Chapter 6: Mortality

- In 2014, adjusted mortality rates for ESRD, dialysis, and transplant patients, were 136, 166, and 30, per 1,000 patient-years, respectively. By dialysis modality, mortality rates were 169 for hemodialysis patients and 157 for peritoneal dialysis patients, per 1,000 patient-years (Figure 6.1).

- Since 1996, crude mortality rates have decreased by 26% for dialysis patients and have increased by 2% for transplant recipients over the same period. However, when accounting for changes in population characteristics, adjusted mortality rates continue to decrease for dialysis and transplant patients, falling by 32% and 44%, respectively (Figure 6.1).

- Patterns of mortality during the first year of dialysis differ substantially by modality. For hemodialysis patients, reported mortality is highest in month 2, but declines thereafter; this effect is more pronounced for patients aged 65 and over. In contrast, mortality rises slightly over the course of the year for peritoneal dialysis patients (Figure 6.3).

- The relationship between race and mortality differs considerably by age among dialysis patients. White dialysis patients younger than age 22 have mortality rates comparable to Black/African American patients, but experience higher mortality than Blacks at older ages (Figure 6.1.a).

- Dialysis patients continue to have substantially higher mortality, and fewer expected remaining life years, compared to the general population and Medicare populations with cancer, diabetes, or cardiovascular disease. However, the relative and absolute decline in mortality for dialysis patients in the past 15 years has been greater than for Medicare patients in these other diagnostic categories (Tables 6.4 and 6.5, Figure 6.5).

- The decline in mortality shown in this chapter has important implications for both patients and resource allocation. Increasing lifespan among ESRD patients is likely the main reason for continued growth in the prevalent ESRD population.

Introduction

Mortality analyses in this chapter are based on both end-stage renal disease (ESRD) data and general population data. ESRD data are from the USRDS ESRD Database. General population data are based on the Medicare 5% standard analytical files and U.S. Census mortality data. Note that universal reporting of ESRD patient deaths to the Centers for Medicare & Medicaid (CMS) is required via CMS form 2746 as a condition of coverage for dialysis units and transplant centers. In addition, mortality ascertainment is augmented by Social Security Death Master File data to the extent allowed by regulation (which differs by state).

For analyses in this chapter, the term "incident" refers to patients new to ESRD, while "prevalent" refers to patients receiving ESRD treatment on a specific date, and "period prevalent" includes patients treated for ESRD over a particular period of time. Modality is assigned as of the earliest date within the range used in the analysis, without use of the 60-day stable modality rule (i.e., the requirement of 60 days on a modality for change in modality assignment) or the 90-day rule for outcomes (the attribution of outcomes to the previous modality, for up to 90 days after a change in modality).

Methods

The findings in this chapter are based on data from multiple data sources, including the Centers for Medicare & Medicaid Services (CMS), the Organ Procurement and Transplantation Network (OPTN), the Centers for Disease Control and Prevention (CDC), the U.S. Census, and the National Vital Statistics Report. For details about these data sources, see the Data Sources section of the *ESRD Analytical Methods* chapter.

See the section on Chapter 6 in *the ESRD Analytical Methods* chapter for an explanation of the analytical methods used to generate the study cohorts, figures, and tables in this chapter.

Mortality Among ESRD Patients, Overall, and by Modality

Overall mortality rates among ESRD (dialysis and transplant) patients continue to decline, with steeper reductions observed during more recent years. Between 1996 and 2014, the crude death rate (not shown) for the ESRD population decreased by 26%, from 186 to 137 per 1,000 patient-years, while the adjusted death rate (Figure 6.1.a) decreased by 34%. (Note that the reference population for each adjusted rate is described within the footnote of each table or figure: e.g., for Figure 6.1, the reference population consists of period prevalent ESRD patients in 2011). The crude death rate for the dialysis population decreased by 26%, while the adjusted death rate decreased by 32%. The crude death rate for the transplant population increased by 2%, while the adjusted death rate decreased by 44%.

The differences between the crude and adjusted rates largely reflect changes in the age distribution of the ESRD population. Death rates for dialysis and transplant patients have decreased by over 30% between 1996 and 2014 within most age groups, and the adjusted rate reflects this decrease. The crude rate is affected by both this decrease and by the fact that the ESRD population is older in 2014 than in 1996, which offsets this effect. For example, patients over the age of 65 comprised 42% of the dialysis population in 1996 and 45% in 2014; among transplant recipients, these numbers were 8% and 26%, respectively. Thus, the very large change in age among transplant patients has masked overall improvements in mortality.

The adjusted mortality rate decreased by 9% from 1996 to 2003, and by 25% from 2004 to 2014 for the ESRD population (Figure 6.1.a). The trend was similar for dialysis (hemodialysis and peritoneal dialysis) patients, with the adjusted mortality rate decreasing by 7% from 1996 to 2003 and by 25% from 2004 to 2014 (Figure 6.1.b). Among transplant patients, mortality decreased by 9% from 1996 to 2003 and by 33% from 2004 to 2014. Since 1996, the net reduction in mortality was 34% for all ESRD patients, including 32% for dialysis patients and 44% for transplant patients.

