Thirty-day readmission rate as a surrogate marker for quality of care in neurosurgical patients: a single-center Canadian experience

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OBJECTIVE Readmission to the hospital within 30 days of discharge is used as a surrogate marker for quality and value of care in the United States (US) healthcare system. Concern exists regarding the value of 30-day readmission as a quality of care metric in neurosurgical patients. Few studies have assessed 30-day readmission rates in neurosurgical patients outside the US. The authors performed a retrospective review of all adult neurosurgical patients admitted to a single Canadian neurosurgical academic center and who were discharged to home to assess for the all-cause 30-day readmission rate, unplanned 30-day readmission rate, and avoidable 30-day readmission rate.

METHODS A retrospective review was performed assessing 30-day readmission rates after discharge to home in all neurosurgical patients admitted to a single academic neurosurgical center from January 1, 2011, to December 31, 2011. The primary outcomes included rates of all-cause, unplanned, and avoidable readmissions within 30 days of discharge. Secondary outcomes included factors associated with unplanned and avoidable 30-day readmissions.

RESULTS A total of 184 of 950 patients (19.4%) were readmitted to the hospital within 30 days of discharge. One-hundred three patients (10.8%) were readmitted for an unplanned reason and 81 (8.5%) were readmitted for a planned or rescheduled operation. Only 19 readmissions (10%) were for a potentially avoidable reason. Univariate analysis identified factors associated with readmission for a complication or persistent/worsening symptom, including age ($p = 0.009$), length of stay ($p = 0.007$), general neurosurgery diagnosis ($p < 0.001$), cranial pathology ($p < 0.001$), intensive care unit (ICU) admission ($p < 0.001$), number of initial admission operations ($p = 0.01$), and shunt procedures ($p < 0.001$). Multivariate analysis identified predictive factors of readmission, including diagnosis ($p = 0.002$, OR 2.4, 95% CI 1.4–5.3), cranial pathology ($p = 0.002$, OR 2.7, 95% CI 1.4–5.3), ICU admission ($p = 0.004$, OR 2.4, 95% CI 1.3–4.2), and number of first admission operations ($p = 0.01$, OR 0.51, 95% CI 0.3–0.87). Univariate analysis performed to identify factors associated with potentially avoidable readmissions included length of stay ($p = 0.03$), diagnosis ($p < 0.001$), cranial pathology ($p = 0.02$), and shunt procedures ($p < 0.001$). Multivariate analysis identified only shunt procedures as a predictive factor for avoidable readmission ($p = 0.02$, OR 5.6, 95% CI 1.4–22.8).

CONCLUSIONS Almost one-fifth of neurosurgical patients were readmitted within 30 days of discharge. However, only about half of these patients were admitted for an unplanned reason, and only 10% of all readmissions were potentially avoidable. This study demonstrates unique challenges encountered in a publicly funded healthcare setting and supports the growing literature suggesting 30-day readmission rates may serve as an inappropriate quality of care metric in neurosurgical patients. Potentially avoidable readmissions can be predicted, and further research assessing predictors of avoidable readmissions is warranted.

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KEYWORDS 30-day readmission; thirty-day; neurosurgery; unplanned; preventable

ABBREVIATIONS ICU = intensive care unit; LOS = length of stay; QOL = quality of care; USD = United States dollars.

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READMISSION to the hospital within 30 days of discharge has been shown to be associated with significant morbidity and economic burden.^{15,19} Previous studies have found the cost of a neurosurgical readmission to be greater than \$90,000 in United States dollars (USD)²⁸ and the total annual Medicare cost of readmissions within 30 days to be \$17.4 billion USD.¹⁵ As such, the 30-day readmission rate is now being used as a surrogate metric for both quality and value of care^{38,39} with hospitals in the US being subject to reimbursement penalties based on this metric.^{6,7,38}

