118 Introduction

120 Overall hospitalization & mortality
  (admissions by diagnosis, vintage, & modality) (survival) (mortality rates)

122 Cause-specific hospitalization & mortality
  (admission rates for cardiovascular & vascular procedures) (cause-specific mortality)

124 Cause-specific hospitalization & mortality by modality
  (admission rates by vintage, for cardiovascular disease, infection, cardiovascular procedures & vascular access insertions)

126 Fractures
  (fracture rates by vintage & demographic characteristics) (relative risk of mortality after fractures)

128 Major infections & mortality
  (admission rates for principal procedures & diagnoses) (five-year survival) (cause-specific mortality)

130 Complications & mortality
  (event rates & relative risks for sepsis, pneumonia, cardiovascular & other events) (relative risk of mortality after cardiovascular & other events)

132hospitalization & mortality
  (admission rates for cardiovascular disease, infection, cardiovascular procedures, & vascular access insertions)

134 Standardized mortality ratios
136 Standardized hospitalization ratios
138 Summary

CHAPTER

122 Cause-specific hospitalization & mortality
  (admission rates for cardiovascular & vascular procedures) (cause-specific mortality)

124 Cause-specific hospitalization & mortality by modality
  (admission rates by vintage, for cardiovascular disease, infection, cardiovascular procedures & vascular access insertions)

126 Fractures
  (fracture rates by vintage & demographic characteristics) (relative risk of mortality after fractures)

128 Major infections & mortality
  (admission rates for principal procedures & diagnoses) (five-year survival) (cause-specific mortality)

130 Complications & mortality
  (event rates & relative risks for sepsis, pneumonia, cardiovascular & other events) (relative risk of mortality after cardiovascular & other events)

132 Hospitalization & mortality
  (admissions by diagnosis, vintage, & modality) (survival) (mortality rates)

134 Standardized mortality ratios
136 Standardized hospitalization ratios
138 Summary

Where you used to be, there is a hole
in the world, which I find myself constantly walking around in the
daytime, and falling into at night.

Edna St. Vincent Millay

Letters
Chapter Six has been expanded this year, as we update data on hospitalization, mortality, and survival, and present new information on the relation between fractures and mortality, on cancers in women treated with dialysis, and on pregnancy rates and complications.

Figure 6.1 shows that all-cause hospitalization rates for prevalent dialysis patients fell 2 percent between 1993 and 2002. Admissions for vascular access declined 26.4 percent, but those related to cardiovascular disease and infections grew 7.2 and 20.1 percent, respectively. Cardiovascular admission rates in children increased 33.4 percent over the period, a particularly striking increase.

Hospitalization rates by dialysis patient vintage continue to fall for patients with less than two years on the therapy, and to increase for those of longer vintage. Compared to those of hemodialysis patients, rates are higher in patients on peritoneal dialysis, particularly for infections. This difference appears related to time on the therapy; while rates are similar for the two modalities in the first two years, they increase for peritoneal dialysis patients as vintage increases. In further analyses we will investigate how patients who fail on hemodialysis and move on to peritoneal therapy may influence these rates.

Rates of mortality due to major cardiovascular and infectious events have improved in both the dialysis and transplant populations, though with notable exceptions. Mortality due to malignancy, for example, has risen over the past decade, as has mortality due to a cardiac arrest or septic event. (Outcomes after cardiac events are addressed further in...
Further studies are needed to investigate potential ex-
ably lower rates of fetal distress and poor fetal growth.

The character of infectious hospitalizations in the dialysis
populations has changed over time, with hospitalizations
for pulmonary infections now twice as likely in hemodialysis
patients as in those on peritoneal dialysis. The rate of admis-
ion for peritonitis in peritoneal dialysis patients has de-
clined, while in hemodialysis patients hospitalizations for
vascular access infections have doubled in the past ten years.

The competing effects of growing infection rates and bet-
ter identification and treatment of cardiovascular disease ap-
pear to be associated with net improvement in five-year
survival. Analyses by patient vintage, however, show that
time on a therapy continues to have a growing association
with mortality, as mortality rates decline for patients of
younger vintage, and rise for those on a modality five or
more years. More detailed assessments by cause of death
and vintage are needed to determine whether a shift has oc-
curred that may help explain these changing patterns.

We give expanded attention here to infectious complica-
tions and mortality. Particularly striking are data showing
that the mortality rate six months after a septicemia diagno-
sis is seven times higher than in the reference population,
and remains 1.6 times higher after four years. While sepsis
events may identify patients at risk for early death, an alter-
native hypothesis relates these events to an increasing in-
flammatory burden and cardiovascular disease.

