Readmission within 30 days of Hospital Discharge among Children Receiving Chronic Dialysis

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Abstract

Background and objectives The hospital admission rate for children receiving chronic dialysis has been increasing over the last decade. Approximately one third of patients with ESRD age 0–19 years are readmitted to the hospital within 30 days of discharge. The objective of this study was to examine hospital readmissions among a cohort of children receiving chronic dialysis to identify factors associated with higher rates of 30-day readmission.

Design, settings, participants, & measurements A retrospective cohort of index admissions was developed among chronic dialysis patients age 3 months to 17 years at free-standing children's hospitals reporting information to the Pediatric Hospital Information System between January 2006 and November 30, 2010, and followed until December 31, 2010. The primary outcome was any-cause 30-day readmission, and the secondary outcome was 30-day readmission for a cause similar to that of the index hospitalization.

Results In this cohort, 25% of hospital admissions were followed by a readmission within 30 days. Children older than 2 years of age had a lower odds of readmission (odds ratio [OR], 0.6; 95% confidence interval [95% CI], 0.5 to 0.8). Those receiving hemodialysis had a higher risk of readmission (OR, 1.2; 95% CI, 1.0 to 1.4), and admissions >14 days were also more likely to be followed by a readmission (OR, 1.5; 95% CI, 1.1 to 2.0). Approximately 50% of the readmissions were for a similar diagnosis as the index admission; however, the specific admitting diagnosis was not associated with readmission.

Conclusions A significant number of admissions among children receiving long-term dialysis are followed by readmission within 30 days. Further investigation is required to reduce the high rate of readmissions in these children.

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Introduction

Children with ESRD receiving chronic dialysis are hospitalized approximately 1–2 times per year (1,2), a rate 40–70 times higher than that of the general pediatric population (3) in the United States. The admission rate for pediatric dialysis patients has been increasing over the last decade, and about 35% of patients with ESRD age 0–19 years are readmitted to the hospital within 30 days of discharge (1). Hospitalizations are a burden for patients, caregivers, and the health care system. Admissions represent greater illness acuity and have been associated with higher mortality among adults undergoing chronic dialysis (4). The Centers for Medicare & Medicaid Services is considering adding a 30-day readmission measure to the ESRD Quality Incentive Program (5) and penalizing dialysis units with high readmission rates.

Previous studies examining readmissions in children do not provide a detailed view of the dialysis population (6,7). Our objective was to examine hospital readmissions among a cohort of children receiving chronic dialysis to identify factors associated with higher rates of 30-day readmission in this vulnerable population.

Materials and Methods

Data Source

The Pediatric Hospital Information System (PHIS) contains data from 43 free-standing children's hospitals in the United States. The database contains information on >3.3 million inpatient admissions. Participating hospitals report demographic, clinical, and charge information for each hospitalization. Patients have unique medical record numbers, and each admission has a unique discharge identification allowing for tracking of patients over time. The data are sufficiently deidentified, and the study was considered exempt from institutional review board review.

Cohort Selection

We included index admissions of patients age 3 months to 17 years to PHIS hospitals with complete clinical and charge data reporting (n=38 of 43 hospitals) occurring between January 1, 2006, and November 30, 2010, and followed patients until December 31, 2010, to allow for 30 days of follow-up. To capture chronic dialysis patients, admissions with both an associated International Classification of Diseases, Ninth

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Revision, Clinical Modification (ICD-9-CM) procedure code for hemodialysis (HD) or peritoneal dialysis (PD) and an ESRD-identifying diagnosis (Table 1) were selected. Admissions without an ESRD-identifying diagnosis (n=729) were excluded because these may represent patients receiving acute inpatient dialysis and not those with ESRD. We included index hospitalizations with any patient disposition, but eliminated any admissions during which a patient died. Readmissions that met inclusion criteria were analyzed as an index admission because this allowed for the most complete evaluation of the outcome measures.

Outcome Measures

The unit of analysis was the hospital admission. The primary outcome of interest was admission for any cause within 30 days of discharge from the index hospitalization (all-cause readmission), and the secondary outcome was admission for a principal diagnosis similar to that of the index admission within 30 days of discharge (similar-cause readmission). Readmission was considered a similar-cause readmission if it fell within the same principal diagnosis group as the index admission. (see below and Supplemental Table 1 for description of the principal diagnosis groups). In a separate analysis, we compared the characteristics of patients with three or fewer admissions to those with four or more admissions during the study period.