Historically, little has been published to assess the 30-day readmission rate in neurosurgical patients. Concern regarding its applicability in this select population exists due to the increased complexity of care for neurosurgical patients, with many patients requiring continued care after hospital discharge for disease progression.³⁶ However, over the past 5 years, a number of studies have evaluated the 30-day readmission rate in general care for neurosurgical patients, cohorts,^{3,5,22,28,36,38,41} as well as subspecialty neurosurgical cohorts.^{1,2,8,11,12,14,17,18,21,23–25,29,31–34,37,42–44} Furthermore, recent systematic reviews have assessed and dichotomized patient readmission rates into spine^{4,9} and cranial¹⁰ groups. While it was initially thought that neurosurgical patients would have a higher readmission rate, this was not in fact found to be the case. Reported rates ranging from 6.9% to 11.8% in studies assessing all neurosurgical patients^{3,5,22,36,38,41} have been much lower than the 20% readmission rate found in other medical fields.¹⁵ This is in part due to the inclusion of patients with spine pathology, who are known to have lower readmission rates than patients with cranial pathology.³⁸ Nonetheless, several publications have called into question the validity of 30-day readmission rates used in other areas of medicine as a quality of care (QOL) metric in neurosurgical patients.^{11,16,26,35,36,39,40} In order to improve generalizability, one systematic review recognized the need for more data from developed countries outside the US given the predominance of US publications to date.¹⁰ Here, we perform a retrospective review of all adult neurosurgical patients admitted to a single Canadian neurosurgical academic center and who were discharged to home to assess for the all-cause 30-day readmission rate, unplanned 30-day readmission rate, and avoidable 30-day readmission rate. Factors associated with unplanned and avoidable readmissions are reviewed.

Methods

Ethics approval for the completion of this study was received from the local institutional Health and Research Ethics Board. Using a hospital administrative database and electronic medical records, a retrospective review of all adult patients admitted to the local neurosurgical center from January 1, 2011, to December 31, 2011, was performed. Patients discharged to a location other than home were excluded from assessment. Patient clinical and demographic information collected included age, sex, distance to home from hospital, diagnosis (dichotomized as general neurosurgery diagnosis [including infection, hydrocephalus, spontaneous/idiopathic hemorrhage, Chiari malformations, and congenital abnormalities] or other di-

agnosis [including vascular pathology, trauma {including traumatic hemorrhages}, oncology, stereotactic and functional, epilepsy, spine, and peripheral nerve diagnoses]), presence of cranial or spinal pathology, need for intensive care unit (ICU) stay during admission, type of operation (dichotomized as shunt related or other), and number of operations required during initial admission.

Patient records were then reviewed for readmission within 30 days of discharge to any hospital within the province. The reason for readmission was recorded. A staff neurosurgeon with over 10 years of clinical experience, blinded to patient demographics, determined whether the readmission was avoidable at the time of previous discharge. A potentially avoidable readmission was defined as a case in which a targeted alternative patient management and follow-up may have prevented a readmission to the hospital within 30 days. Details regarding subsequent readmissions within 30 days of discharge were included in the assessment. The primary outcome for this study was to identify the number of all-cause, unplanned, and avoidable 30-day readmissions of neurosurgical patients after being discharged to home. Secondary outcomes included factors associated with unplanned and avoidable 30-day readmissions.

Demographic and clinical characteristics of the patients were described using means for continuous variables and medians for ordinal variables. For the univariate analysis, continuous variables were compared using a t-test, and categorical variables were compared using a Fisher's exact test. Analysis of factors related to readmission for both a complication/persisting symptom and an avoidable complication/persisting symptom was conducted with logistic regression analysis. Factors in the multivariate analysis included those found on the univariate screen to have a significance level of $p < 0.10$. Statistical significance for the logistic regression model was set at $p < 0.05$. Statistical analysis was conducted on SAS 9.4 (SAS Institute).

Results

A total of 950 patients were admitted to the neurosurgical service over the review period (Table 1). One hundred eighty-four patients (19.4%) required readmission within 30 days of discharge. The median number of days from discharge to readmission was 16.5 days. Table 2 lists the most common reasons for patients readmitted for an unplanned reason. Of the readmitted patients, 103 patients were admitted for an unplanned reason, accounting for 10.8% (103/950) of all patients and 56% (103/184) of readmitted patients. Unplanned readmissions consisted of 92 patients (50%) admitted for a complication or persistent/worsening symptom, and 11 (6%) admitted for a new, unrelated symptom requiring operation. An additional 30 patients (16%) were admitted for a scheduled operation, and 51 patients (28%) were admitted for a previous cancellation and/or rescheduled operation.