We introduce data this year on newly identified cancers in
women receiving dialysis therapy, and on pregnancy rates
and complications. Rates of pregnancies in dialysis patients
have remained relatively stable since 1991, while those in trans-
plant patients have fallen dramatically. Reasons for this are
unknown, but may be explained in part by women choosing
to delay pregnancy until more than three years after their
transplants; after this point, we can no longer track these
patients. Live birth rates are significantly lower in dialysis
patients, though babies born to these patients have notice-
ably lower rates of fetal distress and poor fetal growth. Fur-
ther studies are needed to investigate potential ex-
planations for changes in these rates and for the often dra-
matic differences between the modalities.

Mortality comparisons on a provider level have long been
the subject of review by policy makers and health plans. The
Standardized Mortality Ratio (SMR), the primary method
used in these comparisons, has been modified to incorpo-
rate adjustments for age, gender, race, primary diagnosis,
time on dialysis, and comorbidity at initiation, but the SMR’s
year-to-year variability, which could reflect either real changes
or random variations, has been a major concern.

The USRDS Coordinating Center recently published a new
Bayesian adjusted mortality rate methodology, addressing
more completely the inherent variability of small versus large
providers to determine which units are true outliers, and
which are within the normal degree of variation. To illustrate
differences between the traditional and new methods we have
included two new spreads in this chapter, presenting data by
provider and census division, and looking at mortality and
hospitalization ratios; transplantation ratios are presented
in Chapter Seven. We provide information here, for example,
on how frequently each of the two methods would classify a
unit in the same group, demonstrating the difficulties in sim-
ply interpreting a ratio as “good” or “suboptimal.”

The two methods generally provide similar results, but
we believe the Bayesian method is superior for identify-
ing true outliers, and provides more confidence in
assessing providers. This will now be the sole
method used by the USRDS to report these ra-
tios, and we will continue to examine alter-
native methods of assessing outcomes at
the provider level. Areas of disagree-
ment should be viewed with cau-
tion, as it may be difficult,
particularly in smaller pro-
viders, to distinguish a
real finding from
random varia-
[6.6] Adjusted
mortality rates in
prevalent dialysis
patients continue to
fall for those with less
than five years on the
therapy, but since 1994 have
increased in patients with a vintage
of five years or greater. [6.20 & 6.22]
Admissions for cardiac arrest have
increased in the dialysis population, as have
those for bacteremia/septicemia. [6.61–66]
Pregnancy rates for women with ESRD, as well as ante-
partum and post-partum complication rates, show
differential patterns between dialysis and transplantation.
[6.67–82] In calculations of mortality and hospitalization ratios,
the Bayesian method, developed by the USRDS, takes into account the
inherent variability of small providers and produces more stable rates.

Chapter highlights
Hospital admissions by primary diagnosis have remained relatively steady since 1993 (Figure 6.2). Patients whose ESRD is caused by diabetes are admitted most frequently—2.3 times per year in 2002—while rates are lowest for patients with glomerulonephritis. Transplant patients have the lowest admission rates. Peritoneal dialysis patients with diabetes are admitted slightly more often than their hemodialysis counterparts.

By vintage—a patient’s time with ESRD—admission rates in the hemodialysis population are highest for patients who have had ESRD less than two years, and have been relatively steady in this population since the early 1990s (Figure 6.3). Rates for patients with five or more years on the therapy, in contrast, have been rising, from 1.8 admissions per patient year at risk in 1993 to 2.0 in 2000–2002. This growth of nearly 9 percent has occurred in peritoneal dialysis patients of older vintage as well, as rates for younger vintage patients on the modality have fallen slightly.

Compared to those of the previous period, five-year survival probabilities for the population incident in 1993–1997 increased across modalities—6 percent overall, and 15 percent for patients on peritoneal dialysis (Figures 6.4–5). By primary diagnosis, the greatest improvement has occurred in the diabetic populations, with probabilities rising 13 and 28 percent for hemodialysis and peritoneal dialysis, respectively. Patients with diabetes continue, however, to have the lowest probabilities of survival, with only 27 percent of those on hemodialysis, and 23 percent of peritoneal dialysis patients, expected to survive five years after initiation.

We show in Chapter Three that incident patients carry a greater degree of comorbidity than ever before. Despite this, however, their survival rates—across modalities and primary diagnoses—are improving. This improvement may be even greater if disease burden is taken more directly into account.

Among prevalent dialysis patients, overall mortality rates have fallen 10 percent since their 1988 peak, in 2002 reaching 248 deaths per 1,000 patient years (Figure 6.6). This slight fall, however, masks significant differences by patient vintage. Since 1985, rates for patients on dialysis less than two years have fallen 24 percent. Rates for patients on the modality five or more years, in contrast, have increased—14 percent since their lowest point in 1994, to a 2002 level of 286 deaths per 1,000 patient years. These data show the need for more attention to conditions that develop over time, such as lipid disorders and diabetic, cardiovascular, and infectious complications.

