The State of Chronic Kidney Disease, ESRD, and Morbidity and Mortality in the First Year of Dialysis

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This review examines trends in the ESRD program, assessing progress in preventive care, hospitalizations, and mortality since 1989, the year of the Dallas Morbidity and Mortality Conference. The number of prevalent dialysis patients nearly tripled, to 366,000 in 2007 from 123,000 in 1989. Prevalent population mortality rates declined in the mid-1980s but did not change overall through the 1990s; rates declined for patients on dialysis for less than 5 yr but increased for patients on dialysis for longer than 5 yr. Death rates throughout the prevalent population have subsequently declined since 2000. In the incident dialysis population, death rates after the first year have declined, but first-year rates have remained flat since 1996; rates peak in months 2 and 3, then decline to the level of the first month by 12 mo. Infectious hospitalization rates in the prevalent population increased 40% in the last 10 yr. For incident patients, infectious hospitalizations increased almost 100% over 10 yr, vascular access hospitalizations by 200%, and cardiovascular hospitalizations by 30%. Use of dialysis catheters is high; 82% of patients start dialysis with a catheter. Poor planning for dialysis initiation may contribute to catheter use and the associated high infectious hospitalization rate, limiting potential for improved patient survival during the first year. Public health programs, including the new Medicare chronic kidney disease education benefit, are needed to promote better care of patients who may need dialysis to reduce the high morbidity and mortality in the first year.


In September 1989, Drs. Thomas Parker III and Alan Hull convened a symposium in Dallas, Texas, to address morbidity and mortality and the related dialysis prescription in the United States, and to address potential factors contributing to the high U.S. mortality rate compared with other parts of the world. This seminal event set the stage for an extensive quality improvement program in the United States to address the more than 25% annual gross mortality rate in the dialysis population. Numerous organizations, including the Renal Physicians Association, the American Society of Nephrology, the National Institutes of Health, and the Centers for Medicare & Medicaid Services (CMS; then the Health Care Financing Administration), undertook activities designed to improve hemodialysis and peritoneal dialysis adequacy, promoting use of internal vascular access in the form of fistulas for hemodialysis patients, and improving anemia treatment through clinical practice guidelines. These efforts culminated in the Dialysis Outcomes Quality Initiatives (DOQI) guidelines, first published in September 1997 (1).

In April 2009, nearly 20 yr after the initial Dallas Morbidity and Mortality Conference, Drs. Thomas Parker and Theodore Steinman convened a repeat conference to assess progress in overall patient survival, dialysis adequacy, and use of fistulas over the intervening 20 yr, and to identify ongoing significant shortcomings in ESRD patient care and outcomes. This review article summarizes the most recent U.S. Renal Data System (USRDS) findings regarding the ESRD program, vascular access at initiation of dialysis therapy, and morbidity and mortality, particularly in the first year of treatment for the hemodialysis population.

Growth of the ESRD Program

The ESRD program has grown substantially; incident patient counts were 17,980 in 1980, 41,262 in 1988, and 111,000 by 2007. The prevalent dialysis population has grown to 368,544 patients, from 49,855 in 1980 and 110,656 in 1988, and the prevalent transplant population to 158,739 through 2007, from 10,138 in 1980 and 41,194 in 1988 (see reference 2, Tables A.1 and D.1). The prevalent dialysis population appeared to double every 10 yr, and the transplant population to grow by slightly more than double over the same time periods. However, incident population growth has slowed significantly over the last 7 yr, rising only 1% to 2% per year over the last 5 yr.

The National Institutes of Health and the Department of Health and Human Services routinely request projections of the dialysis population for the Healthy People 2010 and soon-to-be-developed 2020 health care goals for the U.S. kidney disease population. Projections to 2020 were reported in the 2008 USRDS Annual Data Report; the 2006 dialysis population of 354,754 patients was projected to rise to 533,800 by 2020 (Figure 1). The transplant population was projected to grow from 151,502 in 2006 to 250,813 by 2020 (see reference 3, Figure 2.2). These projections have been tempered by slowing of the adjusted incident rates, which have been relatively flat since 2000 at approximately 350 ESRD patients per million U.S. population. Despite some evidence of a 3.4% increase in incidence...
rates in 2006, by 2007 these numbers had returned to the 2005 level, thereby demonstrating relative stability in the ESRD incident disease rates (see reference 2, Figure 2.3).

Although the rate of growth is relatively flat, the total number of patients entering the ESRD program appears to be driven by the group aged 45 to 64 yr. This group represents the post-World War II “baby-boomer” generation, whose members are beginning to reach their sixties, the age when ESRD rates begin to increase. Several causes of ESRD appear to be on the decline, most notably GN; rates are now what they were in the early 1980s. Hypertension incident rates have reached a plateau, as have diabetes rates, findings that represent the first such reported plateau of rates around the world.

