RESEARCH ARTICLE

Comparison of Clinical Risk Factors Among Pediatric Patients With Single Admission, Multiple Admissions (Without Any 7-Day Readmissions), and 7-Day Readmission

Jeffrey C. Winer, MD, MSHS, MA,[a] Elena Aragona, MD,[b] Alan I. Fields, MD,[c] David C. Stockwell, MD, MBA[c]

ABSTRACT

BACKGROUND AND OBJECTIVE: Readmissions have received increasing attention. The goal of this study was to identify demographic and clinical factors associated with hospital utilization and 7-day readmissions.

METHODS: This retrospective case–control study of inpatient and observation encounters was conducted at a freestanding children's hospital. Over a 1-year period, patients were categorized into 3 groups: patients with a single admission, patients with multiple admissions without any 7-day readmissions, and patients with at least one 7-day readmission. Factors associated with risk of future hospital utilization were determined, and post hoc testing was performed to compare groups.

RESULTS: Patients with a single admission had statistically significant lower numbers of medications at admission and discharge, lower rates of home health care at admission and discharge, and fewer diagnosis codes during index admission than patients with multiple admissions. There were no statistically significant differences among patients with multiple admissions between those with and without 7-day readmissions.

CONCLUSIONS: This study found that patients with multiple admissions were similar regardless of whether they had any 7-day readmissions. Because patients with multiple admissions seemed to represent a single high-risk group, it is possible that many readmissions represent a consequence of medical complexity rather than a failure of care. Further studies are necessary to determine if providing targeted interventions to high-risk patients will lower their future hospital utilization.

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Address correspondence to Jeffrey C. Winer, MD, MSHS, MA, University of Florida, 800 Prudential Dr, 3rd Floor, Jacksonville, FL 32207. E-mail: jeffrey.winer@jax.ufl.edu

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[a]Wolfson Children's Hospital, Jacksonville, Florida; [b]Tufts Floating Hospital for Children, Boston, Massachusetts; and [c]Children's National Health System, Washington, District of Columbia

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Dr Winer conceptualized and designed the study, performed statistical analysis, and drafted the initial manuscript; Drs Aragona and Fields were involved in the initial design of the study, performed chart reviews for data collection, and reviewed and revised the manuscript; Dr Stockwell was involved in the initial design of the study and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

Decreasing readmissions has received increased attention recently due to the focus on improving quality of care as well as decreasing health care costs. Much of this interest derives from the Hospital Readmissions Reduction Program enacted through the Patient Protection and Affordable Care Act.[1,2] For adult hospitals, there have been reimbursement penalties assigned for hospitals with higher than average readmission rates for specific diagnoses.[3,4] Pediatric hospitals have also developed programs to measure and reduce readmissions.[2] In addition, pediatric readmissions have been identified as a quality measure by the Pediatric Quality Measures Program,[5] and some states' Medicaid programs have begun to apply penalties to pediatric readmissions.[6]

Given estimates that only 20% of all pediatric readmissions are preventable, some investigators have questioned whether readmissions should be used as a quality measure.[1,2,7] Preventing readmissions is complex because of patient factors, quality of care, continuity and coordination of care, and resource availability of the family and hospital.[1] Many definitions of readmission exist and are used in pediatrics, including 7-, 15-, and 30-day readmissions. There is also ongoing debate about which readmissions, such as planned readmissions and nonpreventable readmissions, should be included in quality metrics. Many patients have multiple admissions, but different sets of these admissions will be counted toward a given readmissions metric, depending on the definition used.

To prevent short-term readmissions, it is necessary to influence the care provided during or immediately after an admission. One proposed method for preventing pediatric readmissions has been to identify patients at high risk for readmission and allocate resources (eg, postdischarge follow-up telephone calls, home visits) before discharge.[1,4] The advantage of this approach is that it may have additive or synergistic effects over time.[8,9] These interventions might even have a long-term effect on resource utilization for at-risk patients.

