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Risk Factors and Patterns of Potentially Avoidable Readmission in Patients With Cancer

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QUESTION ASKED: What are the risk factors associated with 30-day potentially avoidable readmissions in patients with cancer?

SUMMARY ANSWER: Almost 40% of patients with cancer had a 30-day readmission, and almost one third of these were deemed potentially avoidable. Risk factors included the number of medications, liver disease, low sodium, and low hemoglobin level at discharge.

WHAT WE DID: In a retrospective cohort of 2,916 patients discharged from the oncology division of an academic tertiary medical center, we identified predictors of potentially avoidable 30-day readmissions by using the SQLape algorithm and multivariable logistic regression.

WHAT WE FOUND: Among the cohort, 37.3% were readmitted within 30 days, and of these, 31.4% of all readmissions, 11.7% of the cohort, were considered potentially avoidable. Several independent risk factors for potentially avoidable readmission were identified. Causes of readmission were similar to the causes of the index readmission: neoplasm, infection, nutritional and metabolic disorders, GI disorders, and renal failure.

BIAS, CONFOUNDING FACTOR(S), REAL-LIFE IMPLICATIONS: Although we were not able to account for the stage of cancer, and we cannot prove preventability of readmissions in these patients, the use of these easily available risk factors can help physicians to identify patients who may benefit from intensive transitional care interventions. JOP

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Abstract

Purpose

Patients with cancer are particularly at risk for readmission within 30-days after discharge. To identify the patients who might benefit from more-intensive discharge interventions, we identified the risk factors associated with 30-day potentially avoidable readmissions.

Methods and Materials

We included all consecutive discharges from the oncology division of an academic tertiary medical center in Boston, Massachusetts, between July 1, 2009, and June 30, 2010. Potentially avoidable 30-day readmissions to the index hospital and two other hospitals within its network were identified. We performed a multivariable logistic regression in which the final model included variables found in bivariable testing to be significantly associated with the outcome.

Results

Among the 2,916 patients discharged during the study period, 1,086 (37.3%) were readmitted within 30 days. Of these, 341 (31.4% of all readmissions, 11.7% of all discharges) were identified as potentially avoidable. In the multivariable analysis, the following patient factors were associated with a significantly higher risk of a potentially avoidable readmission: total number of medications at discharge, liver disease, last sodium level, and last hemoglobin level before discharge. In addition, potentially avoidable readmissions occurred significantly earlier than unavoidable readmissions (median, 10 *v* 13 days; $P < .001$).

Conclusion

Almost 40% of patients with cancer had a 30-day readmission, and almost one third of these were deemed potentially avoidable, and several risk factors for this were identified. Interventions at discharge may be prioritized to patients with these risk factors.

INTRODUCTION

Avoidable hospital readmission is a widely recognized problem within the modern health care system because of its direct effects on patient outcomes and costs of care and because it represents a natural target for quality improvement efforts. Several studies have identified specific factors associated with hospital readmissions, but emerging data have demonstrated that the nature of the problem is both multifaceted and complex. Underlying diagnoses as well as comorbidities can influence the likelihood of a patient's hospital readmission in ways that remain incompletely understood.[1,2] Geriatric patients are at increased risk for hospital readmission after an index hospitalization,[3] but a recent study identified

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patients with cancer as another group at particular risk for readmission within 30 days of hospital discharge.[1]

Evaluation of hospital readmissions within the oncology patient population presents a particular challenge for several reasons. First, many oncology hospitalizations are planned for the administration of elective chemotherapy and do not represent a failure of the system to prevent avoidable readmissions. Second, patient comorbidities are key factors that contribute to avoidable hospital readmissions.[1] Oncology patients may have multiple and complex comorbidities as a result of not only the etiology of their malignancy but also the expected, and thus incompletely preventable, complications of treatment. Finally, many oncology patients will face end-of-life decisions, another independently identified variable that can contribute to potentially avoidable readmissions.[4]

Overall, oncology patients represent a large and growing complex and medically vulnerable population. Identification of specific risk factors associated with potentially avoidable readmissions in this population may allow for more targeted interventions to prevent readmissions and thereby improve disease outcomes, quality of life, and cost-effective delivery of care. We used a retrospective cohort of consecutive adult patient discharges from an academic tertiary hospital with a large inpatient oncology census to identify specific risk factors associated with 30-day potentially avoidable readmissions.