Table 3 lists the causes for readmission for patients with a complication or persistent/worsening symptom. The majority of these patients were readmitted for persistent/worsening symptom (56/92, 61%), while the next most prevalent cause was for a wound-related complica-

TABLE 1. Demographic characteristics of readmitted patients

Characteristic	Value (%)
Total admissions	950
Total all-cause 30-day readmissions	184 (19.4)
Total unplanned 30-day readmissions	103 (10.8)
Sex (male)	98 (53)
Mean age, yrs	50.8
Median days to readmission	16.5

tion (26/92, 28%). Table 4 identifies factors in the univariate analysis associated with readmission within 30 days for a complication or persistent/worsening symptom, including patient age (47 vs 52 years, $p = 0.009$), mean initial length of stay (LOS) (6.3 vs 4.2 days, $p = 0.007$), a general neurosurgery diagnosis (38% vs 20%, $p < 0.001$), cranial pathology (86% vs 60%, $p < 0.001$), ICU stay during the first admission (82% vs 2%, $p < 0.001$), the number of operations on the first admission (0.87 vs 0.75, $p = 0.01$), and a shunt-related diagnosis (12% vs 2%, $p < 0.001$). Sex and mean distance from the hospital were not associated with 30-day readmission in the univariate analysis. Table 4 also demonstrates a subsequent logistic regression analysis, which revealed a significant model (likelihood ratio test, $p < 0.0001$). Variables found to be significant were general neurosurgery diagnosis ($p = 0.002$, OR 2.4, 95% CI 1.4–5.3), cranial location of pathology ($p = 0.002$, OR 2.7, 95% CI 1.4–5.3), ICU stay ($p = 0.004$, OR 2.4, 95% CI 1.3–4.2), and number of operations on the first admission ($p = 0.01$, OR 0.51, 95% CI 0.3–0.87).

None of the patients readmitted for an unrelated symptom requiring operation were readmitted for an avoidable reason. Only the readmissions of 19 patients for a complication or persistent symptom were deemed to be avoidable, accounting for 19% (19/103) of unplanned readmissions. This represents only 10% of the entire patient population readmitted within 30 days during the study review period. Table 5 identifies factors in the univariate analysis associated with avoidable admission, including mean initial LOS (6.8 vs 4.4 days, $p = 0.03$), a general neurosurgery diagnosis (53% vs 15%, $p < 0.001$), cranial pathology (89% vs 62%, $p = 0.02$), and a shunt operation (26% vs 3%, $p < 0.001$) (Table 5). From the univariate analysis, factors included in the logistic regression analysis were age, initial LOS, a general neurosurgery diagnosis, cranial pathology, and the type of operation during the initial admission (shunt vs other). Table 5 also demonstrates a logistic regression analysis for avoidable readmissions, which revealed that overall the model was significant to predict having an avoidable complication ($p < 0.001$, like-

TABLE 2. Description of all-cause 30-day readmissions (n = 184)

Reason for Readmission	No. (%)
Complication or persistent/worsening symptom	92 (50)
Scheduled operation related to previous admission	30 (16)
Scheduled operation unrelated to previous admission	11 (6)
Previous cancellation and/or rescheduled operation	51 (28)

TABLE 3. Description of readmissions for complication or persistent/worsening symptom (n = 92)

Complication	No. (%)
New and/or worsening symptom	56 (61)
Wound-related complication	26 (28)
CSF leak	7 (8)
Hydrocephalus	3 (3)

lihood ratio test). The only variable that was found to be a factor in predicting an avoidable readmission was having a shunt-related procedure ($p = 0.02$, OR 5.6, 95% CI 1.4–22.8). Thirteen of the 19 patients (68%) readmitted for an avoidable reason required an operation during their readmission.

Discussion

Thirty-Day Readmission Rates and Associated Factors

The all-cause 30-day readmission rate for neurosurgical patients discharged to home was 19.4%, while the rate of unplanned readmissions (i.e., complication, persistent/progressive symptom, or new unrelated symptom requiring operation) during this time was nearly half that (10.8%). Our unplanned readmission rate is comparable to those of other published studies evaluating all neurosurgical patients, with a range of 6.9%–11.8%.^{11,16,26,35,36,39,40} An additional study evaluating a general neurosurgical cohort found a higher rate of readmission at 19.4%, though this cohort included only patients undergoing craniotomies and excluded spine procedures.²⁸ In keeping with our study, cranial pathologies had a higher rate of readmission than spine pathologies.³⁸

