Chapter 6: Transplantation

- In 2016, 20,161 kidney transplants were performed in the United States (19,301 were kidney-alone; Figure 6.6).
- Fewer than a third (28%) of kidneys transplanted in 2016 were from living donors (Figure 6.6).
- From 2015 to 2016, the cumulative number of recipients with a functioning kidney transplant increased by 3.4%, from 208,032 to a total of 215,061 (Figure 6.7).
- On December 31, 2016, the kidney transplant waiting list had 81,418 candidates on dialysis, 51,238 (62.9%) of whom were active. Eighty-five percent of all candidates were awaiting their first transplant (Figure 6.1).
- Among candidates newly wait-listed for either a first or repeat kidney-alone transplant (living or deceased-donor) during 2011, the median waiting time to transplant was 4.0 years (Figure 6.4). This waiting time varied greatly by region of the country, from a low of 1.4 years in Nebraska to a high of 5.1 years in Georgia (Reference Table E.2.2).
- Unadjusted rates of kidney transplantation among dialysis patients had been declining since at least 2006 for candidates for both living and deceased donors. These appear to have stabilized as of 2013, at about 2.5 per 100 dialysis patient-years for recipients from deceased donors and about 1.0 per 100 dialysis patient-years for recipients from living donors (Figure 6.8).
- The number of deceased kidney donors, aged 1-74 years, with at least one kidney retrieved increased by 62.7%, from 5,981 in 2001 to 9,732 in 2016 (Figure 6.19.a).
- The rate of kidney donation from deceased Blacks/African Americans nearly doubled from 2002 to 2016, from 4.5 to 7.9 donations per 1,000 deaths (Figure 6.21.b). This rate overtook that of Whites in 2009. Asians consistently had the highest rate of deceased kidney donation during this time, at about 9 per 1,000 deaths.
- Since 1999, Whites have had the highest rate of living kidney donation, although this has been in decline along with all other races except Asians, who as of 2016 showed rates of living donation essentially equivalent to Whites (Figure 6.16.b).
- Eighteen percent of kidneys recovered from deceased donors were discarded in 2016; this rate has increased slightly since 2010.
- The number of kidney paired donation transplants has risen sharply since 2005, with 642 performed in 2016, which represented 11% of living-donor transplants that year. The rate plateaued during 2012-2014 but increased again in 2016 (Figure 6.18).
- Since 1999, the probabilities of graft survival have improved among recipients of both living and deceased-donor kidney transplants, over both the short-term (one-year survival) and long-term (five and ten-year survival) (Figure 6.25).
- In 2015, the probabilities of one-year graft survival were 93% for deceased and 98% for living-donor kidney transplant recipients (Figure 6.25).
- In 2015, the probabilities of patient survival within one-year post-transplant were 96% and 99% of deceased- and living-donor kidney transplant recipients (Figure 2.6).
- The one-year graft-survival and patient-survival advantages experienced by living-donor transplant recipients persisted at five and ten years post-transplant (Figures 6.25 and 6.26).

Introduction

Kidney transplantation is the renal replacement therapy of choice for the majority of patients with end-stage renal disease (ESRD). Successful kidney transplantation is associated with improved survival, improved quality of life, and health care cost savings when compared to dialysis. This chapter reports on the trends of the kidney transplant waiting list, kidney transplants performed over the years, and the health outcomes of those who have received a transplant. To enhance further our understanding of the donor pool, we report the trends and epidemiology of deceased kidney donations among deaths of all causes and traumatic deaths. In addition, this year we add data on trends in the proportion of patients transplanted within one year of being wait-listed (Figure 6.5).

The Organ Procurement and Transplantation (OPTN) network conducted major revisions of the kidney allocation system (KAS) which took effect on December 4, 2014, with the objectives of reducing discards of potentially usable donor kidneys, decreasing access disparities, and decreasing unrealized life-years from the available organ supply. Some of the substantial KAS changes included the following:

(1) A move to a continuous, percentile based (lower is better) description of donor quality, the Kidney Donor Profile Index (KDPI; OPTN, 2016). This metric consists of ten donor factors, and replaces the previous binary categories of standard criteria donor (SCD) or extended criteria donor (ECD) types that incorporated only four factors.

(2) For use in conjunction with the KDPI, the calculation of an Expected Post-Transplant Survival (EPTS) score for all adult kidney recipient candidates. The EPTS is based on four factors: age, time on dialysis, prior transplant of any organ, and presence of diabetes. This allows preferential allocation of donor kidneys with the best KDPI scores of 20% or less, to younger and healthier candidates with the best EPTS scores of 20% or less.

(3) Priority changes for sensitized candidates, with priority given via a logarithmic point system based on their calculated panel reactive antibodies (PRA). The new approach is thought to more accurately reflect difficulty in donor-recipient matching.

(4) The inclusion of pre-waiting list dialysis time in a candidate's waiting time (OPTN, 2015). This particular change was instituted to partially dissipate the effects of late referral for transplantation. Under the new KAS, waiting time includes time from the point of listing, with a requirement for a GFR ≤20 mL/min, or the time from initiation of dialysis (or return to dialysis if the patient had a failed kidney transplant).

In this year's chapter, where relevant, we highlight any trend changes that may have resulted from the new policy. As this chapter includes data through the end of 2016, we are able to assess the impact of the allocation policy change through the first two full years of its implementation.

Methods

The findings presented in this chapter were drawn from multiple data sources, including from the Centers for Medicare & Medicaid Services (CMS), OPTN, the Centers for Disease Control and Prevention (CDC), and the U.S. Census. Details of these are described in 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. Downloadable Microsoft Excel and PowerPoint files containing the data and graphics for these figures and tables are available on the *USRDS website*.

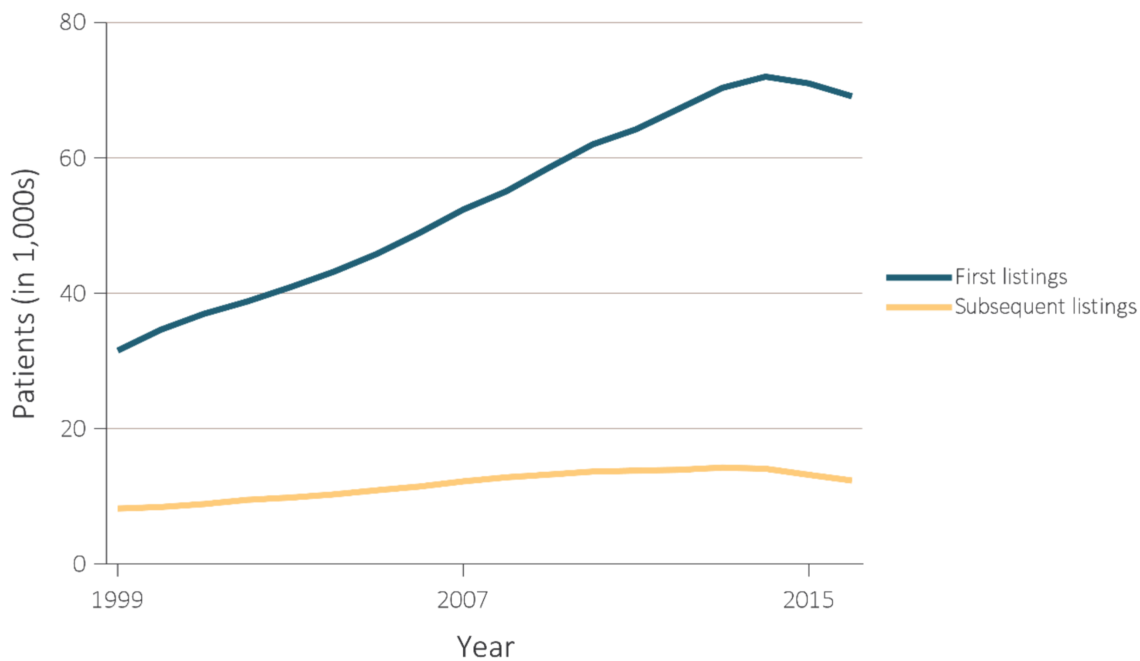
Kidney Transplant Waiting List

As of December 31, 2016, the number of people on the kidney transplant waiting list continued to decline, for the second year in a row, by 3.3% over the previous year, to 81,418 candidates (dialysis patients only), 85% of whom were awaiting their first kidney transplant (Figure 6.1). This decline was primarily driven by a reduction in the number of inactive wait-listed candidates to 30,180, a 3.6% reduction compared to the previous year (Reference Table E.3). This decrease almost certainly resulted from the new KAS policy changes. For patients already on dialysis at the time of listing, the KAS now ties the start of waiting time to date of dialysis initiation, regardless of when listing occurred. This change reduces the incentive to list dialysis patients until they are actively ready for transplantation, and may also diminish resistance to delisting of patients.

For those who meet glomerular filtration rate (GFR) criteria and are pre-dialysis, however, there is still an advantage to listing before dialysis initiation. Nevertheless, with about 20,000 kidney transplants performed in the United States in 2016, the active waiting list remains substantially larger than the supply of donor kidneys, which presents a continuing challenge.

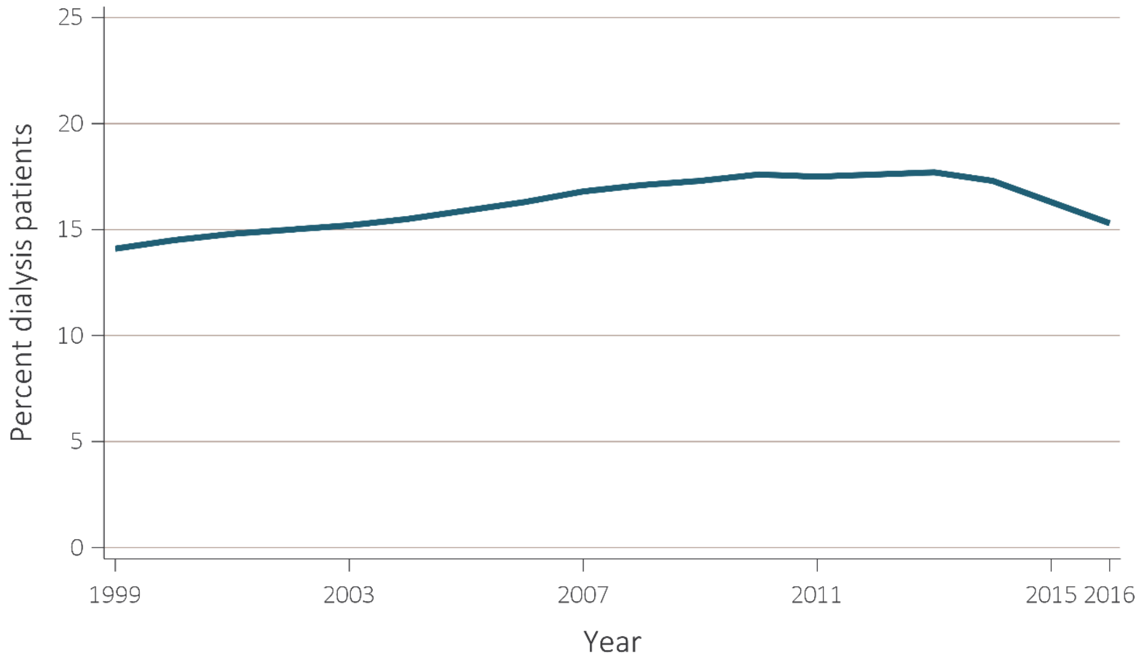
Like the trends shown in Figure 6.1, the percentage of prevalent dialysis patients wait-listed for a kidney has also recently declined (Figure 6.2).

vol 2 Figure 6.1 Number of patients wait-listed for kidney transplant, 1999-2016



Data Source: Reference Table E.3. Number of patients wait-listed for kidney transplant. Waiting list counts include all candidates listed for a kidney transplant on December 31 of each year. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014, as more fully described in the text.