Admitting Diagnoses

Principal diagnoses were characterized into seven groups to test for associations between cause of admission and the odds of readmission (Supplemental Table 1 lists ICD-9-CM diagnoses included in each group): (*1*) peritonitis and PD catheter-related infection or complication, (*2*) HD access infection or complication, (*3*) cardiovascular admission, (*4*) electrolyte and fluid disorders, (*5*) complication of transplanted kidney, (*6*) other infection, and (*7*) all other diagnoses. The rate of 30-day readmission for each diagnosis group was examined, and association between diagnosis group and readmission was tested. The groups were used to test our secondary outcome of readmission for similar principal diagnosis within 30 days of discharge.

Table 1. Diagnoses and procedures used to identify patients as having ESRD

ICD-9-CM Code	Procedure or Diagnosis
Procedure	
55.53	Removal of transplanted or rejected kidney
55.52	Nephrectomy of remaining kidney
55.54	Bilateral nephrectomy
39.27	Arteriovenostomy for renal dialysis
39.53	Repair of arteriovenous fistula
39.93	Insertion of vessel-to-vessel cannula
39.50	Angioplasty or atherectomy noncoronary vessel(s)
39.42	Revision of arteriovenous shunt for renal dialysis
Diagnosis	
996.1	Mechanical complication due to other vascular device
996.56	Mechanical complication due to peritoneal dialysis catheter
585.5	Chronic kidney disease stage 5
585.6	Chronic kidney disease stage 5 D
V45.1	Dialysis status
403.01	Malignant hypertension ESRD
403.91	Hypertension ESRD
403.11	Benign hypertension ESRD

ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification.

Explanatory Variables

Multiple variables were tested for association with the odds for 30-day readmission. These included patient demographic characteristics and admission-level factors. Age was divided into groups of younger than and older than 2 years at the time of admission because prior studies have shown that children younger than 2 years of age have a higher likelihood of readmission (8). Race was divided into black versus all other. Primary payer was divided into commercial, Medicaid, and Medicare.

Patient comorbid conditions were ascertained from secondary diagnosis codes and medication charges listed for each admission (Supplemental Table 2 lists diagnoses and medications used to define comorbid conditions). Comorbid conditions were categorized into groups (anemia, electrolyte abnormality, nutritional deficiency, psychiatric diagnosis, bone mineral disease, and hypertension), and the total number of comorbid conditions for each hospitalization was calculated by adding these groups at the admission level.

Dialysis modality was defined by the ICD-9-CM procedure code for the modality of dialysis performed during the hospitalization. In the case of a patient admitted for peritonitis or complications of a PD catheter, the long-term modality was presumed to be PD even if a patient received HD during the hospitalization.

The underlying renal diagnosis, or the presumed cause of ESRD, was identified for a patient by the ICD-9-CM admission, principal, or secondary diagnoses codes related to each admission and divided into glomerular or congenital/obstructive disease (Supplemental Table 3 lists ICD-9-CM codes and diagnoses used to define underlying renal diagnosis). When an underlying diagnosis was identified for a patient, it was applied to all the patient's admissions. In the case of a patient with ICD-9-CM codes consistent with both glomerular and obstructive/congenital disease (n=83), the patient was categorized as having glomerular disease because we assumed the patient's admission pattern would more closely resemble that of a patient with glomerular disease.

Statistical Analyses

Descriptive statistics for continuous variables were reported as medians and interquartile ranges (IQRs), and categorical variables were reported as proportions. A chi-square test was used to compare patients with three or fewer admissions to those with four or more admissions during the study period. The association between each

Table 2. Characteristics of index hospitalization, 30-day readmission, and unadjusted odds ratio for all-cause 30-day readmission

