HHS Public Access

Author manuscript

J Neurosurg. Author manuscript; available in PMC 2017 December 14.

Published in final edited form as:

J Neurosurg. 2016 March ; 124(3): 743–749. doi:10.3171/2015.2.JNS142771.

Causes of 30-day readmission after aneurysmal subarachnoid hemorrhage

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Abstract

OBJECTIVE—Hospital readmission is a common but controversial quality measure increasingly used to influence hospital compensation in the US. The objective of this study was to evaluate the causes for 30-day hospital readmission following aneurysmal subarachnoid hemorrhage (SAH) to determine the appropriateness of this performance metric and to identify potential avenues for improved patient care.

METHODS—The authors retrospectively reviewed the medical records of all patients who received surgical or endovascular treatment for aneurysmal SAH at Barnes-Jewish Hospital between 2003 and 2013. Two senior faculty identified by consensus the primary medical/surgical diagnosis associated with readmission as well as the underlying causes of rehospitalization.

RESULTS—Among 778 patients treated for aneurysmal SAH, 89 experienced a total of 97 readmission events, yielding a readmission rate of 11.4%. The median time from discharge to readmission was 9 days (interquartile range 3–17.5 days). Actual hydrocephalus or potential concern for hydrocephalus (e.g., headache) was the most frequent diagnosis (26/97, 26.8%), followed by infections (e.g., wound infection [5/97, 5.2%], urinary tract infection [3/97, 3.1%], and pneumonia [3/97, 3.1%]) and thromboembolic events (8/97, 8.2%). In most cases (75/97, 77.3%), we did not identify any treatment lapses contributing to readmission. The most common underlying causes for readmission were unavoidable development of SAH-related pathology (e.g., hydrocephalus; 36/97, 37.1%) and complications related to neurological impairment and immobility (e.g., thromboembolic event despite high-dose chemoprophylaxis; 21/97, 21.6%). The authors determined that 22/97 (22.7%) of the readmissions were likely preventable with alternative

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Disclosure

Dr. Derdeyn reports having ownership in Therapeutics and being a consultant for Microvention and Penumbra.

Author Contributions

Conception and design: Zipfel, Greenberg, Washington, Dacey, Derdeyn. Acquisition of data: Zipfel, Greenberg, Derdeyn. Analysis and interpretation of data: all authors. Drafting the article: Greenberg, Guniganti. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Statistical analysis: Greenberg. Study supervision: Zipfel, Derdeyn.

management. In these cases, insufficient outpatient medical care (for example, for hyponatremia; 16/97, 16.5%) was the most common shortcoming.

CONCLUSIONS—Most readmissions after aneurysmal SAH relate to late consequences of hemorrhage, such as hydrocephalus, or medical complications secondary to severe neurological injury. Although a minority of readmissions may potentially be avoided with closer medical follow-up in the transitional care environment, readmission after SAH is an insensitive and likely inappropriate hospital performance metric.

Keywords

hospital readmission; patient readmission; subarachnoid hemorrhage; qualitative research; quality indicators; health care; vascular disorders

IN search of ways to improve the quality and efficiency of health care, policymakers in the US have focused on a variety of performance metrics, including inpatient complications, such as hospital-acquired conditions, patient safety indicators, and, increasingly, rates of hospital readmission.[3–5] A recent report from the Robert Wood Johnson Foundation found that hospital readmission is a common, costly problem in the US.[5,10,12,16] For example, almost 20% of Medicare beneficiaries are readmitted within 30 days of discharge, leading to an estimated $17 billion annually, or nearly one-fifth of all Medicare hospital payments.[12,15] To incentivize hospitals to reduce readmission rates, the Centers for Medicare and Medicaid Services (CMS) has begun financially penalizing hospitals that have “excess” readmissions.[5] While readmission penalties are currently focused on patients with myocardial infarction, heart failure, and pneumonia, that list is growing, prompting readmission research in a variety of conditions and raising questions about the effectiveness of this quality measure.[5,26]

Affecting 21,000 to 33,000 people each year in the US, subarachnoid hemorrhage (SAH) is a major source of morbidity and mortality, accounting for 27% of stroke-related potential years of life lost before age 65.[29] Although 30-day readmission has begun to be used as a quality marker in SAH research,[19] most studies investigating readmission in stroke patients have focused on ischemic etiologies, and, therefore, evidence describing the causes underlying rehospitalization after SAH is lacking.[6,20,21,30] While small-scale efforts have been made to identify predictors of readmission after SAH,[28] the reasons for readmission, including both medical/surgical diagnoses and underlying root causes, remain unknown. Stakeholders need such information to determine the extent to which readmission reflects deficiencies in clinical care and subsequently plan quality improvement initiatives to address potential shortcomings. Consequently, the objective of this study was to qualitatively analyze the reasons for 30-day hospital readmission after SAH to evaluate the appropriateness of this performance metric and to identify opportunities for improved patient care.

