Potentially Preventable Hospital Readmissions After Patients' First Stroke —A National Population-Based Study In Taiwan

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Abstract

Readmission is an important indicator of the quality of care. The purpose of this study was to explore the probabilities and predictors of 30-day and 1-year potentially preventable hospital readmission (PPR) after a patient's first stroke. We used claims data from the National Health Insurance (NHI) from 2010 to 2018. Multinomial logistic regression was used to assess the predictors of 30-day and 1-year PPR. A total of 41,921 discharged stroke patients was identified. We found that hospital readmission rates were 15.48% within 30-days and 47.25% within 1-year. The PPR and non-PPR were 9.84% (4,123) and 5.65% (2,367) within 30-days, and 30.65% (12,849) and 16.60% (6,959) within 1-year, respectively. The factors of older patients, type of stroke, shorter length of stay, higher Charlson Comorbidity Index (CCI), higher stroke severity index (SSI), hospital level, hospital ownership, and urbanization level were associated significantly with the 30-day PPR. In addition, the factors of gender, hospitalization year, and monthly income were associated significantly with 1-year PPR. The results showed that better discharge planning and post-discharge follow-up programs could reduce PPR substantially. Also, implementing a post-acute care program for stroke patients has helped reduce the long-term PPR in Taiwan.

Introduction

As an important indicator of the quality of care, readmissions may occur because of events or conditions in the initial hospital stay, such as poor clinical care and poor coordination of services during hospitalization[1,2], incomplete treatment of the underlying problem, and/or the development of a complication that becomes evident only after discharge[3]. Stroke patients have a high probability of being readmitted to the hospital after discharge. In most studies, 30-days post-discharge was identified as the most common readmission period[4]. The extant literature has provided the frequency of hospital readmission, ranging from 6.5–24.3% within 30-days[4–8], and from 31–49% within 1-year[9–11].

However, studies have demonstrated that some of these readmissions are unavoidable, even with optimal care[12]. Hospital readmission has also been highlighted as a source of significant healthcare expenditure and may constitute a potential target for cost savings, which supports the logic of using all-cause readmissions as a hospital performance metric[13]. Indeed, if readmission rates are considered a key indicator of hospital quality of care, readmissions can be identified as potentially preventable and/or unpreventable based upon clinical evidence criteria.

A readmission is defined as a subsequent hospitalization in an acute care hospital that follows a prior acute care admission within a specific time interval. Based upon administrative data, the potentially preventable readmission (PPR) method is used commonly to identify hospital readmissions that may indicate problems with a prior admission, and therefore be potentially preventable[14]. PPRs are those readmissions that could be avoided potentially given better clinical management, better stabilization of patients' prior discharge, appropriate discharge planning, better outpatient treatment post-discharge, and resources at home that are sufficient to meet patients' needs[15]. Overall, PPRs are events that could have been prevented with a better quality of hospital care, community care, and/or home care.

PPRs were defined according to AHRQ Prevention Quality Indicators (PQIs). The U.S. Agency for Healthcare Research and Quality (AHRQ) has used PQIs to define PPRs[16]. These PQIs constitute a set of evidence-based measures that use hospital inpatient administrative data to identify avoidable hospitalizations[8]. They have been employed widely to assess the quality of care and common ambulatory care-sensitive conditions[15, 17–21], many of which are related to readmission risk factors after stroke[9, 15].

Patient characteristics, social circumstances, health systems, clinical care processes, and health outcomes are potential factors in readmission after a stroke[5]. Predictors may vary and reflect different underlying mechanisms of the causes of readmission. Bjerkreim et al.[11] found that the most frequent causes of readmission were infections, recurrent ischemic stroke, other cardiovascular events, and events associated with primary stroke. Patients readmitted early had a shorter length of index admission, poorer physical function, higher frequencies of an atherosclerotic etiology of index stroke, atrial fibrillation, and complications attributable to infection during index admission compared to patients readmitted late. Late readmission was correlated with older age and prior myocardial infarction. Readmissions within a short time post-discharge may indicate poor clinical care, unresolved problems at initial discharge, the quality of immediate post-hospital care, and a more chronically ill population[22].

The strategies used to prevent short-term and long-term PPR should differ. It is important for organizations to identify the managerial strategies necessary to reduce patient readmission after stroke to improve the quality of care and save costs[4, 23, 24]. Nevertheless, few studies have targeted PPR after stroke using nationally-based data and few have compared the short- (30-day) and long-term (1-year) PPR after a patient's first stroke. Thus, this study was designed to explore the preventable and non-preventable predictive factors that may influence readmission using nationwide population-based data.

Materials And Methods

Data Source

This study employed a population-based retrospective cohort study design. We used claims data derived from the National Health Insurance (NHI), Taiwan (LHID2005: Longitudinal Health Insurance Database 2005). This database consists of a national representative sample of one million individuals from the population of Taiwan overall. There were no statistically significant differences when age, gender, or insurance premium distributions of all NHI-enrolled individuals were compared[25]. The Taipei Veterans General Hospital Institutional Review Board reviewed and approved the study proposal (VGHIRB No. 2015-05-006BC#4). The database contained no identifiable personal information; hence waiver of informed content was granted. We confirm that all experiments were performed in accordance with relevant guidelines and regulations.

