Avoidable Hospitalizations in Youth With Kidney Failure After Transfer to or With Only Adult Care

AUTHORS: Susan M. Samuel, MD, MSc, Alberto Nettel-Aguirre, PhD, Andrea Soo, MSc, Brenda Hemmelgarn, MD, PhD, Marcello Tonelli, MD, SM, and Bethany Foster, MD, MSc

Departments of Pediatrics, Community Health Sciences, and Medicine, University of Calgary, Calgary, Alberta, Canada; Department of Medicine, University of Alberta, Edmonton, Alberta, Canada; Departments of Pediatrics and Epidemiology, Biostatistics and Occupational Health, McGill University, Montreal, Quebec, Canada

KEY WORDS: adolescence, age, end-stage renal disease, emerging adulthood, transfer of care, transition to adulthood

ABBREVIATIONS: ACSC—ambulatory care-sensitive condition; CIHI DAD—Canadian Institute for Health Information Discharge Abstract Database; CORR—Canadian Organ Replacement Register; ESRD—end-stage renal disease; IQR—interquartile range.

WHAT’S KNOWN ON THIS SUBJECT: The period of transition from childhood to adulthood and the period immediately after transfer of care is a challenging time for young people with kidney failure.

WHAT THIS STUDY ADDS: Young patients with kidney failure cared for exclusively in adult-oriented facilities experience increased rates of avoidable hospitalizations during late adolescence and young adulthood. Avoidable hospitalizations increased among pediatric kidney failure patients during the years immediately after transfer to adult care.

OBJECTIVE: Hospital admissions for ambulatory care-sensitive conditions (also called avoidable hospitalizations) are a measure of quality and access to outpatient care. We determined if young patients with end-stage renal disease (ESRD) are at increased risk of avoidable hospitalizations.

METHODS: A national organ failure registry was used to identify patients with ESRD onset at <22 years of age between April 1, 2001, and March 31, 2010, who had received care in an adult care facility after age 15 years. The cohort was linked to the national hospitalizations database to identify avoidable hospitalizations relevant for young patients with ESRD. Patients were followed up until death, loss to follow-up, or study end. Two groups were studied: (1) patients transferred from pediatric to adult care; and (2) patients receiving ESRD care exclusively in adult centers. We determined the association between overall and avoidable hospitalization rates and both age and transfer status by using Poisson regression models.

RESULTS: Our cohort included 349 patients. Among the 92 (26.4%) patients transferred to adult care during the study period, avoidable hospitalization rates were highest during the period 3 to <4 years after transfer (rate ratio: 3.19 [95% confidence interval: 1.42–7.18]) compared with the last year in pediatric care. Among the 257 (73.6%) patients with ESRD care exclusively in adult centers, avoidable hospitalization rates increased with age.

CONCLUSIONS: Among those who were transferred to adult care, avoidable hospitalization rates increased after transfer. Avoidable hospitalization rates increased with age in ESRD patients who received care in adult centers. Young patients with ESRD are at increased risk of avoidable hospitalizations.
Adolescence and emerging adulthood, the transition period between childhood and adulthood, is a stage of life filled with changes and challenges. In addition to the numerous changes faced by healthy individuals, adolescents and emerging adults with end-stage renal disease (ESRD [defined as kidney failure requiring renal replacement therapy with dialysis or kidney transplantation]) must learn to take responsibility for their own health while experiencing the limitations and restrictions associated with their condition. Adolescents with ESRD demonstrate high rates of non-adherence with both clinic visits and prescribed medications. Transfer to adult-oriented health services occurs in late adolescence (around age 18 years) and may exacerbate these high-risk behaviors. These periods of non-adherence to medications, clinic appointments, and routine blood work may lead to detrimental and sometimes irreversible outcomes. Therefore, adolescence and emerging adulthood in general, as well as the time after transfer of care in particular, are critical periods. There is limited evidence regarding the quality of care of ESRD patients during this period.