METHODS AND MATERIALS

Study Design and Population

We included all consecutive adult patients discharged from the oncology service of the Brigham and Women's Hospital (BWH)/Dana-Farber Cancer Institute (DFCI) between July 1, 2009, and June 30, 2010. BWH is a 750-bed academic medical center in Boston, Massachusetts. DFCI is a National Cancer Institute–designated Comprehensive Cancer Center. Since 1997, all DFCI inpatients are hospitalized within BWH. Hospital stays of $\leq$ 24 h were not included because they are mainly observational stays. We excluded patients who died before discharge of the index hospitalization, were transferred to another acute health care facility, or left against medical advice. We excluded patients who died during the index hospitalization because they were no longer at risk for readmission, and we excluded patients who were transferred to another health care facility because the risk of readmission must be measured at the time of discharge from the second facility and based on that facility's data. The study protocol was approved by the institutional review board of BWH/Partners Healthcare.

Study Outcome

The study outcome was any 30-day potentially avoidable readmission to any service of three hospitals within the Partners Healthcare network, which were BWH, Massachusetts General Hospital (a 1,000-bed tertiary care hospital), and Faulkner Hospital (a 150-bed community hospital closely affiliated with BWH). More than 80% of all readmissions after an index medical admission to BWH are captured within this network.[5,6] We identified readmissions deemed potentially avoidable with a validated algorithm (SQLape, Corseaux, Switzerland) that uses administrative data, mainly diagnostic and procedure codes of both index admission and readmission.[7,8] The algorithm excludes unavoidable foreseen readmissions, such as those for chemotherapy or radiotherapy, transplantation, labor and delivery, and other specific surgical procedures. Follow-up and rehabilitation treatments also are considered unavoidable. Readmissions for a disease that occurred in a new organ system (eg, circulatory, respiratory, digestive, hepatic, nervous, blood) not affected during the index hospitalization were also considered unavoidable. Readmissions related to specific difficult-to-cure diseases (eg, multiple sclerosis, idiopathic thrombocytopenia) were considered unavoidable. Conversely, complications of treatment, such as deep vein thrombosis or catheter-associated urinary tract infection, were considered potentially avoidable,[8] as were other readmissions that involve an organ system affected during the index hospitalization. The sensitivity and the specificity of the screening algorithm reached 96% compared with medical chart review (with use of the same criteria) in a random sample of admission-readmission pairs.[9] We chose the SQLape algorithm because it was the only available tool to our knowledge that differentiates unavoidable from potentially avoidable readmissions.

Predictor Variables

We collected data on several types of variables from easily obtainable sources (Table 1), including demographic information, previous health care use, primary care provider information, and index admission characteristics from administrative data sources; procedures and chronic medical conditions from billing data; and last known laboratory values before discharge from the Partners Healthcare clinical data

