Infection-Related Hospitalization Rates in Pediatric *versus* Adult Patients with End-Stage Renal Disease in the United States

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Infection is a common cause of morbidity and mortality in patients with ESRD. Infection-related hospitalization (IH) incidence among US Medicare incident pediatric and adult dialysis and transplant patients within 3 yr of presentation was compared from 1996 to 2001: Hemodialysis (HD) patients (pediatric $n = 1469$; adult $n = 305,323$); peritoneal dialysis (PD) patients (pediatric $n = 982$; adult $n = 27,119$), and kidney transplant (KTx) patients (pediatric $n = 1108$; adult $n = 31,663$). IH were identified from principal diagnosis codes; IH cumulative incidence and rates were calculated from claims data. Cumulative incidence of IH at 36 mo for incident pediatric patients with ESRD during 1996 to 2001 was 39.9% in HD, 51.2% in PD, and 47.4% in KTx patients (HD or PD *versus* KTx, $P < 0.0001$). Cumulative incidence for adults was 52.6% in HD, 51.8% in PD, and 39.8% in KTx patients (HD or PD *versus* KTx, $P < 0.0001$). IH rates per 1000 patient-months were highest for pediatric KTx patients (adjusted rate ratio 1.53 *versus* HD and 1.90 *versus* PD, $P < 0.001$ for each) and adult HD patients (adjusted rate ratio 1.20 *versus* KTx and 1.11 *versus* PD, $P < 0.001$ for each). Within the first 36 mo of incidence, IH rates are highest for incident pediatric KTx patients compared with HD and PD patients, in contrast to findings for adult patients with ESRD. Pediatric KTx patients require infection surveillance after transplantation.

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Infection is a significant cause of morbidity and mortality in pediatric and adult patients with ESRD. It accounted for 14.6% of deaths in all prevalent ESRD patients in the United Sates for 2000 through 2002 combined (1). It accounts for 15.6 to 29.8% of deaths in pediatric patients with ESRD (1–3). Mortality rates as a result of infection are higher in adult dialysis and kidney transplant (KTx) patients compared with the adult general population (4). Infection is a frequent cause of hospitalization in patients with ESRD (1,5–11). Factors that lead to increased risk for infection in these patients include immune dysfunction, malnutrition, young or advanced age, comorbid conditions such as diabetes, vascular access devices, and immunosuppression (4,10–15). Detailed data are not available on the frequency of infection-related hospitalizations (IH) for a national population of children with ESRD by treatment modality, and no study has compared IH rates between children and adults with ESRD. We therefore investigated IH rates in pediatric and adult US Medicare dialysis and KTx patients to determine the incidence and types of IH rates by treatment modality.

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Materials and Methods

Data and Sources

Using the US Renal Data System (USRDS), we identified patients who initiated hemodialysis (HD) or peritoneal dialysis (PD) as their first method of renal replacement therapy (RRT) during 1996 to 2001 and who had Medicare as their primary payer on or before day 91 after initiation. For purposes of analysis, day 91 was treated as day 1. We also identified first-time KTx patients whose transplants occurred during 1996 to 2001 and who had Medicare as their primary payer on the transplant date. For these patients, we required a Medicare claim for the transplant hospitalization but did not require the transplant to be the first method of RRT; KTx patients may have received previous HD or PD. Demographic data, including age, gender, race, primary cause of ESRD, and cause of death were obtained from the Identification, Medical Evidence Report (Centers for Medicare & Medicaid Services [CMS]-2728), and Death Notification (CMS-2746) sections of the CMS Renal Beneficiary Utilization System.

Tables 1 and 2 display demographic characteristics of patients who were excluded because Medicare was not their primary payer. Among pediatric patients, those who were excluded from the dialysis cohort were younger, more often of white race, and initiating PD; those who were excluded from the transplant cohort were older and more often of white race. Excluded adult dialysis patients were younger, more often of nonwhite race, more often male, and initiating PD; excluded adult KTx patients were younger, more often male, and more often of white race.