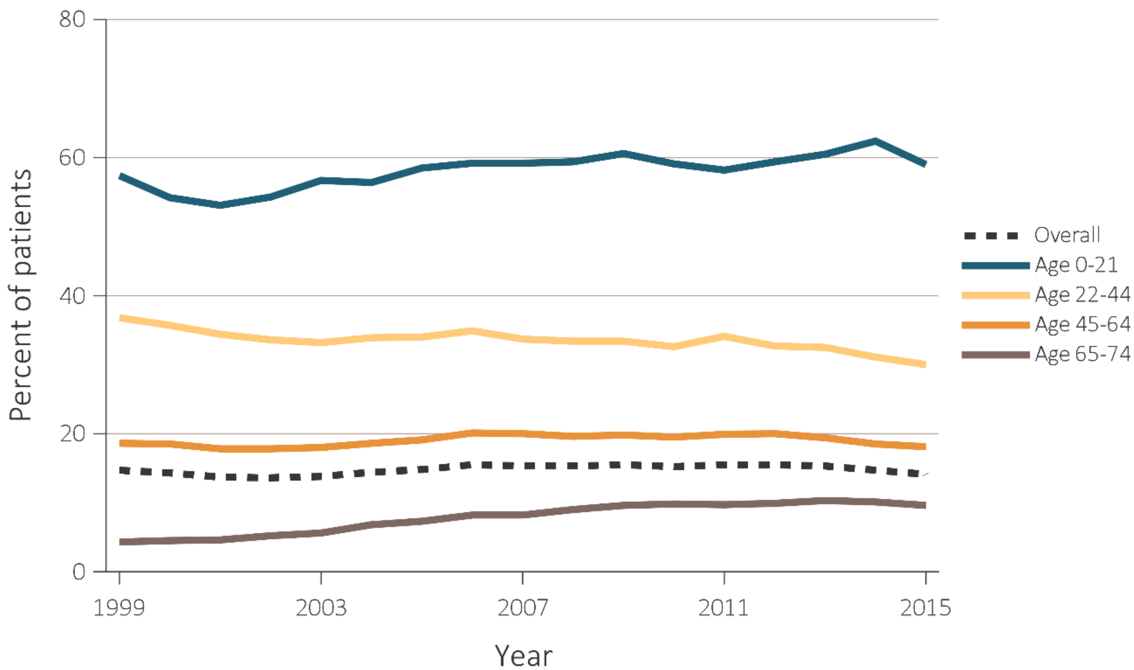
vol 2 Figure 6.2 Percentage of dialysis patients who were wait-listed, 1999-2016



Data Source: Reference Table E.4. Percentage of dialysis patients on the kidney waiting list is for all dialysis patients. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014 as described more fully in the text above.

In 2015, 14.1% of incident ESRD patients who started dialysis that year joined a waiting list, or received a deceased or living-donor transplant within one year of ESRD initiation (Figure 6.3). Since 2001, the overall percentage of patients wait-listed or receiving a transplant in their first ESRD-year has remained relatively flat. However, there has been a slight decline in 2015, which may relate to the allocation policy change. As previously mentioned, the KAS policy reduced the imperative to wait-list patients until they are actively ready for transplantation and would provide priority for transplantation for patients waiting for a long duration on dialysis.

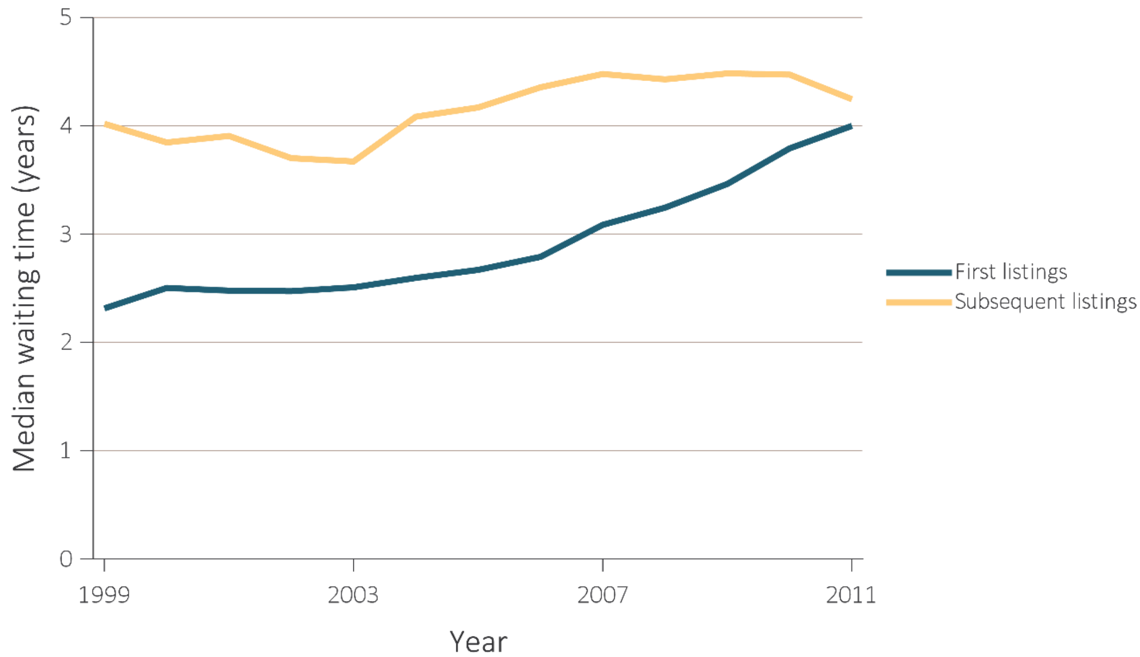
vol 2 Figure 6.3 Percentage of incident patients who were wait-listed or received a kidney transplant within one year of ESRD initiation, by age, 1999-2015



Data Source: Reference Table E.5(2). Waiting list or transplantation among incident ESRD patients by age (0-74 years). Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014, as more fully described in the text above. Abbreviation: ESRD, end-stage renal disease.

Median waiting time to transplantation continues to increase for those listing for the first time, whereas recently it has declined slightly for subsequent listings (Figure 6.4). Among 2011 candidates newly wait-listed for either an initial or subsequent kidney-alone transplant, the median waiting time (deceased or living-donor) was 4.0 years—i.e. 50% of these patients received a transplant within 4.0 years after being wait-listed. For first-time listings, the median 2011 waiting time to transplantation (deceased or living-donor) was 4.0 years, only about 2 months shorter than that for candidates listed for subsequent transplants at 4.2 years. The narrowing gap may represent an impact of the KAS policy, which provided additional priority for highly sensitized candidates. There are also large regional differences in waiting time (Reference Table E.2.2). Two states, Texas and Georgia, have waiting times greater than five years. Four states have waiting times of less than two years, with the lowest seen in Nebraska (1.4 years), Arkansas (1.6 years), and New Hampshire (1.7 years).

vol 2 Figure 6.4 Median waiting time for kidney transplant, 1999-2011

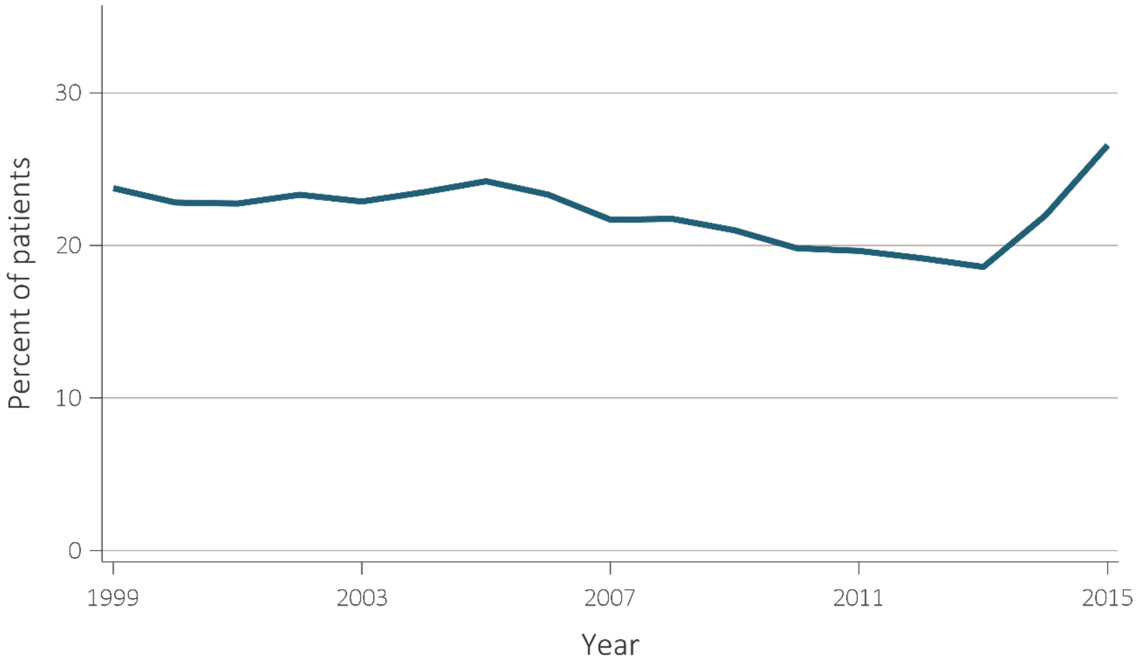


Data Source: Reference Tables E.2. Median waiting time to kidney transplant. Median waiting time is calculated for all candidates enrolled on the waiting list in a given year.