In adult patients, multiple risk factors for readmission have been identified, including severity of disease, therapeutic intensity, number of previous admissions, admission to an oncology service, and previous use of both inpatient and outpatient medical resources.[1,10,11] Studies performed on administrative data in pediatric patients have identified the presence of complex chronic diseases, race, insurer, number of previous admissions, length of stay, and failure of outpatient follow-up to be risk factors for readmission.[5,12,13]

The goal of the present study was to identify demographic and clinical risk factors for 7-day all-cause readmissions to identify high-risk patients for targeted interventions. Patients were categorized into 3 mutually exclusive and exhaustive groups: patients with a single admission, patients with multiple admissions without any 7-day readmissions, and patients with at least one 7-day readmission. Seven-day all-cause readmissions were chosen as a separator because it is the quality metric used locally and by the Children's Hospitals' Solutions for Patient Safety National Children's Network.[14] This network is a Hospital Engagement Network, as part of the Partnership for Patients program of the Centers for Medicare & Medicaid Services.

We defined demographic, preadmission clinical factors, and discharge clinical factors for patients during their index admission. The goal of the present study was to predict: (1) if the patient would have multiple admissions; and (2) whether they would have at least one 7-day all-cause readmission.

METHODS

This retrospective case–control study was conducted at a single study site. Inclusion criterion was admission to inpatient or observation status July 1, 2011, through June 30, 2012, as identified within the electronic medical record. Subsequent admissions were followed up over the same time period regardless of index admission date. The study site is a 303-bed tertiary care hospital with ∼15 000 admissions and 5200 observation days annually. This study was approved by the local institutional review board.

Study Sampling and Outcome Determination

The primary outcome was admission group, defined within the 12-month study period regardless of the date of index admission. Patients were divided between those with a single admission and those with multiple admissions. Patients with multiple admissions were further classified based on whether they had been readmitted within 7 days of discharge at any point in the study period.

Patients were included in the 7-day readmission group if any admission during the study period resulted in a 7-day readmission. This approach was used because our goal was to identify patients at risk for readmission as early as possible in their series of admissions. By separating the patients with and without 7-day readmissions, we were able to investigate whether there were demographic or clinical factors that put patients at risk for inclusion in the 7-day readmission quality metric. We were unable to make conclusions about short-term readmission risk after a given admission.

Samples of 100 patients from each group were randomly chosen by using computerized simple randomization. The minimum sample size to ensure 80% power of detecting a relative risk ratio of 2.5 was calculated to be 81, which was rounded to 100. The resultant 300 patients were used as the study sample. The first episode of care for each patient was identified as the index admission and was used as the basis for data collection.

Potential Risk Factor Determination

The Readmissions Improvement Task Force was used to brainstorm potential administrative and clinical risk factors for readmission drawing on existing literature[2,5,6,12,13] as well as group expertise. The factors included demographic characteristics, clinical data available at the time of admission, and clinical data available at the time of discharge (Tables 1 and 2). Each potential risk factor was operationalized and classified as either available within the electronic medical record database or requiring chart review

TABLE 1 Comparison of Demographic Characteristics Between Patients With a Single Admission, Multiple Admissions Without a 7-Day Readmission, and Patients With at Least One 7-Day Readmission

Characteristic	Single Admission	Multiple Admissions	Readmitted	*P*	Readmission Versus Single Admission	Multiple Versus Single Admission	Readmission Versus Multiple Admissions
Male gender	44%	46%	54%	.326[a]	0.472[a]	1.000[a]	0.774[a]
Age, y[b]	7.1 (5.8–8.3)	6.5 (5.3–7.8)	7.0 (5.7–8.3)	.816[c]	1.000[c]	1.000[c]	1.000[c]
Language				.680[a]	1.000[a]	0.312[a]	1.000[a]
English	89%	95%	84%				
Spanish	7%	5%	9%				
Other	4%	0%	7%				
Ethnicity				.111[a]	0.971[a]	0.804[a]	1.000[a]
Black	50%	57%	46%				
White	32%	24%	24%				
Hispanic	11%	16%	16%				
Asian	2%	2%	5%				
Other	5%	1%	9%				
Residence				.100[a]	0.170[a]	0.492[a]	1.000[a]
Home with family	94%	92%	89%				
Home alone	4%	1%	6%				
Foster care	2%	5%	0%				
Group home or rehabilitation	0%	2%	5%				
Location				.656[a]	0.308[a]	1.000[a]	1.000[a]
Maryland	54%	50%	51%				
Washington, DC	25%	30%	33%				
Virginia	16%	17%	16%				
Other	5%	2%	0%				

[a] Calculated with χ^2 test.
[b] Mean (95% CI).
[c] Calculated with analysis of variance.