Methods

We queried the Barnes-Jewish Hospital (BJH) electronic medical record system to identify all patients who received surgical or endovascular treatment for aneurysmal SAH between

January 2003 and June 2013 and were readmitted within 30 days of hospital discharge. The readmission rate was calculated based on the total number of patients readmitted at least once within 30 days of discharge, but for patients readmitted more than once, each readmission event was analyzed independently. We then conducted a retrospective review of each patient's medical record, abstracting information from the original admission, readmission, and when indicated, outpatient visits. When reviewing each chart, many of the components outlined on the Institute for Healthcare Improvement's Readmission Diagnostic Worksheet were considered (http://www.ihi.org/resources/Pages/Tools/ReadmissionsDiagnosticWorksheet.aspx). Two senior faculty (G.J.Z. and C.P.D.) jointly discussed each patient's case and classified readmissions in 2 ways: first, according to the primary medical or surgical diagnosis associated with the readmission; and second, according to the broader underlying factors that contributed to rehospitalization (e.g., related to the patient's health status, the care provided, or social considerations). Any disagreements were resolved by consensus.

To identify the primary diagnoses associated with readmission after SAH, we focused on the single medical or surgical condition most responsible. Thus, if a patient presented with an altered mental status that was subsequently found to be due to hydrocephalus, then delayed hydrocephalus was listed as the primary diagnosis. If no causal etiology was found, altered mental status was listed as the diagnosis. Although some patients also had secondary or tertiary diagnoses at presentation, the rationale behind the approach taken was to identify the conditions with the largest impact on readmission to help focus potential preventative efforts. For this study, delayed hydrocephalus was defined as any patient presenting with hydrocephalus at the time of hospital readmission who did not require shunt placement during index admission.

To determine the broader underlying factors leading to readmission, we considered the impact of the index hemorrhage and its resulting morbidity, the inpatient and outpatient care provided, and continuity of care in health care transitions (e.g., between original hospitalization and a skilled nursing facility). When making such assignments, we distinguished cases in which specific management changes may have prevented rehospitalization from those in which no treatment lapses were found. A liberal definition was used to categorize a readmission as likely avoidable if any shortcoming was identified in clinical care that may have significantly contributed to readmission, regardless of whether other contributing factors may have been present.

When recorded in the medical record, the discharge disposition from each patient's original admission, as well as the locations from which patients were readmitted (such as home or a rehabilitation center) were reported. For patients readmitted to BJH via transfer from an outside hospital, their location was recorded immediately prior to readmission to the outside facility.

Demographic characteristics were obtained from administrative data queries from the BJH electronic medical record (International Classification of Diseases, Ninth Revision, diagnosis code 430, 852.0, or 852.1 AND procedure code 39.51, 39.52, 39.70, or 39.72). Descriptive statistics were calculated summarizing causes of readmission, and bivariate

analyses (chi-square test, independent samples t-test) were used to compare demographic characteristics of readmitted patients with those of patients who were not readmitted.

To determine the likelihood that the analysis failed to capture readmissions to local community hospitals far from BJH, we examined whether the readmission rate varied with the distance from each patient's home address to BJH. The distance between each patient's home zip code and the BJH zip code (63110) was calculated with Google Maps (http://maps.google.com/) using an SAS macro[36] and address data supplied by BJH administrative electronic medical record queries. The statistical significance of the relationship between distance from BJH (divided into quintiles of distance) and hospital readmission was tested using the Cochran-Armitage test.

All statistical analyses were performed using SPSS (versions 21 and 22, IBM), and SAS (version 9.3, SAS Institute). The Washington University in St. Louis Institutional Review Board approved all study procedures.

