



## INTRODUCTION 130

### CLINICAL INDICATORS 132

mean hemoglobin · mean weekly epo dose · mean monthly hemoglobin & epo dose by race

### PATIENT CHARACTERISTICS AT INITIATION · PREVENTIVE HEALTH 134

mean age at initiation · percent of patients receiving epo at initiation · mean hemoglobin, gfr, & albumin at initiation · vaccinations · lipid testing

### POST-TRANSPLANT COMPLICATIONS 135

cancer · cardiovascular complications · musculoskeletal complications · diabetes infections

### OVERALL HOSPITALIZATION & MORTALITY 136

hospital admissions & days for prevalent dialysis & transplant patients · hospital admissions & days by vintage · patient survival · mortality rates by vintage

### CAUSE-SPECIFIC HOSPITALIZATION & MORTALITY 138

trends in hospitalization, by age, gender, & race/ethnicity · trends in mortality, by age & gender

## SUMMARY 140



# Chapter eight

## Pediatric ESRD

Without, the frost, the blinding snow,

The storm-wind's moody madness—

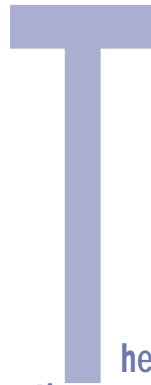
Within, the firelight's ruddy glow,

And childhood's nest of gladness.

The magic words shall hold thee fast:

Thou shalt not heed the raving blast.

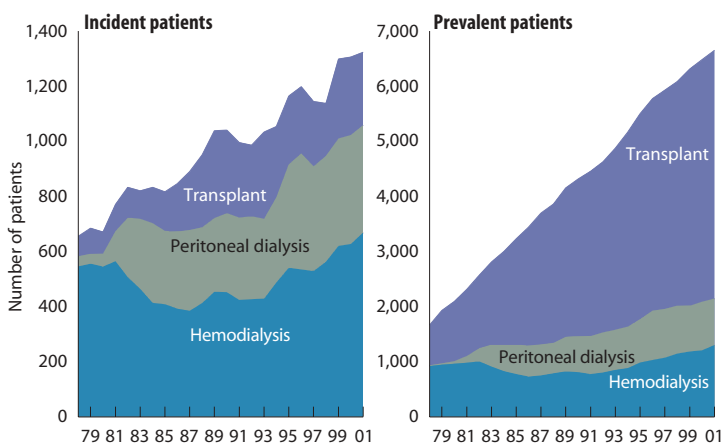
*Lewis Carroll, Through the Looking-Glass*



**T**he pediatric ESRD population is a unique one, as patients enter therapy with a low burden of cardiovascular disease, yet face mortality rates on dialysis that are 150 times greater than those in the general pediatric population. The predominant complications of children with ESRD are related not only to renal disease, hypertension, and infection, but to developmental issues and the difficulties of adjusting to the realities of a chronic disease. ■ In the previous three ADRs we have provided new information on pediatric patients, trying to better understand their particular circumstances and address potential sources of their extraordinary mortality on dialysis. We have focused on severe anemia at initiation, persistent anemia under dialysis care, expanding cardiac disease in the form of cardiomyopathy, and sudden death. This year we present data on the use of ESRD modalities, and on morbidity and mortality, focusing particularly on cardiovascular disease and infection. We look also at preventive care measures such as vaccinations and monitoring of lipid disorders, and at complications after renal transplantation. ■ The distribution of ESRD patients by treatment modality is quite different in children compared to adults, with a far greater use of both peritoneal dialysis and transplant as the first therapy. The initial use of hemodialysis has, however, grown quite steadily since the early 1990s. ■ Children are transplanted at such a high rate that 65 percent of those alive two years after beginning therapy have a functioning transplant, as do 86 percent of those surviving four years. While these observations indicate a frequent use of transplant, to a certain extent they also reflect survivor bias, as premature death affects dialysis patients to a far greater degree than those who receive a renal transplant. ■ The quality of care given to pediatric patients appears to have improved over the last decade. Hemoglobin levels of those treated with EPO, for example, have risen from 9.5–10 g/dl to near the NKF K/DOQI target of 11–12 g/dl. Some groups, however, are still lagging behind. Children younger than 15 do not yet achieve the levels of anemia correction seen in adults, black children consistently have lower hemoglobin levels than those of other races, and levels continue to be lower in peritoneal dialysis patients than in those treated with hemodialysis. ■ The higher hemoglobin levels in children age 15–19 appear related, at least in part, to increased use of EPO. In addition, as shown in the 2002 ADR, iron use in chil-

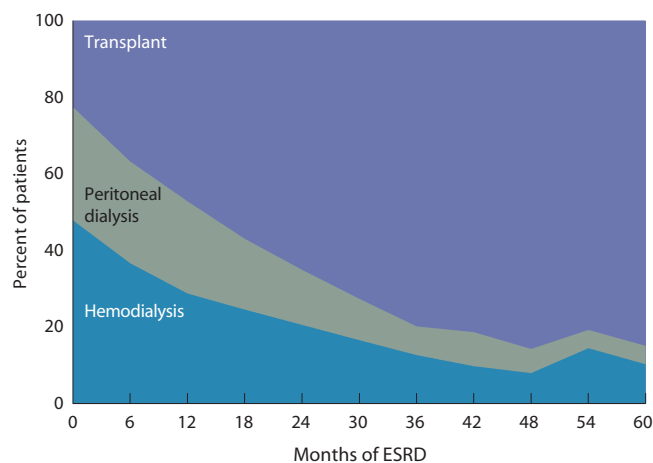
**CHAPTER HIGHLIGHTS** ■ **Figure 8.3** Over the last decade, hemoglobin levels for prevalent pediatric patients have increased 18 percent for those on hemodialysis, and 13 percent for those on peritoneal dialysis—to levels of 11.3 and 10.7 g/dl, respectively. ■ **Figure 8.6** In 1991, 71 percent of pediatric patients on dialysis had hemoglobins less than 10 g/dl; by the second quarter of 2002, this number was only 14 percent. ■ **Figures 8.16–19** From 70 to more than 95 percent of pediatric patients do not receive recommended vaccinations for influenza, pneumococcal pneumonia, or hepatitis, and fewer than half receive lipid testing for the monitoring of cardiovascular risk factors. ■ **Figure 8.23** The cumulative probability of post-transplant diabetes in first three years following a transplant is almost three times higher for children age 10 and older than it is in younger patients.

**8.1** · Trends in incident & prevalent counts, by modality  
*incident & December 31 point prevalent ESRD patients age 19 or younger.*



dren—particularly those on peritoneal dialysis—is below optimal levels. The lower use of both EPO and iron in the youngest patients may, therefore, help explain why younger patients are not achieving desired hemoglobin levels. ■ Pre-ESRD care for children approaching ESRD, as well as preventive care after the start of therapy, still allow for improvement. Children continue to have the lowest hemoglobin levels at initiation, with black children disproportionately affected. Pediatric patients start ESRD treatment at higher eGFRs, but still have very low serum albumins, which may reflect proteinuria, inflammation, or poor nutrition. And despite of their high rates of hospitalization for infection, children still receive influenza vaccinations at rates lower than those of all other patient groups. ■ With the development of heart failure and cardiomyopathies in these children, some investigators have suggested that carnitine deficiency may be a contributing factor. We found the use of carnitine testing in the last six years to be extremely low, and L-carnitine therapy to be minimal. In the 2004 ADR we will expand this investigation to determine if carnitine treatment is associated with changes in clinical complications such as heart failure. ■ In regard to pediatric patient survival, several areas of concern are emerging. Comparisons of cohorts from 1987–1991 and 1992–1996 show that overall incident survival has not changed for children on dialysis, and is up only 1 percent for those with a transplant. Overall survival on peritoneal dialysis is unchanged, and while there has been some improvement for patients with glomerulonephritis, those with secondary glomerulonephritis from vasculitis appear to have lost ground. ■ Mortality analyses show only a 4 percent fall in annual mortality rates for children age 0–9 years, but a 21 percent decline in 10–19 year olds. Cardiovascular mortality rates, however, have increased 27–34 percent over the last 20 years. These survival and mortality findings require closer evaluation to determine if they are associated with aspects of care such as the use of dialysis catheters or the lack of influenza vaccinations.