Figure 6.5 displays trends over time in the percent of patients transplanted (deceased or living donor) within one year of their wait-listing date. There is a recent sharp increase corresponding to implementation of the KAS policy, reversing the prior downward trend. This reversal likely relates to the change in policy, which set qualifying time to the start date of dialysis (for patients already on dialysis), rather than the actual date of wait-listing. As such, patients who have been on dialysis for a long duration at the time of new wait-listing would receive priority, potentially allowing for relatively rapid receipt of a deceased-donor transplant.

Table 6.1 displays outcomes within three years of follow-up for candidates who were first listed in 2013, as a function of their blood type, PRA, and age. Results are shown separately among patients who did not receive a living-donor transplant in order to provide information on the outcome of electing to wait for a deceased donor. Among those not receiving a living-donor transplant, at three years 24% had received a deceased-donor transplant, a quarter had died or been removed from the waiting list, and half remained on the waiting list. Older patients were more likely to be removed from the waiting list or to die while waiting; the outcome of death was more likely than receipt of a deceased-donor transplant for most of the strata of patients aged 65 years or older. As expected, blood type also affected the outcomes. Table 6.2 displays the corresponding outcomes within five years of follow-up for candidates who were first listed in 2011, as a function of their blood type, PRA, and age. Overall, among those not receiving a living-donor transplant, at five years 39% had received a deceased-donor transplant, 37% had died or been removed from the waiting list, and a quarter remained on the waiting list.

vol 2 Figure 6.5 Percent of patients transplanted (living or deceased donor) within one year of wait-listing, 1999-2015



Data Source: Special analyses, USRDS ESRD Database and the Organ Procurement and Transplantation Network (OPTN). Abbreviation: ESRD, end-stage renal disease.

vol 2 Table 6.1 Reported outcomes within three years since first listing in 2013, by blood type, PRA, and age

Patient characteristics			Number who received a living-donor transplant	Outcomes of patients who did not receive a living-donor transplant			
Blood Type	PRA	Age		Total number of patients	Received a deceased-donor transplant (%)	Still on waiting list (%)	Removed from waiting list at death or reason other than transplant (%)
Blood Type A	PRA<20	0≤Age≤21	122	233	73	18	9
		22≤Age≤44	540	1,268	34	47	19
		45≤Age≤64	764	3,694	28	49	24
		Age≥65	234	1,349	30	37	34
	PRA≥20	0≤Age≤21	*	*	50	*	*
		22≤Age≤44	27	107	36	46	18
		45≤Age≤64	36	242	40	37	23
		Age≥65	*	76	30	28	42
Blood Type B	PRA<20	0≤Age≤21	34	117	65	28	7
		22≤Age≤44	176	706	19		18
		45≤Age≤64	255	1,734	16	61	23
		Age≥65	71	586	15	48	37
	PRA≥20	0≤Age≤21	*	*	75	.	*
		22≤Age≤44	*	55	20	71	9
		45≤Age≤64	17	111	29	49	23
		Age≥65	*	34	*	35	41
Blood Type AB	PRA≥0	0≤Age≤21	15	36	89	*	*
		22≤Age≤44	60	157	57	31	11
		45≤Age≤64	94	461	51	30	19
		Age≥65	22	171	54	20	26
Blood Type O	PRA<20	0≤Age≤21	128	388	65	27	7
		22≤Age≤44	639	2,196	19	62	19
		45≤Age≤64	839	5,686	17	59	24
		Age≥65	232	1,876	17	46	37
	PRA≥20	0≤Age≤21	*	20	60	*	*
		22≤Age≤44	35	156	27	53	20
		45≤Age≤64	38	335	26	48	26
		Age≥65	*	88	30	40	31
All			4,378	21,882	24%	51%	24

*Data Source: Special analyses, USRDS ESRD Database and the Organ Procurement and Transplantation Network (OPTN). Reported outcomes within three years since first listing in 2013, by blood type, PRA, and age. PRA is not dichotomized due to small sample size. * Suppressed due to inadequate sample size. A dot (.) represents a zero value. Abbreviations: ESRD, end-stage renal disease; PRA, panel reactive antibodies.*

vol 2 Table 6.2 Reported outcomes within five years since first listing in 2011, by blood type, PRA, and age

Patient characteristics			Number who received a living-donor transplant	Outcomes of patients who did not receive a living-donor transplant			
Blood Type	PRA	Age		Total number of patients	Received a deceased-donor transplant (%)	Still on waiting list (%)	Removed from waiting list at death or reason other than transplant (%)
Blood Type A	PRA<20	0≤Age≤21	105	241	81	8	10
		22≤Age≤44	543	1,233	54	22	24
		45≤Age≤64	873	3,469	46	20	34
		Age≥65	224	1,215	41	10	49
	PRA≥20	0≤Age≤21	*	*	100	.	.
		22≤Age≤44	23	79	63	19	18
		45≤Age≤64	39	236	52	17	31
		Age≥65	*	69	49	*	45
Blood Type B	PRA<20	0≤Age≤21	46	93	76	11	13
		22≤Age≤44	177	585	35	36	29
		45≤Age≤64	316	1,557	28	35	37
		Age≥65	63	516	26	19	55
	PRA≥20	0≤Age≤21	*	*	40	20	40
		22≤Age≤44	15	40	28	30	43
		45≤Age≤64	17	121	35	31	34
		Age≥65	*	36	39	11	50
Blood Type AB	PRA≥0	0≤Age≤21	13	37	84	*	*
		22≤Age≤44	58	151	70	10	21
		45≤Age≤64	91	433	64	10	27
		Age≥65	25	170	55	5	40
Blood Type O	PRA<20	0≤Age≤21	160	419	77	12	11
		22≤Age≤44	666	2,036	33	37	29
		45≤Age≤64	940	5,083	29	32	39
		Age≥65	220	1,707	27	19	54
	PRA≥20	0≤Age≤21	*	22	64	23	14
		22≤Age≤44	34	150	37	29	34
		45≤Age≤64	43	351	39	20	40
		Age≥65	*	115	30	12	58
All			4,691	20,164	39	25	37

*Data Source: Special analyses, USRDS ESRD Database and the Organ Procurement and Transplantation Network (OPTN). Reported outcomes within five years since first listing in 2011, by blood type, PRA, and age. PRA is not dichotomized due to small sample size. * Suppressed due to inadequate sample size. A dot (.) represents a zero value. Abbreviations: ESRD, end-stage renal disease; PRA, panel reactive antibodies.*

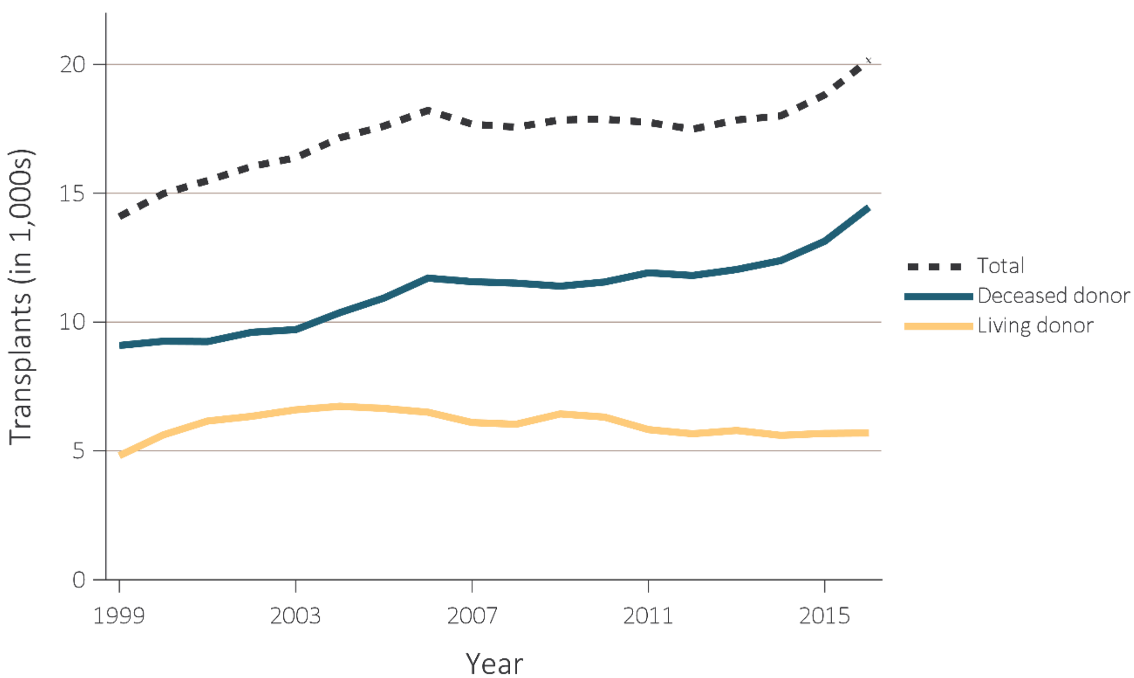
Transplant Counts and Rates

During 2016, 20,161 kidney transplants were performed in the United States (19,301 were kidney-alone; Figure 6.6), a record number. The increase was exclusively from deceased donors. Of the transplants, 5,692 were identified as originating from living donors (28.2%) and 14,451 (71.7%) from deceased donors.

The cumulative number of recipients living with a functioning kidney transplant continued to grow, reaching 215,061 in 2016, a 3% increase over 2015 (Figure 6.7).