Results

During the study period, 778 patients were identified and treated at BJH for aneurysmal SAH. Of those 778 patients, 89 experienced 97 readmission events, giving a total readmission rate of 11.4%. Population demographic characteristics are shown in Table 1. The mean age of readmitted patients was 55.9 ± 14.5 years, and 25.8% of these patients were ≥ 65 years of age. Females comprised 76.4% of the readmitted population. Most (59.6%) readmitted patients were white, whereas 38.2% were black. Age and sex did not differ between patients who were and were not readmitted, but black patients were readmitted almost twice as often as white patients were (18.0% vs 9.8%). The median time to readmission was 9 days (interquartile range [IQR] 3–17.5 days).

Among patients experiencing 30-day readmission, the most common discharge disposition at initial admission was rehabilitation (44.9% of readmitted patients). By comparison, 32.6% were discharged home, and 22.5% were discharged to a skilled nursing/extended care facility. Data were available regarding where patients were readmitted in 90/97 patients (92.8%). Among these 90 patients, 41 (45.6%) were readmitted from a rehabilitation facility, 31 (34.4%) were readmitted from home, and 18 (20%) were readmitted from a nursing home/extended care facility.

The primary medical and surgical diagnoses associated with 30-day readmission are shown in Table 2. Hydrocephalus or related diagnoses was the most common category (26/97, 26.8% of all readmissions). This group included patients readmitted with delayed hydrocephalus (10/97, 10.3% of all readmissions) or shunt malfunction (3/97, 3.1%), along with other diagnoses that could potentially raise concern for hydrocephalus, such as headache (9/97, 9.3%) or altered mental status (4/97, 4.1%). Among patients presenting with delayed hydrocephalus, the median time from discharge to readmission was 17 days (IQR 8.8–24), and the median time from initial admission to readmission was 42.5 days (IQR 31.3–49.0). Infections (16/97, 16.5%) were another common reason for readmission, with wound infection (5/97, 5.2%), urinary tract infection (UTI) (3/97, 3.1%), and pneumonia

(3/97, 3.1%) being the most common infectious etiologies. Notably, 8/97 (8.2%) patients were readmitted for planned procedures, most commonly bone flap replacement following craniectomy (4/97, 4.1%). Among the remaining unplanned readmissions, thromboembolic complications were responsible for 8/97 (8.2%) events, while a variety of medical (23/97, 23.7%), neurological (12/97, 12.4%), and psychiatric (4/97, 4.1%) diagnoses accounted for most others.

The broader factors underlying 30-day readmissions are shown in Table 3. In most cases (75/97, 77.3%), no treatment lapses contributing to readmission were found. The most common cause of readmission was delayed development of SAH-related pathology, despite appropriate monitoring and treatment during the initial admission (36/97, 37.1%). This category included patients who developed delayed hydrocephalus/shunt malfunction (13/97, 13.4% of all readmissions), along with conditions like new-onset severe headache (7/97, 7.2%), altered mental status (3/97, 3.1%), and seizures (3/97, 3.1%). Complications related to neurological impairment and immobility, in the absence of any treatment lapses, led to approximately one-fifth of the readmissions. This group consisted mostly of infections (9/97, 9.3%), such as UTI in catheter-dependent patients, and thromboembolic events that occurred despite high-dose chemoprophylaxis and routine mechanical prophylaxis (6/97, 6.2%). Complications from initial admission surgery led to 5/97 (5.2%) readmissions, and invariably involved wound infections.

In 22/97 (22.7%) patients, alternative management may have been indicated and likely could have prevented readmission. The most common shortcoming was in outpatient care, where 12/97 (12.4%) readmissions likely would have been avoided with better follow-up of SAH-related pathology (e.g., hyponatremia) and 4/97 (4.1%) may have been prevented with closer management of comorbid disease (e.g., chronic obstructive pulmonary disease [COPD] exacerbation). Inadequate disposition planning and co-ordination of care contributed to 4 (4.1%) readmissions: 2 patients required a higher level of care than their outpatient facility could provide; 1 patient with a deep vein thrombosis (DVT) during original admission developed a pulmonary embolism when not discharged on subcutaneous heparin; and 1 was readmitted for perceived altered mental status at rehabilitation, when in fact she was at her neurological baseline. Only 2 readmissions (2.1%) may have resulted from premature discharge: 1 patient developed symptomatic vasospasm after early discharge, and 1 was called back to the hospital on the day of discharge for a DVT that had not been reported earlier. Even among patients whose readmission may have been avoided with alternative management, most appeared not to suffer any lasting morbidity at the time of discharge that may have otherwise been prevented. However, 1 patient did develop a stroke while potentially not taking necessary antiplatelet medication in the outpatient setting.