The poor long-term survival of ESRD patients is illustrated by comparisons to the general U.S. population (Table 6.a). The expected remaining lifetimes of white dialysis patients are only one-fourth to one-sixth those of the general population; differences are particularly high among women aged 40–65. And despite slightly higher survival rates, expected remaining lifetimes of black dialysis patients are only one-third to one-fifth those of the general population. By modality, expected lifetimes for transplant patients are double those of dialysis patients among black males, and more than three times as high for white females ages 20 and older. Expected remaining lifetimes in transplant patients are still, however, only 52–69 percent as long as those in the general population.
used as reference cohort. [Figures 6.4–5] incident dialysis patients & patients receiving a first transplant in the calendar year. All probabilities are adjusted for age, gender, & race; overall probabilities are also adjusted for primary diagnosis. All ESRD patients, 1996, used as reference cohort. Modality determined on first ESRD service date; excludes patients transplanted or dying during the first 90 days. [Figure 6.6] period prevalent dialysis patients; rates adjusted for age, gender, race, & primary diagnosis. Dialysis patients, 2001, used as reference cohort. [Table 6.a] U.S. data: from Table A in the United States life tables (Arias E). Available at www.cdc.gov/nchs/data/nvsr/nvsr52/nvsr52_14.pdf; data provided only for whites & blacks. ESRD data: prevalent dialysis & transplant patients, 2002.
ialysis patients age 75 and older have the highest hospital admission rates overall, for cardiovascular disease, and for infections not due to internal devices (Figure 6.7). Admissions for infections that are due to internal devices, however, are most common in patients age 20–44.

Hospital admission rates continue to be higher in female dialysis patients than in males—14 percent higher for all hospitalizations, and 9 percent higher for admissions related to cardiovascular disease (Figure 6.8). Overall rates for admissions which include a cardiovascular procedure are also greater in women (Figure 6.11). Rates for admissions including a stent/angioplasty or a bypass procedure, however, are 10 and 46 percent higher, respectively, in men than in women. And while women have greater admission rates for inpatient vascular access insertions overall and for catheters and grafts, 2002 admission rates for fistula creation were 15 percent higher in men (Figure 6.14).

While overall admission rates by race and ethnicity differ little for most patient groups, they are consistently lowest for dialysis patients of Asian descent—in 2002, 1.4 admissions per patient year at risk, compared to 1.9–2.1 in Hispanic patients and those of other races (Figure 6.9). Admissions for cardiovascular disease in the Asian population have, however, been rising slowly, and in 2002 were 14 percent higher than in 1993.

Overall rates for admissions with a cardiovascular procedure are greatest in black dialysis patients, and lowest in those of other races (Figure 6.12). Black patients also have, however, the lowest rates of admissions with a bypass procedure, and among the lowest rates of admissions with a stent or angioplasty, while the highest rates consistently occur in white patients. Since 1993, the rate of admissions including a stent or angioplasty has grown 138 percent for white patients, and 189 percent for blacks.

As more vascular access procedures are done on an outpatient basis, rates of inpatient vascular access insertions overall, and of catheter and graft placements, have decreased for most patient groups (Figures 6.13 and 6.15). Guidelines of the NKF’s Kidney Disease Outcomes Quality Initiative (K/DOQI) advocate the increased use of fistulas; admissions for fistula creation have been relatively steady over time, decreasing slightly in whites and in blacks.

[All figures] dialysis patients, 2002, used as reference cohort. Rates by age are adjusted for gender, race, & primary diagnosis; rates by gender are adjusted for age, race, & primary diagnosis; rates by race/ethnicity are adjusted for age, gender, & primary diagnosis. CMS began collecting Hispanic ethnicity data on the Medical Evidence form in April 1995. Because the model-based adjustment method uses data from the current & previous two years, rates for Hispanic patients are shown only for 1998 & later.

[Figures 6.7–9] period prevalent dialysis patients age 20 & older. At the end of 1998 a new ICD-9-CM code was added for infections due to internal devices in peritoneal dialysis patients; data prior to this date are omitted. [Figures 6.10–12] period prevalent dialysis patients age 20 & older. Rates reflect all admissions with a cardiovascular procedure (excluding vascular access procedures), not just those for the purpose of a cardiovascular procedure. Categories are not mutually exclusive, so a hospitalization that includes more than one type of cardiovascular procedure will be counted under each category. [Figures 6.13–15] period prevalent hemodialysis patients age 20 & older. Part B physician/supplier claims for vascular access insertions in an inpatient setting.
Adjusted admissions with cardiovascular procedures: prevalent patients

[6.10] by age

Adjusted inpatient VA insertions: prevalent patients

[6.13] by age

Adjusted inpatient VA insertions: prevalent patients

[6.14] by gender

Adjusted inpatient VA insertions: prevalent patients

[6.15] by race/ethnicity

Adjusted inpatient VA insertions: prevalent patients

[6.12] by race/ethnicity

Adjusted inpatient VA insertions: prevalent patients

[6.11] by gender

Adjusted inpatient VA insertions: prevalent patients

[6.15] by race/ethnicity

Adjusted inpatient VA insertions: prevalent patients

[6.11] by gender
ince the early 1990s, adjusted cause-specific mortality rates have generally decreased in both the dialysis and transplant populations. Rates of mortality due to acute myocardial infarction, for instance, have fallen 25 percent since 1991 for all dialysis patients, and 33 percent for those on the modality less than three years (Figure 6.16). The change has been slightly smaller for older vintage patients, for whom rates have dropped 18 percent. Similar changes have occurred for atherosclerotic heart disease, cardiomyopathy, and cardiac arrhythmia (Figures 6.17–19). While rates for transplant patients tend to be less stable, they have decreased since 1991 for all causes examined here.