We examined Medicare claims for the first 12 to 36 mo after day 91 for dialysis patients and for the first 12 to 36 mo after transplant date for transplant patients. Hospitalization type was determined by the principal diagnosis code on the claim; Appendix A shows the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) diagnosis codes that were used to identify IH. Hospitalization rates

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Table 1. Characteristics of pediatric incident dialysis and transplant patients[a]

Characteristic	Pediatric Incident Dialysis Patients					Pediatric Transplant Patients				
	Included		Excluded		*P*	Included		Excluded		*P*
	n	%	*n*	%		*n*	%	*n*	%	
Total	2481		3538			1108		384		
Age (yr)										
0 to 4	363	14.6	580	16.4		162	14.6	50	13.0	
5 to 9	264	10.6	403	11.4		168	15.2	39	10.2	
10 to 14	571	23.0	847	23.9		279	25.2	83	21.6	
15 to 19	1283	51.7	1708	48.3	0.0544	499	45.0	212	55.2	0.0039
Race										
white	1440	58.0	2294	64.8		763	68.9	297	77.3	
black	889	35.8	895	25.3		293	26.4	62	16.1	
other	152	6.1	349	9.9	<0.0001	52	4.7	25	6.5	0.0002
Gender[b]										
male	1309	52.8	1936	54.7		604	54.5	218	56.8	
female	1171	47.2	1602	45.3	0.1377	504	45.5	166	43.2	0.4433
Modality										
HD	1469	59.2	1972	55.7						
PD	982	39.6	1476	41.7						
unknown	30	1.2	90	2.5	<0.0001					
Cause										
diabetes	37	1.5	52	1.5		4	0.4	1	0.3	
hypertension	160	6.4	167	4.7		32	2.9	7	1.8	
GN	787	31.7	1111	31.4		354	31.9	137	35.7	
cystic	75	3.0	144	4.1		56	5.1	19	4.9	
other	1422	57.3	2064	58.3	0.0127	662	59.7	220	57.3	0.5875

[a]Cystic, cystic kidney disease; GN, glomerulonephritis; HD, hemodialysis; PD, peritoneal dialysis.
[b]Gender is unknown for a small number of patients.

were calculated as the total number of each type of hospitalization divided by the total time at risk during the first 12 mo, where the time at risk excluded time spent in the hospital and time after a patient's death, loss of eligibility, or change in RRT (dialysis to transplant, or graft loss for transplant patients). Mortality rates were calculated by dividing the total number of deaths by time at risk. Cumulative incidence included all patients but counted only hospitalizations that occurred before loss of eligibility or change in RRT.

Statistical Analyses

Statistical significance was determined by χ^2 analysis when percentages were compared or by a general linear model when hospitalization or mortality rates were compared and adjusted for age, gender, race, primary cause of renal failure, length of time on RRT, and cohort year. Patients who appeared in multiple years were counted only once in the characteristic totals, except for totals by year and by modality, where one patient may contribute to multiple years or modalities (*e.g.*, a 1996 and 1997 dialysis patient could become a 1999 transplant patient). We used patient-years to account for patients who appeared in multiple years. For each year and treatment modality, continuous data for pediatric patients and adults were compared with *t* test. Differences with $P < 0.05$ were considered statistically significant. All analyses were performed using SAS software (version 8.2; Cary, NC).

Results

Patient Distributions

Patient characteristics are shown in Tables 1 and 2. HD was the modality for 59.2% of pediatric dialysis patients and 91.6% of adult dialysis patients. The primary cause of ESRD was glomerulonephritis for 31.9% of pediatric KTx patients and diabetes for 29.0% of adult KTx patients. The percentage of patients who were on each modality remained fairly constant throughout the cohort years.

IH

Cumulative incidence of IH during the first 12 mo was 25.7% for pediatric patients compared with 30.8% for adult patients (Table 3). Pediatric and adult HD patients showed the greatest IH disparity: 21.3% for pediatric patients compared with 31.8% for adult patients ($P < 0.0001$). IH percentages were 23.4% for pediatric PD and 24.4% for adult PD patients ($P = 0.05$). For KTx patients, cumulative incidence of IH was significantly higher for pediatric patients (33.3%) than for adult patients (25.5%; $P < 0.0001$). Cumulative incidence of IH at 36 mo is shown in Table 3. For dialysis patients, cumulative incidence of IH for internal device infection was 22.0% for pediatric and

