1. Title

Factors associated with emergency readmissions after acute stroke: a retrospective audit of two hospitals

2. Short Title

Understanding readmission events after acute stroke

3. Authorship

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4. Abstract

Rationale, aims and objectives: Emergency hospital readmissions within 30 days of discharge from hospital are considered a marker for the quality of hospital care, patient experience, the discharge process and integration with community services. This paper describes the frequency and variations in cause of emergency readmissions at 30 and 90 days following discharge after acute stroke from two stroke units.

Methods: Retrospective data collection of Hospital Episodes Statistics (HES) and Sentinel Stroke National Audit Programme (SSNAP) of consecutive acute stroke hospital discharges over 24 months from 2017 to 2019 from two specialist stroke units in England. HES data were used to calculate the Charlson comorbidity index (CCI). Covariates were analyzed for their association with readmission rate, including: Age; Gender; CCI; Length of stay for first stroke admission; Living alone; Discharge to a care home; Discharge receiving stroke specialist early supported discharge (ESD) rehabilitation; and stroke severity as determined by NIHSS on stroke admission.

Results: From 2017 to 2019 there were 1999 live discharges with a primary diagnosis of stroke. Both hospitals had a trend of increasing readmission rates with increasing stroke severity and comorbidity. Longer length of stroke admission, especially for patients with increasing stroke severity, and receiving ESD rehabilitation after discharge, reduced 90-day readmissions. This association was stronger at 90 days than at 30 days. Different readmission event rates were found at 30 and 90 days and when event between the two hospitals.

Conclusion: Understanding differences in readmission event rates between hospitals at 30 and 90 days can support planning local patient needs in the first weeks after stroke discharge and to investigate ways for hospital to reduce the impact of readmission. It is recommended that stroke services use both 30 and 90-day readmissions to inform service evaluation and improvement.

5. Keywords

stroke; early supported discharge; comorbidity; HES data ; stroke unit ; hospital admission

6. Main text

Introduction

Unplanned, emergency hospital readmissions are undesirable for patients and add workload to hospital services. The National Health Service (NHS) in England defines emergency readmissions as any emergency readmission to hospital within 30 days of discharge [1]. Despite challenges to the validity of emergency readmissions as a measure of quality of care, it continues to be used by NHS England as a quality measure for in-hospital care, discharge planning, follow-up and community support [2-5]. Additionally, the World Health Organisation suggest availability of imaging, thrombolysis, length of hospital stay and duration of rehabilitation contribute to variations in mortality and readmission[6].

Stroke is the leading cause of disability in the UK and accounts for more than 85,000 hospital admissions per annum [7]. A recent NHS review of stroke services in England reported the national average 30-day (all-cause) readmission rate after stroke as 11.3%[5]. NHS stroke services in England have been developed aspiring to have an integrated, multidisciplinary pathway approach [7-9]. Readmission rates after stroke are used as a measure of the effectiveness and integration of local stroke pathways from admission to community rehabilitation[5]. Emergency readmissions are usually measured at 30 days of discharge from a stroke event[1,5]. There is evidence to suggest that measuring emergency readmissions up to 90 days, instead of the standard 30 days, may be more appropriate for older patients with decline in functional mobility or activities of daily living[10]. The purpose of our study was to describe the rates and cause of readmission at 30 and 90 days after discharge from two specialist stroke units in the southwest of England. The secondary outcomes were to ascertain differences in the cause of readmission between the two services, compare differences in readmission cause at 30 and 90 days after discharge and consider the value of 90-day readmissions in informing stroke pathway quality improvements.

Methods

Data were collected from two district general hospitals, located six miles apart. Key characteristics of both sites are detailed in table 1. The hospitals were of similar size and served an area with similar diverse geography (urban and rural) with a demography featuring the greatest concentration of over 75-year-olds in England. The hospitals both provided urgent and emergency care, medical care, surgery, critical care, end-of-life care, outpatient, and diagnostic services. Each hospital had a combined stroke unit – a specialist stroke unit with hyper-acute, acute and rehabilitation beds and early supported discharge team. Both delivered thrombolysis and had access to interventional stroke treatments at another site. Although the stroke units served a similar and overlapping population, there were differences in the stroke service design and size. One site (site 2, table 1) had a lower number of annual stroke admissions, a smaller number of beds and a higher proportion of patients discharged with stroke specialist ESD rehabilitation which provided no cover out-of-hours and weekends.