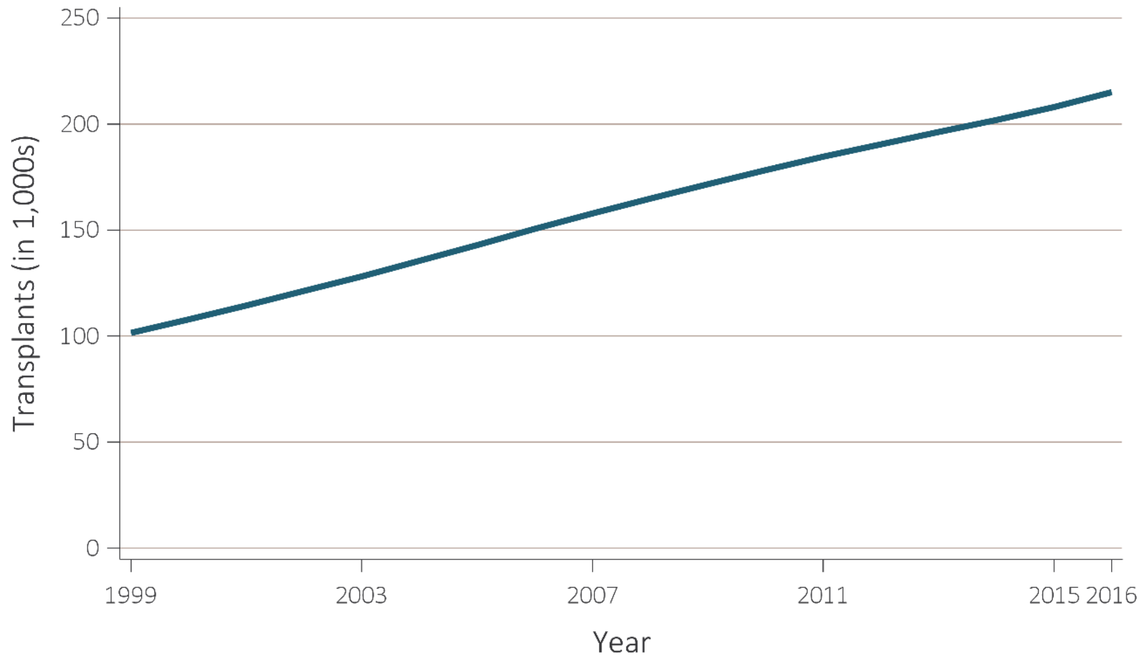
As the overall dialysis population expanded, the annual unadjusted transplant rate per 100 dialysis patient-years saw a continuous decline, although it plateaued since 2013 (Figure 6.8), and has recently started to increase slightly. The rise is likely driven by the relatively large increase in deceased-donor counts since 2015.

vol 2 Figure 6.6 Number of kidney transplants by donor type, 1999-2016



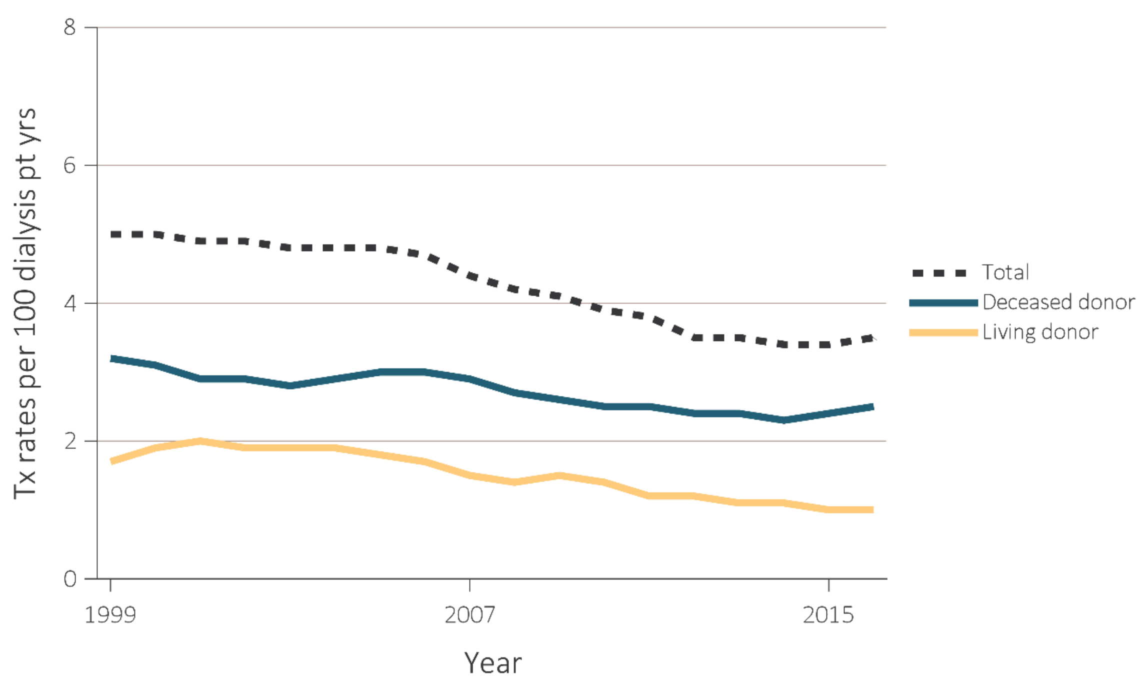
Data Source: Reference Tables E.8, E.8(2), and E.8(3). Number of kidney transplants by donor type. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014.

vol 2 Figure 6.7 Number of patients with a functioning kidney transplant, 1999-2016



Data Source: Reference Table D.9. Prevalent counts of patients with a functioning kidney transplant as of December 31 of each year. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014.

vol 2 Figure 6.8 Unadjusted kidney transplant rates, by donor type, 1999-2016



Data Source: Reference Table E.9. Unadjusted transplant rates are for all dialysis patients. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014. Abbreviations: pt yrs, patient-years; tx, transplant.

In 2016, transplant rates remained stable relative to 2015 for most patient categories (Table 6.3). In upcoming sections, we present counts and rates of transplants separately for deceased- versus living-donor sources, as trends differed substantially for certain subgroups. These changes resulted from KAS policy changes, which primarily influence deceased-donor transplants.

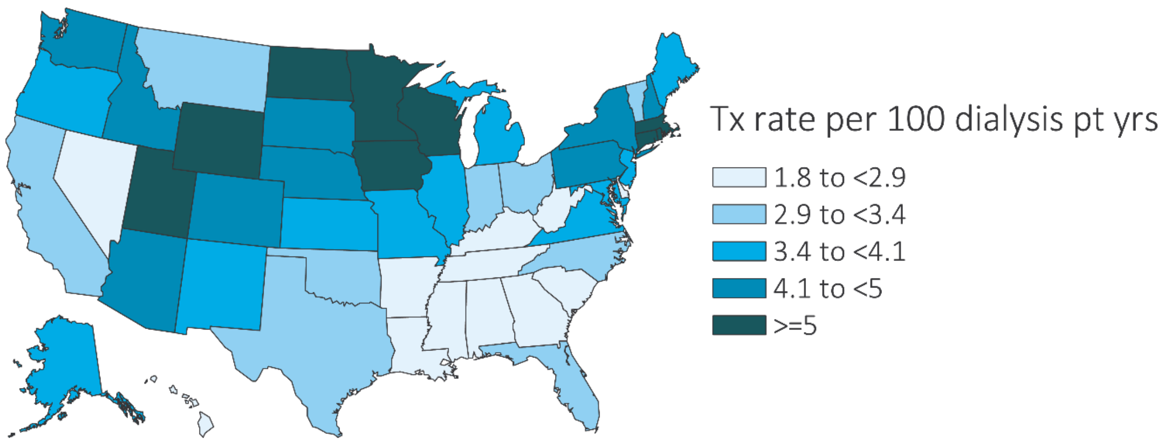
vol 2 Table 6.3 Unadjusted kidney transplant rates, all donor types, by age, sex, race, and primary cause of ESRD, per 100 dialysis patient-years, 2007-2016

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Age										
0-21	31.6	32.5	34.7	32.8	32.0	32.5	31.6	31.9	33.4	34.4
22-44	9.5	8.8	8.7	8.1	7.7	7.6	7.3	7.2	8.6	8.5
45-64	5.4	5.1	4.9	4.8	4.5	4.2	4.3	4.1	4.0	4.3
65-74	2.5	2.6	2.6	2.6	2.6	2.5	2.4	2.4	2.2	2.4
75 and older	0.4	0.3	0.4	0.4	0.4	0.4	0.3	0.4	0.3	0.3
Sex										
Male	4.9	4.6	4.4	4.3	4.1	3.9	3.8	3.7	3.7	3.7
Female	3.8	3.7	3.7	3.5	3.3	3.1	3.1	3.0	3.1	3.3
Race										
White	5.2	4.9	4.8	4.5	4.3	4.1	4.0	3.9	3.7	3.9
Black/African American	3.0	2.9	2.9	2.9	2.8	2.5	2.5	2.4	2.7	2.7
American Indian/Alaska Native	2.9	3.5	3.6	2.8	3.0	2.4	2.1	2.6	3.0	2.8
Asian	5.2	5.4	5.0	4.9	4.7	4.6	4.6	4.6	4.9	5.1
Native Hawaiian or Pacific Islander	3.3	3.2	3.1	2.9	2.4	2.4	2.2	2.6	2.6	2.4
Other or Multiracial	4.9	5.2	6.1	6.9	6.7	6.6	3.0	4.1	3.6	4.7
Unknown	12.5	13.3	11.1	8.6	9.4	8.3	8.4	12.3	12.2	10.2
Primary Cause of ESRD										
Diabetes	3.0	2.8	2.7	2.6	2.5	2.3	2.3	2.2	2.0	2.1
Hypertension	3.0	2.9	2.8	2.7	2.5	2.5	2.5	2.4	2.5	2.6
Glomerulonephritis	8.5	8.2	8.1	8.2	7.8	7.4	7.2	7.0	7.6	7.4
All	4.4	4.2	4.1	3.9	3.8	3.5	3.5	3.4	3.4	3.5

Data Source: Reference Table E.9. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014. Abbreviation: ESRD, end-stage renal disease.

Rates of transplantation per 100 dialysis patient-years are presented by geographic region in Figure 6.9, without statistical adjustment. The upper Midwest Plains states, Rocky Mountain states, and New England demonstrated the highest transplant rates, with lowest rates found in Nevada, and areas of the Southwest and South. The wide regional variations may relate to geographic differences in organ availability and ESRD incidence (Mathur et al., 2010).

vol 2 Figure 6.9 Geographic distribution of unadjusted transplant rates by state, 2016



Data Source: Special analyses, USRDS ESRD Database. Geographic distribution of unadjusted transplant rates by state, 2016. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014. Abbreviations: pt yrs; patient-years; tx, transplant.