Sample Selection

We included patients hospitalized for their first-ever stroke (ICD-9-CM 430-437) between 2010 and 2018 who were examined within 30 days with computed tomography (CT) or magnetic resonance imaging (MRI). We excluded patients with a stroke diagnosis before the index date, those who died during hospitalization, discharged themselves voluntarily, were transferred, had fewer than three outpatient visits within one year after discharge, had no insurance record, and were younger than 18-years-old. The final sample comprised 41,921 patients. The sample selection procedure is shown in Fig. 1.

Causes of Readmission

Preventable readmissions were defined according to the Agency for Healthcare Research and Quality (AHRQ) Prevention Quality Indicators (PQIs)[8, 16], which include chronic lung condition indicators (chronic obstructive pulmonary disease and adult asthma), diabetes-related preventable conditions (short- and long-term complications, and uncontrolled diabetes), cardiovascular-related indicators (hypertension, congestive heart failure, and angina without procedure), and acute condition indicators (dehydration, bacterial pneumonia, and urinary tract infection) (Table 1). Non-PPR was defined as readmission after initial admission with a stroke diagnosis where the aforementioned diseases were not diagnosed at the time of readmission. Patients who were not readmitted to the hospital were defined as having no readmission.

Table 1
Secondary diagnoses at the time of readmission linked to potentially preventable readmission (PPR)

Diagnosis	ICD-9
COPD	490, 466.0, 491.0, 491.1, 491.20, 491.21, 491.8, 491.9, 492.0, 492.8, 494, 494.0, 494.1, 496
Asthma	493.0, 493.1, 493.2, 493.8, 493.9
Diabetes	250.1, 250.2, 250.3, 250.4, 250.5, 250.6, 250.7, 250.8, 250.9, 250.02, 250.03
Primary hypertension	401.0, 401.9, 402.00, 402.10, 402.90, 403.00, 403.10, 403.90, 404.00, 404.10, 404.90
Heart failure	398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.0, 428.1, 428.2, 428.3, 428.4, 428.9
Angina	411.1, 411.81, 411.89, 413.0, 413.1, 413.9
Volume depletion disorder	481, 482.2, 482.30, 482.31, 482.32, 482.39, 482.41, 482.42, 483.0, 483.1, 483.8, 485, 486
Pneumococcal pneumonia	276.5
Urinary tract infection	590.0, 590.1, 590.2, 590.3, 590.8, 590.9, 595.0, 595.9, 599.0

Covariates and Subgroups

The covariates in this study included gender, age group, year of first admission for stroke, length of stay (LOS), stroke type (ISC: ischaemic stroke (codes 433-434), ICH: intracerebral hemorrhage (codes 431-432), SAH: subarachnoid hemorrhage (codes 430), and other (codes 435-437), monthly income based upon the NHI premium each patient paid, which was used as a proxy for income, hospital level, ownership, and region, and urbanization level, in which level 1 represents the most urbanized area and level 5 the least[26]. A modified version of the Charlson Comorbidity Index (CCI) was used to summarize comorbidities[27, 28].

The comorbidities with PPR and non-PPR after discharge post-stroke were calculated according to 29 diagnosed diseases (Table 2), which include any primary and secondary diagnosed conditions in outpatient or inpatient data during the period between the first admission for stroke and readmission post-discharge. The items included in the Stroke Severity Index (SSI) essentially reflect the management of stroke-related complications, and are generally correlated with stroke severity and other accompanying neurological deficits. We extracted the above claims information from the inpatient claims database at first admission for stroke and then computed each patient's SSI. Following a previous study, patients were categorized as having mild (SSI $\leq$ 5), moderate (SSI 5 to $\leq$12), or severe (SSI > 12) stroke[29].