Characteristic	Patients, *n* (%)	30-Day Readmission, *n* (%)	Odds Ratio for 30-Day Readmission (95% CI)
Sex			
Male	2723 (53.3)	665 (24.4)	Reference
Female	2389 (46.7)	617 (25.8)	1.07 (0.89 to 1.28)
Age			
<2 yr	703 (13.8)	231 (32.9)	Reference
≥2 yr[a]	4409 (86.2)	1051 (23.8)	0.60 (0.50 to 0.80)
Race			
All Other	3484 (68.2)	853 (24.5)	Reference
Black	1628 (31.8)	429 (26.4)	1.05 (0.85 to 1.29)
Underlying diagnosis			
Congenital, obstructive	1319 (25.8)	340 (25.8)	Reference
Missing[a]	1805 (35.3)	418 (23.2)	0.53(0.4 to 0.68)
Glomerular	1988 (38.9)	524 (26.4)	1.07 (0.86 to 1.33)
Dialysis modality			
PD	2594 (50.8)	626 (24.1)	Reference
HD	2518 (49.2)	656 (26.0)	1.10 (0.92 to 1.31)
Principal diagnosis for admission			
Infection	615(11.9)	134(21.8)	Reference
Peritonitis and PD complication	756(14.8)	136(18.0)	0.80 (0.59 to 1.09)
HD access complication and infection	526(10.3)	101(19.2)	0.80 (0.57 to 1.10)
Cardiovascular	823(16.1)	166(20.2)	0.90 (0.70 to 1.27)
Electrolyte and fluid	298(5.8)	81(27.4)	1.20 (0.86 to 1.80)
Complication of transplant	203 (4.0)	39 (19.2)	0.90 (0.56 to 1.40)
Other	1891 (37.2)	625 (33.0)	1.09 (0.87 to 1.80)
Length of stay			
1 d	837 (16.4)	209 (25.0)	Reference
2–6 d	2570 (50.3)	543 (21.1)	0.99 (0.8 to 1.23)
7–13 d	814 (15.9)	162 (19.9)	0.89 (0.68 to 1.18)
≥14 d[a]	891 (17.4)	368 (41.3)	1.28 (1.0 to 1.73)
Total comorbid conditions			
0	1443 (28.2)	265 (18.4)	Reference
1–2	1285 (25.1)	450 (35.0)	1.25 (0.86 to 1.8)
≥3[a]	2384 (46.6)	567 (23.8)	1.44 (1.03 to 2.0)
Primary payer			
Commercial	1048 (20.5)	290 (27.7)	Reference
Medicare	1742 (34.0)	463 (26.6)	1.00 (0.79 to 1.29)
Medicaid	1814 (35.5)	455 (25.0)	1.00 (0.79 to 1.27)
Other/missing[a]	508 (10.0)	74 (14.6)	0.64 (0.44 to 0.93)
Discharge season			
Summer	1268 (24.8)	320 (25.2)	Reference
Fall	1286 (25.2)	319 (24.8)	0.92 (0.74 to 1.14)
Winter	1244 (24.3)	312 (25.0)	0.97 (0.78 to 1.20)
Spring	1314 (25.7)	331 (25.2, o)	0.97 (0.78 to 1.19)
Operating room charge			
No	3674(71.9)	1045(28.7)	Reference
Yes[a]	1438(28.1)	237(16.5)	0.72(0.60 to 0.87)
ICU charge			
No	4263(83.4)	1111(26.1)	Reference
Yes	849(16.6)	171(20.1)	0.94 (0.77 to 1.16)

Odds ratios, and 95% confidence intervals (95% CIs) were calculated using mixed-effects logistic regression, clustering by patients within hospital to account for repeated admissions across multiple centers. PD, peritoneal dialysis; HD, hemodialysis; ICU, intensive care unit.
[a]$P<0.05$.

explanatory variable and the primary outcome of 30-day readmission was tested using mixed-effects logistic regression clustering by patient within hospital to account for repeated admissions across multiple centers. All explanatory variables were tested initially in univariate analysis. Variables that were found to be statistically significant in univariate analysis along with dialysis modality were included in a multivariate model. All analyses were performed using Stata statistical software, version 12.0 (Stata Corp., College Station, TX).

Results

Descriptive Statistics

We identified 5112 index admissions among 1857 children with ESRD receiving chronic dialysis across 38 hospitals from January 1, 2006, until November 30, 2010. Table 2 lists population characteristics. Of the 5112 admissions, 2723 (53%) were of male patients, the median age was 12 years (IQR, 4–15 years), and 1628 (32%) were of black patients. An underlying diagnosis was identified in 3307 (65%) of admissions, and it was glomerular disease in 1988 (60%). HD patients made up 2518 of the admissions (49%). The median length of stay was 4 days (IQR, 2–9 days). The primary payer was commercial insurance, Medicare, and Medicaid in 20%, 34%, and 35% of admissions, respectively.

Principal diagnoses for the index admissions are presented in Supplemental Table 1. There were 526 (10.3%) admissions due to HD access infection or complication, 756 (14.8%) due to peritonitis and PD catheter-related infection or complication, and 610 (11.9%) due to other infection (of which 33.4% were viral). There were 823 (16.1%) admissions for cardiovascular diagnoses, 296 (5.6%) for electrolyte and fluid disorders, and 203 (4.0%) for complication of transplanted kidney. All other diagnoses made up 1898 (37.2%) of index admissions, and, of these, 1149 (60.8%) had a nonspecific principal diagnosis of ESRD, CKD, or a renal disease.

Of the 1857 children, 840 (45%) had a single admission during the study period, 372 (20%) patients had two admissions, and 216 (12%) had three admissions. These 1428 patients (77%) accounted for 44% of admissions. The remaining 429 (23%) patients had four or more admissions during the study period and accounted for 56% of admissions. Table 3 compares the characteristics of patients with three or fewer admissions to those with four or more admissions. Patients with four or more admissions, analyzed at the patient level, were more likely to be younger (P=0.001), to be black (P<0.001), to have public insurance (P<0.001), and to have comorbid conditions (P<0.001).