Table 1. Summary of hospital characteristics

Characteristic	**Site 1**	**Site 2**
Population size	500,000	500,000
Hospital bed numbers	600	600
Stroke Unit admissions/year	800	480
Stroke Unit bed number	36	27
Consultant cover	5 days	5 days
Mean length of stay of stroke admission	14	18
Length of ESD provision	2 weeks	2 weeks
ESD cover	7 days, evenings	5 days, no evenings
% Discharged with ESD	37.8%	44.5%
Access to community rehabilitation beds	No	Yes

Abbreviations: ESD, Early Supported Discharge Community Rehabilitation Team

Inclusion/exclusion criteria

The initial stroke admission was defined as an emergency admission with primary discharge diagnosis of ischaemic or haemorrhagic stroke (ICD-10 codes I61 to I64 inclusive); aged over 18 years old; admitted between 1st September 2017 to 31st August 2019. Exclusions were patients with a diagnosis of transient ischaemic attack, those who died during their acute stroke admission and those discharged out-of-area. Inclusion as a readmission episode was defined as any emergency (unplanned) readmission to either hospital site, with any diagnosis. No lower time limit on readmission (i.e. within hours of discharge) was applied. The inclusion of two admitting hospitals, with overlap in population served, captured patients discharged from one hospital and readmitted to the other.

Ethical considerations

This study protocol was reviewed and approved by the Clinical Audit Departments at Poole Hospital NHS Foundation Trust and Bournemouth and Christchurch Hospitals NHS Foundation Trust. The study was conducted in line with the hospitals' clinical governance and data protection policies.

Data collection

Data sources were Hospital Episodes Statistics (HES) and Sentinel Stroke National Audit Programme (SSNAP). HES is an electronic record of every inpatient or day case episode of patient care in NHS hospitals. SSNAP is a national prospective audit that collects a minimum dataset on patients with stroke in England, Wales and Northern Ireland. SSNAP measures both the organisation and processes of care provided to stroke patients against evidence-based standards[11]. HES and SSNAP data from 1st September 2017 to 31st August 2019 were retrieved for all consecutive stroke admissions to any ward at both hospitals. Data were retrieved for each patient every time they were re-admitted to either hospital up to one year after discharge. HES data were cross validated with SSNAP data to ensure all stroke admissions were captured. For each stroke admission case, information was obtained on primary discharge diagnosis, admission National Institute for Health Stroke Scale (NIHSS), age, co-morbidities, admission and discharge date, day of discharge, length of stay (LOS), discharging ward, discharge destination, living alone at discharge and receipt of ESD community rehabilitation after stroke discharge. HES data on subsequent emergency readmissions were retrieved for each case up to 90 days after discharge from original stroke admission.

Data sorting and cleaning

Original stroke admissions coded with ICD-10 code I64x had their admission brain imaging reviewed and re-coded as ischaemic or haemorrhagic stroke. Readmission codes were checked with case notes if there was a possibility of a different underlying cause, for example, if a skin tear or fracture was caused by a mechanical fall, or if a readmission diagnosis of paraesthesia was caused by seizures. Missing NIHSS data were obtained from case notes where available. In total, there were 211 different readmission diagnoses. Due to the large number of readmission diagnoses, two authors (CG and MD) jointly agreed the grouping of similar clinical codes, for example all malignant cancers were grouped together, to aid analysis and interpretation in line with the study objectives.

Analysis

HES data were used to calculate the Charlson Comorbidity Index (CCI) [12] which is an accepted method to retrieve patient information on co-morbidities [13]. The Deyo algorithm was used to adapt ICD-10 data to the CCI [14,15]. A higher CCI score indicates patients having greater co-morbidities.