In the past 5 years, multiple publications have evaluated the rate of readmission in various subspecialty neurosurgical cohorts. For example, readmission rates for neurooncology patients admitted to a neurosurgical service have ranged from 7.5% to 15.8%.^{12,24,29} In various neurovascular patient cohorts, readmission rates have been identified as 7.3% in carotid artery stenosis patients undergoing carotid endarterectomy,³² 8%–17% in patients initially presenting with subarachnoid hemorrhage,^{14,21,37} 16% in patients initially presenting with intracerebral hemorrhage,²¹ and 6.1% in patients treated for unruptured intracranial aneurysms.¹¹ Readmissions for spine procedures range from 2.28% to 9.94%,^{1,2,17,23,25,30,34,42,43} with rates dependent on location⁴³ and number of vertebral levels involved.⁴² A study evaluating functional neurosurgical patients found that, of those receiving deep brain stimulation, 6.6% of patients were readmitted within the first 30 days. A few publications have also evaluated readmission of pediatric neurosurgery patients. Readmission rates in the pediatric population range from 10.4% to 16.5% depending on whether shunt-treated patients are included (pediatric patients with shunts tend to have higher readmission rates, which may partially relate to both increased patient complexity and frequency of shunt-related issues within the first 30 days).^{8,33,44} Two systematic reviews assessing spine pathology readmission rates have found overall readmission rates to vary between 2.54% and 14.7%.^{4,9} One sys-

TABLE 4. Factors associated with 30-day readmissions for complication or persistent/worsening symptom

Factor	Complication (n = 92)	No Complication (n = 858)	p Value		Odds Ratio (95% CI), Multivariate Analysis
			Univariate Analysis	Multivariate Analysis	
Mean age, yrs	47 (SD 16.5)	52 (SD 16.1)	0.009	0.06	1.03 (0.99–1.03)
Male sex	52 (57%)	475 (55%)	1		
Mean initial LOS, days	6.3 (SD 7.2)	4.2 (6.2)	0.007	0.51	0.99 (0.96–1.01)
Diagnosis					
General neurosurgery	35 (38%)	118 (20%)	<0.001	0.002	2.4 (1.4–5.3)
Other*	57 (62%)	740 (80%)			
Cranial pathology	80 (86%)	515 (60%)	<0.001	0.002	2.7 (1.4–5.3)
ICU admission	75 (82%)	21 (2%)	<0.001	0.004	2.4 (1.3–4.2)
Mean distance from hospital, km	142 (SD 327)	191 (SD 509)	0.2		
Mean no. of operations on admission					
Type of operation	0.87 (SD 0.37)	0.75 (SD 0.47)	0.01	0.01	0.51 (0.3–0.87)
Shunt	11 (12%)	21 (2%)	<0.001	0.34	1.6 (0.62–3.9)
Other	82 (88%)	857 (98%)			

* Included vascular, trauma, oncology, stereotactic and functional, epilepsy, spine, and peripheral nerve diagnoses.

tematic review evaluating cranial pathologies has recently identified overall readmission rates of 6.9%–23.89%.¹⁰ Unfortunately, due to the recent publication of several other readmission studies, many of these publications have not been included for assessment in the systematic reviews.

Following multivariate analysis, our study identified a general neurosurgery diagnosis, cranial pathology, ICU admission, and number of operations on first admission as predictors of readmission for a complication or persisting/worsening symptom. The only predictor of a potentially avoidable readmission, however, was having had a shunt procedure. Older age was associated with readmission for complications or persistent/worsening symptom on univariate analysis, but it was not significant in the regression model. Age was also not significant for predicting avoidable readmissions. The association between age and readmission (avoidable or not) has not been borne out in the literature. Some studies suggest that there is in fact an association with readmission (in the case of cranial pathology),¹⁰ while in other circumstances there is not (cases of spine

pathology).⁹ In contrast, cranial pathology has consistently shown a higher rate of readmission than spine pathology. The reason for this discrepancy has been said to be that cranial neurosurgical patients often are more debilitated by their disease and also show higher rates of disease progression.¹⁰ Severity of illness and premorbid status were shown to be associated with readmission in recent systematic reviews.^{9,10} In keeping with this, our study identified that factors which are likely associated with the overall severity of patient debilitation (such as LOS, ICU admission, and the number of operations required) are also associated with readmission for a complication and/or persistent symptom, noting that only LOS was not significant following logistic regression. In addition, our study identified shunt-related surgery as a predictor of potentially avoidable readmission. Shunt-treated patients are known to exhibit increased general medical complexity and suffer from unique hardware-related issues in the perioperative period.^{33,39,44} This may highlight the specific need for closer follow-up of shunt-treated patients postdischarge.