TABLE 2 Comparison of Clinical Factors Between Patients With a Single Admission, Multiple Admissions Without a 7-Day Readmission, and Patients With at Least One 7-Day Readmission

Variable	Single Admission	Multiple Admissions	Readmitted	*P*	Readmission Versus Single Admission	Multiple Versus Single Admission	Readmission Versus Multiple Admissions
Clinical factors available at the time of index admission							
Admission medications[a]	1.9 (1.5–2.4)	3.8 (3.0–4.6)	3.0 (2.2–3.7)	0.001[b]	0.054[b]	<0.001[b]	0.375[b]
Home health care on admission	9%	30%	26%	0.001[c]	0.004[d]	<0.001[d]	0.955[d]
Emergency department visits in previous year[a]	0.6 (0.3–0.9)	1.1 (0.8–1.4)	0.8 (0.5–1.0)	0.047[b]	1.000[b]	0.054[b]	0.330[b]
Admission source				0.751[c]	1.000[c]	1.000[c]	1.000[c]
Emergency department	62%	57%	59%				
Direct admission	30%	30%	32%				
OR/PACU	8%	13%	8%				
Child protective services involvement	6%	5%	2%	0.353[c]	0.419[d]	1.000[d]	0.667[d]
Clinical factors available at the time of index discharge							
Discharge medications[a]	2.0 (1.5–2.4)	4.2 (3.4–5.0)	3.9 (3.1–4.7)	<0.001[b]	<0.001[b]	<0.001[b]	1.000[b]
Home health care on discharge	10%	25%	29%	0.016[c]	0.002[c]	0.016[c]	1.000[c]
Diagnosis count [a]	4.8 (4.1–5.5)	6.3 (5.4–7.1)	7.2 (6.3–8.0)	0.000[b]	<0.001[b]	0.030[b]	0.381[b]
Procedure count[a]	1.5 (1.0–2.0)	1.8 (1.3–2.2)	2.8 (2.0–3.5)	0.009[b]	0.021[b]	1.000[b]	0.087[b]
Discharge outpatient appointments[a]	1.8 (1.6–2.0)	1.7 (1.5–1.8)	1.8 (1.6–2.0)	0.506[b]	1.000[b]	0.741[b]	1.000[b]
Length of stay[a]	5.8 (3.1–8.5)	6.6 (4.7–8.5)	9.4 (5.5–13.2)	0.209[b]	0.417[b]	1.000[b]	0.624[b]
ICU during admission	25%	27%	28%	0.888[c]	1.000[c]	1.000[c]	1.000[c]
Initially in ICU	20%	23%	22%	0.872[c]	1.000[c]	1.000[c]	1.000[c]

OR/PACU, operating room/postanesthesia care unit.

[a] Mean (95% CI).

[b] Calculated with analysis of variance.

[c] Calculated with χ^2 test.

[d] Calculated with Fisher's exact test.

within the electronic medical record. A data dictionary was developed with an operational definition of all factors. Data were gathered from each patient's first admission within the study period. This method was used in an effort to identify high-risk patients as early as possible and therefore provide the greatest opportunity for improvement of care.

Pilot Testing to Ensure Reliability

Data classified as available directly from the medical record database were obtained for the study sample. A pilot sample of 20 patients had computerized data independently verified to ensure validity of computerized data. Six members of the study group participated in chart review for the 300 patients in the study sample. The chart reviewers each received an instruction manual and underwent interactive learning and assessment before the initiation of chart review. A pilot sample of 20 patients was analyzed by all 6 chart reviewers. For each potential risk factor, and across all factors, κ statistics were calculated. Differences in response were discussed collectively, and the chart review instruction manual was refined as needed to further augment interrater reliability before study initiation.

Statistical Analysis

Binary and categorical variables were summarized as number of patients and percentages. Continuous variables were summarized by using means and SDs.

Hypothesis testing to identify binary and categorical variables associated with risk of readmission was performed by using χ^2 testing; Fisher's exact test was used when any of the values were $<$10. Hypothesis testing to identify continuous variables associated with risk of readmission was performed by using an analysis of variance model. Because of the 3 groups, this initial testing was only able to identify differences but not direction.