Impact of Travel Distance on 30-Day Readmission

Among 778 patients with aneurysmal SAH treated at BJH during the study period, the median distance from home to BJH was 30 miles (range 0–1839 miles). The readmission rate consistently decreased with increasing distance from patients' home addresses to BJH (Fig. 1), with the readmission rate ranging from 15.4% for the quintile of patients closest to BJH to 5.8% for the farthest quintile ($z = 3.2$; $p = 0.001$).

Discussion

Hospital readmission is an increasingly important topic in stroke management and neurosurgical practice more broadly. Although several studies have attempted to identify risk factors for readmission, such efforts alone are insufficient to understand the utility of rehospitalization as a quality metric and to identify targets for improved patient care.[20,28] To complement these quantitative approaches, qualitative analyses have been used for a variety of conditions to identify the causes underling readmission, including potential lapses in care and unavoidable disease progression.[9,22,25,33] In this study, we qualitatively analyzed the unique factors leading to rehospitalization after aneurysmal SAH. We found that 11.4% of patients were readmitted within 30 days, and the most common associated diagnosis was hydrocephalus. Notably, most readmissions resulted from delayed development of SAH-related pathology or complications associated with severe neurological impairment, despite appropriate care. Among cases where alternative management likely would have prevented re-hospitalization, most readmissions related to the need for better medical follow-up after discharge.

Hydrocephalus resulting from SAH has been studied since at least the 1960s,[17] and numerous investigations have attempted to identify which factors predict increased risk.[7,8,13,14,24,27,32] However, comparatively less attention has been focused on the development of late hydrocephalus,[13,14] and to our knowledge, no studies have specifically examined predictors of delayed hydrocephalus among patients who initially appeared safe for discharge from initial admission. Therefore, despite years of study, evidence is sparse that guides efforts to manage the risk of hydrocephalus after discharge following aneurysmal SAH. Although 10% of readmitted patients in the study population were diagnosed with hydrocephalus, concern for hydrocephalus with conditions like headache or altered mental status potentially influenced approximately one-fourth of all readmission decisions. Buchanan et al.[2] recently highlighted the burden caused by shunt complications, but our results emphasize the need to identify populations at risk for late hydrocephalus, and subsequently, to develop evidence-based guidelines for focused outpatient follow-up. These efforts will enable earlier identification of patients needing intervention and may also help distinguish which patients can be safely monitored in an outpatient setting.

The results of this study also highlight the relatively high rate of readmission due to infection. Generally a result of neurological impairment and immobility, the infections observed—such as wound infection, UTI, and *Clostridium difficile* (*C. difficile*) infection—represented a heterogeneous collection of diseases whose development may have been influenced by numerous subtle factors during inpatient and outpatient care delivery. Thus, although specific actions were not identified that likely could have prevented these readmissions, the study results emphasize the need for continued quality improvement efforts to combat the persistent burden imposed by infection in SAH patients.

Analyses of hospital readmission may highlight persistent causes of morbidity that warrant further research, but an effective quality of care metric should reflect adherence to the best available evidence rather than the severity of patients' underlying disease. While surgeons constantly strive to minimize postoperative morbidity, less than 25% of readmissions would

likely have been prevented with specific changes in patient management. This number is somewhat lower than that found by Shah et al.[26] (37%), who examined an entire neurosurgical service. While this discrepancy may relate in part to inter-reviewer variability, it likely also reflects the unique challenges of managing SAH, including a large number of delayed complications and adverse events resulting from severe neurological impairment. In addition, like Shah et al.,[26] we identified a meaningful number of scheduled procedures (8%) and readmissions for unrelated disease (5%). Thus, our study results are consistent with a growing body of literature suggesting that a low 30-day readmission rate is a relatively poor performance marker that often fails to correlate with meaningful outcome measures, such as mortality and patient satisfaction.[16,19,31,34,35]

We also found that simply knowing the diagnosis associated with readmission is insufficient to distinguish which readmissions might have been prevented with better care provided to the patient. For example, most readmissions associated with thromboembolic events (one of the patient safety indicators reported by CMS during initial admissions) resulted from recent surgery and prolonged immobility, despite standard-of-care high-dose chemoprophylaxis and routine mechanical prophylaxis. However, 1 readmission resulted from premature discharge, and another may have resulted from not discharging a patient with a DVT on subcutaneous heparin. Likewise, most readmissions for headache represented unavoidable development of SAH-related pathology, although 2 cases resulted from inadequate management of headaches present since initial discharge. Thus, while CMS has proposed plans to account for planned readmissions, the results of this study add to existing evidence suggesting that administrative diagnosis coding alone cannot distinguish which readmissions were avoidable.[1,5]

