When all the world is young, lad,
And all the trees are green;
And every goose a swan, lad,
And every lass a queen;
Then hey for boot and horse, lad,
And round the world away:
Young blood must have its course, lad,
And every dog its day.

*Charles Kingsley*

*The Water Babies*
pediatric end-stage renal disease patients pose unique challenges to providers and to the healthcare system, which must address not only the disease itself in these patients, but the many extra-renal manifestations that affect their lives and their families. ESRD care in pediatric patients has undergone a number of changes over the last two decades. This year, we present updated information on the demographic characteristics of this population, anemia and epoetin treatment at initiation, kidney function, body mass index, dialysis access and complications, and preventive care. Infectious complications in this population are an important issue, and rates are compared here to those of the adult population. We also present data on overall and cause-specific hospitalization and mortality. Between May of 1995 and June of 2004, more than 4,200 children started therapy for ESRD caused by either primary or secondary glomerulonephritis, and another 3,400 began treatment for ESRD caused by cystic kidney disease, a diagnosis occurring most often in patients younger than four. Preventive care measures continue to be underutilized in pediatric patients. Rates of influenza, pneumococcal pneumonia, and hepatitis B vaccinations are far lower in children than in adult patients, as is the percent of patients receiving cardiovascular risk management. Rising BMI levels in children entering ESRD are consistent with trends in the general population, and are a major concern, particularly as there appears to be no slowing of the rate of increase. Rates of catheter use are also much greater in children than in adults. Very striking is the fact that use has been increasing in recent years, despite evidence that catheters are a major source of morbidity and mortality. Long-term use of these accesses poses significant problems for the pediatric population relative to infectious complications and stenoses of central veins. The treatment of anemia in this younger population has undergone major changes over the last ten years. Hemoglobin levels, on average, have increased more than 1.5 g/dl. Boys and girls now have similar hemoglobin levels, and racial disparities have narrowed. Among patients who require erythropoietin therapy, those on peritoneal dialysis continue to have lower hemoglobin levels than do those on hemodialysis, and their erythropoietin doses are considerably lower, most likely due to subcutaneous administration. These lower doses suggest that dosing patterns in peritoneal dialysis patients may not be keeping pace with targeted hemoglobin levels. Additionally, iron dosing in these patients is less than one-fifth that in the hemodialysis population, most likely secondary to more difficult access to the circulation to administer this medication. This would also contribute to the lower hemoglo-
bin levels. Newer erythropoiesis stimulating agents with longer half-lives have recently come on the market, and may influence the effective matching of ESA treatment and route of administration with achieved hemoglobin levels. As reported in previous ADRs, infectious complications are an important consideration in the pediatric population. Compared to their adult counterparts, pediatric patients have fewer infectious complications on dialysis, but a greater degree of infections following transplant. Interestingly, rates of vascular access complications for internal devices are now similar in the adult and pediatric populations. This is particularly true for infectious hospitalizations secondary to peritonitis, which in pediatric patients seemed to decline in the early to mid-1990s before rising significantly since 1999, while rates in the adult population slowly fell. Overall hospitalization rates for pediatric dialysis patients are more than double those of the transplant population, with the latter varying to a lesser degree based on the primary cause of renal failure. The fact that children have close to 2.0 hospitalizations per year—strikingly similar to the rate among adults—is a major concern. The source of these similarities in a population which is substantially younger deserves greater attention. When assessing overall survival, the 1995–1999 cohort shows improved survival of pediatric patients compared to those in the 1990–1994 period. This is true in the overall ESRD population as well as among hemodialysis and peritoneal dialysis patients. The improvements in survival have been greater in the peritoneal dialysis population than in those on hemodialysis. Rates of infectious hospitalization are considerably higher in children than in adults, constituting almost half of the admissions per year, and are almost 50 percent greater in girls than in boys. There also appear to be some racial differences, with black children having higher infectious and cardiovascular hospitalization rates than children of other races. There continues to be little information about the nutritional status of pediatric ESRD patients and their growth and development, which was last evaluated in the early 1990s. The USRDS will work with the Clinical Performance Measures group at the Centers for Medicare and Medicaid Services, which is collecting more extensive information on the prevalent pediatric population.
The number of children starting dialysis with a diagnosis of GN, secondary GN, or cystic kidney disease grew 26 percent between 1995–1999 and 2000–2004 (Figure 8.3). Thirty-nine percent received EPO prior to initiation during 2000–2004, up from 33 in the prior period (Figure 8.4). Mean hemoglobins increased 0.5 g/dl, with the largest increase occurring in patients with GN, at 0.64 g/dl (Figure 8.5). Estimated GFRs at initiation rose from 9.8 to 11.0 ml/min/1.73 m², suggesting that patients may be starting therapy earlier in their progression to ESRD (Figure 8.6). The percent of patients starting therapy with a serum albumin level under the test’s lower limit is highest in patients with secondary GN and lowest in those with cystic kidney disease (Figure 8.7). Body mass index at initiation is highest in blacks, but has remained stable over the past several years (Figure 8.8). In 2001–2004, only 24–27 percent of all pediatric patients, and 30–33 percent of those on hemodialysis, received an influenza vaccination. Pneumococcal pneumonia vaccination rates are only 7–9 percent overall, and less than 5 percent in white and black transplant patients. And hepatitis B vaccination rates reach a high of only 17 percent in white children on hemodialysis (Figures 8.9–11). Rates of lipid testing in
the pediatric population are lowest in black children, at 45 percent, compared to 53 percent in whites and 57 percent in children of other races (Figure 8.12). By modality, rates are highest in children with a transplant.