Counts and Rates of Deceased-Donor Transplants

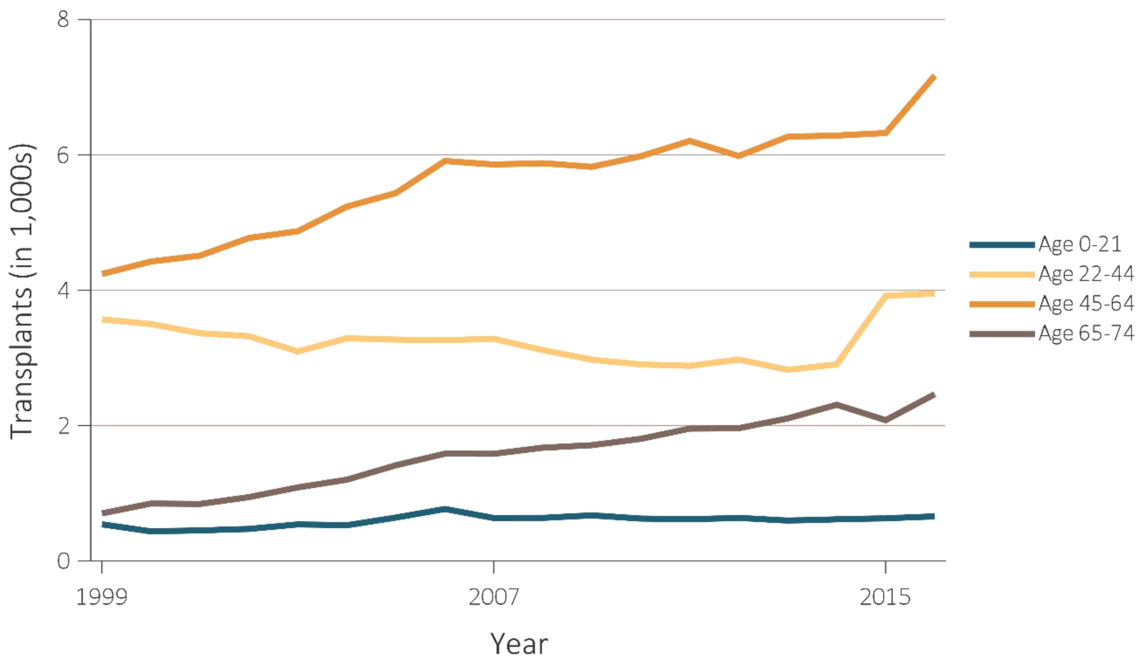
As presented above in Figure 6.6, the overall number of deceased-donor transplants remained consistent between 2006 and 2011, and has increased steadily since 2012. In this section, we review detailed trends in counts and rates of deceased-donor transplants, by age, sex, race, and primary cause of ESRD (Figures 6.10-6.13).

Counts and rates of deceased-donor transplantation per 100 dialysis patient-years are presented by age category in Figure 6.10, without statistical adjustment. Counts in 2016 rose relative to 2015 for all age categories, though patterns varied. For recipients aged 45-64 years, there was a sharp increase in 2016, to 7,172 deceased-donor transplants, a 13.4% rise compared to 2015 (Figure 6.10.a). In contrast, for those aged 22-44 years the number of deceased-donor transplants increased sharply from 2,906 in 2014 to 3,915 in 2015 but only increased slightly in 2016 to 3,952.

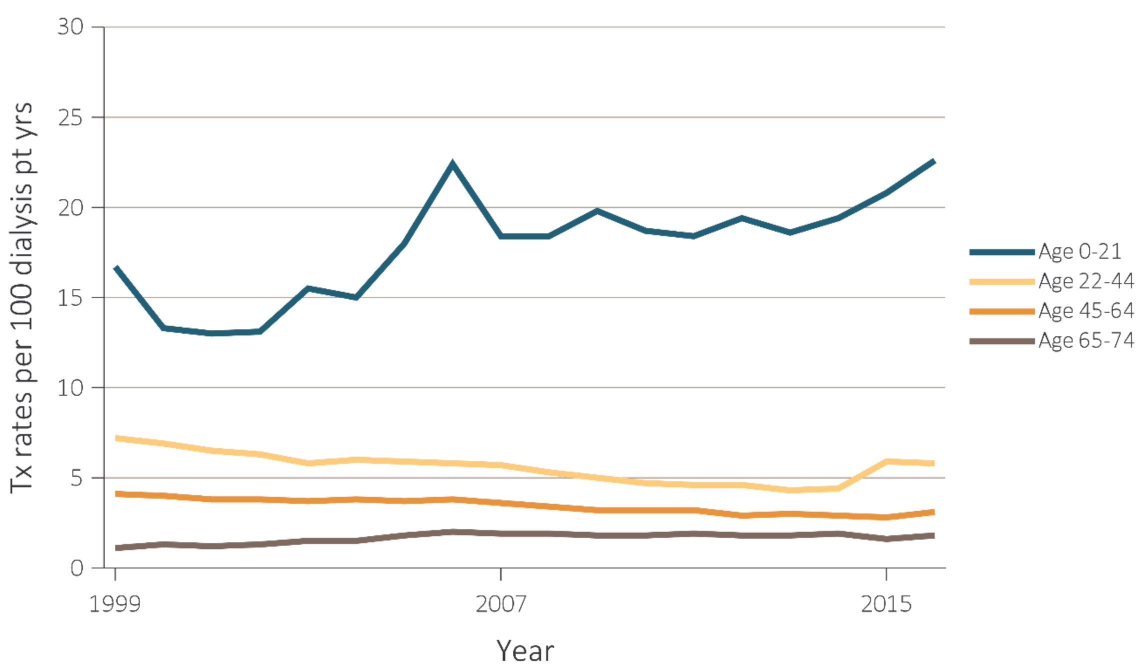
The patterns for deceased-donor transplant counts shown in Figure 6.10.a contrast with the rates shown in Figure 6.10.b, likely because the number of dialysis patients varies, increasing markedly with age. Due to the small denominator for children on dialysis, and the priority for allocating kidneys from deceased donors under the age of 35 years to pediatric patients, deceased-donor transplant rates are highest in the <22 years category that includes children. The rates for this group increased in 2005-2007, then stabilized until 2013, and have since increased (since the numbers have been stable and the rate increased, this corresponds to a decrease in incident ESRD in this population as shown in Figure 1.4 of Volume 2, *Chapter 1*: Incidence, Prevalence, Patient Characteristics, and Treatment Modalities). There has been a slow reduction in deceased-donor kidney transplantation rates for those aged 45-64 and 65-74 years over time, which appears to have plateaued in 2016. The rate for those aged 22-44 years rose sharply in 2015, but plateaued in 2016.

vol 2 Figure 6.10 Number of deceased-donor transplants and unadjusted transplant rates among deceased-donor kidney recipients, by recipient age, 1999-2016

(a) Number of transplants by age



(b) Transplant rates by age



Data Source: Reference Tables E.8(2) and E.9(2). (a) Deceased-donor kidney transplant counts by recipient age. (b) Unadjusted deceased-donor kidney transplant rates by recipient age. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014. Abbreviations: pt yrs, patient-years; tx, transplant.

The trends for counts of deceased-donor transplants by year are similar for males and females—rising over the past decade, with some leveling off after 2006, and an increase seen again after 2013 (Figure 6.11.a). Males received substantially more deceased-donor transplants than did females, on average 52.6% more annually since 1999. This difference seems to be largely explained by the fact that males account for more than 60% of wait-listed candidates (Reference Table E.3).

The rates of deceased-donor kidney transplantation had been declining since 2006 for both male and female dialysis patients (Figure 6.11.b), but have risen in recent years, particularly among females. The difference in transplantation rates between males and females has therefore narrowed. The latter finding may have resulted from the additional prioritization of sensitized candidates in the new allocation policy.

vol 2 Figure 6.11 Number of deceased-donor transplants and unadjusted transplant rates among deceased-donor kidney recipients, by recipient sex, 1999-2016

(a) Number of transplants by sex

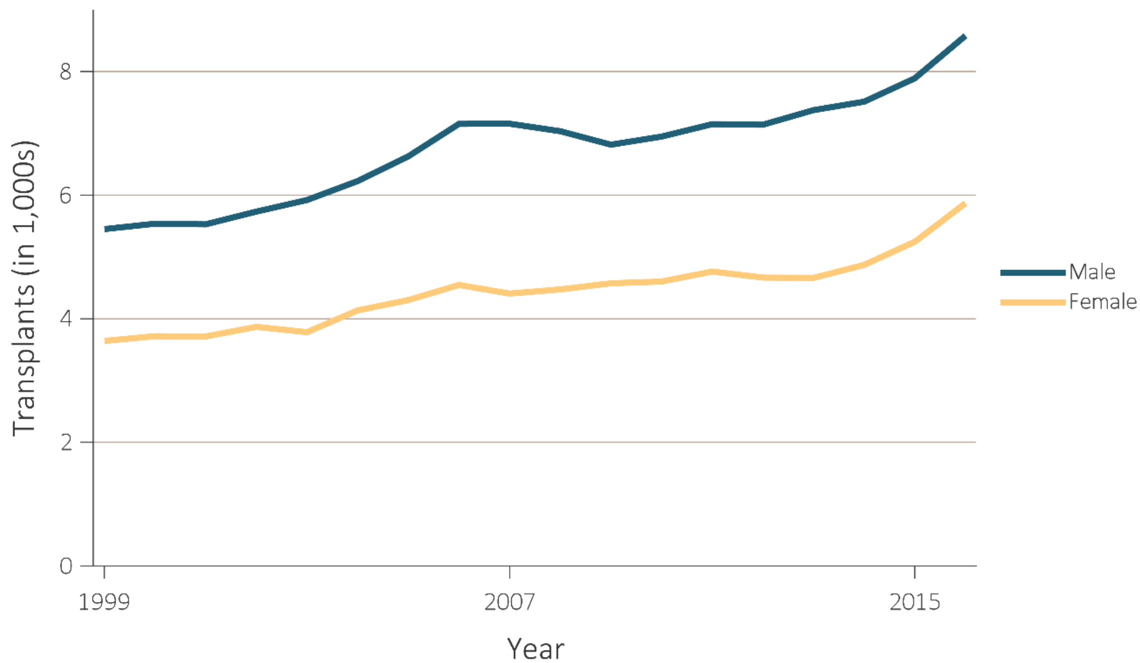
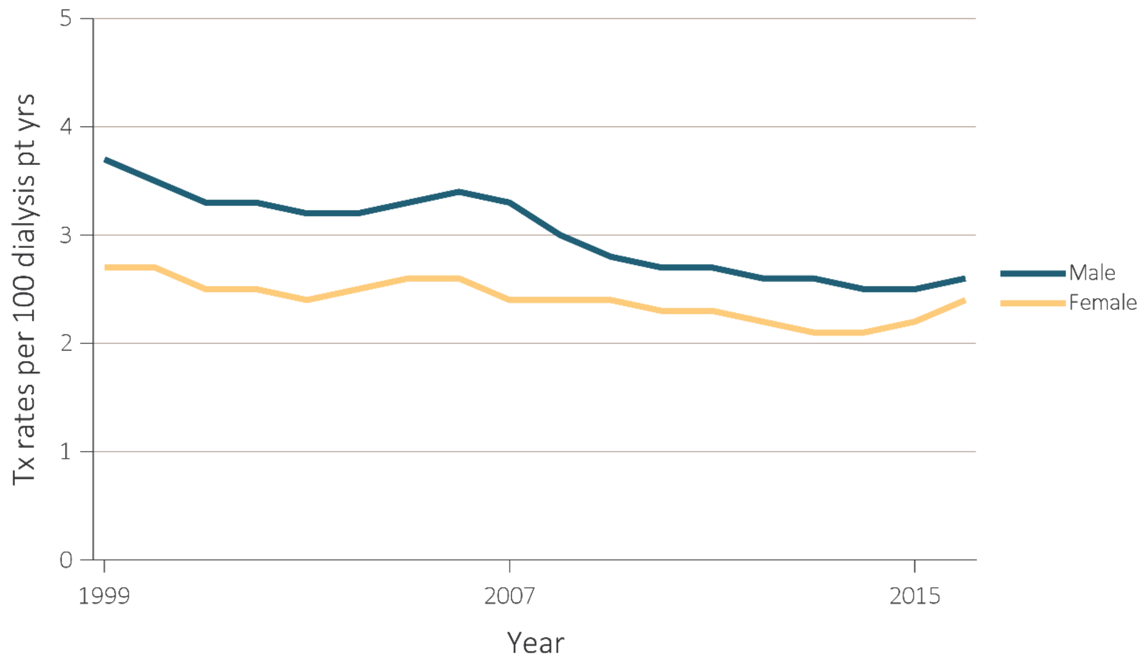