Among hemodialysis patients, the adjusted mortality rate decreased by 4% from 1996 to 2003 and by 24% from 2004 to 2014. Among peritoneal dialysis patients, the mortality rate decreased by 21% from 1996 to 2003 and by 35% from 2004 to 2014 (Figure 6.1.b). The net reductions in mortality from 1996 to 2014 were 29% for hemodialysis patients and 49% for peritoneal dialysis patients.

Adjusted mortality rates in 2014 were 136, 166, and 30 per 1,000 patient-years for ESRD, dialysis, and transplant patients, respectively. By dialysis modality, mortality rates were 169 for hemodialysis patients and 157 for peritoneal dialysis patients per 1,000 patient-years.

vol 2 Figure 6.1 Adjusted all-cause mortality (deaths per 1,000 patient-years) by treatment modality (a) overall, dialysis, and transplant, and (b) hemodialysis and peritoneal dialysis, for period-prevalent patients, 1996-2014

(a) Overall, dialysis, and transplant

(b) Hemodialysis and peritoneal dialysis
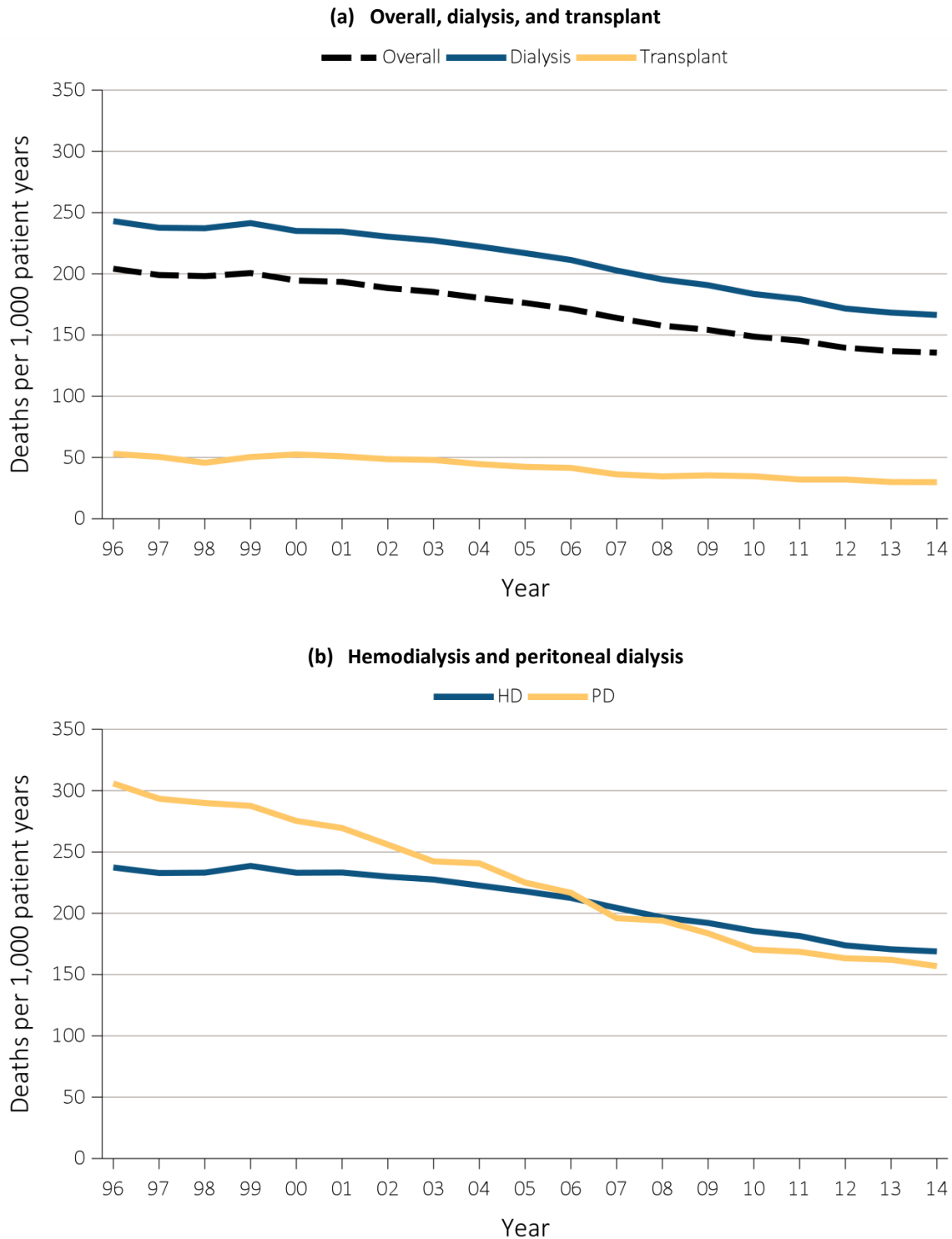
Data Source: Reference Tables H.2_adj, H4_adj, H.8_adj, H.9_adj, and H.10_adj; and special analyses, USRDS ESRD Database. Adjusted for age, sex, race, ethnicity, primary diagnosis and vintage. Reference population: period prevalent ESRD patients, 2011. Abbreviations: HD, hemodialysis; PD, peritoneal dialysis.