Infectious and sepsis events are highest in children with catheters compared to those with an internal access; event-free probabilities at the end of one year for catheters, fistulas, and PD accesses are 0.64, 0.91, and 0.75, respectively (Figures 8.14–15).

The use of hemodialysis in the first 18 months of ESRD therapy has grown since 1999 (Figure 8.16). The time to first transplant after initiation rose between the 1995–1999 and 2000–2004 periods for both whites and blacks. In 1995–1999, for instance, 51 percent of white children and 39 percent of black children were transplanted by month 12, while in 2000–2004 these numbers fell to 42 and 29 percent, respectively (Figure 8.16).

Medicare Parts A & B primary payor coverage. Vaccinations tracked between September 1 & December 31. II Figures 8.10–12: point prevalent ESRD patients, with 90-day rule, age 0–19 prior to January 1 of the first year of a two-year study period, 2001–2002 & 2003–2004, & living through December 31 of the second year; includes only patients with Medicare Parts A & B primary payor coverage during the entire period. Vaccinations tracked in each study period. Age calculated at end of second year. II Figures 8.11–12: point prevalent ESRD patients, 2001–2002, with 90-day rule, age 0–19 prior to January 1 & living through December 31 of each year; includes only patients with Medicare Parts A & B primary payor coverage during each year. Vaccinations & lipid testing tracked in each year. Vaccinations tracked in each calendar year following December of the incident year. Infection & sepsis from Medicare claims during the calendar year following incidence; infection refers to an infection of the vascular access/internal device. II Figure 8.15: hemodialysis patients: same as in Figure 8.14. Peritoneal dialysis patients: incident peritoneal dialysis patients, age 0–19, 1995–2003 combined, with Medicare as primary payor on day 91. Infection/sepsis identified during last 90 days prior to September 1 & living through December 31 of each year; includes only patients with Medicare Parts A & B primary payor coverage on January 1 of the year following incidence. Access obtained from CPM data; represents the current access as reported during October–December of the incident year. Infection & sepsis from Medicare claims during the calendar year following incidence; infection refers to an infection of the vascular access/internal device. II Figure 8.15: hemodialysis patients: same as in Figure 8.14. Peritoneal dialysis patients: incident peritoneal dialysis patients, age 0–19, 1995–2003 combined, with Medicare as primary payor on day 91. Infection/sepsis identified during last 90 days prior to September 1 & living through December 31 of each year; includes only patients with Medicare Parts A & B primary payor coverage on January 1 of the year following incidence.
emoglobin levels in pediatric dialysis patients are similar in boys and girls, rise with age, and vary slightly by race and ethnicity (Figure 8.18). In 2003–2004, the mean hemoglobin in hemodialysis patients was 11.7 g/dl overall, and 11.2 in patients age 0–9; the mean adult hemoglobin was 11.9. Levels in peritoneal dialysis patients were slightly lower, at 11.2 g/dl overall and 11.0 in those age 0–9, compared to 11.6 in adults.