Figure 6.11 continued on next page.

vol 2 Figure 6.11 Number of deceased-donor transplants and unadjusted transplant rates among deceased-donor kidney recipients, by recipient sex, 1999-2016 (continued)

(b) Transplant rates by sex



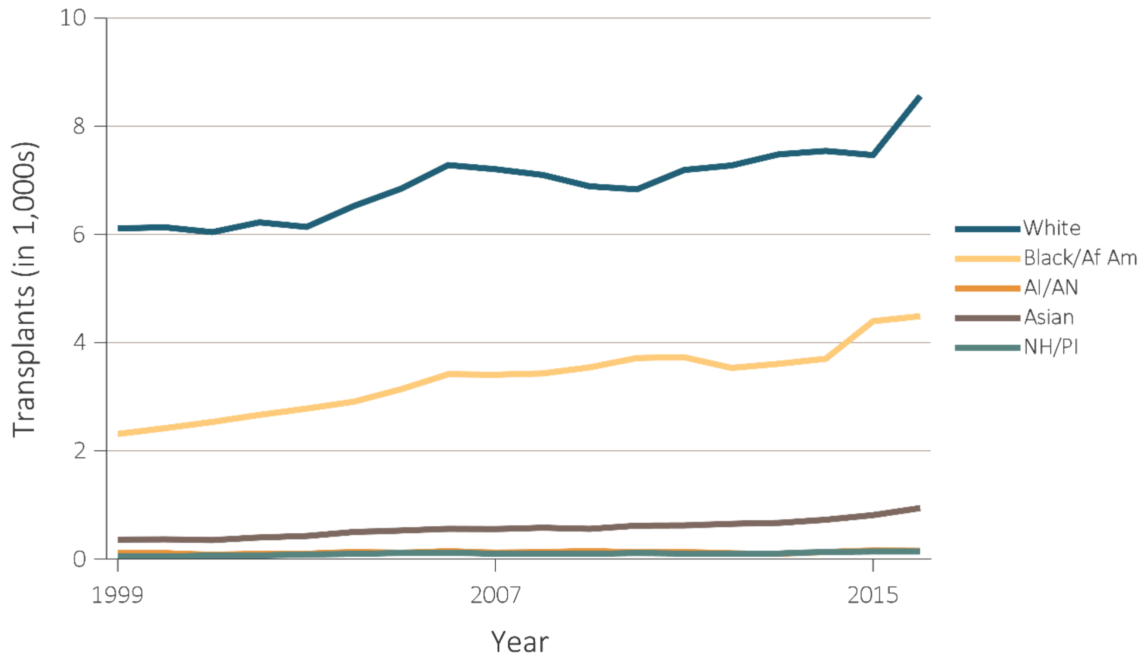
Data Source: Reference Tables E.8(2) and E.9(2). (a) Deceased-donor kidney transplant counts by recipient sex. (b) Unadjusted deceased-donor kidney transplant rates by recipient sex. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014. Abbreviation: pt yrs; patient-years; tx, transplant.

For dialysis patients of White race there was a sharp increase in the number of transplants in 2016, whereas there was a modest rise among Black patients, following a sharper increase in those patients in 2015 soon after the new allocation system was instituted (Figure 6.12.a).

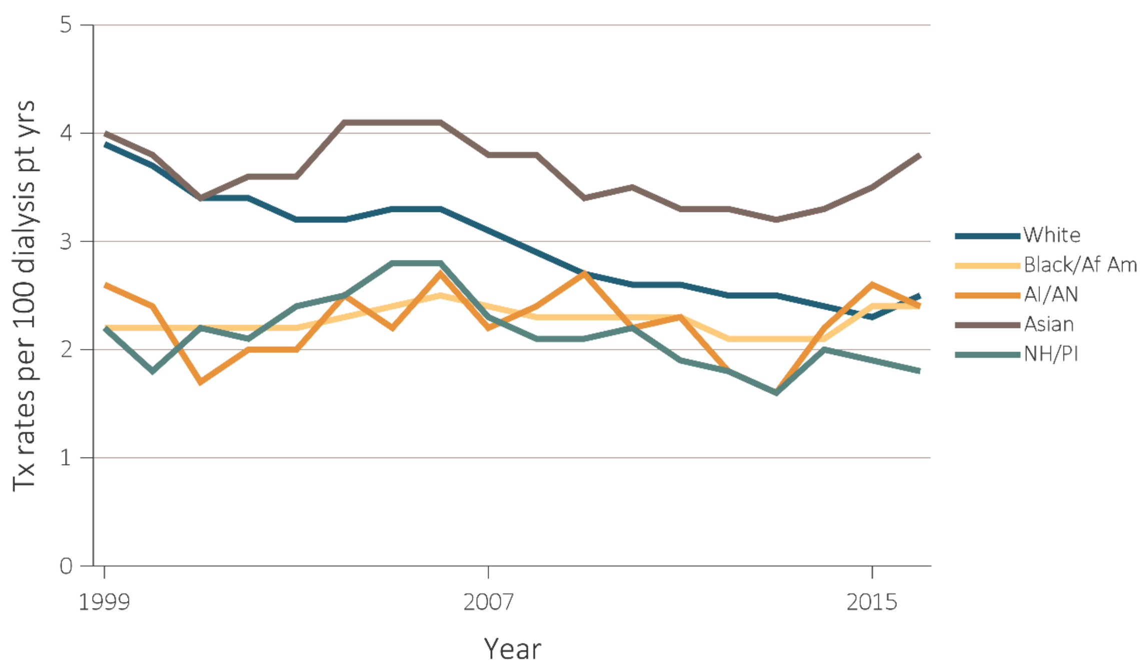
Deceased-donor transplant rates for White patients had been declining since 1999 but rose slightly in 2016 (Figure 6.12.b). Since 2002, deceased-donor transplant rates have been highest for Asians. In 2016, the rates of deceased-donor transplants for Blacks and American Indians/Alaska Natives were similar to that of Whites. This recent convergence may be an impact of the new allocation policy, which dates the start of waiting list time to the initiation of dialysis, even if listing occurred after many years on dialysis. This may assist minorities and low-income persons, who often take longer to get wait-listed.

vol 2 Figure 6.12 Number of deceased-donor transplants and unadjusted transplant rates among deceased-donor kidney recipients, by recipient race, 1999-2016

(a) Number of transplants by race



(b) Transplant rates by race



Data Source: Reference Tables E.8(2) and E.9(2). (a) Deceased-donor kidney transplant counts by recipient race. (b) Unadjusted deceased-donor kidney transplant rates by recipient race. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014. Abbreviations: AI/AN, American Indian or Alaska Native; Black/Af Am, Black/African American; NH/PI, Native Hawaiian or Pacific Islander; pt yrs, patient-years; tx, transplant.

When considering transplant counts by primary cause of ESRD, the largest growth in deceased-donor transplantation numbers has been among recipients with DM or hypertension (HTN; Figure 6.13.a). This growth is not surprising, as DM has consistently been the most common disease among the major causes of ESRD.

Despite the increasing number of deceased-donor transplants over time, the rates of deceased-donor transplants for all diagnosis groups had been in relative decline since 2006 (Figure 6.13.b). This trend has either reversed or stabilized in 2016 across all diagnosis groups.

vol 2 Figure 6.13 Number of deceased-donor transplants and unadjusted transplant rates among deceased-donor kidney recipients, by recipient primary cause of ESRD, 1999-2016