Table 2. Characteristics of adult incident dialysis and transplant patients

Characteristic	Adult Incident Dialysis Patients					Adult Transplant Patients				
	Included		Excluded		*P*	Included		Excluded		*P*
	n	%	*n*	%		*n*	%	*n*	%	
Total	333,453		180,853			31,663		8669		
Age (yr)										
<65	131,899	39.6	124,027	68.6		27,644	87.3	8231	94.9	
65 to 74	104,673	31.4	32,579	18.0		3789	12.0	412	4.8	
74 to 85	80,776	24.2	20,506	11.3		226	0.7	25	0.3	
≥85	16,105	4.8	3741	2.1	<0.0001	4	0.0	1	0.0	<0.0001
Race										
white	217,245	65.2	113,742	62.9		20,506	64.8	6592	76.0	
black	98,261	29.5	52,888	29.2		9347	29.5	1669	19.3	
other	17,947	5.4	14,223	7.9	<0.0001	1810	5.7	408	4.7	<0.0001
Gender[a]										
male	174,460	52.3	99,951	55.3		19,026	60.1	5363	61.9	
female	158,987	47.7	80,893	44.7	<0.0001	12,636	39.9	3306	38.1	0.0028
Modality										
HD	305,323	91.6	159,976	88.5						
PD	27,119	8.1	19,911	11.0						
unknown	1011	0.3	966	0.5	<0.0001					
Cause										
diabetes	151,483	45.4	79,529	44.0		9170	29.0	2578	29.7	
hypertension	97,156	29.1	42,428	23.5		7036	22.2	1374	15.8	
GN	26,192	7.9	20,269	11.2		7141	22.6	2200	25.4	
cystic	5475	1.6	5784	3.2		2100	6.6	853	9.8	
other	53,147	15.9	32,843	18.2	<0.0001	6216	19.6	1664	19.2	<0.0001

[a]Gender is unknown for a small number of patients.

19.3% for adult patients, compared with 4.1% for pediatric and 4.8% for adult patients for urinary tract infection (UTI). The corresponding numbers for UTI for KTx patients were 16.8% for pediatric and 10.0% for adult patients.

Comparisons of IH Rates by Modality and Age

IH rates for any infection were highest for pediatric KTx patients and adult HD patients. The adjusted rate ratios (RR) of pediatric KTx patients to HD and PD patients were 1.53 and 1.90, respectively ($P < 0.0001$; Tables 4 and 5). Among KTx patients, the IH rate for pediatric patients was twice that of their adult counterparts (adjusted RR 1.99; $P < 0.0001$). For adults, the HD patient adjusted RR was 1.20 *versus* KTx patients ($P < 0.0001$) and 1.11 *versus* PD patients ($P < 0.0001$). Adjusted IH RR for UTI were significantly higher for KTx patients in both the pediatric and adult populations, ranging from 3.90 (adults, *versus* HD) to 13.7 (pediatric patients, *versus* PD). For all modalities, pediatric patients had significantly higher adjusted IH RR for UTI. Models were re-run after patients with <30 d at risk during the follow-up time were removed, because these patients may have inflated rates as a result of minimal time at risk. This sensitivity analysis showed no significant change in the results.

Deaths

Deaths during hospitalization were more frequent among dialysis patients than KTx patients in both the pediatric and adult patient groups, a result that also was found in the comparison of overall adjusted mortality rates (Tables 6 and 7). There was no significant difference in overall hospitalization deaths between the pediatric HD and PD patient groups (4.6 *versus* 4.2%; $P = 0.70$), but overall adjusted mortality seems higher in HD than PD patients (adjusted RR 2.12 for pediatric patients, $P = 0.0012$; 1.23 for adults, $P < 0.0001$). For adults, overall hospitalization deaths were more frequent in PD than in HD patients (16.9 *versus* 13.6%; $P < 0.0001$). For pediatric patients, IH deaths were more frequent in HD patients than in PD patients (8.5 *versus* 4.6%; $P = 0.0380$) or KTx patients (2.4%; $P < 0.0001$), but there was no significant difference between PD and KTx patients. For adult patients, IH deaths were more frequent in PD patients than in HD patients (23.1 *versus* 21.5%; $P = 0.0004$) or KTx patients (8.8%; $P < 0.0001$) and more frequent in HD patients than in KTx patients ($P < 0.0001$). No deaths related to UTI hospitalization occurred in pediatric patients. For adults, death during UTI hospitalization was more frequent in dialysis than in KTx patients (8.5% HD, 9.0% PD, 1.7% KTx; $P < 0.0001$) but did not differ between PD and HD patients. For