Rates in the dialysis population have grown, however, for mortality due to cardiac arrest, bacteremia/septicemia, and malignancy (Figures 6.20, 6.22, and 6.24). This is particularly true for patients of older vintage, in whom rates since 1991 have increased 55, 14, and 44 percent, respectively.

The highest risk of mortality in ESRD patients with cardiovascular, respiratory, and vascular access events occurs in the interval immediately following the event (Figures 6.25–30). Patients who suffer an AMI or pneumonia are the most vulnerable, with a risk of death 3–4 times higher than that in patients without the event.

Mortality risks decrease dramatically as time after an event increases. The risk of death at 24 months following an AMI, for instance, falls from the six-month level by a factor of three (from 4.14 to 1.36), and remains relatively stable, though at four years it is still 48 percent higher than in patients without the event. In patients suffering from episodes of pneumonia, the risk of death decreases by almost half from six months to 12 months, and at four years is 22 percent higher than in the reference group.

The risks of mortality in patients with heart failure, CVA/TIA, or PVD are similar immediately following the event and over the four-year study period. The relative risk of death at six months for patients with heart failure, for example, is 2.5, compared to 2.6 and 2.3 for CVA/TIA and PVD. At the end of four years, risks are 30–45 percent higher than in patients without these conditions.

The lowest risk of death overall occurs in patients with a vascular access event, but the risk at six months is still 33 percent higher than in the reference group. It declines thereafter, however, to only 5 percent higher at 36 months, and after this point there is essentially no difference when compared to the reference group.

While the number of admissions per patient year has remained steady since the early 1990s, the number of hospital days has fallen 12 percent for hemodialysis patients, 16 percent for those with a transplant, and 19 percent for those on peritoneal dialysis (Figure 6.31). Dialysis patients have nearly the same number of yearly admissions, but peritoneal dialysis patients spend more days in the hospital.

Across modalities, causes other than cardiovascular disease and infection account for the greatest number of hospital admissions and days (Figure 6.32). Admissions for infection in hemodialysis patients have increased 28 percent since 1993, while they are only 1–3 percent different in peritoneal dialysis and transplant patients.
Admissions for pulmonary infections in hemodialysis patients have grown 19 percent since 1993, while those for vascular access infections have more than doubled (Figure 6.33).

Survival probabilities for patients incident in 1993–1997 increased slightly compared to those of the previous period, with 34 percent of hemodialysis patients, and 33 percent of those on peritoneal dialysis, expected to survive five years after the beginning of treatment (Figure 6.34).

Since 1985, all-cause mortality rates have decreased 9 percent for hemodialysis patients, and 12 percent for patients on peritoneal dialysis (Figure 6.35). As with the overall rates shown in Figure 6.6, however, these moderate changes conceal dramatic relationships between mortality rates and vintage. For hemodialysis patients on the modality less than two years, rates have fallen 21 percent since 1985; for peritoneal dialysis patients, rates have declined 41 percent. Rates for patients on their modality five or more years, in contrast, have increased. Though equivalent in 1990, mortality rates for older vintage hemodialysis patients are now 25 percent higher than for those on the modality less than two years, and have risen 16 percent since their lowest point in 1994. Rates in the peritoneal dialysis population were essentially equivalent in 1985, but rates for older vintage patients have since increased 18 percent.

Cause-specific mortality rates remain relatively stable, with rates of mortality due to cardiovascular disease and infection higher in the peritoneal dialysis population, and rates for other causes slightly lower (Figure 6.36).

(Figures 6.31–33) period prevalent patients; rates adjusted for age, gender, race, & primary diagnosis. ESRD patients, 2002, used as reference cohort. Cardiovascular procedure category excludes vascular access procedures. Heart catheterizations for transplant patients excluded prior to 1995 because of few events. (Figure 6.34) incident dialysis patients; adjusted for age, gender, race, & primary diagnosis. All ESRD patients, 1996, used as reference cohort. Modality determined on first ESRD service date; excludes patients transplanted or dying during the first 90 days. (Figures 6.35–36) period prevalent dialysis patients; rates adjusted for age, gender, race, & primary diagnosis. Dialysis patients, 2001, used as reference cohort. 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 6.37 shows unadjusted rates of hospitalization with a diagnosis of septicemia, while Figure 6.38 shows an otherwise similar analysis in which adjustment has been made for age, gender, race, and primary diagnosis. Septicemia rates are consistently higher in hemodialysis patients than in peritoneal dialysis patients, and in these latter patients appear to have largely stabilized after 1997. In contrast, rates of septicemia in hemodialysis patients continue to climb, from 13.8 per 100 patient years in 1991 to 26.5 in 2001. This apparent doubling of rates over a time interval of ten years remains unchanged when adjustment is made for age, gender, race, and primary diagnosis.