**8.2** · Prevalent patient distribution, by modality & vintage  
*December 31 point prevalent ESRD patients age 19 or younger, 2001. A patient with 0 to <6 months of ESRD exposure is included in the 0-month group, a patient with 6 to <12 months of exposure is included in the 6-month group, & so on.*



# Clinical indicators

Hemoglobin levels in pediatric dialysis patients tend to be lower than those in adults (Figure 8.3). Levels are similar for males and females, and slightly higher in hemodialysis patients than in those on peritoneal dialysis.

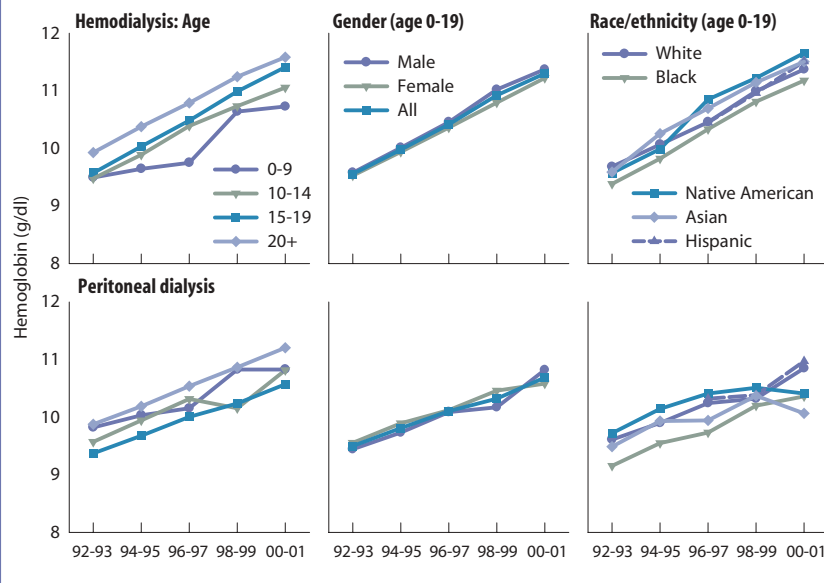
Older children and adults receive the greatest amount of EPO, and mean weekly doses of EPO are 12–23 percent higher in girls than in boys (Figure 8.4). The greatest disparity in EPO dose occurs between modalities, with hemodialysis patients receiving more than three times the amount of EPO compared to patients on peritoneal dialysis.

Carnitine is an essential compound in the oxidative process of fatty acids. Fewer than 2 percent of pediatric dialysis patients received a carnitine test in 2000–2001 (Figure 8.5). Only 5–7 percent of adult patients, and 4 percent of pediatric patients, received L-carnitine injections during this period.

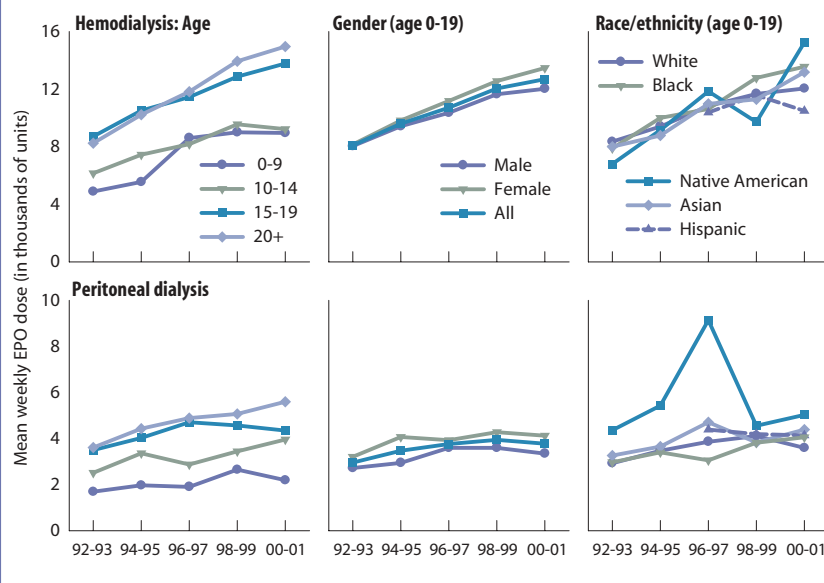
Mean hemoglobin levels continue to rise, and as of 2001 two-thirds of pediatric dialysis patients had levels meeting the K/DOQI target of 11 g/dl or higher (Figure 8.6). Differences are generally small when comparing mean hemoglobin and weekly EPO doses between whites and blacks (Figures 8.7–10).

■ **Figures 8.3–4** period prevalent dialysis patients age 0–19 with at least one EPO claim during their prevalent year. 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 8.5** prevalent dialysis patients; values show the percent of patients with at least one carnitine lab test or levocarnitine claim during the year. HCPCS code J1955 is used for levocarnitine, & 82379 for the carnitine lab test. The code for carnitine testing was first used in 1999. ■ **Figures 8.6–10** period prevalent dialysis patients age 0–19 with EPO claims. The distribution of patients by hemoglobin group represents quarterly averages (sand diagrams), while hemoglobin levels & EPO dose (line graphs) represent monthly averages. ■ **Figures 8.6, 8.8, & 8.10** EPO doses in 2002 are not adjusted for inpatient hospital days.

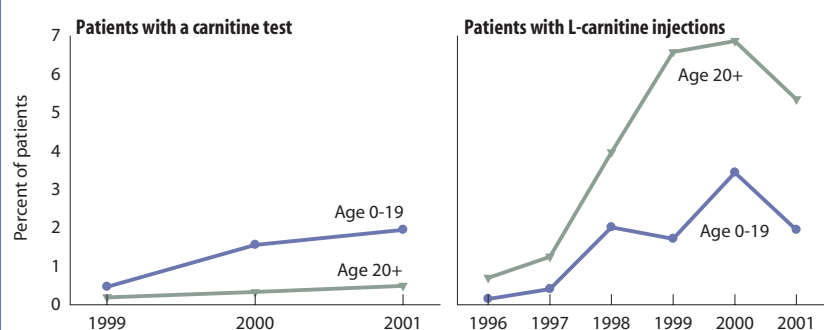
8.3 · Mean hemoglobin, by modality, age, gender, & race/ethnicity: prevalent dialysis patients



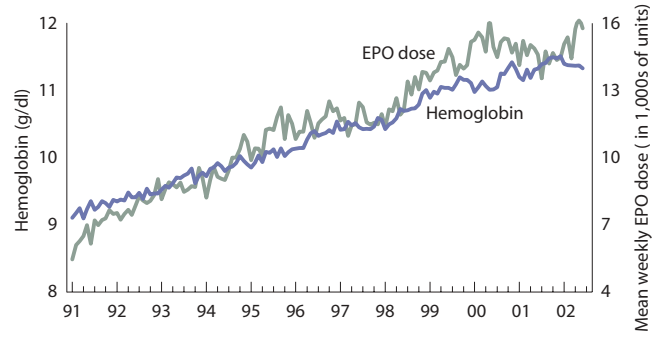
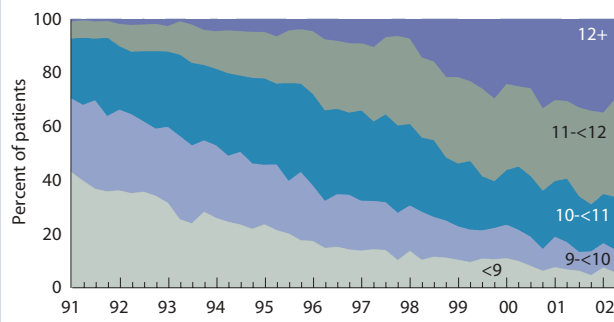
8.4 · Mean weekly EPO dose, by modality, age, gender, & race/ethnicity: prevalent dialysis patients