Table 1. Baseline Characteristics and Bivariable Analysis

Characteristic	No 30-Day Readmission, No. (%)	30-Day PAR, No. (%)	*P*
No. of patients	1,830	341	
Mean age (SD), years	61.0 (13.9)	60.0 (13.8)	.62
Male sex	893 (48.8)	151 (44.3)	.16
Ethnicity			.59
Non-Hispanic white*	1,544 (84.4)	287 (84.2)	
Non-Hispanic black	155 (8.5)	28 (8.2)	
Hispanic	73 (4.0)	19 (5.6)	
Other†	58 (3.2)	7 (2.1)	
Language‡			.33
English*	1,720 (94.0)	322 (94.4)	
Spanish	47 (2.6)	13 (3.8)	
Other§	63 (3.4)	6 (1.8)	
Marital status			.90
Currently married or partner*	1,147 (62.7)	209 (61.3)	
Single or never married	341 (18.6)	66 (19.4)	
Separated, divorced, widowed, or no answer	342 (18.7)	66 (19.4)	
Primary insurance			.33
Medicare	759 (41.5)	133 (39.0)	
Medicaid	110 (6.0)	28 (8.2)	
Private	960 (52.5)	180 (52.8)	
Source of index admission			.43
Direct from home of outpatient clinic	764 (41.7)	134 (39.3)	
Emergency department*	837 (45.7)	156 (45.7)	
Nursing home, rehabilitation, or other hospital	229 (12.5)	51 (15.0)	
Median index hospitalization LOS (IQR), days	4 (3-7)	5 (3-8)	.003
Median No. of hospitalizations in the past year (IQR)	1 (0-2)	1 (0-3)	.02
Urgent/emergent index hospitalization	1,613 (88.1)	312 (91.5)	.08
Identified caregiver at discharge	111 (6.1)	21 (6.2)	.95
Mean No. of medications at discharge (SD)	10.5 (4.8)	11.8 (5.0)	< .001
Opiate medication at discharge	1,005 (56.4)	223 (66.6)	.001
Anticoagulation therapy at discharge	327 (18.4)	87 (26.0)	.002
Median Elixhauser comorbidity index (IQR)	16 (9-28)	19 (9-34)	.001
Mean hemoglobin level at discharge (SD), g/dL	10.3 (1.4)	10.0 (1.3)	.002
Mean sodium level at discharge (SD), mEq/L	136.9 (3.7)	136.1 (3.7)	< .001
Type of malignant neoplasm			
Hematologic neoplasm	694 (37.9)	111 (32.6)	.08
Metastatic neoplasm	877 (47.9)	189 (55.4)	.02
Neuro	31 (1.7)	9 (2.6)	.31
Head and neck	22 (1.2)	4 (1.2)	.97
Pulmonary	201 (11.0)	36 (10.6)	.81
GI	199 (10.9)	45 (13.2)	.22

(continued on following page)

Table 1. Baseline Characteristics and Bivariable Analysis (continued)

Characteristic	No 30-Day Readmission, No. (%)	30-Day PAR, No. (%)	*P*
Renal	30 (1.6)	7 (2.1)	.61
Gynecologic	48 (2.6)	17 (5.0)	.07
Pancreatic	52 (2.8)	14 (4.1)	.21
Selected comorbidities			
Diabetes mellitus	280 (15.3)	55 (16.1)	.72
Congestive heart failure	101 (5.5)	29 (8.5)	.05
Ischemic heart disease	182 (9.9)	39 (11.4)	.46
Atrial fibrillation	125 (5.8)	28 (1.3)	.39
Chronic obstructive pulmonary disease	124 (6.8)	25 (7.3)	.68
Chronic kidney disease	106 (5.8)	20 (5.9)	.96
Liver disease	54 (3.0)	16 (4.7)	.07
Most frequent reasons of the index admission			.37
Neoplasm	435 (23.8)	66 (19.4)	
Infectious disease	203 (11.1)	29 (8.5)	
GI disorder	93 (5.1)	15 (4.4)	
Nutritional and metabolic disorder	81 (4.4)	17 (5.0)	
Liver disorder	39 (2.1)	7 (2.1)	
Renal failure	35 (1.9)	9 (2.6)	
Venous thromboembolism	33 (1.8)	6 (1.8)	

Abbreviations: IRQ, interquartile range; LOS, length of stay; PAR, potentially avoidable readmission; SD, standard deviation.
*Reference group for the multivariable logistic regression.
†Includes Asian, Pacific Islander, Native American, and Alaskan Native.
‡Preferred language based on hospital administrative data.
§Includes Chinese and French.

repository. Variables were chosen a priori and according to the medical literature.[10-12]

Comorbidities were retrieved from the index hospitalization by using the following International Classification of Diseases, Ninth Revision, Clinical Modification, codes: diabetes mellitus (249.00 to 250.99), congestive heart failure (428.x, 425.4 to 425.9, 402.01, 402.11, and 398.91), ischemic cardiac disease (410.00 to 414.99), atrial flutter/fibrillation (427.30 to 427.32), chronic obstructive pulmonary disease (491.00 to 492.99, 493.2, and 496), chronic kidney disease (585.00 to 586.99), and liver disease (571.00 to 573.99).