Examination of health service use for ESRD patients during adolescence and after transfer to adult care may provide valuable information about potential gaps in continuity of care and related morbidity. All-cause hospitalization has been used as a surrogate measure of illness burden and to detect problems with access to care in various settings. Another indicator of access and quality of care is hospitalization for ambulatory sensitive conditions (ACSCs), also known as avoidable hospitalizations. ACSCs can typically be managed in an ambulatory setting; admission to the hospital for an ACSC therefore indicates a potentially avoidable hospitalization resulting from inadequate outpatient primary and/or subspecialty care.

We hypothesized that young patients with ESRD experience an increased rate of potentially avoidable hospitalizations during adolescence and emerging adulthood, particularly after transfer to adult-oriented care. The objectives of the present study were to determine: (1) the association between age and avoidable hospitalization rate among young patients with ESRD, after adjustment for potential confounders; and (2) if there was an increase in avoidable hospitalizations after transfer of pediatric ESRD patients to adult care compared with the year before transfer.

METHODS
Development of ACSCs for Pediatric ESRD

A modified Delphi process was used to develop a list of ACSCs relevant to children and young adults with ESRD. We used published lists of ACSCs developed by the Agency for Healthcare Research and Quality, relevant to both children and adults in the general population, as well as a list of chronic kidney disease-specific ACSCs, to guide the development of a list of ACSCs relevant for pediatric patients with ESRD. We used a modified Delphi process (with 3 iterations) and a panel of physicians to elicit expert opinion on these conditions and to identify other candidate conditions relevant for pediatric patients with ESRD to derive the final list. Nineteen physicians were identified as potential participants for the expert panel; 10 agreed to participate and completed all rounds of the Delphi process. The panelists included 4 pediatric nephrologists, 4 adult nephrologists, and 2 emergency department physicians (1 pediatric and 1 adult care physician). We presented a total of 44 conditions to the panelists for the first stage, and after 3 Delphi iterations, we finalized a list of 21 candidate conditions. The conditions were relevant to both dialysis and transplant patients (Supplemental Information Table 5).

Study Population and Data Sources

The Canadian Organ Replacement Register (CORR) was used to identify patients who initiated ESRD care before 22 years of age between April 1, 2001 and March 31, 2010 in 9 of 10 Canadian provinces (data from the province of Quebec were not available for release to the investigators). CORR is the sole national organ failure registry and is maintained by the Canadian Institute for Health Information. All pediatric and adult dialysis and transplant centers in Canada submit standardized data forms regularly to CORR on all patients with ESRD in Canada. Canadians have universal health insurance coverage, including for dialysis and transplantation. Data were not acquired for patients aged ≥22 years at ESRD onset.

The cohort was linked to the Canadian Institute for Health Information’s national hospital Discharge Abstract Database (CIHI DAD) by using a unique identifier (personal health number). Patients entered observation at ESRD onset or 15 years old (if ESRD onset was at <15 years), and were followed up until death, loss to follow-up, or end of the study period (December 31, 2010). This approach allowed us to capture multiple hospitalizations for a patient. Observation time of patients <15 years old was excluded because it was unlikely that subjects aged <15 years would receive care in adult facilities. Due to the longitudinal nature of national hospitalization data sets within a universal access health care system, we were able to observe hospitalizations in many patients beyond age 22 years. Patients were excluded if they were multiorgan transplant recipients, if they did not link to the hospitalization data set at least once during the observation period, if they were treated solely in pediatric care centers without transferring during the study period, or if they did not have a logically coherent pattern of care (ie, pediatric care followed by consistent...
adult care within expected age ranges or adult care only).

The final cohort of patients was composed of 2 groups: (1) patients transferred to adult care with previous consistent care in a pediatric center (transferred group); or (2) patients cared for exclusively in an adult center (adult care only group). Due to the geographical vastness of Canada and varying referral patterns, some adolescents may be cared for in adult institutions.24

Coding of Hospitalizations

Discharge diagnoses attributed to each hospital admission were obtained from the CIHI DAD. Hospital discharge diagnoses are routinely classified by using codes from the Ninth Revision and 10th Revision of International Classification of Diseases. One diagnosis is identified as being most responsible for the admission, and up to 24 additional discharge diagnoses are recorded for each hospital admission in Canada. Therefore, each hospitalization record found in the CIHI DAD contains up to 25 possible diagnoses. We evaluated the most responsible diagnosis for each hospitalization and classified it as either avoidable or not avoidable by using the list of avoidable hospitalizations described in the previous section.