Post hoc testing was performed comparing the groups in a pairwise fashion. Bonferroni correction was used to determine statistical significance when multiple analyses were performed. Bivariate logistic regression was performed for each comparison found to have statistical significance, and odds ratios were calculated with 95% confidence intervals (CIs). A multivariate model for risk of multiple admissions (regardless of 7-day readmission history) was derived by using both forward and backward stepwise determination utilizing the likelihood ratio method. Factors with bivariate *P* values $<$.25 were candidates for model inclusion. A *P* value of .10 was used as the stopping rule for inclusion/exclusion in the model in both directions.

RESULTS

Selection of Study Subjects

There were 10 636 individual patients admitted during the study period. Of these patients, 8729 (82.1%) had a single admission. Of the remaining 1907 patients, 475 (4.5%) had at least 1 readmission within 7 days of discharge.

Interrater Reliability of Chart Review Items

The factors that were generated through database query were gender, age, ethnicity, language, residence type, insurance type, state of residence, number of emergency department visits in the previous year, diagnosis and procedure count, and ICU usage. In a review of 20 pilot charts, the concordance rate was 0.98. The factors that were generated through chart review were number of admission and discharge medications, home health care at admission and discharge, number of appointments made at discharge, admission source, and involvement of child protective services. For all factors other than language (0.01), home health care at admission (0.39), and number of appointments after discharge (0.52), the κ was $>$0.6. After discussion and refinement, the κ for home health care at admission and number of appointments after discharge increased (0.75 and 0.69, respectively). After extensive review of the pilot charts, language was found to be more reliably attained from the admission database due to contradictory information in the chart.

Demographic Factors

There were no statistically significant differences among the groups for gender, age, language, ethnicity, residence type, or state of residence (Table 1). The patients had 118 different All Patient Refined Diagnosis Related Groups. No differences were found in the rates among these diagnosis groups other than chemotherapy (code 693), for which there were 7 patients in the 7-day readmission group and no others in the study sample. However, these 7 patients had attributes similar to other patients with 7-day readmission and were therefore included in the analysis.

Preadmission Clinical Factors

Statistically significant differences were noted in the mean number of admission medications ($P = .001$) and the number of emergency department visits in the year before the index admission ($P = .047$) among the 3 groups. There were statistically significant differences in the rates of home health care at the time of the index admission ($P = .001$) among the groups.

In bivariate unadjusted analysis, each additional admission medication increased the odds of multiple admissions by 1.17 (95% CI, 1.07–1.28; $P = .001$) compared with single admissions. Home health care on admission increased the odds of multiple admissions by 1.80 (95% CI, 1.12–2.88; $P = .015$) compared with single admissions. There were no statistically significant differences between the 3 groups for the remaining preadmission factors, admission source, and child protective services involvement (Table 2).

Discharge Clinical Factors

There were statistically significant differences in the means of number of discharge medications ($P < .001$), number of diagnosis codes during index admission ($P < .001$), and number of procedure codes during index admission ($P = .009$) among the groups. Statistically significant differences occurred in the rates of home health care at the time of discharge from the index admission ($P = .016$) among the groups.

In bivariate unadjusted analysis, each additional discharge medication increased the odds of multiple admissions by 1.25 (95% CI, 1.13–1.38; $P < .001$). Home health care on discharge increased the odds of multiple admissions by 3.09 (95% CI, 1.55–6.16; $P = .001$). Each additional diagnosis code on discharge increased the odds of multiple admissions by 1.13 (95% CI, 1.06–1.21; $P < .001$).

There were no statistically significant differences among the groups for number of appointments made at the time of discharge from index admission, length of stay of index admission, initial admission to an ICU during index admission, or any time spent in an ICU during index admission (Table 2).

Determination of a Multivariate Model for Risk of Multiple Admissions

Due to the lack of differences among the patients with multiple admissions in bivariate analysis, a multivariate model of risk of multiple admissions (with or without 7-day readmission) versus single admission was calculated. Candidate variables with P values <.25 in bivariate analysis were ethnicity, residence type, number of medications at admission, number of medications at discharge, home health care at admission, home health care at discharge, number of emergency department visits in previous year, number of diagnosis codes, number of procedure codes, and length of stay.