Although this study found rehospitalization most often occurred despite high-quality care, an important subset of SAH readmissions likely could have been prevented with earlier and/or more effective outpatient follow-up. Due to neurological insults and resulting poor health, patients with SAH are at risk for a variety of delayed medical complications, such as hyponatremia and dehydration. Managing these conditions is challenging, but the study analysis suggests that closer primary care follow-up may benefit some patients whose complaints could be treated in an outpatient setting. Currently, the evidence regarding early clinician follow-up preventing readmission is mixed.[11,12,23,34] However, given the complexity of caring for patients with SAH, the role of early follow-up (e.g., within 1 week of discharge) with a primary care physician in preventing readmission may warrant further investigation in this unique population. Recent work has also emphasized the effectiveness of complex, multifaceted strategies in reducing readmission,[18] and a combination of multiple inpatient and outpatient strategies could also be impactful in preventing rehospitalization after SAH.

Notably, the study found that patients living farther from BJH were significantly less likely to be readmitted than those living closer. This finding suggests that the study analysis probably did not include some patients living farther from BJH who may have been readmitted to local community hospitals, a potential shortcoming in any single-center study on hospital readmission. Such missing data may potentially create selection bias if patients readmitted to BJH typically had more severe conditions than those readmitted to local

community hospitals. However, beyond being a tertiary academic center, BJH also serves as the primary local hospital for many patients in the study cohort (half of the cohort lived within 30 miles of BJH), indicating that the results presented herein constitute a broad and representative cross-section of the reasons for readmission following aneurysmal SAH. Thus, although possible selection bias is a limitation, such bias is unlikely to substantially impact the study conclusions.

Beyond the potential for selection bias, this study has additional limitations. First, while 2 experienced clinicians deliberated each case, evaluations were based on retrospective chart review, which likely did not capture some subtle elements, such as complex social dynamics. Second, while an attempt was made to distinguish which readmissions were potentially avoidable, such assertions were limited by the study design. In particular, readmissions that may have been prevented with different outpatient care (16/22) were inherently more speculative and less certain than the less frequent instances where readmission was likely avoidable with later discharge or better discharge planning (6/22). Finally, although our cohort was large, this analysis was based on a single tertiary medical center and could reflect, in part, the practice patterns at this institution. Therefore, follow-up studies are needed to determine whether these results generalize to patients with SAH treated at other academic and community hospitals.

Conclusions

Readmission after SAH is an insensitive and likely inappropriate hospital performance metric that is usually unrelated to the quality of the care provided. Hospital readmission most commonly results from delayed consequences of SAH, such as hydrocephalus, or medical complications secondary to severe neurological injury. By ensuring that all patients with SAH receive primary care physician follow-up within 1 week of hospital discharge, a potential focus for future quality improvement studies, some of the latter may be prevented.

Acknowledgments

This work was supported by a training grant awarded to Dr. Greenberg from the Clinical and Translational Science Award (CTSA) program of the National Center for Advancing Translational Sciences (NCATS) of the NIH under award numbers UL1 TR000448 and TL1 TR000449. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

ABBREVIATIONS

BJH	Barnes-Jewish Hospital
CMS	Centers for Medicare and Medicaid Services
COPD	chronic obstructive pulmonary disease
DVT	deep vein thrombosis
IQR	interquartile range
SAH	subarachnoid hemorrhage

UTI urinary tract infection.

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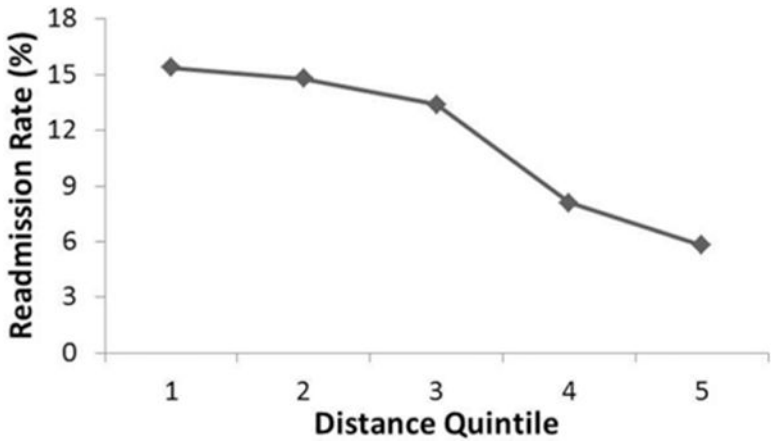

Fig. 1.