Overall and Avoidable Hospitalizations According to Age at Hospitalization in the Transferred and Adult Care Only Groups

Crude rates were calculated for overall hospitalizations and avoidable hospitalizations per 100 person-years of follow-up for both the transferred and adult care only groups in the following age intervals: 15 to <19, 19 to <21, 21 to <23, and 23 to <25 years. The risk of hospitalization may differ dramatically in the pediatric setting compared with the adult care setting by virtue of differences in care “culture” and in the realities of bed availability in a single-payer, universal access health care system.25 Bed availability is much more restricted in adult centers compared with pediatric centers. Therefore, the threshold for admission to adult care facilities may be substantially higher than that to pediatric facilities, with correspondingly lower admission rates; the threshold for admission may also be age dependent, with a much higher risk of admission for younger children. To control for potential differences in hospitalization practices between pediatric and adult care facilities, we expressed avoidable hospitalizations relative to overall hospitalizations (ie, the proportion of all hospitalizations that were avoidable) in adjusted analyses. Also presented here are the crude proportions of avoidable hospitalizations according to age for both transferred and adult care only groups.

For analyses comparing overall hospitalization rates and proportions of hospitalizations that were avoidable between different age intervals, we included only observation in adult centers for both transferred and adult care only groups. Mixed-effects Poisson regression models were used to determine the association between age interval and both overall hospitalization rates and the proportion of avoidable hospitalizations. Mixed-effects models were used because age (at hospitalization) was a time-varying variable, and patients could have hospitalizations in >1 age interval. The model included an interaction term between age group at hospitalization and transfer status (transferred group versus adult care only group) and was adjusted for the following potential confounders: age at ESRD onset, gender, socioeconomic status, etiology of ESRD, ethnicity, and distance to nearest pediatric renal care center. Socioeconomic status was estimated by using median neighborhood income according to postal codes of residence (classified by quintile) based on 2001 Statistics Canada census data. Etiology of renal failure was categorized as congenital anomalies of the kidney and urinary tract, glomerulonephritis/autoimmune, genetic, and unknown/other. Ethnicity, as determined by the health care professional responsible for reporting to CORR, was classified for our study as white, Aboriginal (First Nations, Inuit, or Métis, including Aboriginal people living on federal reserves), black, or other (Asian, Indian subcontinent, Mid-East/Arabian, Pacific Islander, other, or unknown). We used distance from the patient’s residence at ESRD onset to the nearest pediatric renal care center as a measure of geographic remoteness of residence. The geographic coordinates of residences and renal care centers were determined from postal codes and entered into geographic information systems software (ArcGIS 3.0; Esri, Redlands, CA) to determine shortest distances by road between the patient’s residence and the closest pediatric renal care center. We used the distance to nearest pediatric center as a reasonable proxy for geographical remoteness from a major adult center for both transferred and adult care only groups. The majority of tertiary care adult and pediatric renal centers are adjacent to each other in Canada.

We also constructed models adjusted for the same potential confounders as noted earlier, with age at hospitalization as a continuous variable. These models also included an interaction term between age at hospitalization and group (transferred versus adult care only). The models were used to plot predicted overall hospitalization rates per 100 person-years and proportion of avoidable hospitalizations by age for both groups. The predicted rates and proportions used the following fixed covariate profile: age 10 to <15 years at ESRD onset, male, highest income quintile, congenital etiology, white,
and distance of <50 km to the nearest pediatric renal care center.