Descriptive statistical analysis compared data from patients with 90-day readmission(s) against patients with no readmissions; readmission rate over time from discharge; and 90-day readmission diagnoses rates. The readmission rate was calculated based on the total number of patients readmitted at least once within 90 days of discharge and if a patient was readmitted more than once, only the first readmission episode was used in the analysis of readmission rate. For calculation of the most likely diagnosis for readmission, all readmission episodes were included.

Logistic regression analysis was performed to determine the predictors of readmission. The variables were identified prospectively from published literature on causes for stroke readmissions [16]. The variables were: age; gender; CCI; length of stay for first stroke admission; living alone; discharge to a care home; discharge with ESD rehabilitation; and stroke severity as determined by NIHSS on stroke admission. Variables were excluded when there was insufficient evidence to refute the null hypothesis (coefficient corresponding to variable = 0), that is the factor had no effect on readmission rate. The final model only included variables with p-value < 0.05. The outcomes for the model were readmissions within 90 days. The association between readmission rate and readmission diagnoses were analysed using the Chi Squared Test. HES data on discharge destination was only available for 35% records, therefore, analysis of discharge destination and living alone status was not analysed.

Results

The study included 1999 live discharges with a primary diagnosis of stroke. 72 (3.6%) patients died within 90 days of discharge. 497 patients (26% of patients alive at 90 days) were readmitted at least once as an emergency within 90 days to either hospital, 53.3% were female. 16.2% (313) were readmitted within 30 days, and 25.8% (497) within 90 days. The median time for readmission occurring within 90 days of discharge was 19 days (IQR=6-46 days). The majority (n=361, 73%), had one readmission in 90 days, and one patient was re-admitted eight times in 90 days. Table 2 shows the relationship between the variables of age, comorbidity, stroke severity, length of stay and readmission at 90 days. Age did not have a statistically significant relationship with 90-day readmission. Both shorter LOS and NIHSS appear to be associated with increased 90-day readmissions and when both sites' data is combined, this relationship becomes significant (Table 2). CCI had a significant association with 90-day readmission at each site. These associations were further analyzed and will be discussed next.

Table 2. Relationship between stroke admission variables and readmission at 90 days

Variable		Site 1 Odds Ratio	Site 1 95% CI	Site 2 Odds Ratio	Site 2 95% CI	Total Odds Ratio	Total 95% CI
Age	*Reference category* (<40)	1.000		1.000		1.000	
	40-49	1.071	0.205, 8.128	1.714	0.196, 37.364	1.270	0.336, 6.198
	50-59	1.923	0.472, 12.988	1.875	0.288, 36.893	1.904	0.599, 8.462
	60-69	1.157	0.284, 7.799	1.703	0.270, 33.098	1.340	0.425, 5.924
	70-79	1.518	0.390, 10.008	1.656	0.273, 31.709	1.562	0.510, 6.793
	80-89	1.916	0.495, 12.597	2.517	0.420, 47.984	2.117	0.695, 9.179
	90+	2.524	0.636, 16.802	2.862	0.461, 55.280	2.635	0.849, 11.553
	Wald Chi Square	0.048		0.299		0.005	
Comorbidity (CCI)		1.173	1.132, 1.218	1.129	1.090, 1.172	1.144	1.116, 1.174
	Wald Chi Square	0.000		0.000		0.000	
Stroke severity (NIHSS)		1.040	1.019, 1.061	1.029	1.003, 1.055	1.036	1.019, 1.052
	Wald Chi Square	0.000		0.031		0.000	
Stroke admission LOS (days)		1.006	1.001, 1.0116	1.007	1.001, 1.012	1.006	
	Wald Chi Square	0.018		0.027		0.001	

Abbreviations: CCI, Charlson comorbidity index; NIHSS, National Institute for Health Stroke Scale

Co-morbidity (Charlson Comorbidity Index) and Readmission Rate

The relationship between CCI and readmission rate was analyzed as a logistic regression model and testing the significance of factors using the Log-Likelihood Ratio Test. The analyses determined that CCI does have a significant effect on the readmission rate, (p-value < 0.001) with co-morbidity being more significant for re-admission at site 1 (OR 1.173, 95% CI 1.132, 1.218) than site 2 (OR 1.129, 95% CI 1.090, 1.172).