Mortality rates after admission with septicemia are high. Figure 6.39 shows adjusted mortality rates of 120.1 in the initial six months after septicemia, declining to 32.7 per 100 patient years between 42 and 48 months later; Figure 6.40 shows that these rates are 7.1 and 1.6 times, respectively, those of patients not experiencing an episode of septicemia.

Figure 6.41 presents unadjusted rates of pneumonia events, while Figure 6.42 shows an otherwise similar analysis in which adjustment has been made for age, gender, race, and primary diagnosis. Pneumonia rates are consistently higher in hemodialysis patients than in peritoneal dialysis patients. While rates in the latter population were relatively constant between 1991 and 2001, rates in hemodialysis patients have climbed gradually, from 24.8 per 100 patient years in 1991 to 30.6 in 2001.

Mortality rates after pneumonia are high. Figure 6.43 shows...
adjusted mortality rates of 78.3 per 100 patient years in the initial six months after pneumonia, declining to 32.2 between 42 and 48 months later; Figure 6.44 shows that these rates are 5.1 and 1.8 times, respectively, those of patients not experiencing an episode of pneumonia.

Pneumonia is a classic inflammatory state, and a considerable body of research suggests that inflammation is a risk factor for cardiovascular disease. Cardiovascular event rates are high after a diagnosis of pneumonia. Figure 6.45 shows adjusted cardiovascular event rates of 64.8 per 100 patient years in the initial six months after pneumonia, declining to 25.7 between 42 and 48 months later; Figure 6.46 shows that these rates are 3.0 and 1.2 times, respectively, those of patients not experiencing an episode of pneumonia.

(Figures 6.37–38) incident dialysis patients with 90-day rule; adjusted rates adjusted for age, gender, race, & primary diagnosis. Patients with Medicare as a secondary payor or enrolled in an HMO on day 90 are excluded, as are patients with sepsis claims overlapping the start date of the followup period. (Figures 6.39–40) incident dialysis patients, 1996–2000, with 90-day rule & with Medicare as primary payor; adjusted rates adjusted for age, gender, race, & primary diagnosis. Patients with Medicare as a secondary payor or enrolled in an HMO on day 90 are excluded, as are patients with pneumonia claims overlapping the start date of the followup period. (Figures 6.41–42) incident dialysis patients with 90-day rule; adjusted rates adjusted for age, gender, race, & primary diagnosis. Patients with Medicare as a secondary payor or enrolled in an HMO on day 90 are excluded, as are patients with pneumonia claims overlapping the start date of the followup period. (Figures 6.43–46) incident dialysis patients, 1996–2000, with 90-day rule & with Medicare Parts A & B as primary payor; adjusted rates adjusted for age, gender, race, primary diagnosis, & vintage. Patients without pneumonia during the first year + 90 days after initiation are used as the reference cohort.
Fractures of the long bone occur in women at a rate 71 percent higher than in men, and in hemodialysis patients at a rate 64 percent higher than in those on peritoneal dialysis; they are also more than twice as common in whites as in patients of other races (Figures 6.48–50). By diagnosis, patients whose ESRD is caused by diabetes are twice as common in whites as in patients of other races (Figures 6.48–50). By diagnosis, patients whose ESRD is caused by diabetes and patients with hypertension have higher initial risks of death at six months after a fracture—3.1 versus 1.9 after a rib fracture, for example, and 3.7 versus 2.9 after a long bone fracture (Figure 6.54). As time after the event increases, however, the risk of death shows no clear pattern between diabetics and patients with hypertension. 

Males have a higher risk of death than females in the first year following a fracture (Figure 6.55). The risk of death six months after a vertebral fracture, for example, is 4.9 for men, and 3.0 for women; for a rib fracture, the risks are 2.9 and 2.3, respectively.

Risks of death after a fracture vary by race (Figure 6.56). At 12 months, for example, black patients with a vertebral fracture have a mortality risk of 2.5, compared to 1.7 in whites; for rib fractures, however, risks are even between the races.
(6.53) Adjusted relative risk of mortality after fracture, overall

(6.54) Adjusted relative risk of mortality after fracture, by primary diagnosis

(6.55) Adjusted relative risk of mortality after fracture, by gender

(6.56) Adjusted relative risk of mortality after fracture, by race
omen who develop cancer or become pregnant while on ESRD therapy clearly face enormous healthcare challenges. We present here new data on hospitalization and treatment for breast, cervical, uterine, and ovarian cancers in dialysis patients, and on pregnancies in dialysis and transplant patients.