**Avoidable Hospitalizations After Transfer to Adult Care**

To determine whether hospitalization rates varied according to temporal proximity of transfer to adult care, we determined overall hospitalization rates and the proportion of avoidable hospitalizations in each 1-year interval after transfer and compared them with the last year in pediatric care. Date of transfer was defined as 6 months before the date of first recorded adult care visit (recorded in the registry). Mixed-effects Poisson regression models with years since transfer as a time-varying variable were used to determine the association between years since transfer and each of overall hospitalization rates and the proportion of avoidable hospitalizations. Models were adjusted for the following potential confounders: age at ESRD onset, gender, socioeconomic status, etiology of ESRD, ethnicity, distance to nearest pediatric renal care center, and time since ESRD onset at transfer. Models with years since transfer as a continuous variable and adjusted for the same potential confounders as noted earlier were used to plot overall hospitalizations per 100 person-years and proportion of avoidable hospitalizations according to years since transfer. The predicted rates and proportions used the following fixed covariate profile: age 10 to <15 years at ESRD onset, male, highest income quintile, congenital etiology, white, distance of <50 km to the nearest pediatric renal care center, and time since ESRD onset of 3 years.

**RESULTS**

**Patient Cohort**

A total of 826 patients <22 years old initiated ESRD care during the study period. Of these, 477 were excluded: 23 were multiorgan transplant recipients, 39 did not link to CIHI DAD due to technical reasons or lack of a hospitalization during the observation period, 74 did not have a logically coherent pattern of care (ie, regular pediatric care and then transfer on a defined date or consistent adult care), and 341 started in pediatric care but did not transfer to adult care during the study period. Therefore, we studied the experience of 349 patients, 92 (26.4%) of whom were observed in both pediatric and adult care environments and 257 (73.6%) who were observed exclusively in an adult care environment.

**Patient Characteristics**

Characteristics of the study cohort are outlined in Table 1. Gender, ESRD etiology, and proportion of transplant patients with living donors (47.7%) were consistent with the general, young Canadian ESRD population.26 Most patients (52.7%) were white, 6.6% were black, and 8.9% were Aboriginal in ethnicity. Patients in the adult care only group were generally older at ESRD onset (median age: 19.7 years [interquartile range (IQR): 18.7–20.8]) than those in the transferred group (median age: 16.1 years [IQR: 14.8–17.3]). Consistent with the age difference, the ESRD etiology also differed between the groups, with fewer patients in the adult care only group with congenital anomalies of the kidney and urinary tract. The majority of patients lived within 50 km of a pediatric renal care center. Patients were distributed across income quintiles (24.1% and 16.7% were in the lowest and highest income quintile, respectively). Median follow-up was 4.5 years (IQR: 2.6–5.8), with a total of 373 person-years of observation. For those who transferred, the median age at first visit to an adult center was 18.1 years (IQR: 18.0–19.2).

**Overall and Avoidable Hospitalizations After Transfer of Care**

The proportion of avoidable hospitalizations increased after transfer of care (Fig 2). Compared with the year before transfer, the proportion of avoidable hospitalizations was threefold to fourfold higher during the period 3 to <4 years after transfer (risk ratio: 3.19 [95% confidence interval: 1.42–7.18]). There was a decline in overall hospitalization rate during the same interval after transfer of care (Table 4).