Table 3. Cumulative incidence of IH[a]

Parameter	Pediatric Patients			Adult Patients		
	n	12 Mo (%)	36 Mo (%)	*n*	12 Mo (%)	36 Mo (%)
Any IH						
all dialysis	2481	22.1	43.2	333,453	31.4	52.5
HD	1469	21.3	39.9	305,323	31.8	52.6
PD	982	23.4	51.2	27,119	24.4	51.8
unknown	30	8.0	No estimate[b]	1011	18.5	29.9
KTx	1108	33.3	47.4	31,663	25.5	39.8
all patients	3589	25.7	43.9	365,116	30.8	51.0
P, HD *versus* KTx		<0.0001	<0.0001		<0.0001	<0.0001
P, PD *versus* KTx		<0.0001	0.0074		<0.0001	<0.0001
UTI						
all dialysis	2481	1.8	4.1	333,453	2.2	4.8
HD	1469	1.9	4.7	305,323	2.3	4.9
PD	982	1.7	2.7	27,119	1.2	3.0
unknown	30	0.0	0.0	1011	0.6	0.6
KTx	1108	11.1	16.8	31,663	5.5	10.0
all patients	3589	5.1	9.1	365,116	2.5	5.4
P, HD *versus* KTx		<0.0001	<0.0001		<0.0001	<0.0001
P, PD *versus* KTx		<0.0001	<0.0001		<0.0001	<0.0001
Access device						
HD or PD	2451	9.6	22.0	332,442	10.6	19.3
HD	1469	11.6	23.2	305,323	11.0	19.5
PD	982	6.3	21.3	27,119	4.4	16.9
P, HD *versus* PD		<0.0001	0.0026		<0.0001	<0.0001

[a]HD, hemodialysis; IH, infection-related hospitalizations, KTx, kidney transplant; PD, peritoneal dialysis; UTI, urinary tract infection.

[b]Follow-up time for all 30 patients in this group was censored before the end of 3 yr, making the cumulative incidence at 3 yr nonestimable from Kaplan-Meier methods.

Table 4. IH raw rates per 1000 patient-months

Patients	Hospitalization			
	Any	Any IH	UTI	Access Device Infection
Pediatric				
KTx	238	50	15.0	—
HD	102	28	1.9	12.0
PD	109	33	1.5	6.4
Adult				
KTx	222	33	6.0	—
HD	235	45	2.2	12.0
PD	171	39	1.3	5.7

pediatric patients, death during hospitalization for device infection occurred in 2.8% of HD patients and in no PD patients. For adult patients, death during hospitalization for device infection was nearly twice as frequent in PD patients compared with HD patients (20.4 *versus* 11.3%; $P < 0.0001$). Overall adjusted mortality rates followed a pattern similar to that of hospitalization deaths, with the exceptions shown in Tables 6 and 7.

Discussion

Our data show that hospitalization for infection is common in incident US pediatric and adult patients with ESRD, with 12-mo cumulative incidence between 25 and 31% for both groups. Previous studies reported IH rates in adults with ESRD to vary between 13 and 35% (5–8,16). The IH rates for this national sample of 332,442 adult incident dialysis patients are similar to the 35% reported for a contemporary US adult HD cohort (6). Our IH rate of 39.8% over 3 yr in a national sample of 31,663 adult KTx patients is somewhat higher than the 18.5% reported in a single-center study of 220 adult KTx patients who received a transplant between 1990 and 1999 (8). However, infection also was the major cause of hospitalization for those study patients. Although the USRDS database pertains to a national population, it is unclear how IH rates would have been affected by the inclusion of excluded patients. Both old age and young age are risk factors for infection in patients with ESRD, and excluded pediatric and adult dialysis patients were younger than included patients.