Graph showing the relationship between the 30-day readmission rate and the distance between patients' home addresses and BJH. Quintile 1 represents the group of patients closest to BJH, whereas Quintile 5 represents the group farthest from BJH. The p value for the Cochran-Armitage test was 0.001.

TABLE 1

Demographic characteristics of patients treated for spontaneous subarachnoid hemorrhage

		30-Day Readmission (%)		
Characteristic	**Total No.**	**Yes**	**No**	**p Value**
Total	778	89 (11.4)	689 (88.6)	
Mean age ± SD	55.5	55.9 ± 14.5	55.4 ± 14.4	0.76
Age category				
≥65 yrs	189	23 (12.2)	166 (87.8)	0.72
<65 yrs	589	66 (11.2)	523 (88.8)	
Race				0.003
White	541	53 (9.8)	488 (90.2)	
Black	189	34 (18.0)	155 (82.0)	
Other	48	2 (4.2)	46 (95.8)	
Sex				0.19
Female	548	68 (12.4)	480 (87.6)	
Male	230	21 (9.1)	209 (90.9)	

TABLE 2

Primary medical/surgical diagnoses for patients readmitted within 30 days of hospital discharge

Diagnosis	No. of Readmissions (%)
Hydrocephalus & related diagnoses	26 (26.8)
Hydrocephalus	10 (10.3)
Headache	9 (9.3)
Altered mental status	4 (4.1)
Shunt malfunction	3 (3.1)
Infection	16 (16.5)
Wound infection	5 (5.2)
UTI	3 (3.1)
Pneumonia	3 (3.1)
Fever of unknown origin	2 (2.1)
C. difficile infection	2 (2.1)
Viral gastroenteritis	1 (1.0)
Planned procedure	8 (8.2)
Planned bone flap replacement	4 (4.1)
Planned stent placement	2 (2.1)
Planned clipping/coiling	2 (2.1)
Thromboembolic complication	8 (8.2)
DVT	4 (4.1)
Pulmonary embolism	4 (4.1)
Psychiatric disturbance	4 (4.1)
Other neurological reasons	12 (12.4)
New intracranial hemorrhage	4 (4.1)
Seizure	3 (3.1)
Vasospasm	2 (2.1)
Syncope	2 (2.1)
Ischemic stroke	1 (1.0)
Other medical reasons	23 (23.7)
Dilantin drug reaction	3 (3.1)
Hyponatremia	3 (3.1)
Acute renal failure	2 (2.1)
Dehydration	2 (2.1)
Respiratory distress	2 (2.1)
Other	11 (11.3)

TABLE 3

Underlying root causes for 30-day hospital readmission

Cause of Readmission	No. of Readmissions (%)
Delayed development of SAH-related pathology	36 (37.1)
Hydrocephalus/shunt malfunction	13 (13.4)
Headache	7 (7.2)
Altered mental status	3 (3.1)
Seizure	3 (3.1)
Other	10 (10.3)
Complications related to neurological impairment & immobility	21 (21.6)
Infections other than wound infection	9 (9.3)
Thromboembolic complications	6 (6.2)
Respiratory distress	2 (2.1)
Other	4 (4.1)
Complication from a neurosurgical procedure	5 (5.2)
Wound infection	5 (5.2)
Planned admission	8 (8.2)
Unrelated disease	5 (5.2)
Appendicitis	1 (1.0)
Necrotic fibroid	1 (1.0)
Other	3 (3.1)
Potentially inadequate outpatient medical follow-up of SAH-related pathology	12 (12.4)
Hyponatremia	3 (3.1)
Dehydration	2 (2.1)
Headache	2 (2.1)
Other	5 (5.2)
Potentially inadequate outpatient follow-up of comorbid medical disease	4 (4.1)
COPD exacerbation	1 (1.0)
Hypertensive urgency	1 (1.0)
Other	2 (2.1)
Problems w/ healthcare transitions	4 (4.1)
Required higher level of care	2 (2.1)
Altered mental status	1 (1.0)
Pulmonary embolism	1 (1.0)
Premature discharge	2 (2.1)
DVT	1 (1.0)
Vasospasm	1 (1.0)