Adjusted incident rates across all age, sex, racial, and ethnic groups show a plateau effect, but there are significant differences between older and younger age groups and between African Americans, whites, Native Americans, and Hispanics. In the older population, aged 60 and 70 yr, incident rates of ESRD due to diabetes have begun to decline for African Americans, Native Americans, and Hispanics. Diabetes incident rates continue to rise for whites aged 70 yr and older. In the group aged 40 to 59 yr, incident rates of ESRD due to diabetes have also begun to decline for African Americans, Native Americans, and Hispanics. Interestingly, in the group aged 20 to 39 yr, incident rates of ESRD due to diabetes continue to rise at an almost linear rate for the African American and Native American populations. This presents a major public health concern that may relate to increasing obesity and diabetes in the general population, particularly among African Americans and other minority populations (see reference 2, Figures 1.19, 1.20, and 1.21). ESRD prevalence rates continue to grow at approximately 3% per year. The flattening incident rates together with the growing prevalent rates suggest that improved survival of the ESRD population, including kidney transplant patients and dialysis patients, is driving the growth of the prevalent ESRD population. Racial disparities in incident rates relative to diabetes need to be addressed through major public health initia-

tives by governmental and nongovernmental organizations, using the lay press and other media as well as medical journals and editorials to promote early detection of kidney disease and improved lifestyle choices regarding weight loss, smoking, and exercise, and to treat the major risk factors for cardiovascular disease and progression of kidney disease.

Clinical Care of the Dialysis Population

Routine monitoring of the basic components of dialysis adequacy, vascular access, and anemia treatment have been part of the Clinical Performance Measures project from the CMS for several years (4). Dialysis adequacy as measured by a Kt/V of ≥1.2 is achieved in almost 93% of hemodialysis patients. Based on the revised new targets for dialysis adequacy in peritoneal dialysis patients, a Kt/V equivalent to 1.7 is achieved in 92% of patients. In 2006, use of arteriovenous fistulas in the first year of dialysis therapy reached 41%, compared with approximately 27% in 1998 (see reference 2, Figure HP.11).

The USRDS assesses vascular access placement rates for hemodialysis patients based on Current Procedural Terminology (CPT) coded services billed by physicians. Dialysis catheter placement rates, per 1000 patient-years, have fallen to the lowest level since the early 1990s, almost half of the peak rates in 1997 (Figure 2). Fistula placement rates appear to have reached a high point in 2007 of almost 125 placements per 1000 patient-years, almost 2.5 times higher than rates in the early 1990s. Graft placement rates have fallen to less than half of rates in 1991, at only 100 per 1000 patient-years in 2007. The USRDS also reports complication rates associated with vascular access, based on follow-up of members of the Clinical Performance Measures population whose access is known in the last 3 mo of a year and determining complications into the next year. Rates of infectious complications overall, related to hospitalizations for sepsis, are almost four times higher for patients with catheters than for patients with fistulas. Interestingly, complication rates related to vascular grafts are only 10% to 15% higher than rates related to fistulas, suggesting that graft placements may be underused considering the high complication rates associated with catheters.

Cardiovascular evaluations have increased significantly over the last 10 yr across all ESRD populations (see reference 3, Figures 9.4, 9.5, and 9.6). Use of stress testing, coronary angiography, and these procedures together have increased by almost 75%. Almost 20% of incident hemodialysis and peritoneal dialysis patients have undergone stress tests within 3 yr, and between 12% and 13% have undergone coronary angiography within 3 yr after starting dialysis therapy. Almost 25% of the total population incident to dialysis or transplant by 2006 has undergone stress testing and coronary angiography within the first 3 yr of ESRD treatment. Use of echocardiograms has increased by one third over the same time period, and lipid testing across all populations has more than doubled. Approximately 1.5% of incident dialysis and transplant patients underwent percutaneous coronary revascularization in 1995, compared with 3.5% by 2005. Surgical revascularization procedure
rates have remained relatively stable, with a cumulative percent in the incident population of approximately 1.25% in the first year (see reference 3, Figures 9.10 and 9.11). These data are in contrast to the modest rise in comorbidity burden noted in prior Annual Data Reports, indicating increased use of these tests and procedures (see reference 5, Figures EI.12 and EI.13).