Mortality by Duration of Dialysis, Including Trends Over Time

Among hemodialysis patients, from 1996-2011 the average death rate was highest during the first year following dialysis initiation, then dropped to its lowest point during the second year, and then tended to rise for more than 5 years thereafter (Figure 6.2.a). Mortality rates among these patients tended to be higher after 5 years than between 2-5 years on dialysis. Death rate patterns by time-since-dialysis-initiation

have been fairly similar over calendar time (comparing cohorts based on calendar year of initiation of treatment).

Among peritoneal dialysis patients, mortality rates generally increased over the first five years after starting dialysis (Figure 6.2.b). As with hemodialysis patients, peritoneal dialysis patient mortality rates tended to be higher after 5 years than between 2-5 years on dialysis. Death rate patterns by time-since-dialysis-initiation have also been fairly similar over time for peritoneal dialysis patients.

vol 2 Figure 6.2 Adjusted all-cause mortality (deaths per 1,000 patient-years) by treatment modality, cohort (year of ESRD onset), and number of years after start of dialysis among incident (a) hemodialysis patients and (b) peritoneal dialysis patients, 1996, 2001, 2006, and 2011

(a) Hemodialysis patients

Figure 6.2 continued on next page.

vol 2 Figure 6.2 Adjusted all-cause mortality (deaths per 1,000 patient-years) by treatment modality, cohort (year of ESRD onset), and number of years after start of dialysis among incident (a) hemodialysis patients and (b) peritoneal dialysis patients, 1996, 2001, 2006, and 2011 *(continued)*
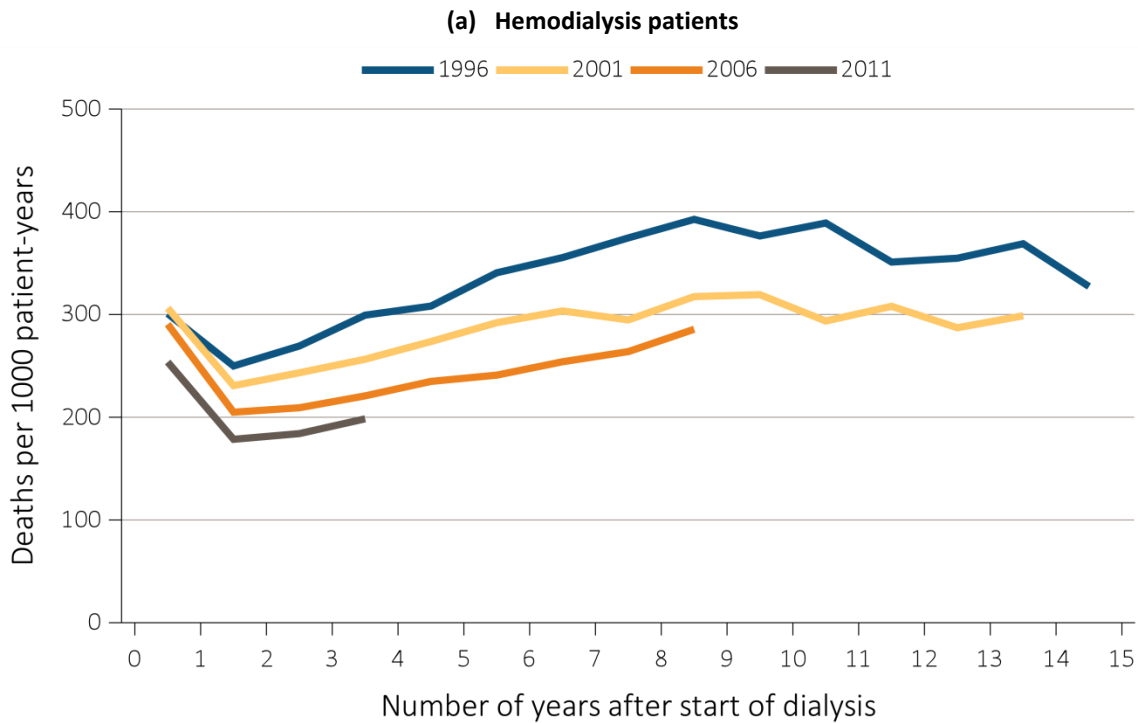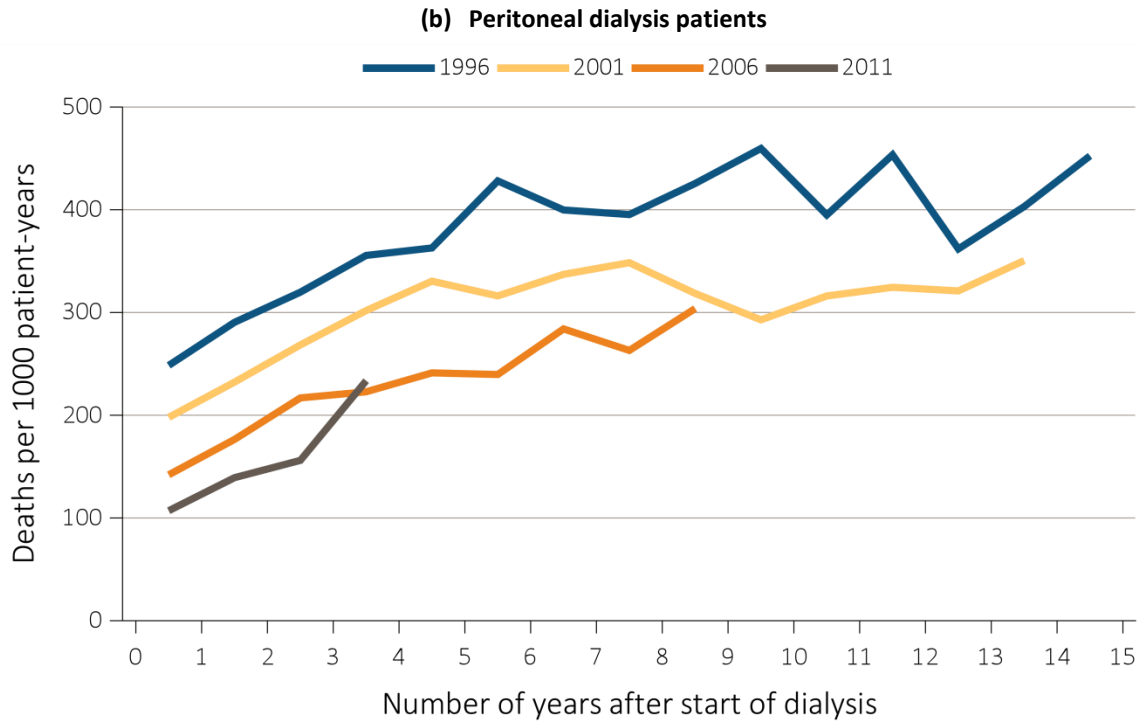