30-Day Readmission

A total of 1282 (25%) index admissions were followed by a readmission within 30 days of discharge. The median time to readmission, if readmission occurred within 30 days, was 12 days (IQR, 5–20 days). Of all 30-day readmissions, 101 (7.9%) were due to HD access infection or complication, 136 (10.6%) were due to peritonitis and PD catheter-related infection or complication, 134 (10.5%) were due to other infection, 166 (13.0%) were due to cardiovascular causes, 81 (6.3%) were due to electrolyte and fluid disorders, and 39 (3.0%) were due to complication of a transplanted kidney. All other diagnoses made up 625 (48.8%) of 30-day readmissions.

Univariate odds ratios (ORs) and associated 95% confidence intervals (CIs) for all-cause 30-day readmission are shown in Table 2. In univariate analysis, age older than 2 years at admission (OR, 0.6; 95% CI, 0.5 to 0.8) and admissions with an operating room charge (OR, 0.7; 95% CI, 0.6 to 0.9) were associated with a lower odds of 30-day readmission. Admitted patients with three or more comorbid conditions (OR, 1.4; 95% CI, 1.0 to 2.0) and admissions with a length of stay>14 days (OR, 1.3; 95% CI, 1.0 to 1.7) were associated with a higher risk of 30-day readmission. Sex, race, dialysis modality, principal admitting diagnosis, discharge season, and an intensive care unit charge were not associated with 30-day readmission.

Results of a multivariate model for all-cause 30-day readmission are shown in Table 4. Older age at index

Table 3. Characteristics of patients with three or fewer admission or four or more admissions during the study period

Characteristic	Patients with ≤3 Admissions	Patients with ≥4 Admissions	*P* Value
Age			
0–2 yr	266 (37.8)	437 (62.2)	0.001
≥2 yr	1966 (44.6)	2443 (55.4)	
Race			
Black	563 (34.6)	1065 (65.4)	<0.001
Other	1669 (47.9)	1815 (52.1)	
Payer			
Medicaid	816 (45.0)	998 (55.0)	<0.001
Medicare	608 (34.9)	1134 (65.1)	
Commercial	522 (49.8)	526 (50.2)	
Other/missing	286 (56.3)	222 (43.7)	
Sex			
Female	1020 (42.7)	1369 (57.3)	0.2
Male	1212 (44.5)	1511 (55.5)	
Modality			
Peritoneal dialysis	1149 (43.7)	1482 (56.3)	0.9
Hemodialysis	1083 (43.7)	1398 (56.3)	
Comorbid conditions			
0	868 (60.2)	575 (39.8)	<0.001
1–2	445 (34.6)	840 (65.4)	
≥3	919 (38.6)	1465 (61.4)	

Unless otherwise noted, values are the number (percentage) of patients.

admission (OR, 0.6; 95% CI, 0.5 to 0.8) and an associated operating room charge (OR, 0.6; 95% CI, 0.5 to 0.8) were independently associated with a lower risk of readmission within 30 days of discharge. Length of stay>14 days (OR 1.5; 95% CI, 1.1 to 2.0) and HD were associated with higher odds of readmission (OR, 1.2; 95% CI, 1.0 to 1.4).

30-Day Readmission for Similar Cause

Of all 30-day readmissions, 658 (51%) were for a principal diagnosis in the same diagnosis group as the index admission. In the multivariate model, older age at admission was associated with a lower risk of readmission with the same diagnosis group (OR, 0.6; 95% CI, 0.5 to 0.9). HD (OR, 1.4; 95% CI, 1.1 to 1.7) and length of stay≥14 days (OR, 2.3; 95% CI, 1.6 to 3.4) were associated with higher odds of readmission with the same diagnosis group. None of the seven principal diagnosis groups examined were significantly associated with readmission with the same diagnosis group as the index admission 30 days following discharge (Table 4).

Discussion

We observed that 25% of hospital admissions of children with ESRD receiving chronic dialysis were followed by a readmission within 30 days of discharge. Admissions with length of stay≥14 days were more likely to be followed by a readmission. An operating room charge during the index hospitalization was associated with a lower risk of readmission. Although 50% of the readmissions were within the same diagnosis group as the index admission, a particular diagnosis group was not associated with readmission. Patients with four or more admissions during the observation period were more likely to be younger, to be black, to have public insurance, and to have more comorbid conditions compared with patients with fewer admissions. However, of these factors, only age younger than 2 years was associated with a higher risk of all-cause and similar-cause 30 day readmission. These findings are consistent with previous work that examined clinical characteristics of children recurrently admitted to children's hospitals (2).