Preventive Care for Infectious Complications
Infectious complications are the second leading cause of hospitalization in the ESRD population. Because pneumonia is a common complication, preventive health care measures have centered on routine influenza and pneumococcal pneumonia vaccinations as the best way to reduce potential morbidity and mortality from these infectious events. Influenza vaccination rates are tracked by the USRDS through use of specific CPT-coded services. In 1996, approximately 41% of ESRD patients received influenza vaccinations during the flu season. This proportion grew to almost 58% by 2003, but has been relatively stable through 2006. Vaccination rates are slightly higher in the hemodialysis population, approaching 60% in 2006; approximately 54% of peritoneal dialysis patients are vaccinated and just over 42% of the transplant population (see reference 3, Figure 5.18). Influenza vaccination rates across the large dialysis provider groups range between 57% and 62% of patients (see reference 3, Figure 10.24). Pneumococcal pneumonia vaccination rates have increased significantly since 2001 to 2002 (Figure 3). Overall, pneumococcal pneumonia vaccination rates were approximately 13% to 14% in the 1997 to 1998 through the 2001 to 2002 time periods, almost doubling by 2005 to 2006 at almost 20%. Pneumococcal pneumonia vaccination rates by dialysis providers differ (Figure 4); overall vaccination rates in 2006 differed by approximately 22%. Some dialysis provider chains vaccinated almost 40% of their patients for pneumococcal pneumonia in 2005 to 2006. These data show significant

Figure 2. Access procedures in prevalent hemodialysis patients, by diabetic status. Period prevalent hemodialysis patients with or without simple fistulas. Data from physician/supplier claims. Some patients may have more than one access at a given point in time: (A), catheters, (B), fistulas, (C), grafts.

Figure 3. Pneumococcal pneumonia vaccination rates, by (A) age, (B) race/ethnicity, and (C) modality. ESRD patients initiating therapy at least 90 d before the start of the period and alive on the last day of the period; vaccinations tracked during entire period.
variations in dialysis provider performance regarding capability of delivering preventive infectious health care vaccinations targeted toward a significant problem of morbidity and mortality.

Mortality and Morbidity

In 1989, when the first morbidity and mortality conference was convened in Dallas, prevalent mortality rates per 1000 patient-years hovered at approximately 275 (Figure 5). By the mid-1990s, the rate had fallen to approximately 260 per 1000 patient-years. The rate was relatively flat until 2000, when the overall prevalent mortality rate began to fall, reaching approximately 228 per 1000 patient-years in 2006. During the 1990s, when the prevalent mortality rate was relatively flat, significant changes in mortality patterns occurred based on duration of dialysis therapy. Death rates fell continuously for patients on dialysis therapy for less than 2 yr, and for patients on dialysis therapy for 2 to 5 yr. Between 1995 and 2001, these falling death rates coincided with rising death rates for patients on dialysis for 5 or more years. Since 2001, even prevalent death rates for patients on dialysis for 5 or more years have fallen by approximately 20% (Figure 6).

However, prevalent death rates are affected by individual duration of dialysis treatment, unlike pure incident-based death rates. The USRDS tracks yearly incident-based mortality rates for patients in the first, second, third, fourth, and fifth years of treatment (Figure 6). In the incident hemodialysis population, first-year mortality rates have been relatively flat since 1996, whereas rates in years 2 through 5 have been slowly falling since the mid-1980s. This flattened death rate in the first year is a major concern relative to morbidity and mortality. As shown in Figure 7, the USRDS has broken down the first-year mortality rate into monthly rates for all patient groups; mortality is now known from the first ESRD service date. Overall, mortality rates are lowest within the first month, peak in
months 1 to <2 and 2 to <3, and slowly decline in months 4 to 12 to levels similar to levels within the first month. Compared with 1993 to 1998, mortality rates in months 1 to <2 through month 5 are higher in 1999 to 2005. Cardiovascular death rates are lower, and infection slightly elevated in the first 3 mo. In the past, concern had been raised that the USRDS did not receive information on all deaths in the population aged less than 65 yr. This has been addressed since 2002, when the Social Security Administration released all deaths to the public, and this information was used to fill in all missing data from the first ESRD service date. Rates within the first month may be lower than anticipated because complex reconciliation of type of ESRD modality is sometimes incomplete within the first month. The higher early mortality rates, which decline later based on the survivors, are consistent with the high hospitalization rates for infections and vascular access, which carry high posthospitalization hazards for death.