Table 2
Comorbidities associated with PPR, non-PPR, and non-readmission

	30days							1 year						
	PPR		non-PPR		Without readmission			PPR		non-PPR		Without readmission		
	n	%	n	%	n	%	*p*-value	n	%	n	%	n	%	*p*-value
N	4123		2367		35431			12849		6959		22113		
Hypertension Uncomplicated	2340	56.75	956	40.39	18162	51.26	<0.001	7577	58.97	2999	43.10	10882	49.21	<0.001
Diabetes	1459	35.39	612	25.86	10836	30.58	<0.001	4775	37.16	1933	27.78	6199	28.03	<0.001
Congestive Heart Failure	1116	27.07	440	18.59	7865	22.20	<0.001	3702	28.81	1415	20.33	4304	19.46	<0.001
Hypertension Complicated	950	23.04	419	17.70	7093	20.02	<0.001	3189	24.82	1311	18.84	3962	17.92	<0.001
Rheumatoid Arthritis/Collagen	800	19.40	463	19.56	6713	18.95	0.617	2542	19.78	1443	20.74	3991	18.05	<0.001
Peptic Ulcer Disease excluding bleeding	663	16.08	403	17.03	5167	14.58	<0.001	2175	16.93	1231	17.69	2829	12.79	<0.001
Chronic Pulmonary Disease	706	17.12	347	14.66	5076	14.33	<0.001	2467	19.20	1061	15.25	2601	11.76	<0.001
Depression	469	11.38	296	12.51	4275	12.07	0.330	1582	12.31	963	13.84	2495	11.28	<0.001
Cardiac Arrhythmia	511	12.39	240	10.14	3612	10.19	<0.001	1648	12.83	764	10.98	1951	8.82	<0.001
Liver Disease	350	8.49	288	12.17	3245	9.16	<0.001	1215	9.46	892	12.82	1776	8.03	<0.001
Fluid and Electrolyte Disorders	319	7.74	148	6.25	1813	5.12	<0.001	1011	7.87	479	6.88	790	3.57	<0.001
Renal Failure	460	11.16	291	12.29	3356	9.47	<0.001	1564	12.17	990	14.23	1553	7.02	<0.001
Other Neurological Disorders	367	8.90	235	9.93	2883	8.14	0.003	1262	9.82	810	11.64	1413	6.39	<0.001
Valvular Disease	236	5.72	102	4.31	1601	4.52	0.002	721	5.61	369	5.30	849	3.84	<0.001
Solid Tumor without Metastasis	264	6.40	282	11.91	2314	6.53	<0.001	923	7.18	840	12.07	1097	4.96	<0.001
Peripheral Vascular Disorders	179	4.34	115	4.86	1419	4.00	0.087	585	4.55	326	4.68	802	3.63	<0.001
Hypothyroidism	72	1.75	48	2.03	590	1.67	0.401	239	1.86	136	1.95	335	1.51	0.010
Deficiency Anemia	96	2.33	69	2.92	723	2.04	0.010	352	2.74	221	3.18	315	1.42	<0.001
Paralysis	48	1.16	38	1.61	329	0.93	0.003	151	1.18	106	1.52	158	0.71	<0.001
Coagulopathy	37	0.90	38	1.61	305	0.86	0.001	135	1.05	107	1.54	138	0.62	<0.001
Psychoses	112	2.72	71	3.00	637	1.80	<0.001	314	2.44	195	2.80	311	1.41	<0.001
Metastatic Cancer	49	1.19	92	3.89	342	0.97	<0.001	146	1.14	224	3.22	113	0.51	<0.001
Drug Abuse	47	1.14	45	1.90	446	1.26	0.019	149	1.16	128	1.84	261	1.18	<0.001
Pulmonary Circulation Disorders	22	0.53	7	0.30	116	0.33	0.094	57	0.44	37	0.53	51	0.23	<0.001
Obesity	10	0.24	4	0.17	98	0.28	0.586	36	0.28	12	0.17	64	0.29	0.242

	30days							1 year						
	PPR		non-PPR		Without readmission			PPR		non-PPR		Without readmission		
	n	%	n	%	n	%	*p*-value	n	%	n	%	n	%	*p*-value
Alcohol Abuse	25	0.61	24	1.01	222	0.63	0.071	87	0.68	74	1.06	110	0.50	<0.001
Lymphoma	18	0.44	18	0.76	94	0.27	<0.001	41	0.32	37	0.53	52	0.24	<0.001
Weight Loss	9	0.22	9	0.38	79	0.22	0.300	41	0.32	26	0.37	30	0.14	<0.001
AIDS/HIV								5	0.04	8	0.11	13	0.06	0.117

Data Analysis

Descriptive statistics were used to summarize all of the covariates considered in this study, in which categorical variables were analyzed using Pearson's Chi-squared test, and continuous variables (LOS) were analyzed using the *t*-test. In this study, separate models were built to examine the covariates associated with readmission status within 30-days and 1-year. Multinomial logistic regression (MLR) was performed to determine the association between related factors and readmissions. Three levels were defined for the dependent variable, readmission status: PPR patients, non-PPR patients, and no-readmission patients. Among them, no readmission was set as the reference level. The MLR results were presented as odds ratios (ORs), 95% confidence intervals (95% CIs), and *p*-values. Statistical significance was set at $p < 0.05$. All statistical analyses were performed with SAS software v. 9.4 (SAS Institute Inc., Cary, NC, U.S.A.).

Results

41,921 discharged stroke patients in total were identified during the study period. Table 3 shows the summary statistics of all covariates for the PPR, non-PPR, and non-readmission groups. Of these patients, 6,490 (15.48%) were readmitted within 30-days, and 19,808 (47.25%) were readmitted within 1-year. Among them, the readmission rates for PPR and non-PPR were 4,123 (9.84%) and 2,367 (5.65%) within 30-days, and 12,849 (30.65%) and 6,959 (16.60%) within 1-year, respectively.