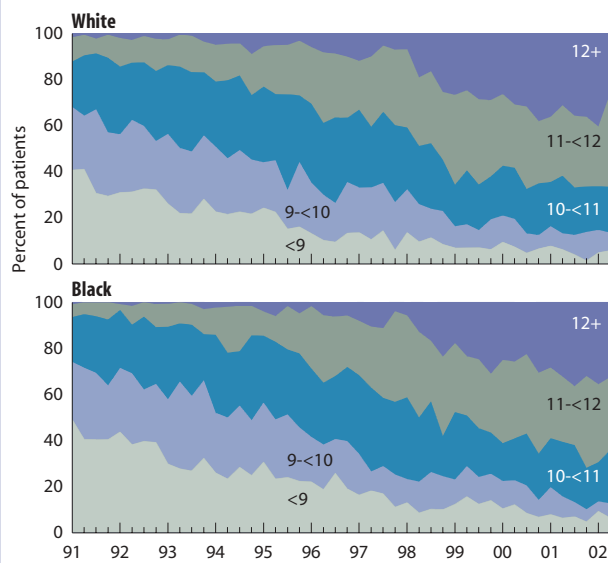
8.5 · Carnitine testing & L-carnitine treatment: prevalent dialysis patients



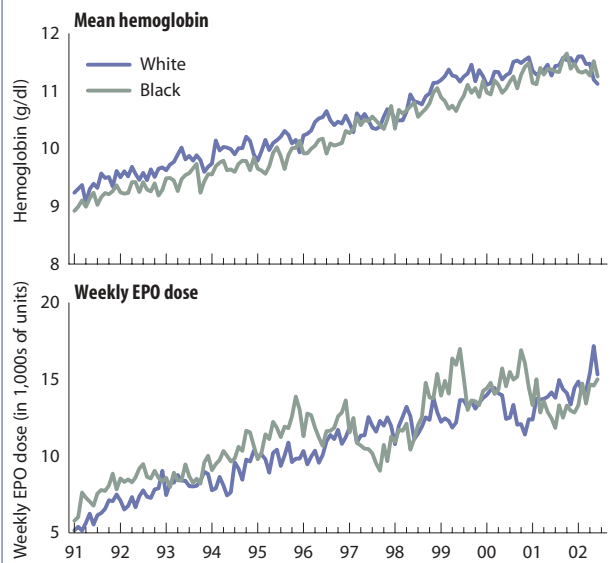
8.6 - Mean hemoglobin (g/dl) & trends in hemoglobin & EPO dose: prevalent dialysis patients



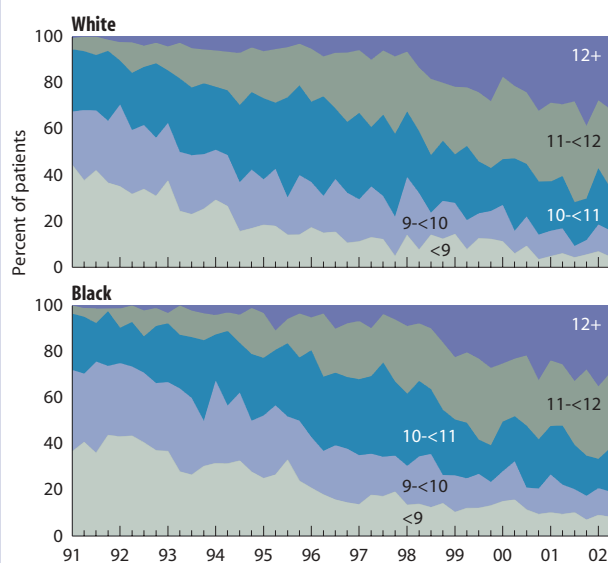
8.7 - Prevalent patient distribution, by mean hemoglobin (g/dl) & race: males



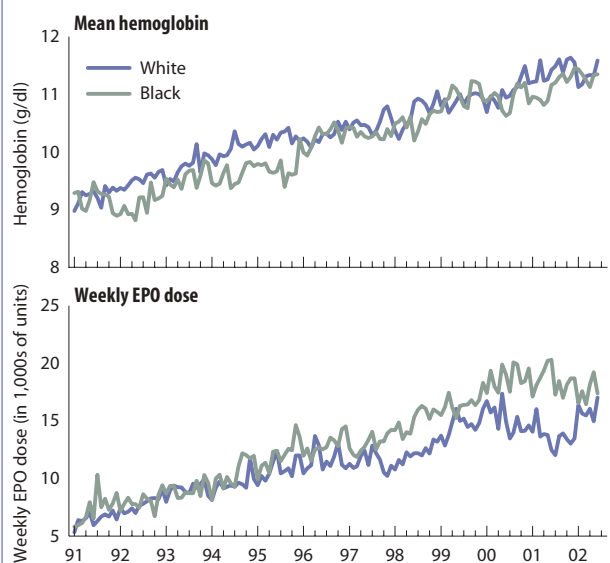
8.8 - Mean hemoglobin & EPO dose, by race: males (prevalent dialysis)



8.9 - Prevalent patient distribution, by mean hemoglobin (g/dl) & race: females

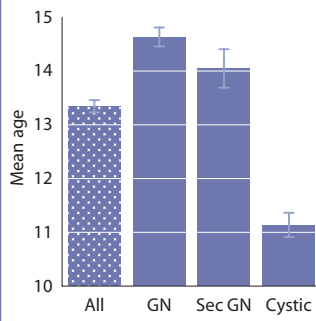


8.10 - Mean hemoglobin & EPO dose, by race: females (prevalent dialysis)

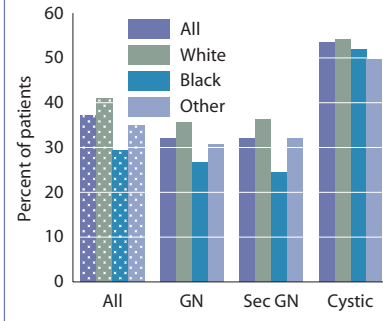


Patient characteristics at initiation

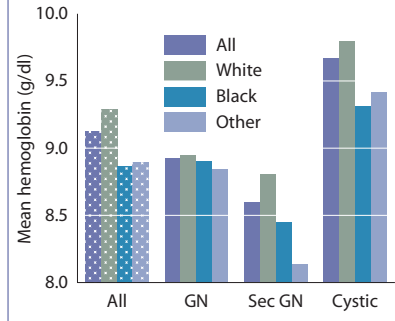
8.11 • Mean age at initiation



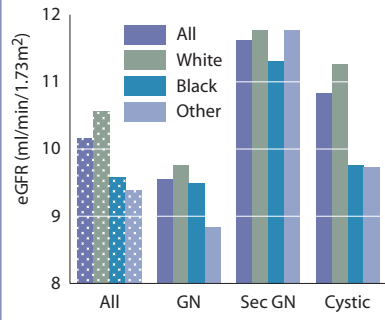
8.12 • Patients receiving EPO prior to initiation



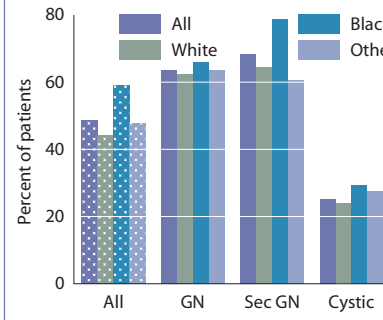
8.13 • Mean hemoglobin at initiation



8.14 • Mean eGFR at initiation



8.15 • Patients with serum albumin < lower limit



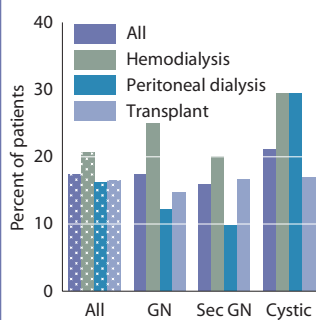
The mean age of children starting ESRD therapy is 13.3; those with a primary diagnosis of glomerulonephritis tend to be older, while those with cystic kidney disease have an average age of 11 (Figure 8.11).