CCI scores were grouped into mild (CCI <2), moderate (CCI 3-5) and severe (CCI >5) comorbidity and summarised in Table 3. According to Figure 1, there were differences in CCI severity and readmission rates across the two sites. Table 3 shows grouping of comorbidities into mild, moderate and severe that demonstrates site differences in readmissions according to CCI severity group. Site 1 had a higher number of 90-day readmissions in patients with mild comorbidities, whereas site 2 had a higher number of 90-day readmissions in patients with severe comorbidities.

Table 3. Proportion of 90 day readmission cases with mild, moderate and severe comorbidity

CCI Grouping	Site 1 % Readmission cases	Site 2 % Readmission cases	Total
Mild	42.41%	25.48%	35.96%
Moderate	32.44%	32.15%	32.33%
Severe	25.15%	42.37%	31.71%

Abbreviations: CCI, Charlson comorbidity index

Length of stroke admission, stroke severity and readmission rate

Table 4 shows the analysis of different models on readmissions for each site. Firstly, stroke admission LOS was compared against null model and was shown to be significant for site 1 (p <0.001, as compared against intercept model) and non-significant for site 2. When stroke severity (NIHSS) was included with LOS, this model is significant fit (p<0.05) for 90-day readmission rates than LOS alone. The addition of the variables successively to the model improves the fit significantly for site 1, but remained non-significant for site 2, with the inclusion of the interaction not improving model fit when compared to Model 2 (Table 4).

Table 4. Comparison of combined model with 90-day re-admission rate

	(1) vs null model	**(2) vs (1)**	**(3) vs (2)**		
Model	**LoS**	**Los + NIHSS**	**Interaction model**	**P***	**P**
	(1)	**(2)**	**(3)**	**(1 vs 3)**	**(2 vs 3)**
Site 1					
30-day readmission rate	0.0068514 **	0.2437596	0.0007375 ***	0.001703 **	0.0007375 ***
90-day readmission rate	5.566e-05 ***	0.02447 *	0.04116 *	0.0099 **	0.04116 *
Site 2					
30-day readmission rate	0.6395	0.4704	0.1396	0.2588	0.1396
90-day readmission rate	0.06265.	0.1439	0.7984	0.3327	0.7984

Signif. codes: 0 ‘*’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1**

Model visualization (shown in figure 1) shows the interaction of LOS and NIHSS score had a significant effect on readmission rate for patients discharged from site 1 and is more significant for readmission within 30 days. For example, patients admitted to site 1 with a NIHSS score of 20 and >7 days LOS experienced a lower 30- and 90-day readmission rate (16%,46%) than those who had <7 days LOS (28%,57%). For site 2, there was insufficient evidence to suggest LOS and NIHSS had an effect on re-admission rate (P-value for interaction p > 0.1).