TABLE 5. Factors associated with avoidable 30-day readmissions

Factor	Avoidable Readmission (n = 19)	No Avoidable Readmission (n = 931)	p Value		Odds Ratio (95% CI), Multivariate Analysis
			Univariate Analysis	Multivariate Analysis	
Mean age, yrs	50.5 (SD 20.7)	51.7 (SD 16.2)	0.09	0.61	0.99 (0.97–1.02)
Male sex	10 (53%)	517 (56%)	0.82		
Mean initial LOS, days	6.8 (SD 9.4)	4.4 (SD 6.2)	0.003	0.15	0.97 (0.93–1.01)
Diagnosis					
General neurosurgery	10 (53%)	143 (15%)	<0.001	0.13	2.5 (0.77–8.0)
Other*	9 (47%)	788 (85%)			
Cranial location	17 (89%)	578 (62%)	0.02	0.18	2.91 (0.61–13.9)
ICU admission	4 (21%)	92 (10%)	0.12		
Mean distance from hospital, km	223 (SD 582)	186 (SD 493)	0.75		
Mean no. of operations on admission					
Type of operation	0.84 (SD 0.37)	0.76 (SD 0.47)	0.34		
Shunt	5 (26%)	27 (3%)	<0.001	0.02	5.6 (1.4–22.8)
Other	14 (74%)	904 (97%)			

* Included vascular, trauma, oncology, stereotactic and functional, epilepsy, spine, and peripheral nerve diagnoses.

Controversy in 30-Day Readmission Rates as a Quality Indicator

Utilizing a 30-day readmission rate as an indicator for quality of neurosurgical care remains controversial.^{14,35,36} In their paper, Joynt and Jha proposed 3 potential issues with the use of 30-day readmission rates as a metric of quality: 1) low rates of preventable readmissions within 30 days, 2) more targeted alternative policies that are likely to be effective in improving discharge planning and care coordination, and 3) potential consequences of hospital efforts to reduce readmissions, including decreasing quality of more pertinent quality-improvement initiatives, such as patient safety.¹⁶ Furthermore, low rates of avoidable readmissions are often driven by factors beyond hospital control (including patient- and community-level factors) and may actually reflect improved QOL due to decreased mortality rates and improved access to hospital care. With many neurosurgical patients suffering from an advanced and often progressive disease course, these latter issues are particularly pertinent. Low avoidable readmission rates have been identified in neurosurgical patients.^{14,36} In our study, only 56% of patients were readmitted for unplanned reasons. Of these, only 18% were deemed avoidable, constituting 10% of all patients readmitted within 30 days and only 19 patients over a 1-year period in a major neurosurgical center. A 2017 systematic review supports these observations, finding no evidence to suggest that a 30-day readmission rate is a suitable indicator for QOL in neurosurgery.³⁵ The analysis in the 2017 systematic review supports the argument that readmissions may in fact be a marker for a high standard of care rather than inappropriate care.

Study heterogeneity and variations in reported 30-day readmission rates contribute to this controversy.^{4,9} One reason explaining this variation relates to how readmission rates have been collected and defined. Several studies assessing neurosurgical cohorts have evaluated the rate of all-cause readmission, while many others have assessed the rate of unplanned readmission. Here, we assessed all-cause readmission because of difficulty delineating unplanned readmission from an administrative database.¹⁵ Nearly half of all-cause patient readmissions were for planned or rescheduled operations. This is higher than what has been previously published in neurosurgical cohorts^{14,36,38} and is more than 4 times the estimated planned readmission rate proposed in a review of nearly 12 million Medicare patients.¹⁵ This is one of the first papers published to evaluate neurosurgical readmission rates in a universal, publicly funded healthcare setting; as such, we believe the all-cause readmission rate found in this study highlights unique challenges to this environment. Potential challenges include restricted operating room availability and frequent bed shortages resulting in cancelled and rescheduled operations. Furthermore, we believe utilization of a 30-day readmission rate as a marker for quality and value of care should be met with scrutiny and is likely of limited relevance in this setting. It does, however, serve to highlight the discrepancy that exists within our own healthcare system between available operative time, post-operative patient care resources, and hospital bed shortages and the prolonged operative patient waiting lists.