(a) Number of transplants by primary cause of ESRD

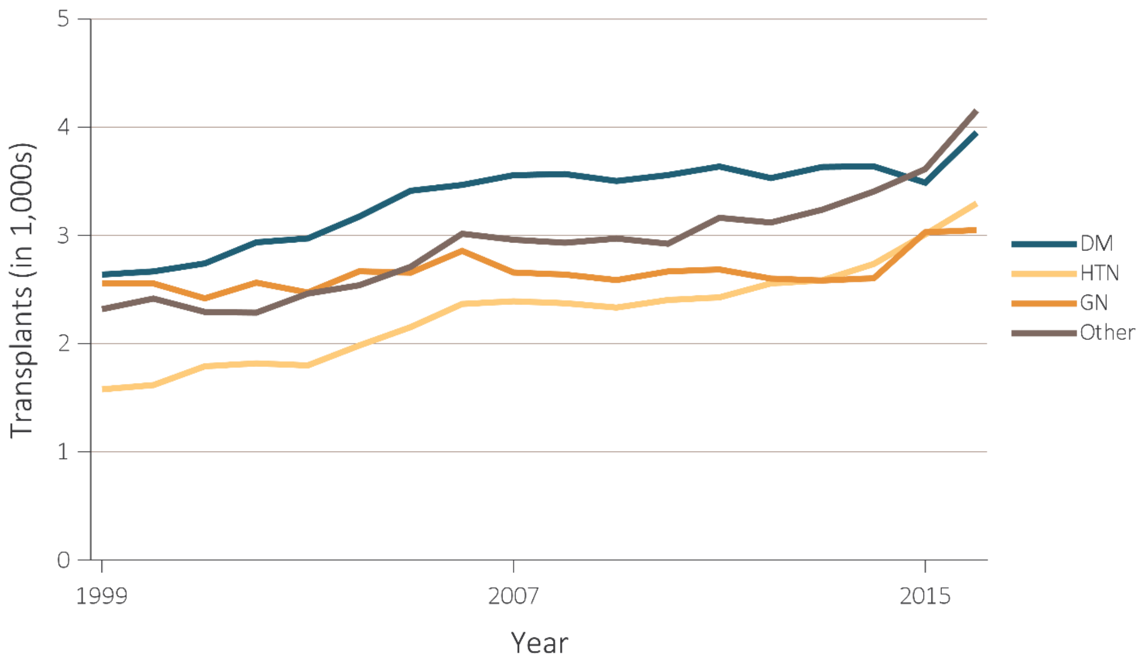
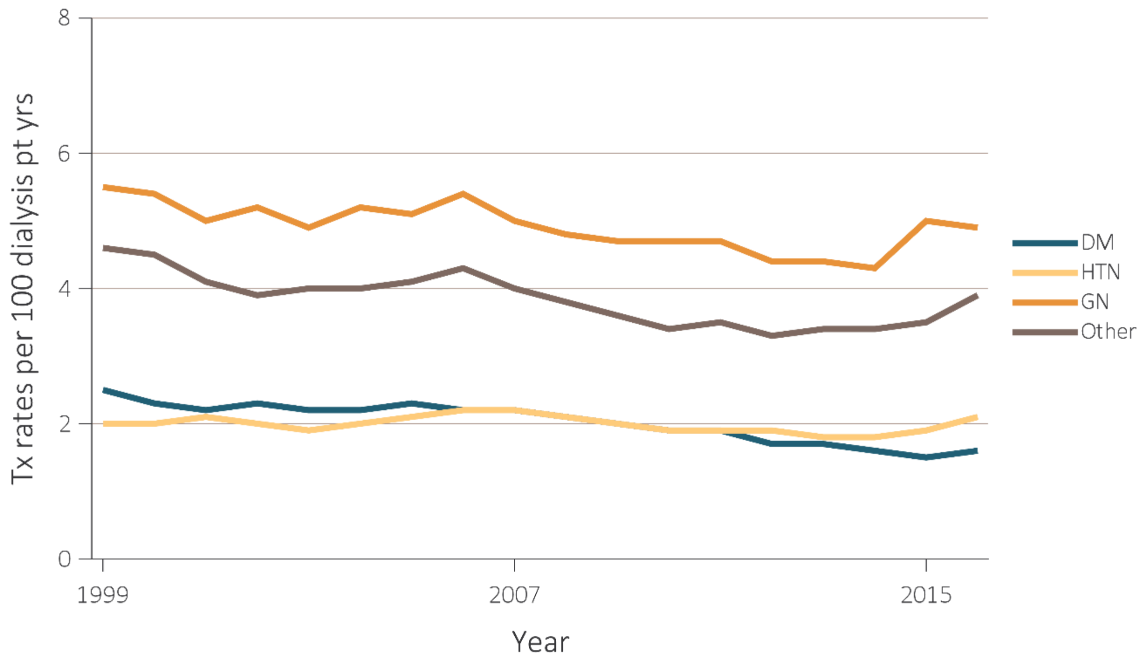


Figure 6.13 continued on next page.

vol 2 Figure 6.13 Number of deceased-donor transplants and unadjusted transplant rates among deceased-donor kidney recipients, by recipient primary cause of ESRD, 1999-2016 (continued)

(b) Transplant rates by primary cause of ESRD



Data Source: Reference Tables E.8(2) and E.9(2). (a) Deceased-donor kidney transplant counts by recipient primary cause of ESRD. (b) Unadjusted deceased-donor kidney transplant rates by recipient primary cause of ESRD. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014. Abbreviations: DM, diabetes mellitus; ESRD, end-stage renal disease; GN, glomerulonephritis; HTN, hypertension; pt yrs, patient-years; tx, transplant.

Counts and Rates of Living-Donor Transplants

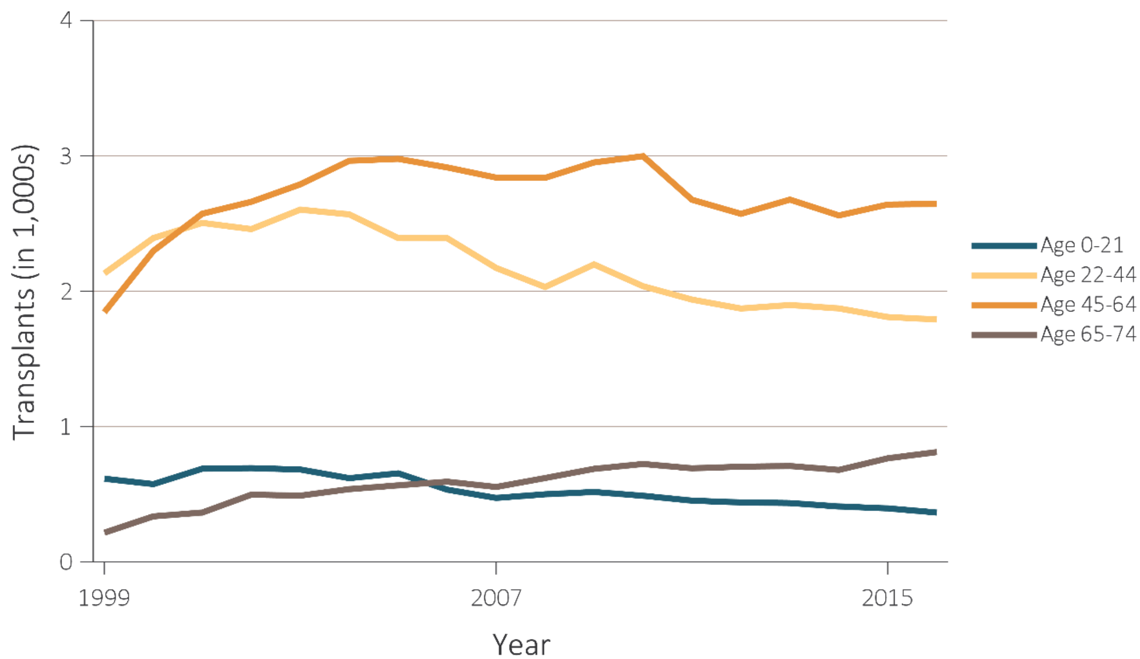
Since 2004 there has been an annual decline in living-donor kidney transplant counts, although this appears to have plateaued in recent years (Figure 6.6). In this section, we review detailed trends in annual counts and rates of living-donor kidney transplants, by age, sex, race, and primary cause of ESRD (Figures 6.14-6.17).

Counts of living-donor transplants for those aged 22-44 years decreased from 2,505 in 2003 to 1,791 in 2016 (Figure 6.14.a). The number of living-donor transplants for the group aged 45-64 years has been stable in more recent years, at 2,645 in 2016, after a fall starting in 2011. Transplant counts for those over 65 years have been steadily increasing.

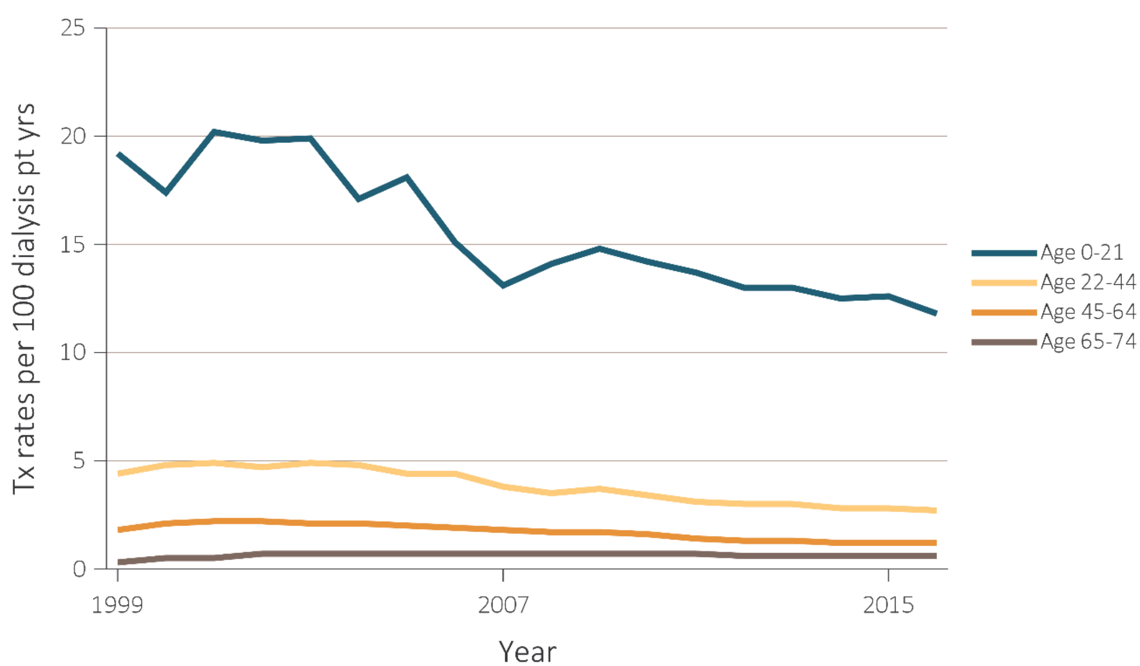
Kidney transplantation rates from living donors show that those in younger age groups have the highest annual rates per 100 dialysis patient-years (Figure 6.14.b). However, beginning in 2003 there was a steep decline in rates for the 0-21 year-old group, likely related to the impact of the deceased-donor kidney allocation priority then given to that age group; recent trends have shown a more modest decline. Among adults, the 22-44 year old group has the highest living-donor transplantation rate, although it too is declining. Only the very low rates for ages 65-74 years have increased slightly over the past decade.

vol 2 Figure 6.14 Number of living-donor transplants and unadjusted transplant rates among living-donor kidney recipients, by recipient age, 1999-2016