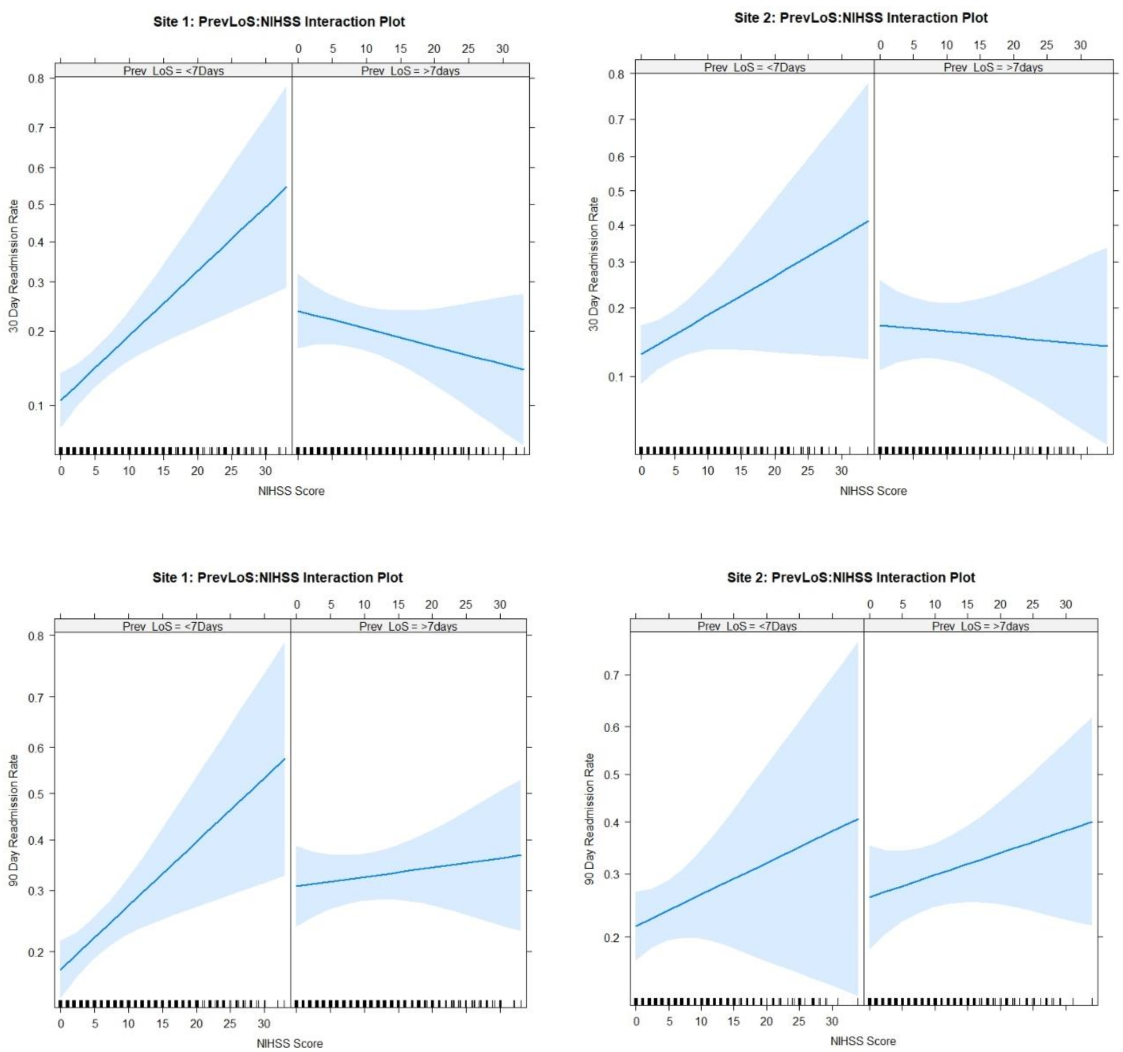

Figure 1: Interaction plots showing stroke admission LOS, NIHSS and 30/90 day re-admission rate for sites 1 & 2

Community stroke specialist rehabilitation (Early Supported Discharge) and readmission rate

SSNAP data were used to ascertain if the patient was discharged after their stroke to receive community rehabilitation from the stroke Early Supported Discharge (ESD) service. For 30-day readmissions, there was no significant association between receipt of ESD rehabilitation and readmission (Table 5). However, this changed for 90-day readmissions, with ESD rehabilitation associated with significantly lower readmissions in site 1 (p=0.004), with this association strengthening with data from both sites were combined (p=0.001).