Thirty-seven percent of all pediatric patients have received EPO prior to starting therapy—53 percent of those with cystic kidney disease (Figure 8.12). Black children are less likely than whites to receive pre-ESRD EPO therapy. The mean hemoglobin at initiation is 9.1 g/dl for all pediatric patients—9.3 for whites, and 8.9 for blacks (Figure 8.13).

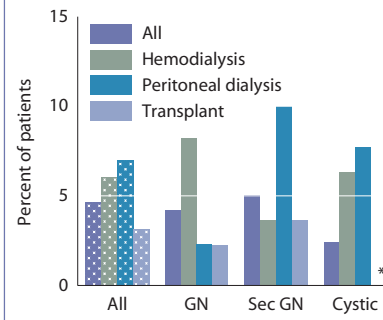
Similar patterns are seen with initial GFRs and albumin levels. The mean eGFR of children starting ESRD therapy is 10.2 ml/min/1.73 m<sup>2</sup> overall, 10.6 for whites, and 9.6 for blacks (Figure 8.14). Forty-nine percent start with albumins below the test's lower limit; the number drops to 44 percent for whites, but reaches 59 percent for blacks, and 79 percent for blacks with secondary glomerulonephritis (Figure 8.15).

Preventive health

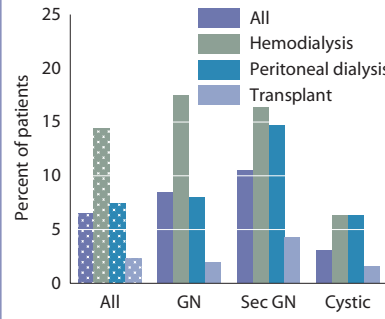
8.16 • Influenza vaccinations



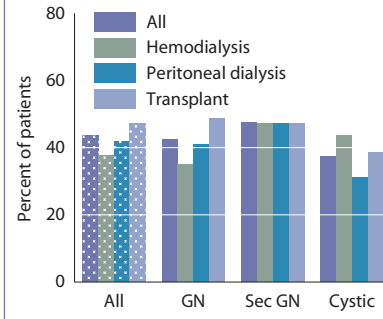
8.17 • Patients receiving pneumonia vaccinations



8.18 • Patients receiving hepatitis B vaccinations

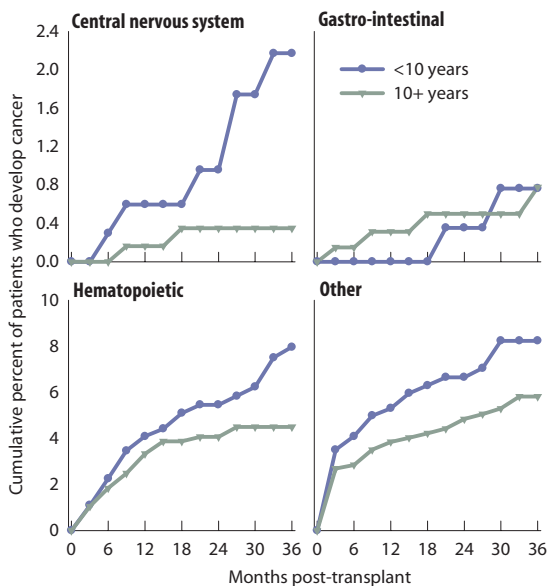


8.19 • Patients receiving lipid testing

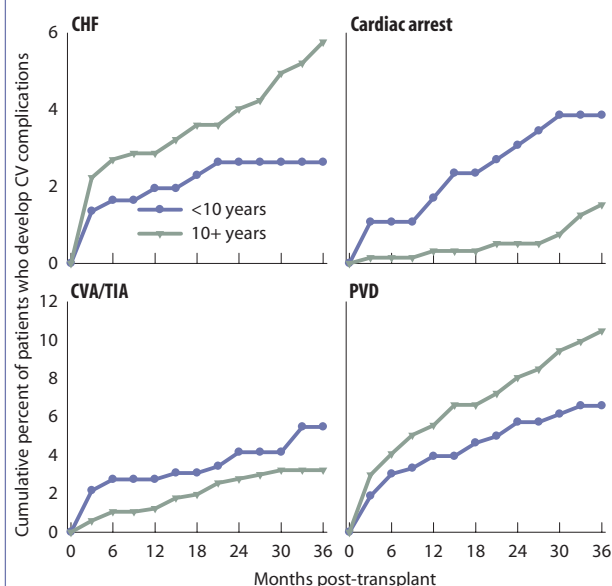


The Healthy People 2010 initiative sets target immunization levels of 90 percent for influenza, pneumococcal pneumonia, and hepatitis B in most populations, particularly those at high risk. Rates in pediatric patients, however, are far from meeting these targets. In 2001, vaccination rates were only 17, 4.6, and 6.5 percent, respectively (Figures 8.16–18). Forty-four percent of children with ESRD received lipid testing in 2001; the proportion was highest (47 percent) in transplant patients.

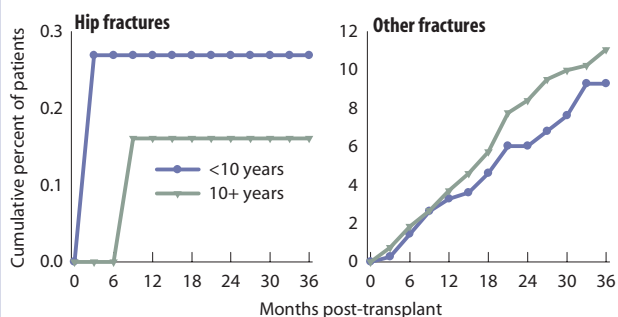
8.20 · Patients developing cancer, by age



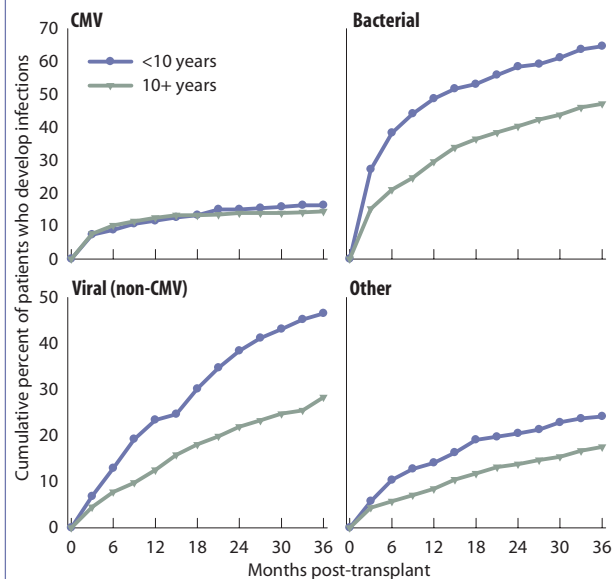
8.21 · Patients developing cardiovascular complications, by age



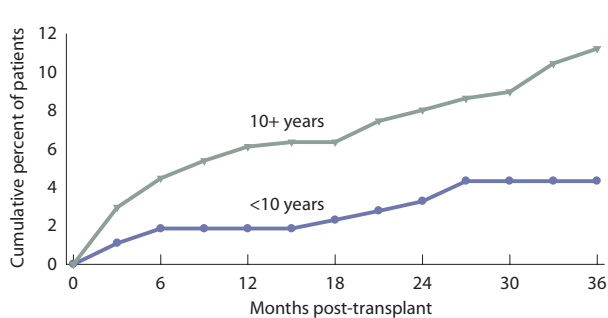
8.22 · Patients developing musculoskeletal complications, by age



8.24 · Patients developing post-transplant infections, by age



8.23 · Patients developing diabetes, by age



Pediatric patients younger than ten are the most likely to develop cancer after a transplant (Figure 8.20). Cardiovascular complications such as CHF or PVD are more common in older children, while cardiac arrest and CVA/TIA tend to occur in younger patients (Figure 8.21). Musculoskeletal complications are infrequent in all pediatric patients (hip fractures occurred in only two children), as is diabetes—children older than ten, however, are more than twice as likely to develop diabetes than their younger

counterparts (Figures 8.22–23). Bacterial and viral infections are the most common post-transplant infections (Figure 8.24).