(b) Peritoneal dialysis patients

Data Source: Special analyses, USRDS ESRD Database. Adjusted for age, sex, race, and primary diagnosis. Ref: period prevalent ESRD patients, 2011. Abbreviation: ESRD, end-stage renal disease.

Mortality During the First Year of ESRD

Among patients starting hemodialysis in 2012, reported all-cause mortality peaked at 382 deaths per 1,000 patient-years in month 2, and decreased thereafter to 189 per 1,000 patient-years in month 12. The decrease in mortality for HD patients during the first year was sharper for patients aged 65 and over (Figure 6.3); this pattern is similar to that previously found by Robinson et al. (2014). Among patients under the age of 65, mortality dropped from 214 deaths per 1,000 patient-years in month 2 to 117 in month 12. Among patients aged 65 and over, mortality dropped from 620 deaths per 1,000 patient-years in month 2 to 297 in month 12. Note that the steep rise in hemodialysis mortality rates between months 1 and 2 may reflect data reporting issues; e.g., some patients who die soon after starting dialysis related to ESRD might not be registered as having ESRD on CMS 2728, and therefore, would not be included in the CMS

database (Foley et al., 2014). The extent to which this occurs is currently unknown.

Among patients with peritoneal dialysis as the initial renal replacement modality, mortality does not peak early, but instead tends to increase gradually during the first year on dialysis. Mortality at month 12 among these patients was 119 per 1,000 patient-years. Among peritoneal dialysis patients under the age of 65, mortality increased from 32 deaths per 1,000 patient-years in month 1 to 54 in month 12. Among patients aged 65 and over, mortality increased from 115 deaths per 1,000 patient-years in month 1 to 214 in month 12. Peritoneal dialysis patients may not experience an early peak in mortality, in part, because patients beginning ESRD via peritoneal dialysis are a highly selected group, in many cases being younger, healthier, and having undergone substantial pre-ESRD planning.