Rates of hospitalization with a new cancer diagnosis in women on dialysis declined slightly during the 1990s—17 percent for breast cancer, to 2.3 hospitalizations per 1,000 patient years, and 24 percent for cervical, uterine, and ovarian cancers, to 1.2 (Figure 6.57).

In 1997–1999, 10–11 percent of patients with any of these cancers received chemotherapy; 25 percent of those with breast cancer received radiation, compared to 34 percent of those with cervical, uterine, or ovarian cancer; and 32 and 41 percent, respectively, received radiation and/or chemotherapy (Figure 6.60).

Among women age 14–45, pregnancy rates are consistently highest for those without diabetes, regardless of modality (Figure 6.61). Changes in these rates over time, however, are quite different between the modalities. Rates for dialysis patients have been relatively stable since 1991. For transplant patients, in contrast, rates have declined steadily—for non-diabetics, from 42 pregnancies per 1,000 patient years in 1991 to 13 in 2001, and for diabetics, from 30 to 8. The use of immunosuppressive medications may help explain this change. In addition, recent literature has suggested that women wait several years after a kidney transplant to become pregnant, and, since Medicare covers only the first three years post-transplant, many of these later pregnancies are not captured in the database.

Complications during pregnancy have followed no clear pattern over time (Figure 6.62). In 2001 nearly one-third of dialysis patients, and one-fifth of those with a transplant, suffered a hemorrhage, while 20 and 35 percent, respectively, went into early labor.

Pregnancy outcomes vary quite dramatically by modality (Figure 6.63). Among dialysis patients, only 16–37 percent of preg-
nancies since 1991 have resulted in a live birth, while live births have occurred in more than half, and up to 63 percent, of pregnancies among women with a transplant. Regardless of modality, the most common cause of an early termination is spontaneous abortion; induced abortions have been slightly more common among transplant patients than among those on dialysis (Figure 6.64). In live births, the use of Caesarean sections has declined among transplant patients; for women on dialysis, because of the small number of patients, types of live births have varied more over time.

Though pregnancies among women on dialysis are less likely to result in a live birth, the children born to these women tend to be somewhat healthier than those born to transplant patients, experiencing less fetal distress and better fetal growth (Figure 6.65).
In the ESRD community, mortality and morbidity rates have long been used as a quality assurance tool to improve patient outcomes. Mortality or any form of morbidity are assessed on the simplest level by comparing the actual number of events—such as deaths or hospitalization—to the expected number of events. Provider-level mortality and morbidity ratios have been used by the USRDS and others for many years, with varying degrees of adjustment based on population complexity and provider characteristics.

What has been clear from the outset is the intrinsic variability in these estimates, which is highly related to the size of the population being assessed. Event rate estimates have a greater degree of statistical instability for small providers than they do for larger ones. This is crudely exemplified in the lower graph of Figure 6.67, which presents standardized mortality ratios (SMRs) calculated using the traditional method, along with their 95 percent confidence intervals, for a random sample of providers. This plot shows that the stabilities of estimated SMRs using this method differ widely, and are closely related to sample size. The lower graph of Figure 6.69 provides a different illustration of the impact of provider size on the variability of SMR estimates—the smaller the provider, the wilder the SMR estimate.

The Bayesian hierarchical model, however, provides an alternative method of SMR estimation, stabilizing the estimates and making comparisons more appropriate. To distinguish two methods, we here use the term BMR to designate the SMR estimated using the Bayesian method, and continue to use SMR to designate estimates using the traditional method. The top graphs in Figures 6.67 and 6.69 show the dramatic improvement in the variation of estimates using the Bayesian method, with the length of the confidence intervals “flatter” and almost all BMRs in a constant band. For details on this method, we refer readers to our paper in Health Services and Outcomes Research Methodology (September 2003 issue), accessible on the web at www.kluweronline.com/issn/1387–3741/contents. All BMRs and SMRs in this section are adjusted for patient age, gender, race, primary diagnosis, and ESRD vintage.

In Figure 6.68 we examine the agreement of results produced by these two methods. For providers with SMRs in the lowest quintile, for example, the BMR places 63 percent in the same quintile, and the remaining units in higher quintiles. For providers with SMRs in the 20–40 percent quintile, the BMR places 60 percent in the same quintile, 37 percent in the lowest quintile, and 3 percent in the middle quintile. Comparisons within this middle quintile give a 73 percent agreement in results of the two methods; 5 percent are placed one quintile higher, and 23 percent one quintile lower. For providers whose SMRs are in the 60–80 percent quintile, the BMR places 77 percent in the same quintile, 18 percent one quintile higher, and 5 percent one quintile lower. And in the highest SMR quintile, the two methods produce an 82 percent agreement; the BMR places 18 percent of units in the next lowest quintile.