The high rate of readmission we observed (25%) in the PHIS hospitals is consistent with, but slightly lower than, data from the most recent US Renal Data System (USRDS) report (35% readmission rate) in patients receiving chronic dialysis (1,9,10). It is possible that the older age of the USRDS cohort lead to this difference. The 30-day readmission rate for children receiving long-term dialysis is far higher than the 6% rate reported for all hospitalized children (8). In that study, diseases of the genitourinary system were grouped together and had a 30-day unplanned readmission rate of 15%. The 30-day readmission rate observed in our study, and in the USRDS data, is higher than the 30-day readmission rate of 20% observed in children with neoplasms, another population with a high prevalence of central line usage (8). Alarmingly, the readmission rate we observed in children with ESRD is at least as high as the 30-day readmission rates for 80-year-old adults with heart failure (25%), acute myocardial infarction (20%), or pneumonia (18%) (11). This demonstrates the complexity of children with ESRD when compared with clinically fragile populations.

The higher readmission rate among the youngest children receiving dialysis is consistent with the general pediatric population, where those younger than 1 year of age had a 9% increase in 30-day readmission compared with children older than 13 years of age (8). Furthermore, a longer length of stay during the index admission has been

Table 4. Multivariate mixed effects logistic regression for all-cause and similar-cause 30-day readmission

Variable	Odds Ratio for All-Cause Readmission (95% CI)	Odds Ratio for Similar-Cause Readmission (95% CI)
Age		
0–2 yr	Reference	Reference
≥2 yr[a]	0.6 (0.5 to 0.81)	0.6 (0.5 to 0.9)
Modality		
Peritoneal dialysis	Reference	Reference
Hemodialysis[a]	1.2 (1.0 to 1.4)	1.4 (1.1 to 1.8)
Length of stay		
1 d	Reference	Reference
2–6 d	1.0 (0.8 to 1.2)	1.1 (0.7 to 1.4)
7–13 d	0.9 (0.7 to 1.3)	1.2 (0.8 to 1.8)
≥14 d[a]	1.5 (1.0 to 1.8)	2.3 (1.6 to 3.4)
Comorbid conditions		
0	Reference	Reference
1–2	0.9 (0.7 to 1.25)	1.4 (0.9 to 2.1)
≥3	1.0 (0.8 to 1.3)	0.9 (0.6 to 1.2)
Operating room charge		
No	Reference	Reference
Yes[a]	0.6 (0.5 to 0.8)	0.4 (0.3 to 0.6)

Odds ratios and 95% CIs were calculated using mixed-effects logistic regression, clustering by patient within hospital to account for repeated admissions across multiple centers.
[a]$P<0.05$.

associated with a higher risk of readmission (8). Lengths of stay≥14 days may represent higher patient acuity, higher admission complexity, or a complication during the admission, making the association of longer length of stay with a higher likelihood of readmission complex. Admissions with an operating room charge may reflect planned, primarily procedural index admission in a relatively stable patient, and the lower odds of readmission following these admissions is probably not causal.

Although the validity of using 30-day readmission as a quality and/or payment metric remains debated (12,13), readmissions of chronic dialysis patients may become a quality measure in the near future (5). It is unknown whether readmissions are a marker of poor hospital care, poor outpatient care (14), suboptimal interactions between discharging hospitals and outpatient dialysis facilities (9), or appropriate and necessary care in a medically complex population (13). However, hospitalizations increase the cost of ESRD care, create a burden on the patient and family, and increase the risk of iatrogenesis and medical complication. Hospitalizations are also a marker of more severe illness acuity. Optimizing medical care across the complex medical system to prevent hospitalizations and readmissions is a prudent future goal.

Readmissions may be lowered by targeting the conditions most commonly resulting in hospitalization, including peritonitis, cardiovascular events, and HD access infections and complications. For example, the use of atriovenous fistulas or grafts is associated with lower rates of hospitalization. Ma *et al*. (15) found that patients with a fistula had a hospitalization rate of 0.4%, while children dialyzed with a central catheter had an admission rate of 3%. Ng *et al.* also found a higher rate of hospitalizations among children with central venous catheters (16). The National Kidney Foundation recommends that pediatric patients on maintenance HD be dialyzed using permanent dialysis access (17). However, permanent access placement in children is complicated by patient size, hospital resources, and the pediatric preference for deceased-donor kidneys. Therefore, almost 80% of children initiating HD do so with a catheter (18). Achievement of quality measures in adolescent HD patients (19) and closer monitoring after hospitalization in adult HD patients were associated with lower hospitalization rates (20). Interventions that target decreasing peritonitis rates, catheter-related bloodstream infections, and the highest risk patients may also decrease hospitalizations and readmissions (10,21–25).