Table 3
Causes of potentially preventable readmission (PPR) and non- preventable readmission (non-PPR) within 30 days/1 year *vs.* non-readmitted patients, all after stroke (n=41921)

	30 days							**1 year**						
								1 year						
Variable	PPR		non-PPR		Without readmission			PPR		non-PPR		Without readmission		
	n	%	n	%	n	%	*p*-value	n	%	n	%	n	%	*p*-value
N	4123	9.8	2367	5.7	35431	84.5		12849	30.7	6959	16.6	22113	52.8	
Gender														
male	2444	9.9	1447	5.9	20790	84.2	0.054	7440	30.1	4223	17.1	13018	52.8	<0.001
female	1679	9.7	920	5.3	14641	84.9		5409	31.4	2736	15.9	9095	52.8	
Age														
18-44	184	7.3	225	8.9	2121	83.8	<0.001	499	19.7	595	23.5	1436	56.8	<0.001
45-64	1239	8.9	788	5.7	11873	85.4		3449	24.8	2211	15.9	8240	59.3	
65-69	426	9.1	259	5.5	3994	85.4		1314	28.1	750	16.0	2615	55.9	
70-79	1071	10.1	550	5.2	9013	84.8		3469	32.6	1690	15.9	5475	51.5	
≧80	1203	11.8	545	5.4	8430	82.8		4118	40.5	1713	16.8	4347	42.7	
Monthly income														
≦19047	1333	10.0	768	5.8	11190	84.2	<0.001	4219	31.7	2257	17.0	6815	51.3	<0.001
19048-21900	1659	10.5	862	5.5	13243	84.0		5111	32.4	2628	16.7	8025	50.9	
>21900	1131	8.8	737	5.7	10998	85.5		3519	27.4	2074	16.1	7273	56.5	
Year														
2010	516	10.5	222	4.5	4196	85	<0.001	1671	33.9	714	14.5	2549	51.7	<0.001
2011	463	9.1	235	4.6	4397	86.3		1669	32.8	765	15.0	2661	52.2	
2012	503	10.4	235	4.9	4106	84.8		1665	34.4	702	14.5	2477	51.1	
2013	466	9.6	234	4.8	4132	85.5		1580	32.7	762	15.8	2490	51.5	
2014	466	9.9	255	5.4	3981	84.7		1491	31.7	769	16.4	2442	51.9	
2015	452	9.6	269	5.7	4001	84.7		1406	29.8	782	16.6	2534	53.7	
2016	426	9.9	289	6.7	3597	83.4		1261	29.2	888	20.6	2163	50.2	
2017	430	10.1	321	7.6	3501	82.3		1200	28.2	917	21.6	2135	50.2	
2018	401	9.5	307	7.3	3520	83.3		906	21.4	660	15.6	2662	63.0	
Stroke type														
ISC	2690	9.7	1476	5.3	23635	85.0	<0.001	8560	30.8	4378	15.8	14863	53.5	<0.001
ICH	885	13.1	497	7.4	5384	79.6		2348	34.7	1367	20.2	3051	45.1	
Other	477	7.2	332	5.0	5821	87.8		1733	26.1	1053	15.9	3844	58.0	
SAH	71	9.8	62	8.6	591	81.6		208	28.7	161	22.2	355	49.0	
LOS(mean,SD)	11.51	9.6	11.25	9.8	16.3	35.8	<.0001	18.56	23.0	19.24	25.1	12.63	39.6	<0.001
CCI														
0	1185	9.2	736	5.7	10943	85.1	<0.001	3216	25.0	1951	15.2	7697	59.8	<0.001
1-3	2065	9.6	1119	5.2	18390	85.2		6673	30.9	3353	15.5	11548	53.5	
4-6	660	11.1	349	5.9	4949	83.1		2311	38.8	1191	20.0	2456	41.2	
≧7	213	14.0	163	10.7	1149	75.3		649	42.6	464	30.4	412	27.0	

	30 days							1 year						
								1 year						
SSI														
Mild	2855	8.4	1653	4.9	29402	86.7	<0.001	9304	27.4	5132	15.1	19474	57.4	<0.001
Moderate	364	13.4	198	7.3	2150	79.3		1002	37.0	503	18.6	1207	44.5	
Severe	904	17.1	516	9.7	3879	73.2		2543	48.0	1324	25.0	1432	27.0	
Hospital level														
Medical center	1368	9.1	863	5.8	12757	85.1	<0.001	4279	28.6	2672	17.8	8037	53.6	<0.001
Regiona hospital	1965	9.3	1102	5.2	18014	85.5		6464	30.7	3302	15.7	11315	53.7	
District hospital	789	13.5	402	6.9	4646	79.6		2103	36.0	983	16.8	2751	47.1	
Hospital ownership														
Public	1217	10.2	682	5.7	9984	84.0	<0.001	3696	31.1	2019	17.0	6168	51.9	0.072
private	898	10.9	493	6.0	6878	83.2		2589	31.3	1343	16.2	4337	52.5	
Legal person	2007	9.2	1192	5.5	18557	85.3		6561	30.2	3595	16.5	11600	53.3	
Urbanization level														
1	543	7.8	330	4.8	6075	87.4	<0.001	1972	28.4	1114	16.0	3862	55.6	<0.001
2	1211	10.5	746	6.5	9608	83.1		3437	29.7	1990	17.2	6138	53.1	
3	879	9.1	495	5.1	8290	85.8		2931	30.3	1571	16.3	5162	53.4	
4	705	10.0	398	5.7	5925	84.3		2234	31.8	1173	16.7	3621	51.5	
5	776	11.7	391	5.9	5453	82.4		2257	34.1	1093	16.5	3270	49.4	

The comparison results showed the significant covariates associated with readmission status within 30-days: age, monthly income, year, stroke type, LOS, CCI, SSI, hospital level, hospital ownership, and urbanization. For both 30-day and 1-year readmissions, the PPR rate of these significant factors was more likely to be higher than non-PPR, and the highest PPR rate of subgroups among the significant factors were one patient 80+, patients with a monthly income of NT$19,048-21,900, those treated in 2010 and 2012, those with ICH, those with CCI 7+, those with severe SSI, and those treated at district, private, and the least urbanized area hospitals.