It is important for policy makers, providers, and health plans to recognize that, compared to the traditional SMR method, the Bayesian method needs a relatively smaller sample size to produce an accurate estimate. If all providers were large enough, the two methods would produce the same results. Because this is not the case, however, we have pursued an alternative analytical approach, and have determined that more accurate results are obtained through the Bayesian model.

Overall, Figures 6.70–72 show that almost all provider groups—by quintile, unit affiliation, and geographic region—have similar median BMR and SMR values, but that the ranges are tighter with the BMR estimates. This holds true as well for hospital-based units, in which mortality ratios calculated by both methods are slightly higher than in other groups. Patients receiving treatment at these providers may
have higher risks caused by factors other than age, gender, race, primary diagnosis, and ESRD vintage. In the West North Central census division the BMR median is larger (closer to 1) than the SMR median; providers in this area are much smaller than those in other areas of the country.

Theoretically, the rank of BMR is optimal under mean square-error loss. But even optimal procedures may perform poorly if the data do not provide enough information. For very small providers, the Bayesian method may over-shrink the estimates to 1. Caution is needed to report the results, and it is necessary to evaluate how much information is contained in the data (Liu et al).

Based on these results, the USRDS will now be conducting all analyses of mortality ratios—along with hospitalization and transplantation ratios—using this new Bayesian method. On the following spread we present similar comparisons of hospitalization ratios, using the traditional and Bayesian methods.

(All figures) adjusted for age, gender, race, primary diagnosis, & vintage. Information on the U.S. Census divisions is available at www.census.gov/geo/www/maps/CP_MapProducts; a map of the divisions is presented on page 137. — [Figure 6.67] prevalent dialysis patients, 2002, in a random sample of dialysis providers. [Figures 6.66–72] prevalent dialysis patients, 2002, in all dialysis providers.

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### Figure 6.69
Variation of provider-level BMR & SMR, by provider size (in patient years)

### Figure 6.70
Distribution of provider-level mortality ratios, overall & by BMR quintile

### Figure 6.71
Distribution of provider-level mortality ratios, by unit affiliation

### Figure 6.72
Distribution of provider-level mortality ratios, by U.S. Census division

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Chain 1 · Fresenius  
Chain 2 · Gambro  
Chain 3 · DaVita  
Chain 4 · Renal Care Group  
Chain 5 · Dialysis Clinics, Inc.  
Chain 6 · Nat’l Nephrology Assoc.  
NC · Non-chain units  
HB · Hospital-based units  
PAC · Pacific  
MTN · Mountain  
WNC · West North Central  
WSC · West South Central  
ENC · East North Central  
ESC · East South Central  
SA · South Atlantic  
MA · Middle Atlantic  
NE · New England
In this spread we assess morbidity using the standardized hospitalization ratio (SHR), which is adjusted for age, gender, race, primary cause of ESRD, and vintage. As noted with the standardized mortality ratio (pages 134–135), there is considerable variation in the SHR based on provider size. To address this, along with the inherent variation in predicted hospitalization rates, we have applied the Bayesian model here as well.

In Figure 6.73 we compare the ranking of providers, using the traditional SHR method and the newer Bayesian model. Providers within the lowest SHR quintile have an only 83 percent agreement with the BHR model, while the remaining 17 percent are placed into higher BHR quintiles.

The two methods appear to give comparable results overall, but they differ at the extremes. On a provider level it appears that the chains and independents have similar BMR and SHRs, while hospital-based providers have higher ratios (Figure 6.75).

We look here as well at cardiovascular and infectious hospitalizations. Based on the modeling of the intrinsic variability of small versus larger providers, the range is smaller here in the BHR compared to the SHR (Figures 6.77 and 6.80). Chain-owned and independent providers appear to have comparable ratios, while ratios for hospital-based providers are higher (Figures 6.78 and 6.81).

Cardiovascular hospitalization ratios are higher in the West South Central and East North Central census divisions, while infectious hospitalization ratios are higher in the Middle Atlantic and New England areas (Figures 6.79 and 6.82).

Used in the calculation of mortality and hospitalization ratios, the Bayesian model offers a more stable way to compare yearly performance while taking into account normal variation. This method can be also used to assess transplant centers for acute graft and patient events and for longer-term outcomes.

Whereas the traditional SMR/SHR calculation may show wide swings in results based on smaller provider variability, the Bayesian model may over-adjust for random variation, thereby shrinking the results toward 1.0. Just as it is unlikely that a provider would truly have a zero mortality or hospitalization ratio, it is also of concern that most units may have ratios close to one. In these cases a more direct review of a provider is required to ensure safety. It is also important not to penalize providers whose increasing variation is due to small size. Another important competing event is that of kidney transplantation. Mortality and hospitalization ratios are vulnerable to this event, which removes healthier patients. The USRDS will continue to investigate these issues in order to provide multiple methods of assessing providers and determining their true performance.