**DISCUSSION**

In this national cohort of young patients with ESRD, we found a marked increase in avoidable hospitalizations with increasing age among patients cared for exclusively in adult care environments. Among patients who had experienced a transfer from pediatric care, there was a clear increase in the proportion of avoidable hospitalizations after transfer of care in the setting of declining overall hospitalization rates. Adolescence and emerging adulthood are periods marked by major physical,
cognitive, emotional, and social development, as well as a period of increasing independence from parents. The results of the present study are consistent with our previous study of young kidney transplant recipients recorded in the United States Renal Data System database, in which we found a gradual increase in graft failure rates starting at 11 to 12 years of age, peaking at 17 to 24 years of age, and declining thereafter. Combined, these studies provide strong evidence that late adolescence and emerging adulthood is a high-risk interval. Most patients who begin ESRD care in pediatric facilities in North America are transferred to adult care during this vulnerable developmental period (~18–21 years of age in most pediatric institutions). After transfer to adult care, many young adults with chronic disease “drop out” of the adult system and emerge later in time with preventable complications. For example, among those with type 1 diabetes, up to 40% of transferred young adults drop out of adult-oriented medical care. Patients who dropped out were subsequently found to experience devastating consequences such as pregnancy loss, legal blindness, amputation, and death. Sudden changes in health care system and provider characteristics that occur after transfer may be disorienting to pediatric patients, who have been accustomed to receiving intense care and attention all their lives. Transfer to adult-oriented care is associated with a shift of focus from family to the individual, with emphasis placed on the patient’s responsibility for his or her own care. The sudden shift may change the way in which patients access medical care and increase the risk of nonadherence with prescribed medical therapy. The period after transfer from pediatric to adult care was associated with a twofold to fivefold increased risk in graft failure in Canadian pediatric kidney transplant recipients. Hospital admission for graft failure was deemed a potentially avoidable hospitalization by the Delphi panelists in this study. We hypothesize that deterioration in adherence to medications and clinic attendance after transfer to adult care may have contributed to the observed increased graft failure risk during the period after transfer and may also play a role in the increased risk of avoidable hospitalizations. Adverse outcomes during adolescence and young adulthood have been suggested to be potentially related to loss of insurance coverage in the United States. This factor, however, is unlikely to be the only explanation for the increased risk of avoidable hospitalizations.

### Table 1: Baseline Demographic Characteristics of the Study Cohort

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>All (N = 349)</th>
<th>Transferred (n = 92)</th>
<th>Adult Care Only (n = 257)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at start of RRT, y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 to &lt;15</td>
<td>25 (7.2)</td>
<td>25 (27.2)</td>
<td>0</td>
</tr>
<tr>
<td>15 to &lt;18</td>
<td>91 (26.1)</td>
<td>58 (63.0)</td>
<td>33 (12.8)</td>
</tr>
<tr>
<td>≥18</td>
<td>233 (66.8)</td>
<td>9 (9.8)</td>
<td>224 (87.2)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>187 (53.6)</td>
<td>48 (52.2)</td>
<td>139 (54.1)</td>
</tr>
<tr>
<td>Female</td>
<td>162 (46.4)</td>
<td>44 (47.8)</td>
<td>118 (45.9)</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>184 (52.7)</td>
<td>51 (55.4)</td>
<td>133 (51.8)</td>
</tr>
<tr>
<td>Aboriginal</td>
<td>31 (8.9)</td>
<td>6 (6.5)</td>
<td>25 (9.7)</td>
</tr>
<tr>
<td>Black</td>
<td>25 (6.6)</td>
<td>6 (6.5)</td>
<td>17 (6.6)</td>
</tr>
<tr>
<td>Other</td>
<td>111 (31.8)</td>
<td>29 (31.5)</td>
<td>82 (31.9)</td>
</tr>
<tr>
<td>Income quintile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (lowest)</td>
<td>84 (24.1)</td>
<td>26 (28.3)</td>
<td>58 (22.6)</td>
</tr>
<tr>
<td>2</td>
<td>79 (22.6)</td>
<td>21 (22.8)</td>
<td>58 (22.6)</td>
</tr>
<tr>
<td>3</td>
<td>80 (17.2)</td>
<td>15 (16.3)</td>
<td>65 (15.6)</td>
</tr>
<tr>
<td>4</td>
<td>52 (14.9)</td>
<td>12 (13.0)</td>
<td>40 (15.6)</td>
</tr>
<tr>
<td>5 (highest)</td>
<td>58 (16.7)</td>
<td>15 (16.3)</td>
<td>43 (16.7)</td>
</tr>
<tr>
<td>Unknown</td>
<td>16 (4.6)</td>
<td>3 (3.3)</td>
<td>13 (5.1)</td>
</tr>
<tr>
<td>Distance to nearest pediatric renal care center, km</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;50</td>
<td>128 (36.7)</td>
<td>38 (41.3)</td>
<td>90 (35.0)</td>
</tr>
<tr>
<td>50 to &lt;150</td>
<td>78 (22.3)</td>
<td>26 (28.3)</td>
<td>52 (20.2)</td>
</tr>
<tr>
<td>150 to &lt;300</td>
<td>45 (12.9)</td>
<td>11 (12.0)</td>
<td>34 (13.2)</td>
</tr>
<tr>
<td>≥300</td>
<td>77 (22.1)</td>
<td>12 (13.0)</td>
<td>65 (25.3)</td>
</tr>
<tr>
<td>Unknown</td>
<td>21 (6.0)</td>
<td>5 (5.4)</td>
<td>16 (6.2)</td>
</tr>
</tbody>
</table>

