understanding of whether patients who have a particular comorbidity in addition to stroke are more likely to experience poorer functional outcomes and to benefit less from rehabilitation than those who do not have that comorbidity. We will extend findings from previous studies [19] [31] by providing clinicians and researchers with a clear strategy for predicting functional outcomes (using the $CHADS_2$ index) after stroke. We believe that the $CHADS_2$ score does not only predicts the risk of stroke, but also predicts poorer functional outcomes after stroke (such as functional changes and discharge destination).

4.5. Study Limitations

This study had some limitations. Accuracy of data collection and data documentation could not be ascertained. A ceiling effect previously reported and involving mild stroke limited clinician's capability of accurately measuring functional improvement during inpatient rehabilitation [32]. The ability to generalize the findings to other regions is limited because data were from the southwestern region of a single province. This study is the only study that has examined the use of $CHADS_2$ scoring index to predict functional outcomes of patients who have one or more comorbidities in addition to stroke.

5. Conclusion

This study presents the independent associations of diabetes, hypertension, and heart failure to inpatient rehabilitation outcomes of stroke patients in a Southwestern Ontario hospital from 2014 to 2018. It also presents the associations between a patient's $CHADS_2$ score (based on a number of comorbidities in addition to stroke, patient's age, and history of previous stroke) and above-mentioned functional outcomes. Despite suggestions that stroke patients with congestive heart failure experience poorer functional outcomes during rehabilitation than patients with no congestive heart failure, we observed only a small to medium effect of congestive heart failure on patient's functional change, a small effect of congestive heart failure on post discharge living setting, and no effect of congestive heart failure on LOS in rehabilitation. Type 2 diabetes and hypertension in stroke were not independently associated with functional changes, LOS, and discharge destination. The presence of a $CHADS_2$ score was associated with lower functional changes and discharge to longer term care settings, but $CHADS_2$ score was not associated with LOS in rehabilitation.

Disclosures

EFT, JV, and NL do not have any conflicts of interests to disclose.

Statement of Authorship

EFT conceived and designed the study, acquired data, analyzed the data, inter-

preted the results, drafted the manuscript, revised the manuscript, and approved the manuscript for publication.

JV contributed to critical reviews for intellectual content and approved the manuscript for publication.

NL contributed to critical reviews for intellectual content and approved the manuscript for publication.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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