Cardiovascular disease is a major cause of morbidity and mortality in children with ESRD (26) and accounted for approximately 16% of all admission in our cohort. Monitoring of a hematocrit-guided ultrafiltration algorithm lowered hospitalization for fluid overload and hypertension among pediatric HD patients (27). Cardiovascular admissions are higher on the day following the longest interdialytic interval in HD patients (28,29); therefore, alternative dialysis schedules deserve further study to determine their impact on hospitalization and readmission (30,31).

We acknowledge the limitations of using administrative data for the evaluation of clinical outcomes. Several important variables, including the type of HD access and the presence of a PD catheter at time of admission, could not be readily discerned from the PHIS dataset. Dialysis vintage is also unknown, and rate of admission around the time of dialysis initiation tends to be higher (1). Indeed, patients who develop ESRD during the index hospitalization would be included in our cohort. Per our inclusion criteria, all admissions had a procedure code for HD or PD in addition to an ESRD code (Table 1). Therefore, any patient who was admitted but did not receive a dialysis treatment during the hospitalization would be missed in our analysis. Our data did not contain information on patient death outside of the hospital or transplantation; therefore, the competing risks of death and transplantation were not included in the evaluation. In contrast to prior reports in the general pediatric population, we could not identify whether readmissions were planned (8); however, >50% of the admissions seem unplanned by their principal diagnoses (*e.g.*, hypertension, peritonitis, HD catheter infection). The PHIS database presents a unique opportunity to investigate less common diseases in children using its large number of admissions. However, this database has not been previously validated in chronic dialysis patients, and it is limited by available coding. For a large proportion of admissions (30%), data on the underlying cause of ESRD (glomerular versus congenital/obstructive) were missing, which was uninformative. We believe that any coding inaccuracies are random in nature and would not bias the results. Finally, patients readmitted to a hospital not reporting data to PHIS would be missed in our analysis. We attempted to control for this by only including patients younger than 17 years of age to reduce the chance that a patient would have transitioned out of a children's hospital.

In conclusion, expenditures for care of long-term dialysis patients are very high, leading payers to seek methods for lowering costs. From 2002 to 2006, hospitalizations of all patients with ESRD in the United States cost $31.5 billion, which was one third of all ESRD costs (1). We observed that a significant number of admissions (25%) in pediatric long-term dialysis patients are followed by readmission within 30 days. Further research is needed to clearly differentiate preventable from unpreventable admissions and to clarify the necessity and possible benefits of hospitalization despite their added costs. Future avenues of research include prospective evaluation and intervention studies to reduce readmission in this patient population. Interventions could focus on inpatient, outpatient, or the transition of care as areas of possible intervention. Studies may benefit from targeting patients at highest risk of readmission, as demonstrated by our findings.

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Disclosures

None.

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See related editorial, "The Role of 30-Day Readmission as a Measure of Quality," on pages 440–442.

Supplementary Table 1: All admissions were divided into diagnosis groups according to the principal diagnosis for the admission. These groups were used to test the association between reason for admission and 30-day readmission. The principal diagnosis groups were generated according to the following diagnoses.

Other Infections	n	%
Gastrointestinal		
Bacterial	34	5.5
Viral	34	5.5
NOS	4	0.7
Septicemia/Bacteremia	104	17.0
Fever	82	13.4
Lower Respiratory		
Bacterial	75	12.2
Viral	58	9.5
NOS	7	1.1
Generalized Viral Syndrome	78	12.7
CNS	2	0.3
Ear, Nose, Throat	54	8.8
Genitourinary	56	9.1
Skin, Muscle, Bone	19	3.1
Fungal Infection	6	0.9
Total	**613**	

Peritonitis and PD catheter Related Infection or Complication	n	%
TB peritonitis-cult POS	1	0.13
Diphtheritic peritonitis	3	0.40
Generalized peritonitis	16	2.12
Peritoneal abscess	3	0.40
Spontaneous bacterial peritonitis	9	1.19
Other suppurative peritonitis	218	28.84
Other peritonitis	70	9.26
Peritonitis NOS	153	20.24
Cloudy dialysis effluent	2	0.26
Mechanical complication PD catheter	133	17.59
Infect D/T PD catheter	106	14.0
Infect comp med care NEC	42	5.6
Total	**756**	

HD Access Infection or Complication	n	%
Mechanical complication other vascular device	173	32.89
Mechanical complication device/graft NEC	2	0.38
Infection D/T vascular device	149	28.33
Infection due to device NEC	2	0.38
Complication D/T renal dialysis device	121	23.00
Complication NEC D/T vascular device NEC	18	3.42
Complication NEC D/T device NEC	1	0.19
Infection complicating medical care NEC	1	0.19
Infection D/T CVC	59	11.22
Total	**526**	