Data are presented as n (%). CAKUT, congenital anomalies of the kidney and urinary tract; GN, glomerulonephritis; RRT, renal replacement therapy.

### Table 2: Overall and Avoidable Hospitalizations According to Age for Patients Who Transferred to Adult Care (n = 92)

<table>
<thead>
<tr>
<th>Age Period</th>
<th>Overall</th>
<th></th>
<th>Avoidable</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crude Rates</td>
<td>Adjusted Rate Ratio</td>
<td>Crude Rates</td>
<td>Proportion</td>
</tr>
<tr>
<td>15 to &lt;19 y</td>
<td>206.9</td>
<td>1.00 (Ref)</td>
<td>42.1</td>
<td>20.3</td>
</tr>
<tr>
<td>19 to &lt;21 y</td>
<td>88.5</td>
<td>0.57 (0.43–0.76)</td>
<td>18.8</td>
<td>21.3</td>
</tr>
<tr>
<td>21 to &lt;23 y</td>
<td>80.5</td>
<td>0.58 (0.42–0.81)</td>
<td>17.0</td>
<td>21.1</td>
</tr>
<tr>
<td>23 to &lt;25 y</td>
<td>40.1</td>
<td>0.51 (0.19–0.95)</td>
<td>7.3</td>
<td>18.2</td>
</tr>
</tbody>
</table>

Overall and avoidable crude hospitalization rates were calculated per 100 person-years of follow-up. Proportions used in risk ratios for avoidable hospitalizations according to age were calculated per 100 overall hospitalizations (i.e., proportion of overall hospitalizations). The Poisson regression model was adjusted for age at start of ESRD, gender, socioeconomic status, etiology of ESRD, ethnicity, and distance to nearest pediatric renal care center.

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to represent a significant problem in Canada. All Canadian patients have free access to health care, and most provincial jurisdictions provide complete coverage for ESRD medications. The concept of transition was defined by Rosen et al32 as "the purposeful, planned movement of adolescents and young adults with chronic physical and medical conditions from child-centered to adult-oriented health care systems." For pediatric patients with chronic disease, this process may take several years and should not be confused with transfer of care, which defines the physical switch from pediatric to adult provider.3,3 Important aspects of transition care include gaining graded medical independence and self-management skills, successful attachment to new care providers, and appropriate community supports. During the period of the study, patients transferring from pediatric care may have had exposure to transition planning and coordination of care with adult care providers. However, transition practices are known to be highly variable across pediatric ESRD clinics and over time. Due to the limitations of our data set, we were unable to account for the quality of or exposure to transitional care.

This is the first study, to our knowledge, to evaluate the effects of both age and transfer of care on avoidable hospitalizations among young patients with ESRD. Among those treated exclusively in adult centers, there was a marked rise in avoidable hospitalizations as patients advanced in age, progressing through late adolescence into emerging adulthood. This group of patients was never exposed to transfer and thus had a uniform care environment throughout this interval. This finding suggests that adult health care systems may not be well suited to address the developmental needs of this group of emerging adult patients with kidney failure. Further evaluation of health system and supports provided to emerging adults in adult-oriented centers is needed.

Interestingly, we did not observe an increase in avoidable hospitalizations with increasing age in the transferred group, despite an increase at 3 to 4 years after transfer (when they were older). It is important to recognize that the reference interval for the analyses comparing time after transfer with the year before transfer may include a different age distribution than the 15- to <19-year-old reference interval in the analyses comparing age periods. It may be that some patients dropped out from routine care after transfer, only to resurface with problems requiring hospitalization years later.