■ **Figures 8.11–15** incident ESRD patients age 0–19, May 1995–June 2002 combined. The lower limit of albumins measured by bromocresol purple is 3.2 g/dl, & by bromocresol green is 3.5 g/dl. The Medical Evidence form indicates the lower limit (& thus the test used) along with the patient’s albumin level; data here reflect all patients whose levels fall below the reported limit. ■ **Figure 8.16** prevalent patients, age 0–19, initiating therapy 90 days prior to September 1, 2001, & living through December 31, 2001. Vaccinations tracked between these dates. ■ **Figure 8.17** point prevalent patients, age 0–19 prior to January 1, 2000, & living through December 31, 2001. Vaccinations tracked in 2000 & 2001. \* Rate = 0. ■ **Figures 8.18–19** point prevalent patients, age 0–19 prior to January 1, 2001, & living through December 31, 2001. Vaccinations/testing tracked in 2001. ■ **Figures 8.20–24** patients receiving deceased donor, kidney-only first transplants, 1995–2001 combined; for Figure 8.23, patients non-diabetic at time of transplant. Cumulative percentages estimated using Kaplan-Meier methodology.

# Overall hospitalization & mortality

While hospital admissions per patient year in the pediatric dialysis population were approximately 4 percent higher in 2001 than in 1991, there is no visible trend in admissions over time (Figure 8.25). Rates for patients diagnosed with glomerulonephritis or secondary glomerulonephritis/vasculitis have fallen more than 18 percent, though a 36 percent rise is evident in patients with cystic/hereditary/congenital disease. Overall time spent in the hospital has decreased by 16 percent, with the largest change occurring in patients with glomerulonephritis.

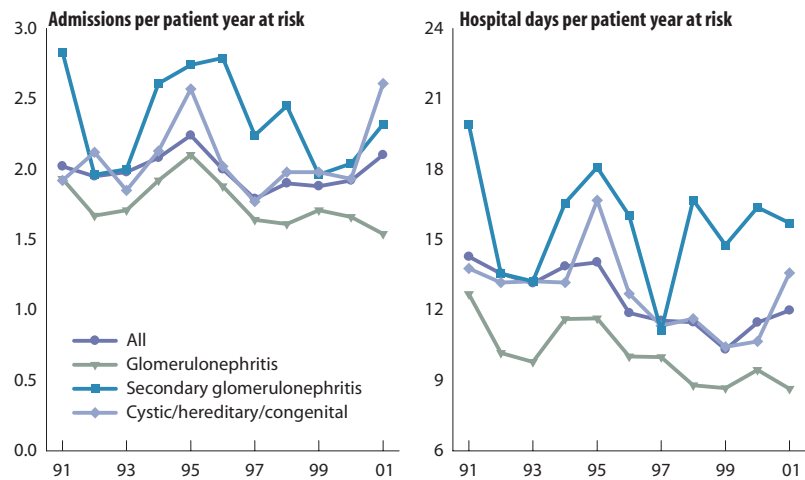
In pediatric transplant patients, hospital admissions have risen by almost 16 percent, yet remain noticeably lower in comparison to those of dialysis patients (Figure 8.26). Hospital days per patient year have decreased by approximately ten percent.

By vintage, admission rates for pediatric patients on dialysis three years or longer grew 11.5 percent from 1991 to 2001, compared to a decrease of 2–3 percent for patients on dialysis less than three years (Figure 8.27).

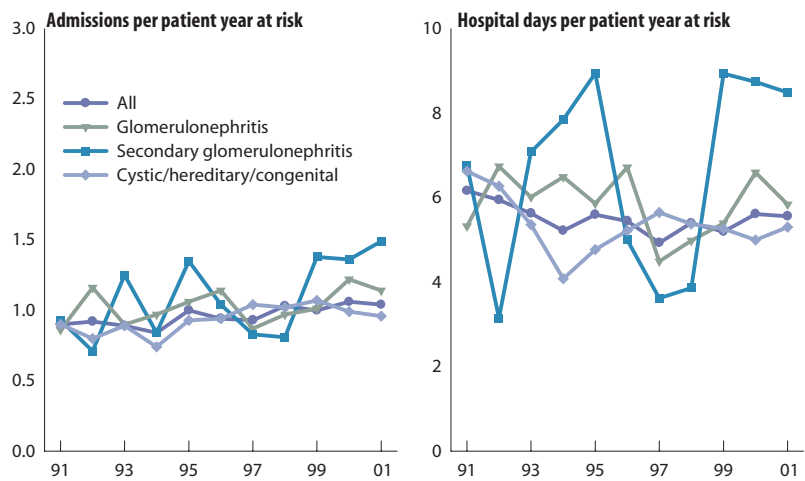
Five-year survival in the pediatric ESRD population is highly dependent on the type of renal replacement therapy (Figures 8.28–29). Of children beginning therapy on hemodialysis in 1992–1996, 83 percent survived five years, compared to 84 percent of those starting on peritoneal dialysis, and 92 percent of those with a preemptive transplant. These probabilities increased between the 1987–1991 and 1992–1996 periods, but only slightly.

By primary diagnosis, the highest survival probabilities for children on hemodialysis currently occur in those with glomerulonephritis, 89 percent of whom survive five years after the beginning of ESRD. The lowest rate, 74 percent, is seen in patients with secondary glomerulonephritis or vasculitis. Among patients beginning

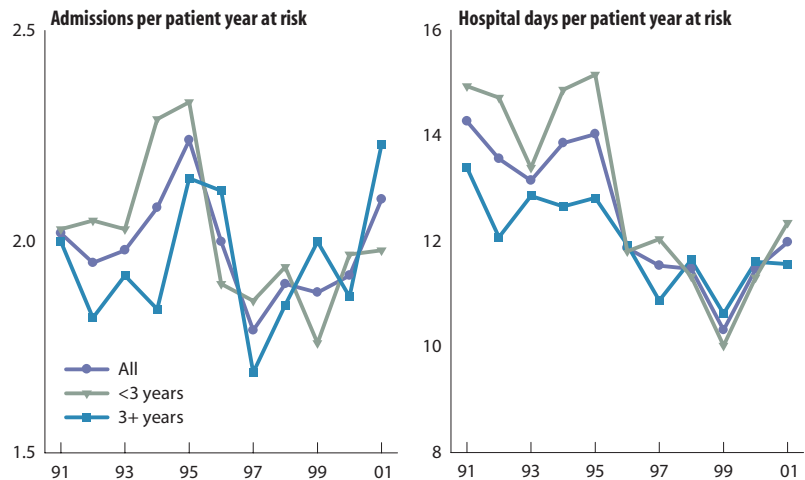
8.25 · Unadjusted hospital admissions & days, by primary diagnosis: prevalent dialysis patients



8.26 · Unadjusted hospital admissions & days, by primary diagnosis: prevalent transplant patients