The mean LOS within 30-days was 11.51 (SD=9.59) for PPR and 11.25 (SD=9.75) for non-PPR and within 1-year were 18.56 (SD=22.97) for PPR and 19.24 (SD=25.08) for non-PPR. The standard deviation of LOS within 1-year appeared to be large, which indicates that the LOS values were distributed over a broader range.

The results of the multinomial logistic regression are shown in Table 4. Compared to no readmission, patients 45-64, 65-69, 70-79, and 80+ years of age vs. those 18-44 years had ORs of 1.29, 1.33, 1.43, and 1.61 for 30-day PPR, and 1.20, 1.39, 1.66, and 2.37 for 1-year PPR. In addition, these ORs indicated that older patients have a higher probability of PPR. Compared to no readmission, within 30-days, LOS had ORs of 0.97 (95% CI=[0.97-0.97]) and 0.97 (95% CI=[0.97-0.97]) for PPR and non-PPR readmission, respectively. Within 1-year, LOS had an OR of 1.01 (95% CI=[1.01-1.01]) and 1.01 (95% CI=[1.01-1.01]) for PPR and non-PPR readmission, respectively. These ORs indicated that a shorter length of stay was associated with readmission within 30-days and had a greater effect on readmission within 1-year. Further, age played a key role in readmission.

Table 4
Factors associated with PPR and non-PPR *vs.* non-readmission after stroke

Table	**30 days**				**1 year**			
PPR vs. without readmission		non-PPR vs. without readmission		PPR vs. without readmission		non-PPR vs. without readmission		
OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	
Gender								
Female								
Male	1.05	(0.98-1.12)	1.08	(0.99-1.18)	**1.07	(1.02-1.13)	***1.14	(1.08-1.21)
Age								
18-44								
45-64	**1.29	(1.09-1.52)	***0.68	(0.58-0.80)	**1.20	(1.07-1.34)	***0.66	(0.59-0.74)
65-69	**1.33	(1.10-1.60)	***0.66	(0.54-0.88)	***1.39	(1.22-1.58)	***0.67	(0.59-0.77)
70-79	***1.43	(1.20-1.69)	***0.62	(0.52-0.74)	***1.66	(1.48-1.86)	***0.71	(0.64-0.80)
≧80	***1.61	(1.35-1.91)	***0.62	(0.52-0.74)	***2.37	(2.11-2.67)	*0.88	(0.78-0.99)
Monthly income								
19048-21900								
≦19047	1.07	(1.00-1.18)	1.02	(0.92-1.14)	***1.11	(1.04-1.17)	*1.08	(1.01-1.16)
>21900	1.07	(0.99-1.17)	0.99	(0.89-1.11)	*1.07	(1.01-1.13)	*1.09	(1.02-1.18)
Year								
2010								
2011	*0.84	(0.74-0.97)	1	(0.83-1.21)	*0.89	(0.81-0.98)	0.96	(0.85-1.08)
2012	0.99	(0.86-1.13)	1.07	(0.88-1.30)	0.97	(0.88-1.06)	0.95	(0.84-1.07)
2013	0.9	(0.78-1.03)	1.05	(0.86-1.27)	0.92	(0.84-1.00)	1.04	(0.92-1.17)
2014	0.95	(0.83-1.09)	1.19	(0.99-1.44)	*0.89	(0.81-0.98)	1.06	(0.94-1.19)
2015	0.95	(0.83-1.09)	**1.31	(1.09-1.57)	***0.81	(0.74-0.90)	1.06	(0.94-1.19)
2016	1.04	(0.90-1.19)	***1.66	(1.38-2.00)	**0.87	(0.79-0.96)	***1.44	(1.28-1.62)
2017	1.07	(0.93-1.23)	***1.88	(1.57-2.26)	***0.84	(0.76-0.93)	***1.52	(1.35-1.70)
2018	***0.99	(0.85-1.14)	***1.80	(1.50-2.16)	***0.49	(0.45-0.55)	***0.85	(0.75-0.96)
Stroke type								
Other type								
ISC	***1.44	(1.30-1.60)	1.06	(0.94-1.21)	***1.20	(1.12-1.28)	0.93	(0.86-1.01)
ICH	***1.97	(1.73-2.25)	**1.29	(1.10-1.52)	***1.40	(1.28-1.53)	1.08	(0.97-1.20)
SAH	**1.48	(1.13-1.95)	*1.39	(1.03-1.87)	1.17	(0.97-1.43)	1.17	(0.97-1.43)
LOS	***0.97	(0.97-0.97)	***0.97	(0.97-0.97)	***1.01	(1.01-1.01)	***1.01	(1.01-1.01)
CCI								
0								
1-3	1.06	(0.98-1.15)	1.01	(0.91-1.12)	***1.40	(1.33-1.48)	***1.28	(1.19-1.36)
4-6	***1.25	(1.12-1.39)	*1.18	(1.03-1.36)	***2.25	(2.09-2.42)	***2.15	(1.97-2.36)
≧7	***1.75	(1.48-2.06)	***2.41	(1.99-2.90)	***3.81	(3.33-4.36)	***4.94	(4.27-5.71)
SSI								
Mild								