Morbidity in the dialysis population is also of major concern and is addressed in the USRDS Annual Data Report each year. Overall, in the hemodialysis population, prevalent hospitalization rates for infection have increased almost 40% over the last 10 yr, even after adjusting for age, sex, race, and primary cause of renal disease (see reference 3, Figure P.22), and concern continues to center on use of dialysis catheters. The new CMS Medical Evidence Report (form CMS-2728), introduced in May 2005, reports first outpatient vascular access for incident hemodialysis patients, providing information on use of dialysis catheters, fistulas, and grafts at dialysis initiation. The 2008 USRDS Annual Data Report assessed vascular access use in incident hemodialysis patients from 2006 and showed that 82% started with a dialysis catheter. Of these, approximately 25% also had an internal access (graft or fistula with a catheter) at initiation. Less than 20% of patients started dialysis with their first outpatient access as an arteriovenous graft or an arteriovenous fistula. This high rate of catheter use at dialysis initiation is a major concern and may be a contributing factor to the higher mortality rate in the first months on dialysis and to infectious hospitalization rates in the first year of hemodialysis therapy.

Overall hospitalization rates within the first year are characterized in Figure 8. The USRDS compared incident hemodialysis populations aged 65 yr and older with hospitalization data from the first ESRD service date, from 1993 through 2005. Hospitalization rates are categorized as cardiovascular and infectious and stratified into hospitalizations within the first month, and in months 1 to 2, 2 to 3, 3 to 6, 6 to 9, and 9 to 12. Cardiovascular hospitalizations have increased by approximately 20 to 30% in the first months of dialysis, whereas infectious hospitalization rates have increased almost 200% in months 1 to 2. Infectious hospitalization rates in the first months of dialysis are now almost equal to rates of cardiovascular hospitalization (Figure 9), a finding not present more than 10 yr ago and of great concern from a communicable disease standpoint, particularly related to the growth of methicillin-resistant *Staphylococcus aureus* reported by the Centers for Disease Control (6).

Figure 10 shows the percent increase in all-cause, cardiovascular, infectious, and vascular access hospitalizations, stratified by the months (<1 mo, 1 to 2, 2 to 3, 3 to 6, 6 to 9, and 9 to 12 months) (7). All-cause hospitalizations in the first months of dialysis have increased by 30% overall and comparably for
cardiovascular hospitalizations. Infectious hospitalizations increased by almost 95%, and vascular access hospitalizations by almost 200%.

The rise in infectious and cardiovascular hospitalizations may be intertwined in that the elevated hazards of mortality after hospitalization predispose patients to subsequent cardiovascular and infectious events. As previously reported by Foley et al. (8), who looked at hazards ratios after cause-specific hospitalizations, including infection, pneumonia, and congestive heart failure, event rates were high and sometimes took months or years to return to baseline.

In conclusion, the ESRD population continues to grow, with the prevalent population almost doubling every 10 yr. Recent reductions in incident rates and slowing of incident population growth have been matched by reduced death rates in the prevalent population, thus driving the growth of the prevalent population. Mortality rates overall in the prevalent population have declined since 2000. However, in the incident population, mortality rates in the first year have been relatively unchanged for 11 yr, raising questions regarding the types of morbidity occurring during the first year. The USRDS has previously addressed extensive adjustments for comorbidity and severity of disease in the Annual Data Report to determine if the lack of progress in the first-year death rates was secondary to increasing severity of disease of the population; these adjustments did not change the results (see reference 5, Figure EI.1, Figure EI.27, and Table EI.D).

Infectious hospitalizations from pneumonia, sepsis, and particularly vascular access continue to be of concern. Preventive health care measures for influenza vaccination have increased but reached only 60% in the last 5 yr. Pneumococcal pneumonia vaccinations, relatively uncommon in the past, are now given to almost one in five dialysis patients, consistent with the vaccine package insert recommending pneumococcal vaccination every 5 yr. High rates of catheter use and infectious hospitalizations, particularly in the first year, are also of great concern and reflect recently published studies on late referral, which may lead to increased catheter use. The new Medicare chronic kidney disease education benefit package passed by the U.S. Congress in 2008 may help address planned transition from stage 4 chronic kidney disease to ESRD treatment. The education benefit is directed at modality selection, vascular access selection and placement, preemptive transplant, cardiovascular risk, nutritional care, and nephrologist referral. Hopefully, early referral will lead to planned transition to ESRD, thereby reducing morbidity and mortality in the first year of treatment. Increased attention to vascular access complications, with less use of dialysis catheters and removal as soon as possible, may prevent many of the infectious complications that have allowed infectious hospitalizations to equal cardiovascular hospitalizations in the first 2 mo of dialysis therapy. The USRDS will continue to monitor trends in morbidity and mortality and access to care to determine if parameters are changing, thereby affecting the health and welfare of the chronic kidney disease and ESRD populations.

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Disclosures
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References