Table 5. Readmissions by receipt of Early Supported Discharge rehabilitation after stroke discharge

	Site 1		Site 2		Both sites	
Access to ESD after stroke discharge	30 days	90 days	30 days	90days	30 days	90 days
Yes	14.59% 68/466	21.03% 98/466	12.94% 44/340	22.94% 78/340	13.90% 112/806	21.84% 176/806
No	17.88% 130/727	28.75% 209/727	18.02% 71/394	28.43% 112/394	17.93% 201/1121	28.64% 321/1121
Pearson's Chi-squared test P-value	0.1585	0.003646	0.07412	0.108	0.02111	0.000925

Abbreviations: ESD, Early Supported Discharge

Cause of readmission

Table 6 shows the top five diagnoses for 90-day readmission according to CCI categories of mild (CCI ≤2), moderate (CCI 3-5)and severe (CCI >5). The most frequent diagnoses were: infection, ischaemic stroke, falls and musculoskeletal problems (Table 6). Comparisons in cause of readmission were made between to the two hospitals due to the similar, and overlapping, population and non-stroke specific community services (Table 1) . Similar causes for readmission were observed at both hospitals, but in different proportions. For example, site 2 saw a greater proportion of ischaemic stroke (site 1=8.98%, site

2=14.23%) and site 1 saw more infections (site 1=19.4%, site 2=14.23%). Both saw a similar proportion of falls (site 1 = 8.51%, site 2=8.46%) and musculoskeletal problems (site 1=5.91%, site 2=5.77%). At site 2, patients with less severe comorbidity, over a quarter were readmitted with an ischaemic stroke, whilst at site 1 readmission with ischaemic stroke was not a 'Top 5' diagnosis. For site 1, infection was the most likely cause for readmission, including those with less severe comorbidity. Further analysis of case notes would help to determine the reasons for these trends.

Table 6. Top five 90-day readmission diagnoses according to site and co-morbidity severity

(n)	Comorbidity severity	1st	2nd	3rd	4th	5th
Site 1						
81	**Mild**	Infection (respiratory), 14.81%	Neurology (other), 9.88%	Fall, 9.88%	Respiratory (other) 7.41%	Musculo-skeletal, 7.41%
143	**Moderate**	Ischemic stroke, 11.27%	Infection (respiratory), 9.86%	Infection (other), 9.15%	Fall, 8.45%	Intracerebral hemorrhage, 4.93%
200	**Severe**	Infection (other), 11.50%	Ischemic stroke, 9.50%	Fall, 8.00%	Infection (respiratory), 7.5%	Musculo-skeletal, 6.50%
424	**Total**	Infection (respiratory), 9.7%	Infection (other), 9.7%	Ischemic stroke, 8.98%	Fall, 8.51%	Musculo-skeletal, 5.91%
Site 2						
(n)	**Comorbidity severity**	**1st**	**2nd**	**3rd**	**4th**	**5th**
14	**Mild**	Ischemic stroke, 28.57%	Infection (other), 14.29%	Infection (respiratory), 14.29%	Neurology (other), 14.29%	Intracerebral hemorrhage, 7.14%
61	**Moderate**	Fall, 14.75%	Infection (other), 8.20%	Respiratory (other), 8.20%	Gastroenterolog ical Disorders, 6.56%	Atrial fibrillation and flutter, 6.56%
185	**Severe**	Ischemic stroke, 15.68%	Infection (respiratory), 8.11%	Fall, 7.03%	Infection (other), 6.49%	Syncope and collapse, 6.49%
260	**Total**	Ischemic stroke, 14.23%	Fall, 8.46%	Infection (other), 7.31%	Infection (respiratory), 6.92%	Musculo-skeletal, 5.77%

Discussion

The purpose of our study was to describe and compare 30 and 90-day causes of readmission after discharge from two specialist stroke units in the southwest of England. The two sites are within proximity and over-lapped the population served, therefore, this study provides a comprehensive data set of readmissions after stroke in the local population, also capturing patients who were admitted with a stroke to one site and readmitted to the other site.

Patient-based factors, such as age, sex and comorbidity drive underlying demand for emergency admission in the over 65s[3]. With the addition of stroke severity, these patient-based factors are similar in stroke patients [17]. Our results reflect high readmission rates and causes reported in the literature[4,16,18]. In our study, there was a trend towards increased readmission with age, but this was not a significant relationship[4]. Comorbidity (CCI) and stroke severity (NIHSS) were associated with increased 90-day readmission, also consistent with previous research[3,17]. However, when individual sites were compared, site 1 had increased 90-day readmissions for less severe strokes and fewer comorbidities. A longer LOS of more than 7 days for increasing stroke severity (NIHSS) tended to reduce readmissions. This association was stronger in site 1. These results suggest that stroke services need to monitor the impact of reducing average days of inpatient care and consider risk of readmission as part of their discharge planning and ongoing support. This is particularly relevant with inpatient stroke services reducing length of stay and increasing rehabilitation in the community.