Post-transplant mortality among the <2% of patients who initiate ESRD treatment with a kidney transplant peaks in month 4, followed by a generally decreasing trend for the remainder of the first year (not shown).

vol 2 Figure 6.3 Adjusted mortality (deaths per 1000 patient-years) by treatment modality and number of months after treatment initiation among ESRD patients (a) under age 65 and (b) aged 65 and over, 2013

(a) Under age 65

(b) Aged 65 and over
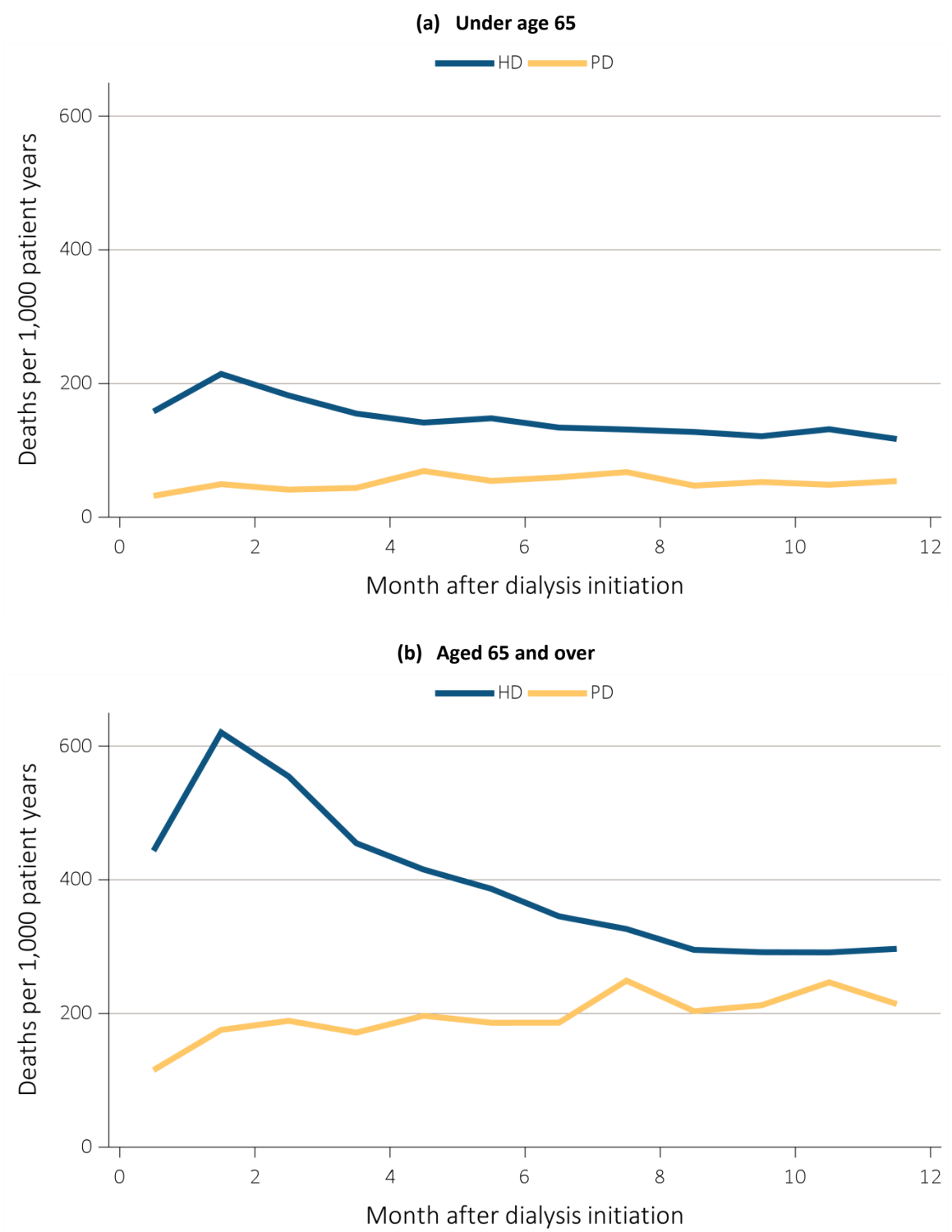
Data Source: Special analyses, USRDS ESRD Database. Adjusted (age, race, sex, ethnicity, and primary diagnosis) mortality among 2013 incident ESRD patients during the first year of therapy. Reference population: incident ESRD patients, 2011. Abbreviations: ESRD, end-stage renal disease; HD, hemodialysis; PD, peritoneal dialysis.

Mortality by Age and Race

Mortality rates among ESRD patients increases with age, as expected. Mortality rates differ by race, but this difference is not constant within age groups or by modality (Table 6.1.a). For example, White patients on dialysis had comparable mortality rates to Black/African American (hereafter, Black) patients among those aged 0-22 years old, but higher mortality than Blacks at older ages. Mortality rates tended to be similar between White and Black transplant patients over the age of 45. It should be noted that these analyses underestimate the survival advantage of Blacks compared to non-Hispanic Whites. As demonstrated by Yan et al. (2013), Hispanics have mortality rates similar to other non-White ethnic groups and inclusion of them in the White calculation underestimates the high mortality rates among non-Hispanic Whites on dialysis.