Cardiovascular	n	%
Malignant hypertension	86	10.5
HTN encephalopathy	40	4.86
Hypertension NOS	23	2.79
Secondary Hypertension	29	3.5
Hypertension CKD	625	75.9
Other cardiac dysrhythmias	4	0.49
CHF NOS/Heart failure	10	1.2
Intracerebral hemorrhage	3	0.36
Cerebral thrombus w/ infarct	1	0.12
Cerebral artery occlusion w/ infarct	1	0.12
Transient cerebral ischemia NOS	1	0.12
Total	**823**	

Complication of Transplanted Kidney	n	%
Comp kidney transplant	203	100.00
Total	**203**	

All Other Diagnoses	n	%
Endocrine	18	1.0
Hematology	54	2.9
Psychiatric	26	1.4
Neurologic	106	5.6
Vascular/Vasculitis	144	7.6
Cardiac/Respiratory	80	4.2
Renal	1181	62.5
Dermatologic/ Musculoskeletal	29	1.5
Genitourinary	26	1.4
Gastrointestinal/Nutrition	202	10.7
Injury/Complication	25	1.3
Total	**1891**	

Electrolyte and Fluid Abnormalities	n	%
Disorder phosphorus metabolism	8	2.70
Hypocalcemia	28	9.46
Hypercalcemia	3	1.01
Hyperosmolality	1	0.34
Hyposmolality	14	4.73
Acidosis	2	0.68
Alkalosis	1	0.34
Dehydration	66	22.30
Hypovolemia	5	1.69
Fluid overload	39	13.1
Hyperkalemia	77	26.01
Hypokalemia	6	2.03
Elect/fluid disorder NEC	2	0.68
Orthostatic hypotension	4	1.35
Hemodialysis hypotension	7	2.36
Iatrogenic hypotension NEC	4	1.35
Hypotension NEC/NOS	29	9.7
Abnormal blood chemistry NEC	2	0.11
Total	**298**	

NEC not elsewhere classified
NOS not otherwise specified

Supplementary Table 2: Patient comorbidities were ascertained from the secondary diagnosis codes and medication charges listed for each admission. Comorbidities were categorized into groups: anemia, electrolyte abnormality, nutritional deficiency, psychiatric diagnosis, bone-mineral disease, and cardiovascular disease. An admission was labeled as having one of the preceding comorbidities if it had either a secondary diagnosis or a medication charge as listed below. If an admission had multiple medication charges or secondary diagnoses within the same category, the comorbidity was only counted once. The total number of comorbidities for each hospitalization was calculated by adding these groups at the admission level. This table lists the secondary diagnoses and medication charges which were used to define co-morbidities for each admission.

Bone Mineral Disease

Medications

Calcitriol	Calcium (acetate) (citrate)
Calcium and vitamin D	Calcium carbonate
Calcium chloride	Calcium gluconate
Cholecalciferol (D3)	Cinacalcet HCl
Ergocalciferol (D2)	Paricalcitol
Sevelamer	

Diagnosis

275.3 Disorder phosphorus metabolism	588.1 Secondary Renal hyperparathyroidism
275.41 Hypocalcemia	275.42 Hypercalcemia
588.0 Renal osteodystrophy	252.08 Hyperparathyroidism NEC
252.1 Hypoparathyroidism	252.8 Hypoparathyroid disorder NEC

Anemia

Medications

erythroproetin	darbapoetin

Diagnosis

285.9 Anemia NOS	285.29 Anemia chronic disease NEC
285.21 Anemia in CKD	

Psychiatric Diagnosis

Diagnosis

292.81	Drug-induced delirium	296.20	MDD one episode-NOS
296.23	MDD one episode-severe	296.32	Recurrent MDD-mod
296.33	Recurrent MDD-severe	969.0	Episodic mood disorder NOS
300.00	Anxiety state NOS	300.01	Panic dis w/o agoraphobia
300.4	Dysthymic disorder	307.59	Eating disorder NEC
307.81	Tension headache	309.0	Adjustment dis-depressed
309.28	Adjust dis-anxiety/depression	309.4	Adjust dis-emotion/conduct
309.9	Adjustment reaction NOS	311	Depressive disorder NEC
312.9	Conduct disturbance NOS	314.01	ADD child w hyperactivity
300.4	Dysthymic disorder	311	Depressive disorder NEC
799.2	Nervousness	799.22	Irritability