(All figures) Prevalent dialysis patients, 2002, in all dialysis providers; adjusted for age, gender, race, primary diagnosis, & vintage. Information on U.S. Census divisions is available at www.census.gov/geo/www/maps/CP_MapProducts.
Distribution of provider-level hospitalization ratios: cardiovascular disease

[6.77] overall & by BHR quintile

![Box plot for cardiovascular disease](image1)

Distribution of provider-level hospitalization ratios: infection

[6.80] overall & by BHR quintile

![Box plot for infection](image2)

[6.78] by unit affiliation

![Box plot for unit affiliation](image3)

[6.81] by unit affiliation

![Box plot for unit affiliation](image4)

[6.79] by U.S. Census division

![Box plot for U.S. Census division](image5)

[6.82] by U.S. Census division

![Box plot for U.S. Census division](image6)

[6.83] U.S. Census divisions

![Map of U.S. Census divisions](image7)

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Chain 1 · Fresenius
Chain 2 · Gambro
Chain 3 · DaVita
Chain 4 · Renal Care Group
Chain 5 · Dialysis Clinics, Inc.
Chain 6 · Nat’l Nephrology Assoc.
NC · Non-chain units
HB · Hospital-based units

PAC · Pacific
MTN · Mountain
WNC · West North Central
WSC · West South Central
ENC · East North Central
ESC · East South Central
SA · South Atlantic
MA · Middle Atlantic
NE · New England
Chapter summary

Introduction

[Figure 6.1 Between 1993 and 2002, the number of admissions for vascular access procedures fell 26 percent, while rates of infectious and cardiovascular hospitalizations rose 20 and 8 percent, respectively.]

Overall hospitalization & mortality

[Figure 6.2 Adjusted hospitalization rates overall for diabetic patients are down slightly in the last eight years. | Figure 6.6 Adjusted mortality rates in prevalent dialysis patients continue to fall for those with less than five years on the therapy, but since 1994 have increased in patients with a vintage of five years or greater.]

Cause-specific hospitalization

[Figure 6.8 Rates of hospitalizations for cardiovascular disease have increased for both males and females in the last four years. | Figures 6.10-12 The rate of hospitalization admissions that include stent placement or angioplasty has increased steadily, with rates highest in patients age 45–74.]

Cause-specific mortality

[Figures 6.16–24 Hospitalization rates for acute myocardial infarction, atherosclerotic heart disease, and cardiomyopathy have all decreased in both dialysis and transplant patients. Admissions for cardiac arrest, however, have increased in the dialysis population, as have those for bacteremia/septicemia. Compared to that in the transplant population, adjusted mortality for dialysis patients with malignancies also appears to have increased.]

Hospitalization & mortality, by modality

[Figure 6.33 In hemodialysis patients, hospital admissions for pulmonary infections and vascular access infections are on the rise. Admissions for peritonitis in patients on peritoneal dialysis, in contrast, have fallen. Although admissions for cardiovascular procedures are down in hemodialysis patients, admissions for cardiac catheterizations have increased for both dialysis populations.]

Major infections & cardiovascular events

[Figures 6.39 & 6.43 Mortality patterns after septicemia events or pneumonia appear to be associated with a very high mortality risk in the first six months, which slowly decreases but never returns to baseline.]

Fractures & mortality

[Figure 6.47 Rates of long bone fractures have increased over the last ten years; rates of vertebral fractures, although low, have more than doubled. | Figure 6.48 Women appear to have higher fracture rates than men, including an approximately 71 percent higher rate of long bone fractures. | Figure 6.53 Mortality risk following a fracture appears to be significant, whether relative to vertebral fracture, rib fracture, or long bone fracture.]

Complications & pregnancy in women with ESRD

[Figures 6.57–59 Hospitalizations associated with a new diagnosis of cancer in women have decreased only slightly for breast, cervical, uterine, and ovarian cancer. These patterns are not different by diabetic status or race. | Figures 6.61–66 Pregnancy rates for women with ESRD, as well as ante-partum and post-partum complication rates, show differential patterns between dialysis and transplantation. | Figure 6.61 Pregnancy rates in the transplant population have fallen by 70 percent over the last ten years and are now comparable to those of patients on dialysis. | Figure 6.63 Early termination of pregnancy occurs in nearly 60 percent of dialysis patients, with live births occurring in 31 percent. In transplant patients, 44 percent of pregnancies end in early termination, while 50 percent end with a live birth.]

Methods for estimating mortality & hospitalization ratios

[Significant variability in mortality and hospitalization ratios occurs in small providers compared to large ones. The Bayesian method developed by the USRDS takes into account the inherent variability of small providers and produces more stable rates. There appears to be little difference in hospitalization and mortality ratios between units owned by dialysis chains and those that are independent.]