We have not presented results of the simple comparison of avoidable hospitalizations by age intervals in the transferred versus adult care only groups.

### Table 3: Overall and Avoidable Hospitalizations According to Age for Those Cared for Exclusively in Adult Centers (n = 257)

<table>
<thead>
<tr>
<th>Age Period</th>
<th>Overall Crude Rates</th>
<th>Overall Adjusted Rate Ratio</th>
<th>Avoidable Crude Rate</th>
<th>Avoidable Proportion</th>
<th>Avoidable Adjusted Risk Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 to &lt;19 y</td>
<td>249.5</td>
<td>1.00 (Ref)</td>
<td>25.4</td>
<td>10.2</td>
<td>1.00 (Ref)</td>
</tr>
<tr>
<td>19 to &lt;21 y</td>
<td>159.2</td>
<td>0.35 (0.28–0.44)</td>
<td>22.3</td>
<td>14.0</td>
<td>1.94 (1.06–3.54)</td>
</tr>
<tr>
<td>21 to &lt;23 y</td>
<td>116.1</td>
<td>0.20 (0.16–0.25)</td>
<td>19.9</td>
<td>17.1</td>
<td>2.22 (1.22–4.04)</td>
</tr>
<tr>
<td>23 to &lt;25 y</td>
<td>93.2</td>
<td>0.15 (0.12–0.19)</td>
<td>21.4</td>
<td>23.0</td>
<td>2.67 (1.43–4.99)</td>
</tr>
</tbody>
</table>

Overall and avoidable crude hospitalization rates were calculated per 100 person-years of follow-up. Proportions used in risk ratios for avoidable hospitalizations according to age were calculated per 100 overall hospitalizations (ie, proportion of overall hospitalizations that are avoidable). The Poisson regression model was adjusted for age at start of ESRD, gender, socioeconomic status, etiology of ESRD, ethnicity, and distance to nearest pediatric renal care center.

### Figure 1

Adjusted (A) all-cause hospitalization rate and (B) avoidable hospitalization curves according to age for transferred and adult care only groups.
These groups are very different in composition, and a direct comparison is not valid. Pediatric age patients starting renal replacement therapy at an adult center generally tend to have developed ESRD at older ages, and most have fewer comorbidities than patients initiating ESRD care in a pediatric center. There are several limitations to our study. We used a Delphi method to define avoidable hospitalizations for pediatric patients with ESRD. Validation of ACSCs by using an independent data set was not conducted, and the validity of administrative data discharge diagnosis coding for pediatric renal disease has not been established. Therefore, there is potential for misclassification of hospitalization type (avoidable or unavoidable). In the Delphi panel, generalist pediatricians were not included, and valuable input may have therefore been missed. We adjusted for propensity of hospital admission in pediatric versus adult centers by calculating avoidable hospitalizations as a proportion of overall hospitalization, and this adjustment could potentially introduce bias into our results (increasing avoidable hospitalization risk observed in adult care that has a lower number of overall hospitalizations). In addition, we did not adjust for modality of renal replacement therapy (dialysis versus transplantation), which may represent a source of confounding. Despite these limitations, our study provides important new information regarding increasing risk of avoidable hospitalizations in young patients with ESRD by using a national cohort of patients.

**CONCLUSIONS**

We found that young patients with ESRD exclusively cared for in an adult environment experienced increasing rates of avoidable hospitalizations during late adolescence and emerging adulthood. We also found that avoidable hospitalizations increased during the years after transfer to adult care. Therefore, intense and developmentally appropriate support is needed during adolescence and emerging adulthood, and in particular after transfer of care. Further research is urgently needed to characterize quality of and access to ambulatory care for young dialysis and transplant patients. In the meantime, it is critical for ESRD programs to provide care that is well matched to the developmental needs of this vulnerable age group.

**ACKNOWLEDGMENTS**

The authors thank the Delphi panelists for their time spent and valuable insight provided for the development of the avoidable hospitalizations list used in this study.


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