To our knowledge, ours is the first study to compare IH rates for both pediatric and adult US incident patients with ESRD and the first to examine IH rates by treatment modality for children with ESRD. We found variation in rates of IH by age

Table 5. IH adjusted RR[a]

Patients	Hospitalization					
	Any			Any IH		
	Adjusted RR	*P*	95% CI	Adjusted RR	*P*	95% CI
Pediatric *versus* adult						
KTx	1.31	<0.0001	1.25 to 1.37	1.99	<0.0001	1.80 to 2.21
HD	1.05	0.0754	1.00 to 1.10	0.92	0.1100	0.84 to 1.02
PD	1.32	<0.0001	1.23 to 1.41	1.11	0.1103	0.98 to 1.27
Pediatric						
KTx *versus* HD	2.06	<0.0001	1.90 to 2.23	1.53	<0.0001	1.29 to 1.81
KTx *versus* PD	2.18	<0.0001	2.00 to 2.37	1.90	<0.0001	1.60 to 2.25
HD *versus* PD	1.10	0.0422	1.00 to 1.20	1.12	0.1987	0.94 to 1.32
Adult						
KTx *versus* HD	1.16	<0.0001	1.15 to 1.18	0.83[b]	<0.0001	0.80 to 0.86
KTx *versus* PD	1.38	<0.0001	1.36 to 1.40	0.92	<0.0001	0.89 to 0.96
HD *versus* PD	1.30	<0.0001	1.28 to 1.31	1.11	<0.0001	1.09 to 1.14
	UTI			Access Device Infection		
Pediatric *versus* adult						
KTx	2.47	<0.0001	2.01 to 3.03	—	—	—
HD	3.16	<0.0001	2.14 to 4.65	0.94	0.4351	0.81 to 1.10
PD	3.46	0.0003	1.77 to 6.75	1.25	0.1574	0.92 to 1.71
Pediatric						
KTx *versus* HD	7.91	<0.0001	5.00 to 12.5	—	—	—
KTx *versus* PD	13.7	<0.0001	7.87 to 24.1	—	—	—
HD *versus* PD	1.78	0.1181	0.86 to 3.65	2.40	<0.0001	1.73 to 3.34
Adult						
KTx *versus* HD	3.90	<0.0001	3.60 to 4.23	—	—	—
KTx *versus* PD	5.19	<0.0001	4.54 to 5.93	—	—	—
HD *versus* PD	1.54	<0.0001	1.38 to 1.72	2.02	<0.0001	1.92 to 2.13

[a]CI, confidence interval; HD, hemodialysis; KTx, kidney transplant; PD, peritoneal dialysis; RR, rate ratio.
[b]1.20 when KTx is reference.

Table 6. Pediatric and adult dialysis and transplant patient percentage of deaths during hospitalization.

Patients	Hospitalization							
	Any		Any IH		UTI		Access Device Infection	
	n	% Deaths	*n*	% Deaths	*n*	% Deaths	*n*	% Deaths
Pediatric								
KTx	2555	1.1	540	2.4	161	0	—	—
HD	1493	4.6	410	8.5	28	0	177	2.8
PD	1061	4.2	323	4.6	15	0	62	0
Adult								
KTx	67,603	4.4	10,187	8.8	1854	1.7	—	—
HD	662,127	13.6	126,260	21.5	6325	8.5	33,746	11.3
PD	45,036	16.9	10,277	23.1	346	9.0	1,503	20.4

and by ESRD modality. Adult HD patients had a 10 to 12% higher cumulative incidence of IH than did pediatric HD patients. The reason for this difference is unexplained; risk factors for infection, such as access device application, affinity of organisms for foreign materials, dialyzer membrane interaction, uremia, nasal and skin colonization with bacteria, vitamin D

Table 7. P values for comparisons of percentage of hospitalizations resulting in death and overall adjusted mortality RR