*$p<0.05$, **$p<0.01$, ***$p<0.001$

Table	30 days				1 year			
Moderate	***1.84	(1.63-2.09)	***1.98	(1.68-2.32)	***1.60	(1.46-1.75)	***1.55	(1.38-1.73)
Severe	***3.69	(3.34-4.07)	***4.18	(3.69-4.74)	***3.27	(3.03-3.53)	***3.18	(2.90-3.47)
Hospital level								
District hospital								
Medical center	0.96	(0.88-1.04)	*0.90	(0.81-1.00)	**1.08	(1.02-1.14)	**0.92	(0.86-0.98)
Regional hospital	***1.37	(1.21-1.54)	*1.22	(1.04-1.42)	***1.40	(1.29-1.53)	*1.12	(1.00-1.24)
Hospital ownership								
Legal person								
Public	*1.11	(1.02-1.21)	1.02	(0.91-1.13)	1.03	(0.97-1.10)	1.04	(0.96-1.11)
Private	*1.12	(1.01-1.23)	0.99	(0.87-1.13)	1.03	(0.96-1.11)	0.98	(0.90-1.07)
Urbanization level								
1								
2	***1.38	(1.24-1.55)	***1.33	(1.15-1.53)	**1.13	(1.05-1.21)	*1.10	(1.01-1.21)
3	*1.17	(1.03-1.33)	0.98	(0.83-1.16)	*1.13	(1.04-1.24)	1.06	(0.95-1.18)
4	***1.28	(1.12-1.46)	1.18	(0.99-1.40)	**1.15	(1.05-1.26)	***1.15	(1.03-1.28)
5	***1.34	(1.16-1.55)	1.34	(1.16-1.55)	**1.24	(1.12-1.37)	1.21	(1.07-1.36)
*p<0.05, **p<0.01, ***p<0.001								

Within 30-days, the CCI level of 7+ and 4-6 (OR: 1.75, 95% CI=[1.48-2.06] and OR=1.25, 95% CI=[1.12-1.39]), SSI levels of moderate and severe (OR=1.84, 95% CI=[1.63-2.09] and OR=3.69, 95% CI=[3.34-4.07]), treatment at a regional hospital (OR=1.37, 95% CI=[1.21-1.54]) and hospital ownership, public and private (OR=1.11, 95% CI=[1.02-1.21] and OR=1.12, 95% CI=[1.01-1.23]), all types of stroke, all age levels and urbanization, were associated significantly with readmission. Similarly, all CCI levels (OR=1.40, 95% CI=[1.33-1.48]; OR=2.25, 95% CI=[2.09-2.42] and OR=3.81, 95% CI=[3.33-4.36]), moderate and severe SSI levels (OR=1.60, 95% CI=[1.46-1.75] and OR=3.27, 95% CI=[3.03-3.53]), treatment at a medical center or regional hospital (OR=1.08, 95% CI=[1.02-1.14] and OR=1.40, 95% CI=[1.29-1.53]), and type of stroke, all age levels, and urbanization had a significant effect on readmission within 1-year. In addition to these covariates, male gender, hospitalization year, monthly income, and treatment at a hospital in the central area of Taiwan, also affected readmission significantly. Moreover, direct trends were discernable for age, CCI, SSI, and urbanization for PPR within 1-year, and age and SSI for PPR within 30-days. Further, Figure 2 shows the forest plot of the odds ratios and 95% confidence intervals for factors associated with 30-day and 1-year PPR.

Discussion

Studies have found that the rates of hospital readmissions after a stroke ranged from 6.5–24.3% within 30-days[5] and 31–49% within 1-year[11]. However, not all readmissions are considered “potentially preventable”[30]. A review paper reported that preventable readmissions ranged from 14–23% within 30-days and from 48–59% within 1-year based upon older patients or general medical patients[15, 31]. Another study estimated that the 1-year cumulative risks of readmission for ischemic stroke patients in Taiwan were 34.1%, 44.7%, and 62.9% for patients with mild, moderate, or severe stroke, respectively[32]. In this study, we determined that hospital readmission rates were 15.48% within 30-days and 47.25% within 1-year; the PPRs based upon the PQI definition were 9.84% within 30-days and 30.65% within 1-year using population-based data in Taiwan. Because our study included only patients older than 18, the readmission rates shown should be the upper bound.

Mittal et al. found that 41(7.6%) of 537 acute ischemic stroke (AIS) patients were readmitted within 30-days post-stroke, and 2.8% among them were PPR[23]. Based upon 79 unplanned readmissions, an investigation at a Hong Kong geriatric center found that only 15 cases (19%) were avoidable[33]. These variations in PPR rates may be associated with age, patient diagnosis, duration of follow-up, methodology, and factors related to the mixtures of case diagnoses[15]. Nakagawa et al. found in a multiethnic population in Hawaii that 840 (8.4%) of 10,050 patients with any type of stroke-related hospitalization had 30-day PPR. Some studies have demonstrated that a higher readmission rate may be attributable to language barriers that affect receiving hospital care and/or accessing post-hospital care[30, 34].