The mean weekly EPO dose rises with age, and, in the hemodialysis population, is slightly higher in girls (Figure 8.19). In 2003–2004 the mean dose reached 17,912 units in hemodialysis patients, and 9,304 units in those on peritoneal dialysis—growth of 69 and 56 percent over 1993–1994 levels. By race and ethnicity, EPO use in hemodialysis patients has recently been greatest in black children, though their hemoglobin levels remain the lowest.

In 2004, nearly 80 percent of pediatric hemodialysis patients received vitamin D, just slightly lower than the 84 percent seen in adults (Figure 8.20). Seventy-nine per-
percent received iron, compared to 15 percent of those on peritoneal dialysis, and to 91 percent of adults (Figure 8.21). Use of both vitamin D and iron is lowest by age in children age 0–9, at 57 percent.

In June, 2005, nearly 74 percent of all pediatric patients had a hemoglobin at or above the K/DOQI target of 11 g/dl, and levels have improved across all age groups (Figures 8.22–23). The average EPO dose is now 16,250 units per week.

The average hemoglobin level in June, 2005, was 11.85 g/dl for dialysis patients age 10–19, compared to 11.99 for adults—growth, since the beginning of 1991, of 29 and 24 percent, respectively (Figure 8.24). Weekly EPO doses in these two populations reached 16,855 and 18,631 units, both nearly double those seen in 1991.

**Figures 8.18–19** period prevalent dialysis patients age 0–19 with at least one EPO claim during the prevalent year. Doses adjusted for inpatient days. For Hispanic patients we present data beginning in 1996, the first full year after the April 1995 introduction of the revised Medical Evidence form, which contains more specific questions on race & ethnicity. **Figure 8.20** period prevalent hemodialysis patients who remain alive, on their current modality, & with Medicare as primary payor for the entire calendar year. Peritoneal dialysis patients omitted because of cell sizes less than ten. **Figure 8.21** period prevalent dialysis patients who remain alive, on their current modality, & with Medicare as primary payor for the entire calendar year. **Figures 8.22–24** period prevalent dialysis patients (in Figure 8.22, age 0–19) with EPO claims. The distribution of patients by hemoglobin group (sand diagrams) represents quarterly averages, while hemoglobin levels & EPO doses (line graphs) represent monthly averages. EPO doses prior to 2005 are not adjusted for inpatient hospital days.
Rates of all-cause infectious hospitalization are highest in the adult hemodialysis population, in which they have grown 79 percent since 1991 (Figure 8.25). Infectious hospitalizations in pediatric and adult peritoneal dialysis and transplant patients, on the other hand, have fallen since 1991, with the most dramatic decrease (79 percent) occurring in children on peritoneal dialysis. In 2004, the rate of infectious hospitalization in pediatric transplant patients was 475 per 1,000 patient years, down only 7 percent from the 1991 high of 511 per 1,000 patient years.

Pediatric cohort sizes can lead to wide variability in pediatric hospitalization rates. Despite this, when compared to adult rates, admissions for bacterial infection have historically been much lower in children. Children on hemodialysis in 2004 had rates 15 times lower than those found in adult hemodialysis patients (Figure 8.26).

Hospital admissions for urinary tract infections are highest in pediatric and adult patients with preemptive transplants (Figure 8.27). Since 1991, rates in children have averaged approximately 150 per 1,000 patient years at risk compared to 69 in the adult population.

Infectious hospitalizations due to an internal device were quite similar in adult and pediatric hemodialysis patients through 2003 (Figure 8.28). In 2004, however, adult rates were 57 percent higher—a disparity which may in part be due to the volatility in rates caused by low counts. Still, this difference warrants attention. Infection rates in both adult and pediatric peritoneal dialysis patients took a dramatic upturn in 1998, rising to 189 and 93 per 1,000 patient years, respectively. Since 2002, however, rates in both populations appear to have stabilized.
with adult rates remaining slightly higher—38 percent in 2004.