Patients	Hospitalization Death Comparison *P* Values				Overall Mortality RR		
	Any	Any IH	UTI	Access Device Infection	Adjusted RR	*P*	95% CI
Pediatric *versus* adult							
KTx	<0.0001	<0.0001	0.1698[a]	—	0.94	0.8811	0.41 to 2.14
HD	<0.0001	<0.0001	0.1661[a]	0.0004	1.40	0.0084	1.09 to 1.80
PD	<0.0001	<0.0001	0.6279[a]	<0.0001[a]	3.05	<0.0001	2.21 to 4.22
Pediatric							
KTx *versus* HD	<0.0001	<0.0001	—	—	0.09	0.0002	0.03 to 0.32
KTx *versus* PD	<0.0001	0.0727	—	—	0.15	0.0022	0.04 to 0.50
HD *versus* PD	0.7044	0.0380	—	0.3309	2.12	0.0012	1.35 to 3.33
Adult							
KTx *versus* HD	<0.0001	<0.0001	<0.0001	—	0.25	<0.0001	0.23 to 0.27
KTx *versus* PD	<0.0001	<0.0001	<0.0001	—	0.33	<0.0001	0.30 to 0.36
HD *versus* PD	<0.0001	0.0004	0.7527	<0.0001	1.23	<0.0001	1.19 to 1.26

[a]Fisher exact test used for this comparison; because of the zero counts for pediatric patients, one should be cautious in interpreting the results.

deficiency, and malnutrition are common to both adults and children (12–14,17). A possible explanation is that most adult patients with ESRD are treated with hemodialysis and the waiting lists for transplantation are long, whereas nearly three fourths of pediatric patients with ESRD receive a transplant within 3 yr of developing ESRD. We found little difference in the incidence of IH between adult and pediatric PD patients.

Although the rates per 1000 patient-months of access-related IH were similar for children and adults, a greater percentage of IH was due to access devices in pediatric HD patients than in adult HD patients (43 *versus* 27%; data not shown). Other studies have reported access-related IH incidence to range from 1.5 to 23% in adult HD patients (5,6,18). A higher percentage of pediatric patients undergo dialysis with catheters for vascular access compared with adults. For 2002, approximately 40 to 50% of adult patients with ESRD initiated dialysis with catheters compared with 78% for pediatric patients who were younger than 13 yr and 44% for those who were 13 yr and older, which may explain partially the increased incidence of IH in pediatric HD patients (19). In a retrospective cohort study of nearly 7500 adult HD patients, the use of a venous catheter for dialysis was associated with a higher incidence of death as a result of infection (3.4%) compared with use of a graft (1.2%) or a fistula (0.8%; $P < 0.001$) (15).

Our results show that IH rates for any infection during the first 12 mo after initiation of ESRD therapy are highest for pediatric KTx patients compared with adult KTx patients and with pediatric and adult dialysis patients. The adjusted rate of IH for pediatric KTx patients is between one-and-a-half and two times that for pediatric dialysis patients and almost twice that of adult KTx patients.

We did not break down instances of IH by type of infection because often the specific organism was unknown. The most common infection diagnoses included the specification "organism NOS." Therefore, we were unable to classify the infection as bacterial, viral, or fungal. It is unclear how new protocols with immunosuppression for transplant patients will affect future rates. However, North American Pediatric Renal Transplant Cooperative Study (NAPRTCS) data show that despite changes in induction and maintenance immunosuppression protocols for pediatric patients since 1987, a more recent year of transplantation is associated with increased IH (11). Similarly, although intuitively the "Fistula First" protocol for dialysis patients should reduce the rate of access infections in the future, our analysis is based on diagnosis codes that do not distinguish between access infections for catheters, fistulas, or grafts; attributing infections for KTx patients to central lines therefore also is impossible. More specific data collection is needed to assess these differences.

Few studies examine IH rates in children with ESRD. Furth *et al.* (20) reported hospitalization risk for 1112 prevalent pediatric ESRD patients, 44% dialysis and 54% KTx, who were aged 17 yr or younger, had growth failure (defined as >2 SD below the mean in height for age and gender), and participated in a 1990 special USRDS Pediatric Growth and Development study. Overall, 73% of patients were hospitalized during 5 yr of follow-up, and infection accounted for 53% of the hospitalizations (20). IH rates were not compared by type of dialysis modality. A retrospective study using NAPRTCS data evaluated morbidity and mortality in 1942 children, 69% PD and 31% HD, who had anemia (defined as hematocrit <33%) and initiated dialysis between 1992 and 2001 (9). Overall, 857 patients, 44% PD and 46% HD, were hospitalized within 12 mo of start of dialysis (9). At 7 to 12 mo after the start of dialysis, infection was the cause of 27% of hospitalizations for nonanemic PD patients, 28% for anemic PD patients, 3% for nonanemic HD patients, and 21% for anemic HD patients (9). Causes of IH were not examined.