Primary Diagnosis of Readmission

The primary diagnosis of each readmission was identified by using the following Medicare Severity Diagnosis-Related Groups codes: congestive heart failure (291 to 293, 189), chronic obstructive pulmonary disease (190 to 192), cardiac ischemic disease (231 to 236, 246 to 251, 280 to 285), arrhythmia (308 to 310), cerebrovascular diseases (061 to 072), adverse drug events (917 to 923), renal failure (682 to 685), nutritional and metabolic disorders (640 to 641), venous thromboembolism (175 to 176, 294 to 295), liver disorders (405 to 434, 438 to 446), GI disorders (391 to 392, 377 to 384), infectious diseases (075 to 076, 094 to 099, 121 to 122, 177 to 179, 193 to 195, 371 to 373, 485 to 489, 548 to 550, 689 to 690, 757 to 759, 853 to 863, 865 to 872), and neoplasm (054 to 055, 146 to 148, 180 to 182, 374 to 376, 435 to 437, 582 to 583, 597 to 599, 656 to 658, 686 to 688, 715 to 724, 736 to 741, 754 to 756, 846 to 849).

Statistical Analysis

Patient baseline characteristics are presented as proportions, means with standard deviations, and medians with interquartile ranges (IQRs) as appropriate. The unit of analysis was any patient's index discharge from the oncology service.

The presence of any difference in baseline characteristics between the groups with a 30-day potentially avoidable readmission and those not readmitted at all was first tested by bivariable logistic regression. We then performed a multivariable logistic regression in which the final model included variables found to be significantly associated with the outcome in bivariable testing at the $P = .05$ level. The time to

readmission within the 30-day frame is presented as median with IQR.

All tests were conducted as two sided at a .05 level of significance. Analyses were performed with SAS 9.3 statistical software (SAS Institute, Cary, NC).

RESULTS

Among the 3,505 patients discharged from the oncology division, 399 were excluded because they were transferred to another acute health care facility, 185 because they died, and five because they left against medical advice. Of the remaining 2,916 patient discharges, 1,086 (37.3%) were followed by a readmission within 30 days. Of these, 341 (31.4% of all readmissions, 11.7% of all discharges) were identified as potentially avoidable (Appendix Fig A1, online only). Table 1 compares the baseline characteristics between the patients who did not have a 30-day readmission and those who had a 30-day potentially avoidable readmission.

From the bivariable analysis, the following factors were associated with a 30-day potentially avoidable readmission at the .10 significance level: length of stay, number of admissions in the previous 12 months, urgent or emergent index hospitalization, total number of medications on discharge, opiate medication use at discharge, anticoagulation at discharge, Elixhauser comorbidity index, hemoglobin level at discharge, sodium level at discharge, hematologic neoplasm, metastatic neoplasm, ovarian neoplasm, congestive heart failure, and liver disease. In the multivariable analysis, the following risk factors remained significantly and independently associated with a potentially avoidable readmission: total number of medications at discharge, liver disease, sodium level at discharge, and hemoglobin level at discharge (Table 2).