Our results suggest that support after leaving hospital, in this study this was in the form of ESD rehabilitation, may be an important factor for 90-day readmissions. Additional support from ESD services on leaving hospital may reduce readmissions for common post-stroke complications such as aspiration pneumonia, urinary tract infections and falls, or support secondary prevention interventions. This association needs further research. The importance of relationships between community and hospital services and how they provide continuity of care affects emergency bed use in UK hospitals[3]. Not all community services may benefit patients recovering from stroke and these need careful review. A meta-analysis of ESD studies in stroke patients showed no significant differences in readmissions between control and ESD rehabilitation[19]. Our study found no association of ESD rehabilitation services on readmission at 30-days, whereas there was a significant reduction in 90-day readmissions suggesting there may be a key period after discharge where ESD rehabilitation can impact readmissions at around three months post discharge. ESD rehabilitation may impact readmissions by reducing complications associated with stroke and supporting stroke secondary prevention management. Further research is required to explore this association and other models of community support for patients not eligible for ESD service.

Comparing cause of re-admission across the two sites with similar patient populations provided a unique opportunity to review differences in the stroke pathway to inform future service improvements. Overall, our study's re-admission causes were similar to findings in Abreu et al's[4] larger study, with the most common being stroke recurrence and infection. Falls and musculoskeletal problems featured in readmissions for all stroke severities and are potentially avoidable readmissions with further community and rehabilitation interventions. However, the rates of readmission cause were different in the two sites. For example, site 2 had more readmissions due to falls and no ESD service at weekends and evenings. Although further research is needed explore these trends, highlighting and exploring how differences in service provision may impact on readmission with falls can lead to quality improvements through sharing of good practice.

Limitations

This study has several limitations that require our results to be interpretated with caution. Firstly, the study was limited due to retrospective data collection and the data quality was reliant on the HES and SSNAP databases and clinical documentation in medical records. Using a combination of HES and SSNAP data, along with cross-referencing data sets where appropriate, led to increase in accuracy for stroke specific ICD-10 codes, however, the causes of readmission may not be accurate due to administrative coding errors of readmission diagnoses. Including data sets from both hospitals enabled capture of patients that were readmitted to either hospital, increasing the accuracy of readmission activity in the local population, but could potentially make comparisons between hospital sites inaccurate. Secondly, there was missing data regarding discharge destination and whether the patient was living alone, so we were unable to analyze whether this impacted readmissions. Deprivation and geographical access are known drivers for emergency bed use in the UK [3]. Due to the retrospective data collection, we were unable to collect accurate geographical data from the HES database to analyze socio-economic and geographic relationship to readmission after stroke. Thirdly, variability in readmission rate is not only influenced by fluctuations in covariates but also by differences in its calculation. The dominator can be inflated by inclusion of patients who died during admission, or within the timescale being measured (in this study, 30 and 90 days). We were unable to collect data on those discharged after hospitalisation for acute stroke who died within the 30- or 90-day period and, therefore, their inclusion in the denominator will result in readmission rates being underestimated. Finally, measuring stroke severity at admission did not account for improvement with thrombolysis or thrombectomy.

Conclusion

This study confirms other research that stroke recurrence and infection are the top causes for readmission after stroke. Information on rates and cause of readmission may help stroke services in targeting transition and post-discharge interventions. It is important to understand variations across services and preventable factors that may influence readmission. When measuring 90-day readmissions, a time point not routinely collected by NHS stroke services, this study highlights shorter length of stroke hospital stay and lack of access to ESD service is associated with increased 90-day readmission. Further prospective research is required into the associations between shortening length of stroke hospital stay and ESD services on cause and rate of readmissions.

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Disclosure

The authors report no conflicts of interest in this work.

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