Reducing 30-Day Readmission in Select Patients

A small proportion of readmissions may still be avoidable with appropriate preventative strategies. Previous studies have supported the development of cost-effective strategies to reduce readmission rates in select patients.^{5,38} A recent systematic review of neurosurgical patients admitted with cranial pathology supported systematic changes as a preventative method for readmissions.¹⁰ Specific changes in neurosurgery proposed to date have included programs designed to manage surgical complications⁵ and reduce perioperative complications, such as hydrocephalus and venous complications.²⁴ Managing and preventing perioperative complications has been cited as the most important preventative method for spine patients.⁹ Patient-centered strategies with education and empowerment, complication avoidance, and changes for system-wide error prevention and quality improvement have been other methods proposed in recent reviews. In a study by Greenberg et al., 25% of patients with aneurysmal subarachnoid hemorrhage were identified as having preventable causes for their readmission.¹³ However, no specific patient predictors for readmission were identified on multivariate analysis. Instead, the authors suggested that cost-effective strategies be applied to most, or all, of their patients. As a corollary in the medical literature, a recent systematic review and meta-analysis showed significant and incremental effects for different methods of comprehensive support, including strategic discharge planning with logistical case management, patient education and self-management, telephone and scheduled follow-ups, and continuity of management.²⁰ Indeed, continuity of management may be particularly important in neurosurgical patients, where readmission rates have been shown to be significantly reduced when patients are seen at their index hospital emergency department.²⁷

In contrast to findings by Greenberg et al., our study suggests that the most cost-effective method for reducing potentially avoidable readmissions in the general neurosurgical population is to target patients more likely to return for an avoidable reason (in this case, patients with shunt-related procedures). This is especially true given the overall low rate of potentially avoidable readmissions. Therefore, continued investigation with multivariate analysis, similar to that done in this study, to identify factors predicting those patients at highest risk for an avoidable readmission (such as those with a prolonged LOS, general neurosurgery diagnosis, or cranial pathology, or those undergoing shunt-related procedures) is warranted. Ultimately, assessing the value of a preventative readmission program targeting such patients in a prospective manner will be needed.

Limitations and Future Direction

As a retrospective study, this study is prone to inherent bias. Reliance on an electronic medical record and administrative database for data collection has been well described as a limitation for ensuring comprehensive inclusion of readmission rates.³ Moghavem et al. have noted that as many as 57% of patients do not return to their index hospital for readmission.²⁸ We felt that the use of a provincial database would reduce the likelihood of ascertain-

ment bias, but some patients may have been transferred to and/or from locations outside the province (and as a result not have been captured). Another potential limitation is the heterogeneity of the entire neurosurgical patient cohort. This heterogeneity makes it difficult to assess comparisons between patients without stratifying them on the basis of certain characteristics (which then necessitates increased patient numbers in order to increase the likelihood of a significant result). However, we felt that the inclusion of this heterogeneous cohort provided a more comprehensive assessment of a neurosurgical practice and has been assessed in a similar fashion in previous publications.^{3,5,22,36,38,41} Finally, avoidable cases were evaluated by only one staff neurosurgeon utilizing a qualitative definition of potentially avoidable readmission, and no interobserver variability could be evaluated for accuracy of this measurement. Although the reviewer was a senior neurosurgeon and blinded to patient demographics, there remains a risk for selection bias of avoidable readmissions in this single-reviewer study.

Our study has supported prior publications demonstrating that avoidable 30-day readmissions are limited to only a small number of discharges. Furthermore, our study is one of the few to use multivariable analysis to assess factors associated with readmission. Given the limited number of publications on this topic assessed in recent systematic reviews and the controversy as to the most cost-effective methods for reduction of avoidable readmissions, further study into predictive features for readmission is warranted. This is particularly pertinent to developed countries outside the US. Eventually, repeated systematic reviews including many of the recent publications will aid in this evaluation. Ultimately, prospective trials applying models of targeted and/or comprehensive care will be needed to assess for readmission reduction in neurosurgical patients.

Conclusions

Almost one-fifth of neurosurgical patients were readmitted within 30 days of discharge, though only 56% of these patients were admitted for an unplanned reason, and only 10% of all readmissions were potentially avoidable. Our study demonstrates unique challenges encountered in a publicly funded healthcare environment and supports the growing literature suggesting that the 30-day readmission rate may serve as an inappropriate quality of care metric in neurosurgical patients. More data from publicly funded healthcare systems are needed to better identify readmission rates in this environment. Nonetheless, a small proportion of readmissions may still be avoidable and an opportunity exists to select patients at highest risk for potentially avoidable readmission (such as those requiring a shunt-related procedure), for which cost-effective programs can be designed in an effort to reduce readmissions. More studies assessing for predictors of avoidable readmissions with multivariate analysis are warranted.

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Author Contributions

Conception and design: Wilson, Jack, Chow. Acquisition of data: Wilson. Analysis and interpretation of data: all authors. Drafting the article: Wilson, Jack, Nataraj, Chow. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Wilson. Statistical analysis: Nataraj.

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