Hospital admissions due to peritonitis have increased dramatically in children since 2000, but since then have declined sharply (Figure 8.29). In 2004, rates in pediatric and adult peritoneal dialysis patients were 33 and 54 per 1,000 patient years, respectively.

Figures 8.30–32 show the 36-month cumulative incidence of infection in pediatric and adult hemodialysis, peritoneal dialysis, and transplant patients. The cumulative incidence of infections of all types is highest in pediatric and adult patients on peritoneal dialysis, at 57.6 and 59.9 percent, respectively (Figure 8.31). In hemodialysis patients, the incidence of infections is 44.0 and 53.3, and in transplant patients, 46.1 and 42.2, (Figures 8.30 and 8.32). In dialysis patients, admissions due to infection from an internal device are similar in both children and adults, and range from 18.9 to 24.7 percent. Adult hemodialysis patients have the highest incidence of bacterial infection, at 19.5 percent, while viral and urinary tract infectious hospitalizations are highest in transplant patients.

Adjusted hospital admissions and days per patient year indicate that pediatric dialysis patients who have glomerulonephritis as their primary cause of renal failure are admitted less frequently and spend fewer days in the hospital than patients with a diagnosis of either cystic/hereditary/congenital or "other" disease (Figure 8.33). These patients also show the largest decrease in admissions and hospital days since 1993 and, in 2004, had rates of 1.7 admissions and 10.2 days per patient year at risk.

In pediatric transplant patients, admission rates and hospital days vary little by primary diagnosis (Figure 8.34). In 2004, these patients had hospital admission rates that were 90 percent lower than those of dialysis patients, and they spent less than half as many days in the hospital.

By dialysis type, 2004 admission rates in hemodialysis patients were approximately 10 percent higher than those found in peritoneal dialysis patients; hospital days in peritoneal patients, however, were slightly higher (Figure 8.35).

Five-year survival in pediatric patients has changed little since the early 1990s (Figure 8.36). Overall, 89.2 percent of patients starting therapy in 1995–1999 survived at least five years, up only slightly from the 88.5 percent of patients initiating in 1990–1994. Survival remains associated with modality; 80 and 83 percent of those starting on hemodialysis or peritoneal dialysis, respectively, survive five years, compared to 93 percent of those who begin ESRD therapy with a transplant.

By primary diagnosis, pediatric patients with glomerulonephritis or with cystic/hereditary/congenital disease continue to have the greatest probability of surviving five years after the start of treatment. Survival probabilities for patients with secondary glomerulonephritis or vasculitis remain among the lowest, at 77 and 75 percent for those beginning ESRD therapy on hemodialysis and peritoneal dialysis, respectively.
In the pediatric ESRD population as a whole, overall adjusted mortality rates have been quite stable, with almost identical rates in 1991 and 2004 of slightly more than 25 per 1,000 patient years (Figure 8.37). The transplant population has also seen little variation, with rates remaining between 9 and 12. Among dialysis patients, however, rates in the past 7–8 years are generally greater than those seen in the early 1990s, and the 2004 rate of 56.5 is 16 percent higher than that seen in 1991.
Adjusted cause-specific hospital admissions, by age 0–19 period prevalent dialysis patients

Adjusted cause-specific hospital admissions, by gender period prevalent dialysis patients age 0–19

Adjusted cause-specific hospital admissions, by race/ethnicity period prevalent dialysis patients age 0–19
Hospital admission rates in 2004 for dialysis patients age 0–19 were 10 percent higher than those found in adults; rates in patients younger than ten were 40 percent higher (Figure 8.38). Not surprisingly, rates for cardiovascular admissions were 20 percent higher in adult patients. Rates for infectious hospitalizations, however, were 48 percent higher in the pediatric population overall, and twice as high in those age less than ten. These higher rates may be due in part to infections stemming from an internal device or peritonitis, since peritoneal dialysis is used more frequently in this younger population.

Overall, girls are hospitalized more frequently than boys—18 percent more in 2004—and rates are highest for girls in all cause-specific categories (Figure 8.39).