Among dialysis and transplant patients, males aged 0-44 years tended to have lower adjusted mortality than females, but higher adjusted mortality at ages 65 and over (Table 6.1.b).

vol 2 Table 6.1 Adjusted all-cause mortality (deaths per 1,000 patient-years) (a) by age and race, and (b) by age and sex, among ESRD patients, 2014

(a) Age and race

Age	Race	ESRD	Dialysis	Transplant
0-21	White	10	33	4
	Black/African American	18	35	6
	Other	8	26	4
22-44	White	33	64	9
	Black/African American	43	54	11
	Other	20	37	4
45-64	White	108	155	35
	Black/African American	98	112	34
	Other	77	102	20
65-74	White	209	249	80
	Black/African American	171	185	79
	Other	139	161	59
75+	White	357	377	136
	Black/African American	270	276	143
	Other	233	240	111

(b) Age and sex

Age	Sex	ESRD	Dialysis	Transplant
0-21	Male	9	31	3
	Female	12	36	4
22-44	Male	34	56	9
	Female	39	66	10
45-64	Male	105	141	36
	Female	107	144	31
65-74	Male	205	245	83
	Female	196	224	74
75+	Male	357	379	140
	Female	330	342	129

Data Source: Special analyses, USRDS ESRD Database. (a) Adjusted (race and primary diagnosis) all-cause mortality among 2014 period prevalent patients. (b) Adjusted (sex and primary diagnosis) all-cause mortality among 2014 period prevalent patients. Reference population: period prevalent ESRD patients, 2011. Abbreviation: ESRD, end-stage renal disease.

Cause-Specific Mortality Rates

The largest category of known cause-specific mortality for dialysis patients is death due to cardiovascular disease (CVD), which comprises 41% of the deaths and 54% of the deaths with known causes. The cause of death information (based on CMS 2746) is missing or unknown for 24% of dialysis patients and 73% of transplant patients.

vol 2 Table 6.2 Unadjusted percentages of deaths due to cardiovascular disease (CVD), infection, other specified causes, and with missing data, by modality among ESRD patients, 2013

	Cause-specific mortality			
	CVD	**Infection**	**Other cause**	**Missing cause**
Modality				
ESRD	39%	8%	25%	28%
Dialysis	41%	8%	26%	24%
Transplant	9%	5%	13%	73%

Data Source: Special analyses, USRDS ESRD Database. All-cause mortality among 2012 prevalent patients. Reference population: period prevalent ESRD patients, 2011. Abbreviations: CVD, cardiovascular disease; ESRD, end-stage renal disease.

Survival Probabilities for ESRD Patients

Survival has improved between the 2001 and 2009 incident ESRD cohorts for all modalities. For example, five-year survival rose from 36% to 42% among hemodialysis patients, from 39% to 51% among peritoneal dialysis patients, from 66% to 76% among deceased donor transplant patients, and from 76% to 85% among living donor transplant patients. Adjusted survival was consistently higher in the transplant population than in dialysis patients, and among living donor transplant recipients than deceased donor recipients.

Despite improvements in survival on dialysis over the years, adjusted survival for hemodialysis patients who were incident in 2009 is only 56% at three years after ESRD onset (Table 6.3). For peritoneal dialysis patients, adjusted survival is 67% at three years. For deceased-donor and living-donor recipients, three-year survival is 84% and 91% respectively.

Average three-year survival among an age- and sex-matched general population is considerably higher. The general population matched to hemodialysis patients' age and sex distribution has a 92% three-year survival, and the general population matched to peritoneal dialysis patients' age and sex distribution has a 94% three-year survival. For the age and sex distribution among both deceased-donor and living-donor recipients, the matched three-year survival in the general population was 98% (calculated using the Social Security Administration "Period Life Table 2013").

vol 2 Table 6.3 Adjusted survival (%) by treatment modality and incident cohort year (year of ESRD onset)

	3 months	12 months	24 months	36 months	60 months
Hemodialysis					
2001	91.0	74.8	61.4	50.8	35.6
2003	91.0	74.8	61.8	51.4	36.5
2005	91.2	75.4	62.7	52.9	38.5
2007	91.5	76.3	64.1	54.6	39.9
2009	91.7	77.4	65.6	56.1	41.5
Peritoneal dialysis					
2001	95.5	82.1	67.3	55.4	39.4
2003	96.3	83.9	69.0	57.7	42.9
2005	96.4	85.6	72.3	61.6	45.7
2007	96.9	87.5	74.8	64.6	49.0
2009	97.3	87.8	76.5	66.5	51.4
Deceased-donor transplant					
2001	94.9	89.4	83.2	77.8	66.1
2003	95.7	90.0	84.6	79.5	69.2
2005	95.6	89.9	85.1	80.5	71.3
2007	96.7	92.3	88.1	83.7	73.3
2009	96.8	92.3	88.5	84.3	75.7
Living donor transplant					
2001	97.3	93.6	89.6	85.5	76.0
2003	98.1	95.6	91.9	87.8	79.3
2005	98.2	95.3	92.0	88.7	81.0
2007	99.1	97.2	94.8	91.9	85.1
2009	98.9	97.1	94.5	91.4	84.6