The final multivariate logistic model was identical in both the forward and backward direction (Table 3). In this model, each additional discharge medication had an odds ratio for multiple admissions of 1.17 (95% CI, 1.04–1.32; $P = .007$); presence of home health care on admission had an odds ratio for multiple admissions of 2.80 (95% CI, 1.15–6.81; $P = .023$); and each additional diagnosis code on discharge had an odds ratio for multiple admissions of 1.07 (95% CI, 0.99–1.15; $P = .102$).

DISCUSSION

Multiple studies have raised the question of whether most readmissions in pediatrics are related to failure to provide quality care or to intrinsic patient characteristics. This study aimed to compare clinical factors of patients with a single admission versus those with multiple admissions, looking specifically for differences between patients who would go on to have a 7-day readmission and those who did not. Among patients with multiple admissions, we found no differences between those with and those without a 7-day readmission.

Between patients with a single admission and those with multiple admissions, regardless of whether they had had a 7-day readmission, the differences we found were in factors associated with medical complexity or chronic disease, including number of medications, home health care, diagnosis codes, and previous emergency department visits. Due to the nature of our study, we were unable to determine whether these factors led to constant increased risk of future hospitalization or whether medical complexity made those patients particularly susceptible to the effects of inadequate discharge care.

Within our study, a group of patients at high risk for short-term and longer term future hospitalization were identified. Because many proposed interventions for decreasing readmission are resource intensive, allocation of such resources to a targeted group of patients may allow for more efficient interventions. Such interventions have the potential not only to decrease short-term readmissions but long-term hospital utilization as well. Prospective studies of such interventions are necessary to test whether this scenario is truly the case.

Another finding of this study was that information obtained at both the time of admission and discharge was helpful for predicting a patient's risk of future hospital utilization. Based on our multivariate model, the best independent predictors were number of medications at the time of discharge, home health care at the time of admission, and number of diagnoses identified at the time of discharge. If risk determination were being performed at the time of admission, using available values would be reasonable.

This study has multiple limitations. First, because of the need for chart review, the sample size is much smaller than the previous studies that used administrative databases. As such, the power to identify factors with small associations was limited. This study was powered to identify factors with odds ratios for readmission of 2.5 to find the most highly correlated factors. Some factors, especially language, may be less accurate due to the use of administrative data, leading to exposure misclassification and therefore decreased power. In addition, this was a case–control study and can therefore only be used to identify associations.

This single site included only readmissions to our own institution, and thus there may be misclassification of the outcome if patients were readmitted elsewhere. We analyzed patients over a 12-month period without observing them for 12 full months after their index admission, which may lead to outcome misclassification. Because we looked solely at the index admission regardless of timing of the 7-day readmission, we cannot make conclusions regarding short-term readmission risk among these patients. Due to the method of data abstraction, we were unable to compare the total number of admissions. Because all-cause readmission rates, we were unable to account for preventable or planned readmissions.

TABLE 3 Multivariate Model for Prediction of Multiple Admissions (Regardless of 7-Day Readmission)

Clinical Factor[a]	Adjusted Odds Ratio (95% CI)	P
No. of discharge medications	1.17 (1.04–1.32)[b]	.007
Home health care before admission	2.80 (1.15–6.81)	.023
No. of diagnosis codes at discharge	1.07 (0.99–1.15)[b]	.102

[a] Candidate factors included ethnicity, residence type, number of medications at admission, number of medications at discharge, home health care at admission, home health care at discharge, number of emergency department visits in previous year, number of diagnosis codes, number of procedure codes, and length of stay.

[b] Adjusted odds ratio for each additional increase of 1.

CONCLUSIONS

This study found differences between patients with a single admission and those with multiple admissions. There were no differences identified among patients with multiple admissions based on whether they will go on to have 7-day readmissions. These patients seem to represent a single high-risk group. Thus, it is possible that many readmissions represent a consequence of medical complexity rather than a failure of care. However, identification of high-risk patients may allow for opportunities to design targeted interventions. Further studies are necessary to determine if such interventions will lower the risk of subsequent admissions for these high-risk patients.

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