The five most frequent primary diagnoses at readmission were neoplasm, infection, nutritional and metabolic disorder, GI disorder, and renal failure (Table 3). Of note, these were five of the top six primary diagnoses for the index hospitalization (Table 1). The median time of occurrence of 30-day potentially avoidable readmissions was 10 (IQR, 9 to 11) days versus 13 (IQR, 12 to 14) days for 30-day unavoidable readmissions ($P < .001$). The median time of 30-day potentially avoidable readmission varied from 4 to 12 days according to the primary diagnosis of readmission (Table 3). Readmissions due to adverse drug events, GI disorders, renal failure, or infection tended to

Table 2. Multivariable Analysis of Risk Factors for 30-Day Potentially Avoidable Readmission in Patients With Cancer

Variable	Odds Ratio (95% CI)	*P*
Length of stay, per 1-day increase	1.01 (1.00 to 1.02)	.32
Urgent/emergent index hospitalization	1.34 (0.82 to 2.19)	.24
No. of admissions in the previous year*	1.05 (0.99 to 1.12)	.10
Total No. of medications at discharge*	1.03 (1.01 to 1.06)	.02†
Opiate medication at discharge	1.20 (0.88 to 1.62)	.25
Anticoagulation therapy at discharge	1.36 (0.99 to 1.85)	.05
Elixhauser comorbidity index, per 1-unit increase	1.00 (0.99 to 1.01)	.96
Congestive heart failure	1.58 (0.96 to 2.59)	.07
Liver disease	1.75 (1.02 to 3.00)	.04†
Hematologic neoplasm	1.08 (0.73 to 1.62)	.70
Metastatic neoplasm	1.26 (0.82 to 1.95)	.29
Ovarian neoplasm	1.88 (0.88 to 4.00)	.10
Hemoglobin, per 1 mmol/L decrease	1.14 (1.03 to 1.25)	.01†
Sodium level, per 1 mmol/L decrease	1.04 (1.00 to 1.07)	.03†

*Per 1-unit increase.
†Statistically significant.

Table 3. Median Time of Readmission According to the Cause of 30-Day Potentially Avoidable Readmissions (n = 341)

Primary Diagnosis of Readmission	No. (%)	Median Time of Readmission (IQR)
Neoplasm	67 (19.7)	10 (4-19)
Infection	45 (13.2)	9 (4-14)
Nutritional or metabolic disorder	17 (5.0)	11 (6-14)
GI disorder	16 (4.7)	6.5 (4-14)
Renal failure	11 (3.2)	8 (4-17)
Arterial or venous thrombosis	5 (1.5)	14 (14-19)
Adverse drug event	5 (1.5)	6 (6-17)
Heart failure	3 (0.9)	12 (4-26)
Other	172 (50.4)	11 (5-17)

Abbreviation: IQR, interquartile range.

occur earlier, whereas readmissions due to nutritional or metabolic disorders, heart failure, and thrombosis occurred later.

DISCUSSION

In this cohort of 2,916 patients with cancer, we found that almost 40% were readmitted within 30 days and that approximately one third of these readmissions were considered potentially preventable. Several factors were identified as independently associated with 30-day potentially avoidable readmission, including the total number of medications at discharge, liver disease, last sodium level, and last hemoglobin level before discharge. Of note, potentially avoidable readmissions occurred significantly earlier than unavoidable readmissions, with time to readmission varying substantially according to the readmission diagnosis.

Patients with cancer have a particularly high risk for readmission,[2,13] but the characteristics of this population are not clear. The majority of the studies on readmission among patients with cancer looked at surgical patients with postoperative readmission for specific cancers.[14-19] Much less is known about the readmission characteristics for general patients with cancer hospitalized within a medical or oncology service.[20-22]

Many of the potentially avoidable readmissions in this study simply represent progression of disease or unavoidable adverse effects of treatment (and thus, are not truly preventable). However, as in other studies that used the SQLape algorithm, those with potentially avoidable readmissions should be thought of as a population enriched for patients whose readmissions might have been prevented with more-intensive transitional care activities.

The risk factors identified in this study seem plausible. The total number of medications likely represents a proxy for patient comorbidities and/or higher risk for readmission due to adverse drug events. Liver disease in patients with cancer may represent metastatic disease, which carries a poor prognosis as well as a risk for bleeding, infection, hepatic encephalopathy, and other complications of cirrhosis. Low sodium level is associated with poor outcomes in many disease states[23-26] and may reflect a higher risk due to comorbidities that cause hyponatremia (eg, heart failure), chemotherapy-induced dehydration, or syndrome of inappropriate antidiuretic hormone secretion due to total cancer burden or lung or brain involvement. Finally, a low hemoglobin may reflect bone marrow suppression associated with certain chemotherapies, poor nutritional status, and/or anemia of chronic inflammation. Most of these risk factors are not modifiable, however, and we do not imply that by addressing these risk factors themselves, even if they are modifiable, postdischarge outcomes would be improved. However, these risk factors identify patients who may benefit from intensive transitional care interventions.