By race/ethnicity, hospitalization rates for all causes are 21–63 percent higher in black children compared to whites and children of other races (Figure 8.40). Cardiovascular hospitalization rates are more than 30 percent greater in blacks compared to whites and Hispanics, and rates for infectious hospitalizations are 58 and 39 percent higher when compared to individuals of other races and Hispanics, respectively.

Adjusted mortality rates in pediatric patients tend to be only one-fourth as high as those in adult patients (Figure 8.41). Since 1991, overall rates have fallen 2 percent in adult patients and 13 percent in children age 0–9. In these youngest children, rates of mortality due to cardiovascular disease have remained stable, and those due to infection have fallen 19 percent. No similar decrease, however, has occurred among patients age 10–19. In these older children, cardiovascular mortality has increased 62 percent since 1991, and the rate of mortality due to infection is up nearly 19 percent.

By gender, mortality rates in pediatric patients tend to be higher in girls—in 2004, 1.2–1.4 times higher across all causes of death (Figure 8.42). Between 1991 and 2004, the overall mortality rate increased 11 percent in boys, but 21 percent in girls; rates of cardiovascular mortality grew 36 and 55 percent, respectively.
Figure 8.1 On December 31, 2004, hemodialysis was being provided to 1,354 pediatric ESRD patients, and peritoneal dialysis to 957; 4,907 children had a functioning graft.

Figure 8.6 The mean estimated glomerular filtration rate of children beginning ESRD therapy rose from 9.8 ml/min/1.73 m² in 1995–1999 to 11.0 in 2000–2004, suggesting that therapy may be starting earlier in the progression to ESRD. Figure 8.9 In the 2001–2004 period, only 24–27 percent of all pediatric patients, and 30–33 percent of those on hemodialysis, received influenza vaccinations.

Figure 8.17 The time to first transplant after initiation of ESRD increased between the 1995–1999 and 2000–2004 periods. In 1995–1999, for instance, 51 percent of white children and 39 percent of black children were transplanted by month 12, while in 2000–2004, the percentages fell to 42 and 29, respectively.

Figures 8.20–21 Use of both vitamin D and iron is lowest in children age 0–9, at 57 percent. Figure 8.24 The average hemoglobin level in June, 2005, was 11.8 g/dl for dialysis patients age 10–19, compared to 11.9 for adults—growth, since the beginning of 1991, of 29 and 24 percent, respectively. Weekly EPO doses in these two populations reached 16,855 and 18,631 units, both nearly double those seen in 1991.

Figure 8.25 Infectious hospitalizations in pediatric and adult peritoneal dialysis and transplant patients have fallen since 1991, with the most dramatic decrease (79 percent) occurring in children on peritoneal dialysis. Figure 8.27 Hospital admissions for urinary tract infections are highest in pediatric and adult patients with preemptive transplants. Figure 8.31 The cumulative incidence of infections of all types is highest in pediatric and adult patients on peritoneal dialysis, at 57.6 and 59.9 percent respectively.

Figure 8.35 In 2004, hospital admission rates for pediatric hemodialysis patients were approximately 10 percent higher than those found in peritoneal dialysis patients; hospital days in peritoneal patients, however, were slightly higher. Figure 8.37 In the pediatric population as a whole, overall adjusted mortality rates have been quite stable, with almost identical rates in 1991 and 2004 of slightly over 25 per 1,000 patient years. The transplant population has also seen little variation, with rates remaining between 9 and 12. Among dialysis patients, however, rates in the past 7–8 years are generally greater than those seen in the early 1990s, and the 2004 rate of 56.5 is 16 percent higher than that seen in 1991.

Figure 8.38 Hospital admission rates in 2004 for dialysis patients age 0–19 were 10 percent higher than those found in adults; rates in patients younger than ten were 40 percent higher. Rates for infectious hospitalization were 48 percent higher in the pediatric population as a whole, and twice as high in those age less than ten. Figure 8.41 In children age 10–19, cardiovascular mortality has increased 62 percent since 1991, and the rate of mortality due to infection is up nearly 19 percent.