Electrolyte Abnormality

Medications

Sodium polystyrene

Diagnosis

276.0	Hyperosmolality	276.1	Hyposmolality
276.2	Acidosis	276.7	Hyperkalemia
276.8	Hypokalemia	276.9	Elect/fluid disorder NEC
790.6	Abnormal blood chemistry NEC	276.3	Alkalosis
276.6	Fluid overload	276.69	Fluid overload NEC

Nutritional Deficiency

Diagnosis

261	Nutritional marasmus	263.9	Protein-calorie malnutrition NOS
783.3	Feeding problem	783.21	Loss of weight
783.7	Adult failure to thrive	783.41	Failure to thrive
V85.52	BMI 5%-84% for age pediatric		

Cardiovascular Comorbidity

Medications

Amlodipine	Atenolol
Benazepril HCl	Captopril
Carvedilol	Clonidine HCl
Diltiazem HCl	Doxazosin mesylate
Enalapril maleate	Esmolol HCl
Felodipine	Fenoldopam mesylate
Guanfacine HCl	Hydralazine HCl
Isradipine	Labetalol HCl
Lisinopril	Losartan potassium
Metoprolol	Minoxidil
Nadolol	Nesiritide
Nicardipine HCl	Nifedipine
Nitroglycerin	Nitroprusside sodium
Papaverine HCl	Prazosin HCl
Propranolol HCl	Quinapril HCl
Ramipril	Tamsulosin
Timolol maleate	Valsartan
Verapamil HCl	

Diagnosis

401.0 Malignant hypertension	401.9 Hypertension NOS
403.00 Malignant HTN CKD I-IV/NOS	403.01 Malignant HTN CKD V-ESRD
403.11 Benign HTN CKD V-ESRD	403.90 HTN CKD NOS I-IV/NOS
403.91 HTN CKD NOS V-ESRD	404.02 Malignant HTN heart & ESRD w/o HF
404.03 Malignant HTN w HF/CKD	404.91 HTN heart & CKD I-IV w HF
404.92 HTN heart & CKD V-ESRD s HF	404.93 HTN heart & CKD V-ESRD w HF
405.01 Malignant renovascular HTN	405.91 Renovascular HTN NEC
405.99 Secondary HTN NEC & NOS	437.2 HTN encephalopathy

ADD	attention deficit disorder
Dis	disorder
HF	heart failure
HTN	hypertension
MDD	major depressive disorder
NEC	not elsewhere classified
NOS	not otherwise specified
w/	with
w/o	without

Supplement Table 3: The presumed cause of ESRD (underlying renal diagnosis) was identified for a patient by the *ICD-9-CM* admission, principal, or secondary diagnoses codes related to each admission. The underlying renal diagnosis was divided into glomerular or congenital/obstructive disease.

3a: Glomerular Disease

ICD-9-CM	Diagnosis
446.0	Polyarteritis nodosa
446.21	Goodpasture's syndrome
446.4	Wegener's granulomatosis
580	Acute proliferative glomerulonephritis
580.4	Acute rapidly progressive glomerulonephritis
580.9	Acute nephritis NEC
580.9	Acute nephritis NOS
581.0	Nephrotic syndrome w/ lesion proliferative glomerulonephritis
581.1	Epimembranous nephritis
581.3	Minimal change nephrosis
581.89	Nephrotic syndrome NEC
581.9	Nephrotic syndrome NOS
582.1	Chronic membranous nephritis
582.4	Chronic rapid progressive nephritis
582.89	Chronic nephritis NEC
583.1	Membranous nephritis NOS
583.2	Membranoproliferative glomerulonephritis
583.4	Rapidly progressive glomerulonephritis NOS
583.4	Rapidly progressive glomerulonephritis NOS
583.89	Nephritis NEC
583.9	Nephritis w/ lesion NOS
710.0	Systemic lupus erythematosus
581.2	Membranoproliferative nephrosis
580.0	Acute proliferative glomerulonephritis
283.11	Hemolytic-uremic syndrome

3b: Congenital/obstructive Disease

ICD-9-CM	Diagnosis
596.54	Neurogenic bladder NOS
593.89	Renal/ureter disorder NEC
593.89	Renal/ureter disorder NOS
599.69	Urinary obstruction NEC
753.0	Renal agenesis
753.10	Cystic kidney disorder NOS
753.13	PKD-autosomal dominant
753.12	Polycystic kidney NOS
753.14	PKD-autosomal recessive
753.15	Renal dysplasia
753.16	Medullary cystic kidney
753.22	Cong obstruction UVJ
753.19	Cystic kidney disorder NEC
753.29	Renal pelvis/ureter obstruction NEC
753.3	Kidney anomaly NEC
753.6	Congenital urethral stenosis
753.8	Cystourethral anomaly NEC
756.71	Prune belly syndrome

NEC not elsewhere classified
NOS not otherwise specified
w/ with