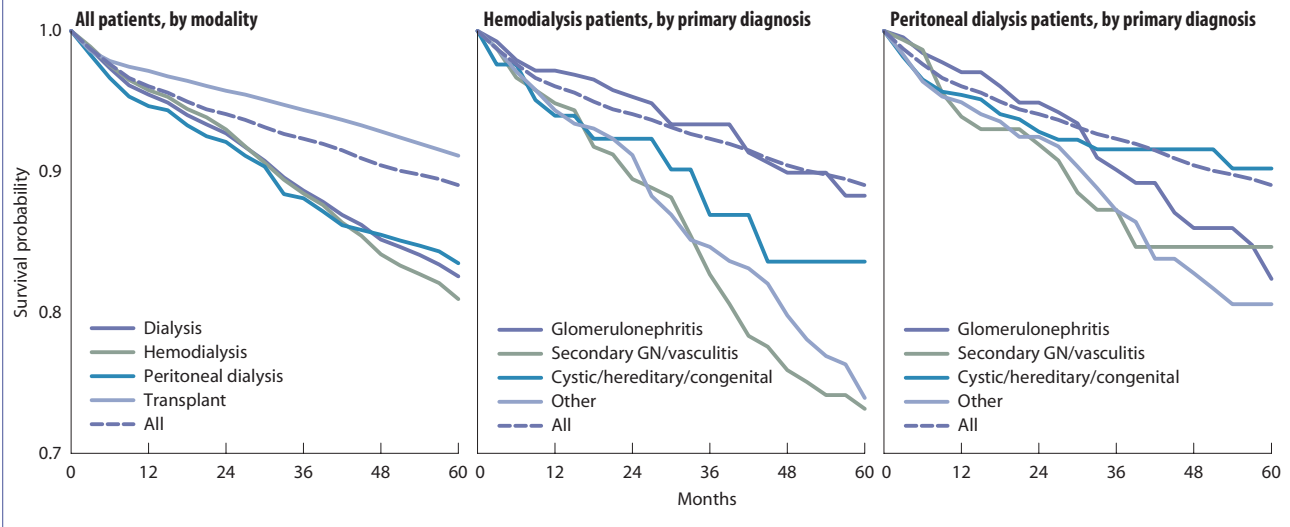


8.27 · Unadjusted hospital admissions & days, by vintage: prevalent dialysis patients

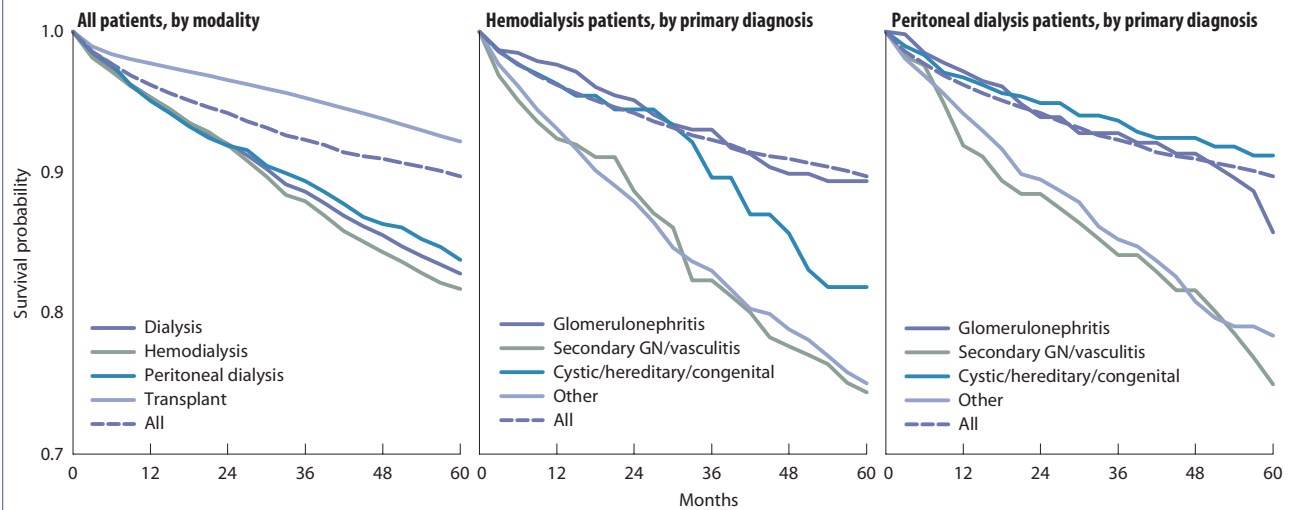




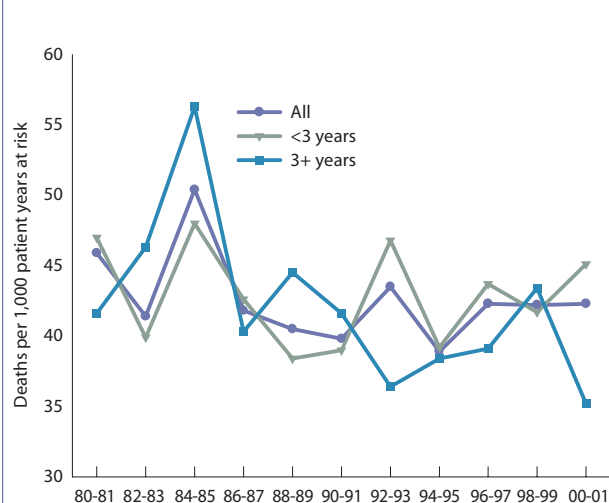
**8.28 · Adjusted five-year survival, by modality & primary diagnosis: 1987–1991 (combined) incident patients**



**8.29 · Adjusted five-year survival, by modality & primary diagnosis: 1992–1996 (combined) incident patients**



**8.30 · Unadjusted mortality rates, by vintage: prevalent dialysis patients**

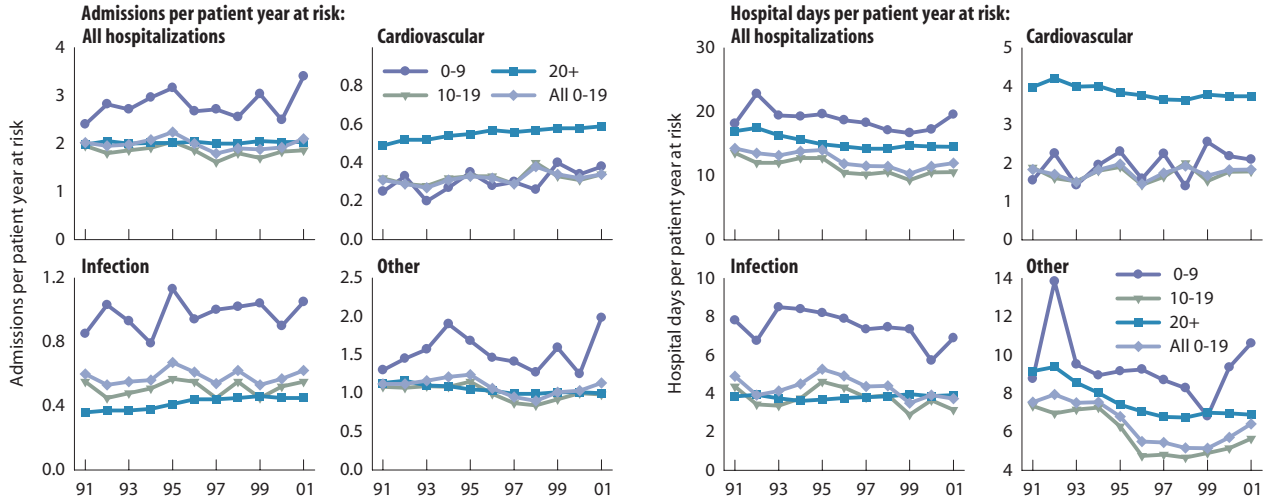


treatment on peritoneal dialysis, the patterns are slightly different. The highest survival probabilities for this therapy occur in children with cystic/hereditary/congenital kidney disease, among whom the five-year survival is 91 percent—higher than the 82 percent survival seen in hemodialysis patients with the same primary diagnosis.