The study has several limitations. First, we included in the analysis only predictors easily obtainable from electronic data sources. We cannot exclude the presence of other important risk factors for readmission, such as the functional status of the patient. In addition, we were not able to capture the stage of the cancer. On the basis of the available data, we show that metastatic neoplasm was not an independent risk factor for 30-day potentially avoidable readmission in multivariable analysis. This finding suggests that the stage may not be as important as expected, but we acknowledge that this coding is an imperfect proxy for cancer stage and that further studies are needed to explore this particular relationship. Second, no gold standard is available for the definition of preventable readmission. The identification of potentially avoidable readmission with the SQLape algorithm is not perfect, and whether the algorithm is any more or less diagnostic for oncology patients than any other category of hospitalized medical patients is unknown. However, SQLape has been used in numerous other studies; uses clear and logical criteria, which allow for reproducibility and reliability in the analysis of large databases; and is useful for identifying risk factors. The study

may have been underpowered to identify all clinically important risk factors. We do not have information to draw conclusions about whether the risk factors for potentially avoidable readmission differ for patients readmitted to a different hospital from the site of their index hospitalization. Finally, this single-center study was from an academic hospital with a major cancer institute, and results might not be generalizable to other settings. Next steps could include detailed medical record review to determine the true preventability of these readmissions, identify potentially actionable risk factors unique to this population, and better understand the differences in time to readmission among various populations.

In conclusion, readmission in this large cohort of patients with cancer was frequent, with approximately one third of readmissions deemed potentially preventable. Risk factors associated with 30-day potentially avoidable readmission are the number of medications, liver disease, and low sodium and hemoglobin levels. Patients discharged with these factors could benefit from transitional care interventions. JOP

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AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

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Appendix

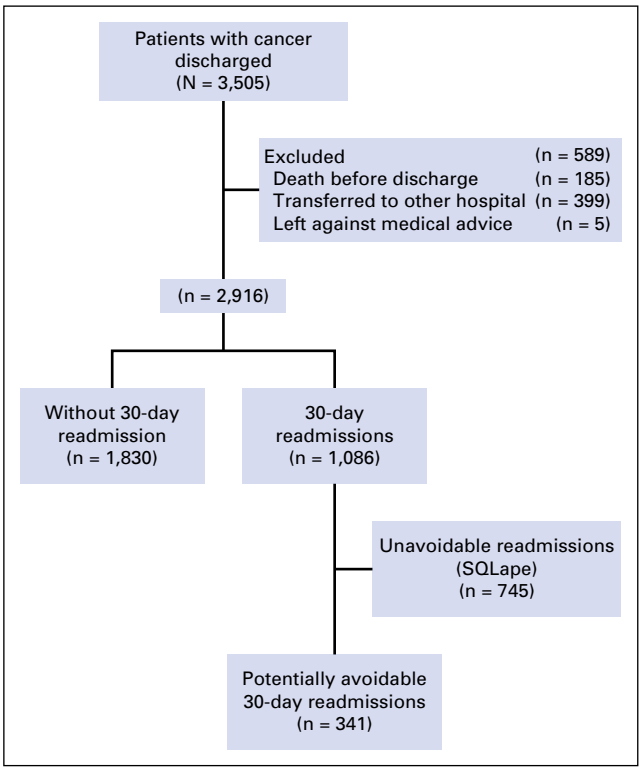

FIG A1. Study flow diagram describing the readmissions of all consecutive discharges from the oncology division of an academic tertiary medical center in Boston, MA, between July 1, 2009, and June 30, 2010.