Data Source: Reference Tables I.1_adj-I.36_adj. Adjusted survival probabilities, from day one, in the ESRD population. Reference population: incident ESRD patients, 2011. Adjusted for age, sex, race, Hispanic ethnicity, and primary diagnosis. Abbreviation: ESRD, end-stage renal disease.

Expected Remaining Lifetime: Comparison of ESRD Patients to the General U.S. Population

The differences in expected remaining lifetime between the ESRD and general populations are striking (Table 6.4). Dialysis patients younger than 80 years old are expected to live less than one-third as long as their counterparts without ESRD, and dialysis patients aged 80 years and older are expected to live around one-half as long as their counterparts without ESRD. Transplant patients fare considerably better, with expected remaining lifetimes for people under the age of 75 estimated at 68% to 85% of expected lifetimes in the general population.

vol 2 Table 6.4 Expected remaining lifetime (years) by age, sex, and treatment modality of prevalent dialysis patients and transplant patients, and the general U.S. population, 2013

| | ESRD patients, 2013 | | | | General U.S. population, 2013 | |
| | Dialysis | | Transplant | | | |
Age	Male	Female	Male	Female	Male	Female
0-14	22.6	23.3	60.1	59.8	70.7	75.4
15-19	21.6	19.0	47.9	48.5	59.7	64.4
20-24	18.5	16.4	43.4	44.2	55	59.5
25-29	16.2	14.3	39.2	40.2	50.3	54.6
30-34	14.3	13.0	35.1	36.4	45.7	49.7
35-39	12.6	11.6	31.0	32.8	41	45
40-44	11.0	10.4	27.2	28.9	36.4	40.3
45-49	9.2	8.9	23.4	25.2	31.9	35.6
50-54	7.9	7.8	19.9	21.7	27.7	31.1
55-59	6.6	6.6	16.7	18.3	23.7	26.8
60-64	5.5	5.7	13.8	15.3	19.8	22.6
65-69	4.5	4.8	11.4	12.6	16.2	18.5
70-74	3.8	4.0	9.5	10.4	12.8	14.7
75-79	3.2	3.5	7.7[a]	8.7[a]	9.8	11.3
80-84	2.6	2.9			7.1	8.4
85+	2.2	2.4			3.7	4.4

Data Source: Reference Table H.13; special analyses, USRDS ESRD Database; and National Vital Statistics Report. "Table 7. Life expectancy at selected ages, by race, Hispanic origin, race for non-Hispanic population, and sex: United States, 2013 (2016)." Expected remaining lifetimes (years) of the general U.S. population and of period prevalent dialysis and transplant patients. [a]Cell values combine ages 75+. Abbreviation: ESRD, end-stage renal disease.

Mortality Rates: Comparisons of ESRD Patients to the Broader Medicare Population

COMPARISON TO THE GENERAL MEDICARE POPULATION

The population of people without ESRD but still covered by Medicare under the age of 65 tends to be non-representative of the general population under the age of 65. For this reason, Table 6.5 focuses on comparisons between the ESRD population and the general Medicare population using age groups starting at age 65, where the Medicare population is expected to be much more representative. Dialysis patients over the age of 75 years experienced mortality rates 3.8 times higher for males and 4.0 times higher for females, compared with males and females in the general Medicare population (Table 6.5). Among kidney transplant patients, mortality rates were 2.5-2.9 times higher than for the general Medicare population aged 65-74, and 1.3-1.5 times higher at age 75 and older.

vol 2 Table 6.5 Adjusted mortality (deaths per 1,000 patient-years) by age, sex, treatment modality, and comorbidity among ESRD patients and the general Medicare population, 2013-2014

Age	Sex	Dialysis	Transplant	All Medicare	Cancer	Diabetes	CHF	CVA/TIA	AMI
65-74	Male	228	64	26	75	41	106	71	92
	Female	215	53	18	67	31	102	59	97
75+	Male	345	119	91	139	110	236	168	206
	Female	324	119	82	134	101	220	150	205

Data Source: Special analyses, USRDS ESRD Database and Medicare 5% sample. Adjusted for race. Medicare data limited to patients with at least one month of Medicare eligibility in 2013. Reference population: Medicare patients, 2014. Abbreviations: AMI, acute myocardial infarction; CHF, congestive heart failure; CMS, Centers for Medicare & Medicaid; CVA/TIA, cerebrovascular accident/transient ischemic attack; ESRD, end-stage renal disease.