The extant literature has reported that certain patient characteristics, such as age and socioeconomic status, were potential factors associated with readmission after stroke[5, 8, 15]. Our study found the same effect of age, but patients with the highest and lowest monthly income had a significantly higher rate of readmissions than those with the median income. This may indicate inequalities in healthcare and additional investigation is necessary to determine the reasons[35].

The severity of stroke upon the first admission was also a significant predictor of 28-day readmission in Australia[5]. Further, CCI was found to be associated with the 30-day PPR after stroke discharge[30]. In this study, we identified a direct, positive relation between age, CCI, SSI, and long-term PPR. In cases of long-term PPR, the increase in these factors was associated with increasing readmission. These findings were similar to a 234 hospital-based study in Florida, which found that PPR was related to the severity of illness and older age. In addition, their results showed that increased severity of the disease and time between admission and readmission increased readmission rates[14].

After adjusting for other variables, regional hospitals showed a higher risk of PPR compared to medical centers and district hospitals. The effect of hospital-level on short- and long-term readmissions was consistent with those of previous studies[32, 36]. We assume that medical centers provide a better quality of inpatient care[32], and suggest that regional hospitals' policymakers give more attention to the quality of patient care. In addition, the fact that district hospitals had lower PPR than regional hospitals may be attributable to the implementation of the Post-Acute Care (PAC) program in Taiwan described in the next paragraph. The district hospitals received more PAC patients, which led to a decreasing readmission rate.

Our results showed that the hospitals' urbanization level was related significantly to both short- and long-term PPR; the most urbanized area had the lowest readmission rate compared to the least urbanized area. One study suggested that this may be related to the poor quality of care in rural areas[37]. Most discharged stroke patients still need to receive follow-up healthcare at home or in a skilled nursing or inpatient rehabilitation facility; however, those resources may not be allocated sufficiently in rural areas compared to urban areas[38]. As a result, the quality of post-discharge care in rural areas may be poorer than that in urban areas and have led to a higher readmission rate.

Our study demonstrated further that, compared to no-readmission patients, a one-day increase in LOS was associated significantly with 0.97 times the risk of 30-day PPR. However, a one-day increase in LOS was associated significantly with 1.01 times the risk of 1-year PPR. Hence, LOS may have different implications for short- and long-term PPR. This finding is consistent with that in Bjerkreim's study[11]. LOS' short-term effect on PPR may be explained by incomplete treatment during the index hospitalization[14], and suggests the need for a better quality of care and discharge planning. On the other hand, LOS' long-term effect on PPR may be related to the severity of the stroke or comorbidities[10, 39, 40], and suggests the need to improve the continuity of follow-up care.

The comorbidities associated with PPR diagnosed most frequently in our study were hypertension without complications, diabetes, and congestive heart failure. Previous reports have indicated that patients who were readmitted either early or later seemed to have higher frequencies of hypertension, atrial fibrillation, cerebrovascular disease, and diabetes as prior comorbidity conditions[10, 11]. To decrease the risk of short-term PPR after discharge, our results showed that older patients, stroke type (ICH), CCI level of 4-6 and 7+, either moderate or severe SSI, and patients treated at regional, public or private, and hospitals in less urbanized areas are the groups most likely to experience a first-ever stroke, which suggest that adequate discharge planning must be provided for the first month after these patients are discharged. Although a previous study indicated that readmission reduction initiatives might not be highly effective for patients who are socioeconomically disadvantaged[41], we found that more attention should be given to median-income patients to decrease readmission rates.

An important finding was that the ORs of long-term PPR vs. no readmission showed a decreasing trend. We believe that this is attributable to Taiwan's implementation in 2014 of the national health insurance post-acute care (PAC) program for first-ever stroke patients. Patients who qualify for the PAC can receive intensive rehabilitation and integrated care within the treatment period. The PAC plan proposes to improve the incentives and review of discharge care for stroke patients in these hospitals.

PPR events may be avoided and healthcare costs reduced by improving the quality of care during the index inpatient stay and the period immediately following discharge. As a consequence, our study suggests that specific groups of patients should be targeted for PPR intervention.

Limitations

This study has certain limitations. First, it was a retrospective cohort study with data derived from Taiwan's National Health Insurance (NHI) claims database. Consequently, data on certain important factors, such as patient behavioral characteristics, the process of care, and health-related quality of life could not be collected[23]. Nonetheless, compared to a hospital chart review database, the NHI claims database provides a population-based sample from a wide range of hospitals, as well as longitudinal follow-up information on readmission post-stroke. Second, the diagnosis codes' accuracy was uncertain. Therefore, the results may be limited to patients who are hospitalized with a primary discharge diagnosis of stroke in Taiwan[36].

Conclusion

We recommend that hospital managers provide better discharge planning and post-discharge follow-up programs for these patients before and after discharge, as the combination is likely to reduce the number of PPR substantially.

Declarations

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Authors' Contributions: LJC participated in designing the study, data analysis, data interpretation, first drafted and revised the manuscript. HCL was the PI of the study, participated in the conception and design of the study, monitored data collection, interpreted findings, drafted and revised the manuscript.