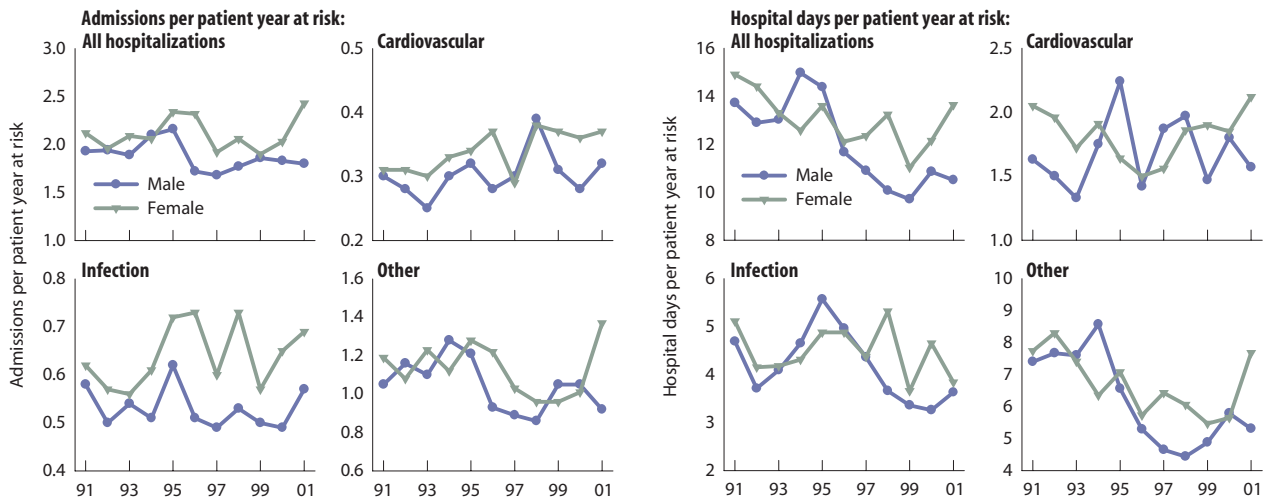
Trends in mortality rates by patient vintage show inconsistent patterns (Figure 8.30). When averaged over a 20-year period, however, rates are similar overall and for each vintage category at approximately 42 deaths per 1,000 patient years.

■ **Figure 8.25** period prevalent dialysis patients, age 0–19; unadjusted. ■ **Figure 8.26** period prevalent transplant patients, age 0–19; unadjusted. ■ **Figure 8.27** period prevalent dialysis patients, age 0–19; unadjusted. ■ **Figures 8.28–29** incident ESRD patients, age 0–19. All probabilities are adjusted for age, gender, & race; overall probabilities are also adjusted for primary diagnosis. ESRD patients age 0–19, 1995 & 1996, used as reference population. ■ **Figure 8.30** period prevalent dialysis patients, age 0–19; unadjusted.

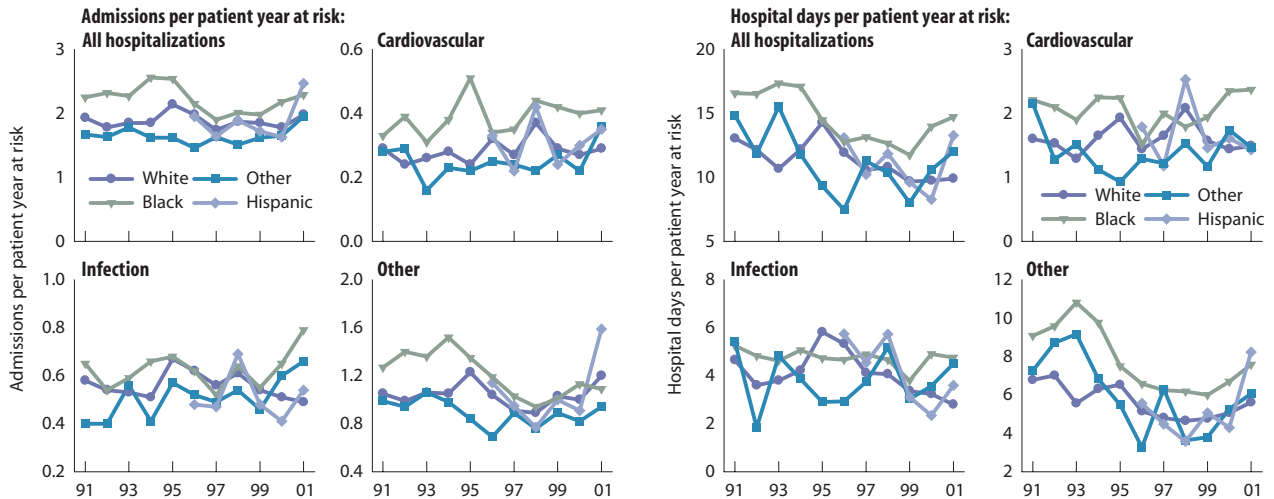
**8.31** • Unadjusted cause-specific hospital admissions & days, by age: prevalent dialysis patients



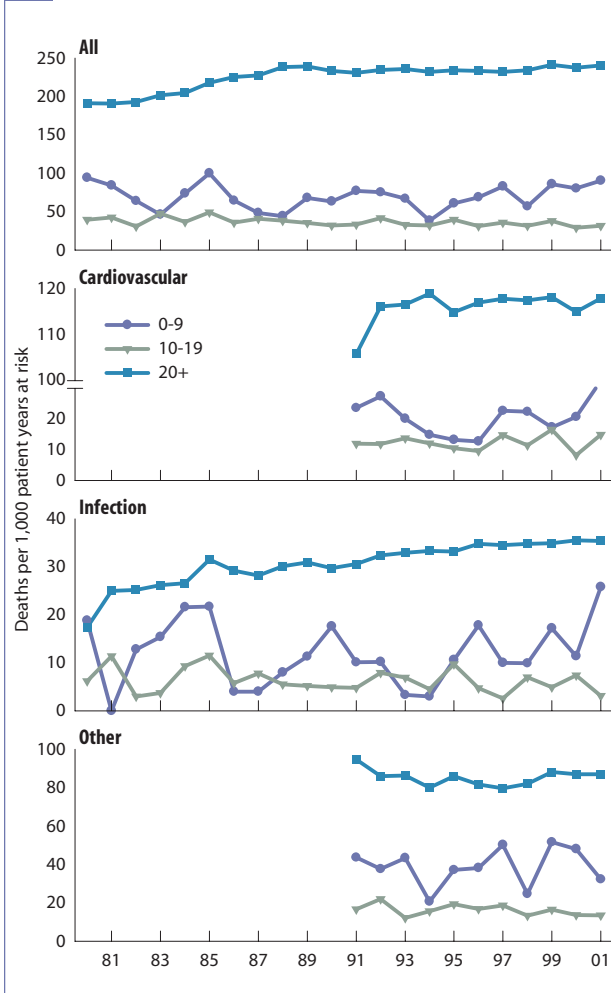
**8.32** • Unadjusted cause-specific hospital admissions & days, by gender: prevalent dialysis patients