A recent report from NAPRTCS compared hospitalization incidence for infection and rejection during a 2-yr period for 6701 children who received transplants between 1987 and 2000

(11). In the NAPRTCS study, the percentage of IH increased slightly overall from 38% in 1987 to 40% in 2000 (11). We found no significant variation in IH rates for pediatric KTx patients for each calendar year between 1996 and 2001. NAPRTCS is a voluntary registry, and the reporting of hospitalizations or cause of hospitalization may have been incomplete.

We found IH rates for UTI to be high for both adult and pediatric KTx patients. In the single-center study of 164 pediatric KTx patients, UTI was the most common cause of IH beyond the first 2 wk after transplantation (10). The larger NAPRTCS study of pediatric KTx patients did not report IH data by site of infection (11). In a retrospective cohort study of 28,942 adult Medicare KTx patients in the USRDS database between January 1, 1996, and July 31, 2000, 28% had claims for UTI during a hospitalization (21). UTI was coded as the primary discharge diagnosis in 25% of the 8812 KTx patients with inpatient claims for it.

Deaths during IH were more frequent for dialysis patients than for KTx patients in both the adult and pediatric patient groups. For pediatric dialysis patients, deaths during IH were more frequent for HD than for PD patients. In the pediatric dialysis study by Warady and Ho (9), infection was the primary cause of death in 21% of anemic patients and 18% of nonanemic patients. However, infection-related deaths were not analyzed by hospitalization status, cause of hospitalization at the time of death, or type of dialysis. Infection as a major cause of death among pediatric patients with ESRD is well documented (1–3,9,20,22–24). However, we could not find previous pediatric studies that evaluated patients with ESRD for IH deaths or analyzed infection-related deaths by type of treatment modality. For adult dialysis patients, deaths during IH were more frequent in PD than in HD patients. A study from the 1990s compared cause of death among a large national sample of prevalent adult dialysis patients using USRDS data and found a 40% higher infection-related death rate for PD patients (4.8 per 100 patient-years) compared with HD patients (3.4 per 100 patient-years) (25). Although the findings are similar to ours, their analysis was not limited to deaths during IH.

A potential limitation of our study is that we examined IH using only *ICD-9-CM* codes that listed infection as the primary diagnosis for hospitalization. This limitation is offset, however, by the fact that the national Medicare data contain relatively complete hospitalization records. We relied on information that was contained in the CMS Death Notification (CMS-2746) for cause of death; these forms may contain some inaccuracies. The criteria for admission to hospital may differ between pediatric and adult patients. Finally, we did not analyze for adequacy of dialysis. Despite the limitations, a large national study such as this one may be the only way to assess the complications that we address.

Conclusion

Our study of incident US patients with ESRD shows that pediatric patients have a high burden of hospitalizations from infection. Compared with adults, pediatric patients have fewer IH on HD and more IH after KTx. These results indicate opportunity for improvement in reducing infection and IH rates in patients with ESRD. In particular, pediatric KTx patients require more infection surveillance and likely require prolonged prophylactic antibiotic treatment after transplantation. A focus of future research should include analysis of secondary infections during hospitalizations in patients with ESRD and differences in IH death rates for PD and HD patients.

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Disclosures

None.

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This paper provides data on the high rates of infection-related hospitalizations in both pediatric and adult hemodialysis, peritoneal dialysis, and transplant patients over a 5-yr period and is related to two papers in the current issue of *CJASN* that discuss infectious issues in dialysis patients: an article by Kshirsagar *et al.* (pages 238–243) that describes the adverse associations of periodontitis with other clinical parameters, and a review by Szeto *et al*. (pages 244–250) of 245 cases of *Staphylococcus aureus* peritonitis in peritoneal dialysis patients.