COMPARISON TO COMORBIDITY-SPECIFIC MEDICARE PATIENTS

From 1996 to 2014, adjusted mortality among ESRD patients aged 65 years and older declined by 51%, from 348 to 171 per 1,000 patient-years (Figure 6.4). Among dialysis patients, adjusted mortality fell 39%, from 360 to 218. Among transplant patients, adjusted mortality fell 24%, from 96 to 74. The decline in mortality for dialysis patients was greater than for other major diagnostic groups, including cancer, diabetes, congestive heart failure (CHF), cerebrovascular accident/transient ischemic attack (CVA/TIA), and acute myocardial infarction (AMI). Adjusted mortality fell 37% for patients with cancer and 33% for patients with diabetes, but somewhat less for cardiovascular conditions, at 21% for heart failure, 28% for CVA/TIA, and 22% for AMI.

In 2014, mortality rates among dialysis patients aged 65 years and older ranged from 1.6 times higher than mortality rates among heart failure patients to 4.1 times higher than mortality rates among patients with diabetes. For transplant patients aged 65 and older, the mortality rate was within the range of mortality rates for Medicare patients with the other listed conditions.

vol 2 Figure 6.4 Adjusted mortality (deaths per 1,000 patient-years) by calendar year, treatment modality, and comorbidity among ESRD patients and comorbidity-specific Medicare populations aged 65 & older, 1996-2014
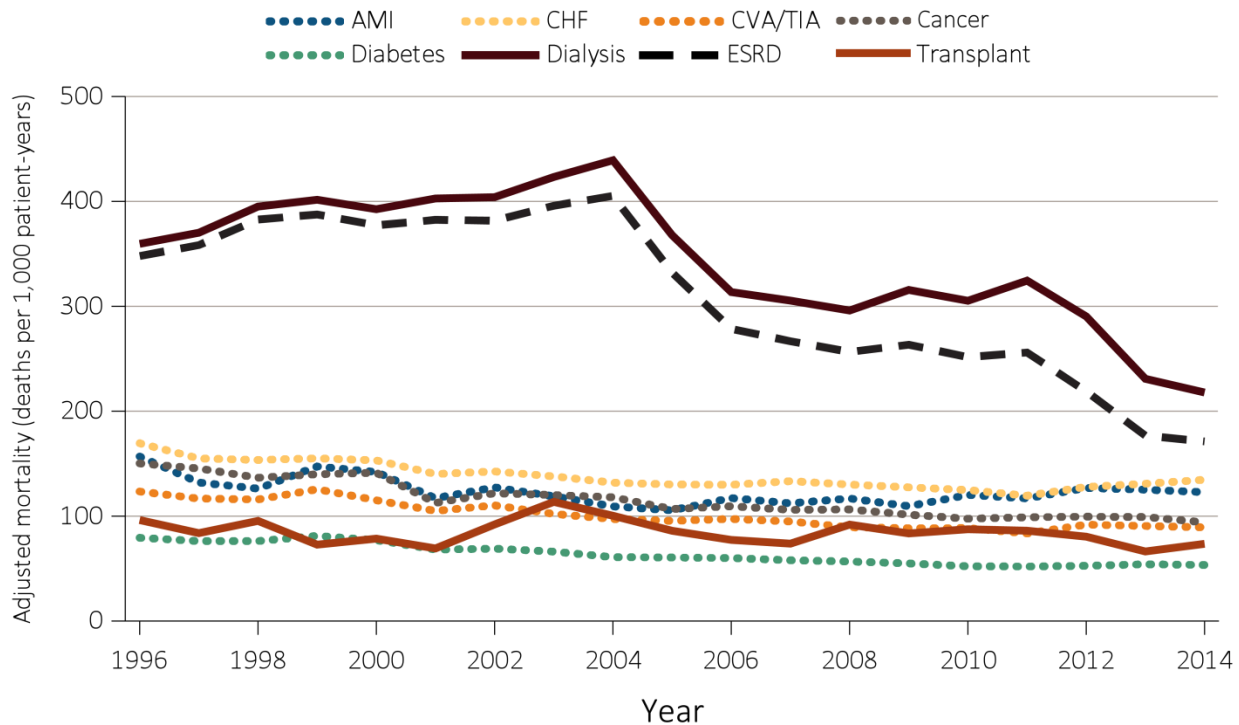
Data Source: Special analyses, USRDS ESRD Database and Medicare 5% sample. Unadjusted and adjusted (sex and race) mortality rates starting with the January 1 point prevalent sample in the ESRD and general populations, aged 65 and older (per 1,000 patient-years at risk). Reference population: period prevalent ESRD patients, 2012. Abbreviations: AMI, acute myocardial infarction; CHF, congestive heart failure; CVA/TIA, cerebrovascular accident/transient ischemic attack; ESRD, end-stage renal disease.

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Notes