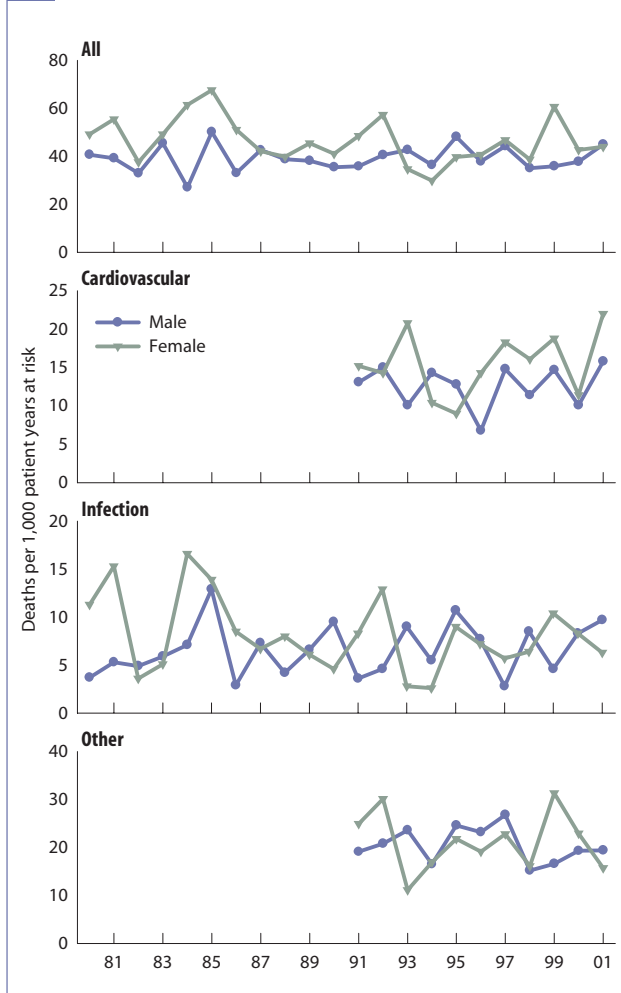
**8.33** • Unadjusted cause-specific hospital admissions & days, by race/ethnicity: prevalent dialysis patients



8.34 · Unadjusted cause-specific mortality, by age: prevalent dialysis patients



8.35 · Unadjusted cause-specific mortality, by gender: prevalent dialysis patients



## Cause-specific hospitalization & mortality

Overall hospital admissions for pediatric dialysis patients have remained steady since 1991 (Figure 8.31). The youngest patients have the highest rates of hospitalization and spend the most time in the hospital for all causes, infections, and other causes; admission rates and hospital days for cardiovascular disease, in contrast, are greatest in adult patients.

Girls have higher admission rates than boys, and in 2001 were 35 percent more likely to be admitted for all causes (Figure 8.32). They spend more time in the hospital as well; their rate of hospital days per patient year was 13.6 in 2001, compared to 10.5 for males.

By race and ethnicity, black and Hispanic children on dialysis have the highest overall hospitalization rates (Figure 8.33). Rates of hospital days have decreased for all groups except Hispanics, for whom a 38 percent increase has occurred since 1999.

Rates of all-cause mortality in the youngest children show only a minor decrease of 4 percent since 1980, in contrast to a 21 percent decrease in children age 10–19 (Figure 8.34). Rates of cardiovascular mortality, however, have increased since 1991 by 37 and 24 percent, respectively, but are significantly lower than those seen in adult patients.

All-cause mortality rates have risen in both males and females (10–11 percent) since 1980, and are slightly higher in females; cardiovascular mortality rates are higher in females as well (Figure 8.35).

■ **Figure 8.31** period prevalent dialysis patients; unadjusted. ■ **Figures 8.32–8.35** period prevalent dialysis patients, age 0–19; unadjusted. “Other” race includes races other than white or black. The Death Notification form was revised in September 1990 to include more detailed categories for cause of death; prior to this time cardiovascular deaths were often classified as being of “other” causes. Because of this, data for cardiovascular & “other” deaths prior to 1991 have been omitted here.

■ **Figure 8.33** 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.

## chapter summary

**INTRODUCTION** ■ **Figure 8.1** Between 1978 and 2001, the prevalent pediatric hemodialysis population increased 41 percent, while counts of transplant patients were six times higher than in 1978. ■ **Figure 8.2** At initiation, 23 percent of patients receive a transplant. By the end of the fifth year of ESRD, however, 85 percent have been transplanted. **CLINICAL INDICATORS**

■ **Figure 8.3** Over the last decade, hemoglobin levels for prevalent pediatric patients have increased 18 percent for those on hemodialysis, and 13 percent for those on peritoneal dialysis—to levels of 11.3 and 10.7 g/dl, respectively. ■ **Figure 8.5** Fewer than 2 percent of pediatric dialysis patients received a carnitine test in 2000–2001. ■ **Figure 8.6** In 1991, 71 percent of pediatric patients on dialysis had hemoglobins less than 10 g/dl; by the second quarter of 2002, however, this number was only 14 percent. By June 2002 the mean achieved hemoglobin level was 11.3 g/dl, in the lower half of the K/DOQI target range of 11–12 g/dl. ■ **Figures 8.7 & 8.9** By race, 68 percent of white children and 74 percent of black children had hemoglobins less than 10 g/dl in 1991; by June of 2002 these numbers had decreased to 13.5 and 12.6 percent. **PATIENT CHARACTERISTICS AT INITIATION** ■ **Figure 8.11** The mean age of children starting ESRD therapy is 13.3; those with a primary diagnosis of glomerulonephritis tend to be older, while those with cystic kidney disease have an average age of 11. ■ **Figure 8.12** Thirty-seven percent of children—41 percent of whites, and 29 percent of blacks—receive erythropoietin prior to the initiation of dialysis. The highest use occurs in patients with cystic and hereditary diseases. ■ **Figure 8.13** The mean hemoglobin at initiation is 9.1 g/dl—9.3 for whites, and 8.7 for blacks. Those with cystic and hereditary diseases, who are more likely to receive erythropoietin, have the highest hemoglobin levels at initiation. ■ **Figure 8.14** The mean estimated GFR for children initiating therapy is 10.2 ml/min—10.6 for whites, and 9.6 for blacks. Patients with secondary glomerulonephritis initiate with the highest eGFR levels. ■ **Figure 8.15** Almost half of pediatric patients begin therapy with albumin levels below the test's lower limit. **PREVENTIVE HEALTH** ■ **Figures 8.16–19** From 70 to more than 95 percent of pediatric patients do not receive recommended vaccinations for influenza, pneumococcal pneumonia, or hepatitis, and fewer than half receive lipid testing for the monitoring of cardiovascular risk factors. **POST-TRANSPLANT COMPLICATIONS** ■ **Figure 8.20** In the three years following a transplant, 2.2 percent of pediatric patients younger than 10 have developed a cancer of the central nervous system, and 8 percent have developed hematopoietic cancer. Cancer rates are generally lower in patients age 10 or older. ■ **Figure 8.21** Six percent of children age 10 or older develop congestive heart failure in the three years following a transplant, and 10.5 percent develop peripheral vascular disease. ■ **Figure 8.23** The cumulative probability of post-transplant diabetes in first three years following a transplant is almost three times higher for children age 10 and older than it is in younger patients. ■ **Figure 8.24** In the three years after a transplant, bacterial infections occur in 65 percent of children younger than 10, and 47 percent of those age 10 and older. **OVERALL HOSPITALIZATION & MORTALITY** ■ **Figures 8.25–26** Overall hospitalization rates for dialysis patients remained relatively unchanged between 1991 and 2001, while total hospital days have generally declined. Hospitalization rates increased 15 percent for transplant patients. ■ **Figures 8.28–29** Compared to those of pediatric patients incident in 1987–1991, survival rates for those beginning therapy in 1992–1996 were virtually unchanged. ■ **Figure 8.30** Mortality rates for children on ESRD therapy more than three years declined 15 percent between 1980–1981 and 2000–2001; year-to-year variability, however, is considerable. **CAUSE-SPECIFIC HOSPITALIZATION & MORTALITY** ■ **Figure 8.31** Cardiovascular hospitalization rates increased 10 percent overall between 1991 and 2001, and 52 percent in children age 0–9, compared to 6.3 percent in those age 10–19. Infectious hospitalizations increased overall by 3.3 percent, but grew 24 percent in the youngest children. ■ **Figure 8.34** Mortality rates for prevalent dialysis patients age 0–9 have changed little since 1980, but have decreased 21 percent for those age 10–19.