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Data Availability Data are sourced from Taiwan National Health Insurance (NHI). Due to legal restrictions imposed by the government of Taiwan in relation to the "Personal Information Protection Act", data cannot be made publicly available. Requests for data can be sent as a formal proposal to the NHIRD (http://nhird.nhri.org.tw).

Compliance with Ethical Standards

Conflict of Interest: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics Approval: Institutional Ethical Review (VGHIRB No. 2015-05-006BC#4)

Consent to Participate: N/A

Consent for Publication All the authors have agreed this publication.

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Figures

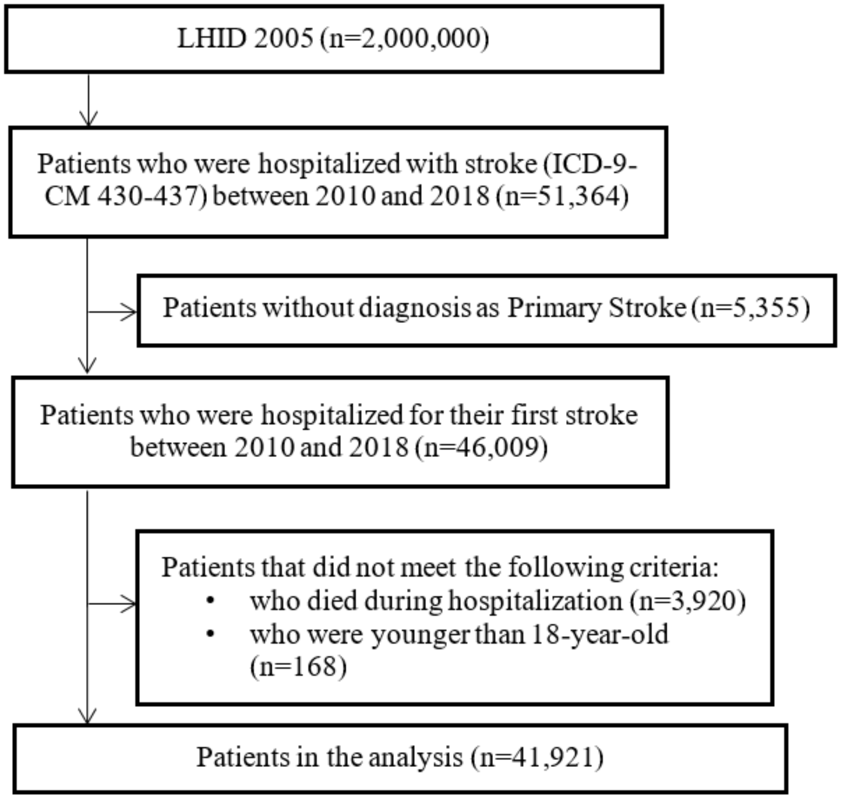

Figure 1

Flow chart of the data processing

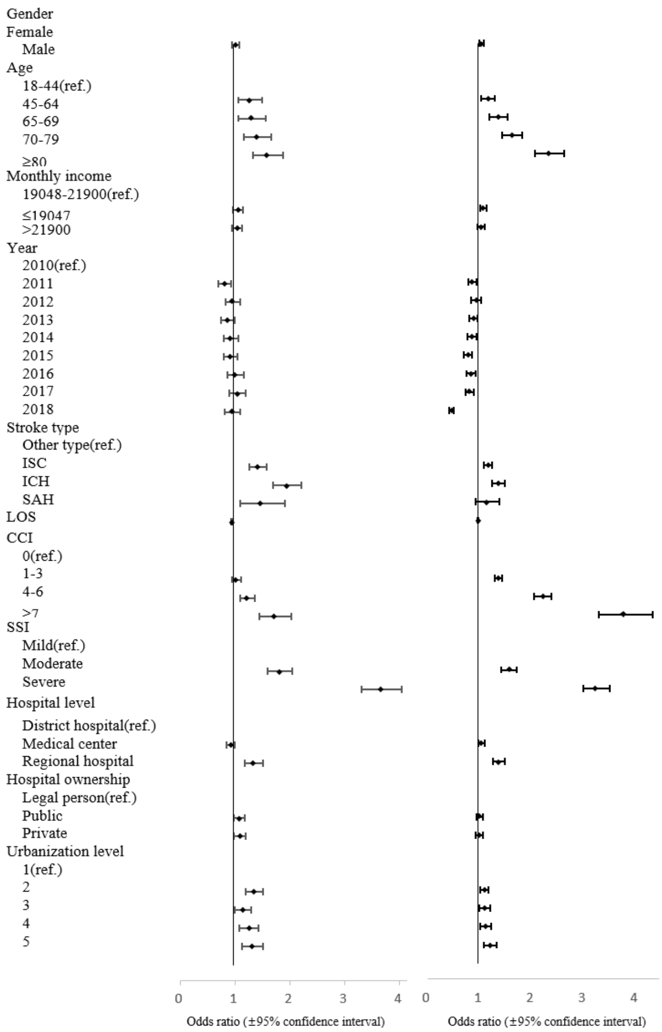

Figure 2

Forest plot displaying Odds ratios and 95% confidence intervals for 30-day and 1-year PPR after multinomial logistic regression