(a) Number of transplants by age



(b) Transplant rates by age

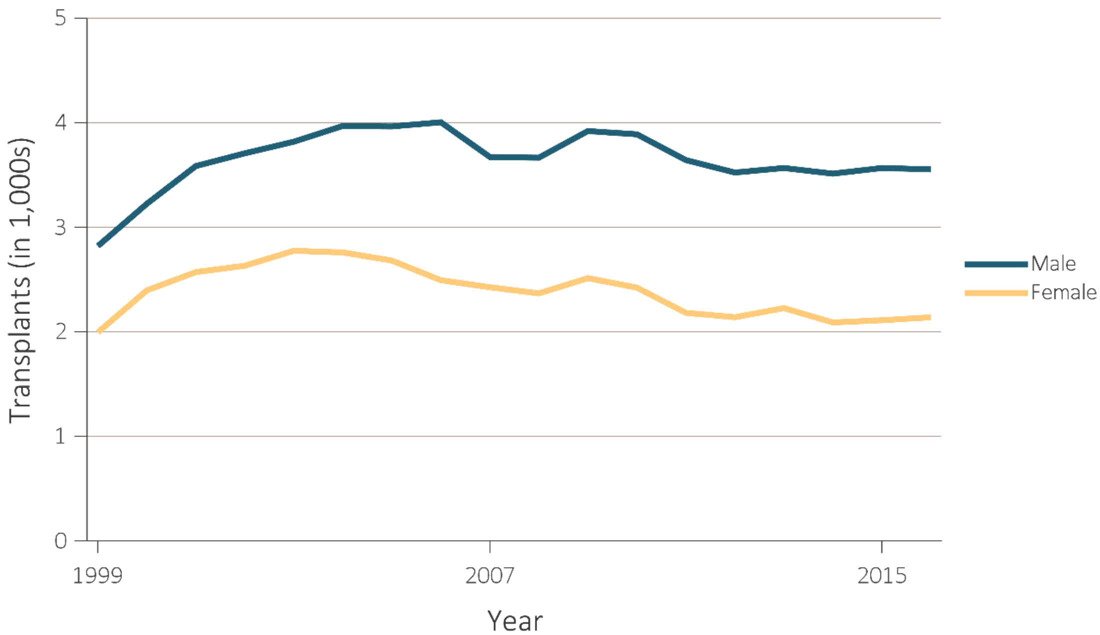


Data Source: Reference Tables E.8(3) and E.9(3). (a) Living-donor kidney transplant counts by recipient age. (b) Unadjusted living-donor kidney transplant rates by recipient age. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014. Abbreviation: pt yrs, patient-years; tx, transplant.

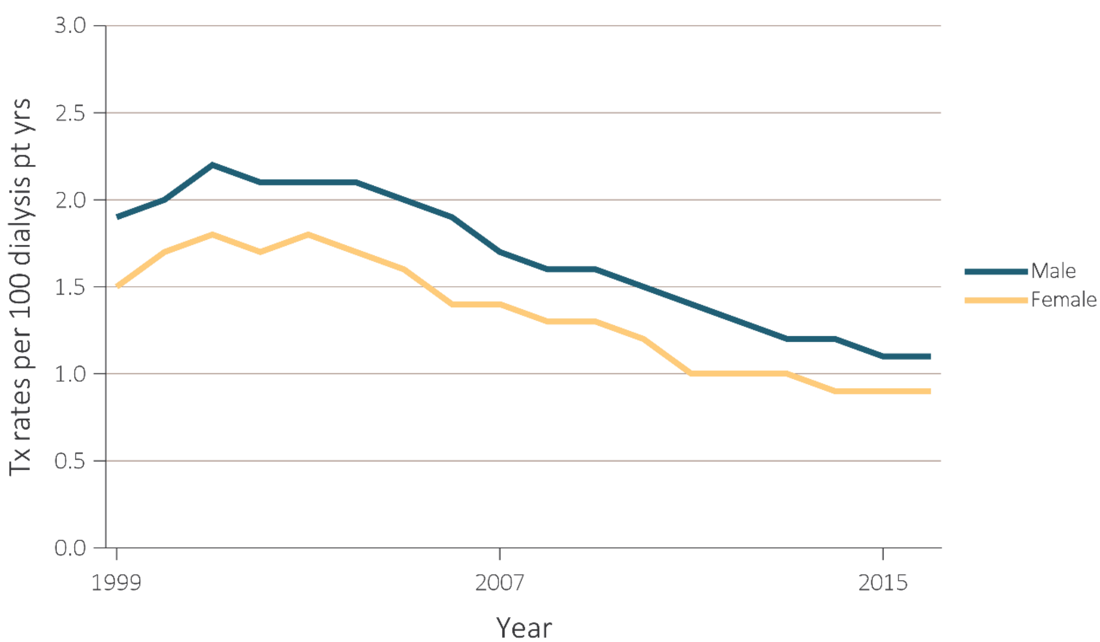
The annual counts of living-donor kidney transplantation by sex showed consistently higher numbers of male recipients (Figure 6.15.a). However, while the living-donor transplant rates continued to remain higher for males than for females, the difference was relatively small (Figure 6.15.b).

vol 2 Figure 6.15 Number of living-donor transplants and unadjusted transplant rates among living-donor kidney recipients, by recipient sex, 1999-2016

(a) Number of transplants by sex



(b) Transplant rates by sex



Data Source: Reference Tables E.8(3) and E.9(3). (a) Living-donor kidney transplant counts by recipient sex. (b) Unadjusted living-donor kidney transplant rates by recipient sex. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014. Abbreviation: pt yrs, patient-years; tx, transplant.

Consistent with the overall trend, living-donor kidney transplant counts steadily increased until 2004 for recipients of all races (Figure 6.16.a). Since then, the annual number of living-donor kidney transplants has decreased for Whites and Blacks, though most recent counts have been relatively stable. The counts for Asians have shown a small increase over time. Living-donor transplant rates for Whites and Asians are higher than for the other race groups, while rates among Blacks have consistently been lowest (Figure 6.16.b).

vol 2 Figure 6.16 Number of living-donor transplants and unadjusted transplant rates among living-donor kidney recipients, by recipient race, 1999-2016

(a) Number of transplants by race

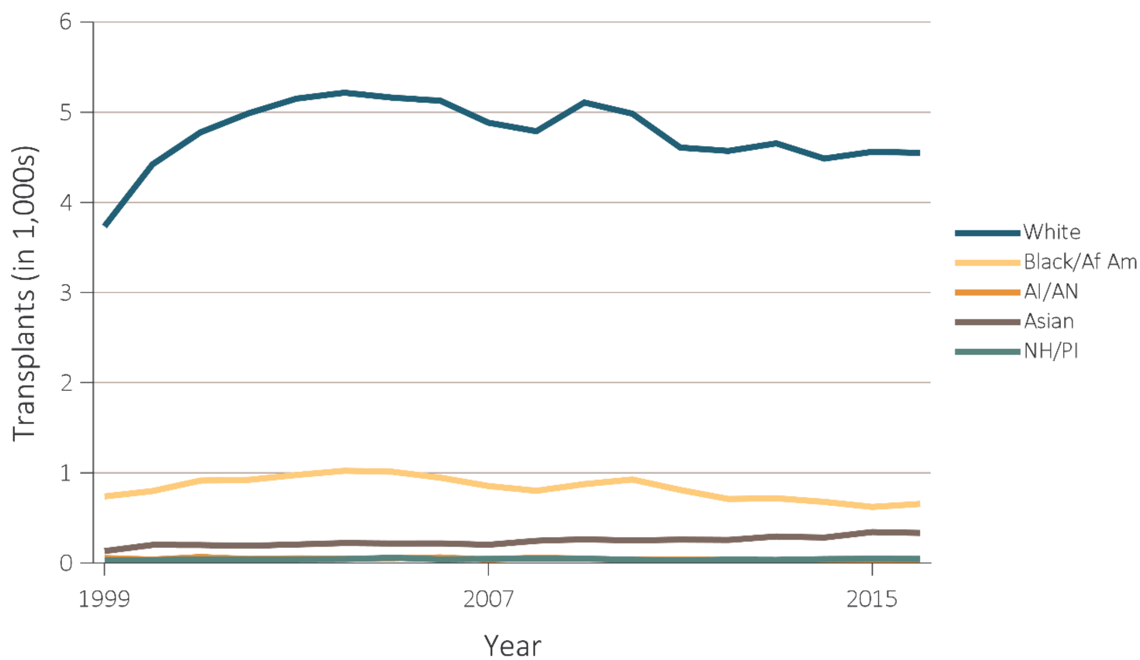
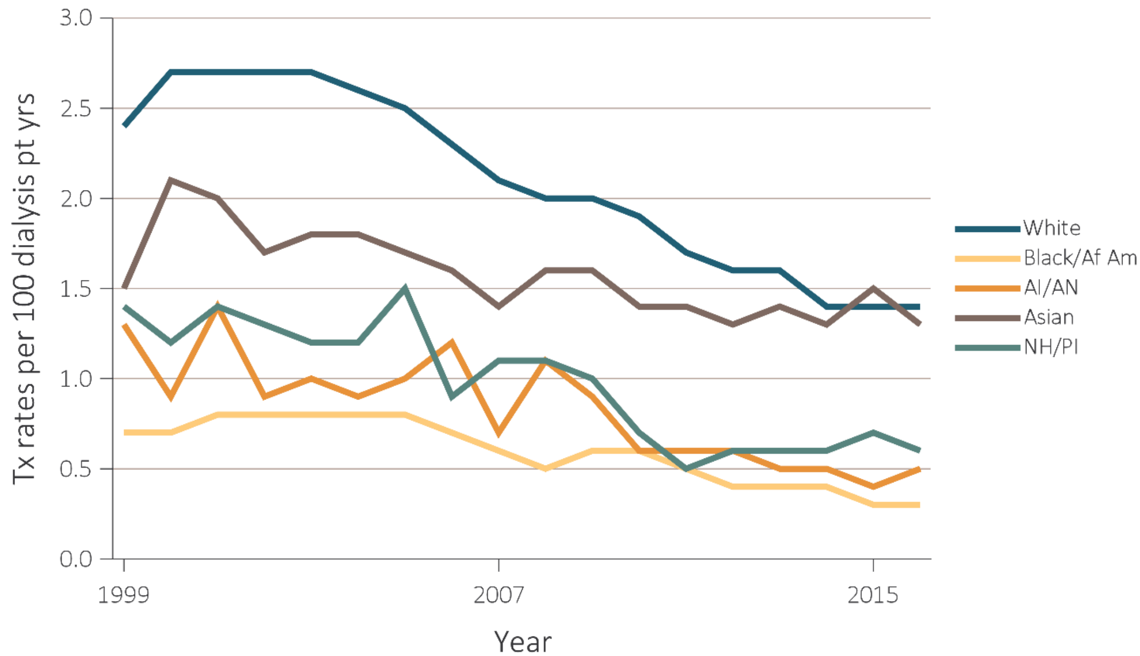


Figure 6.16 continued on next page.

vol 2 Figure 6.16 Number of living-donor transplants and unadjusted transplant rates among living-donor kidney recipients, by recipient race, 1999-2016 (continued)

(b) Transplant rates by race



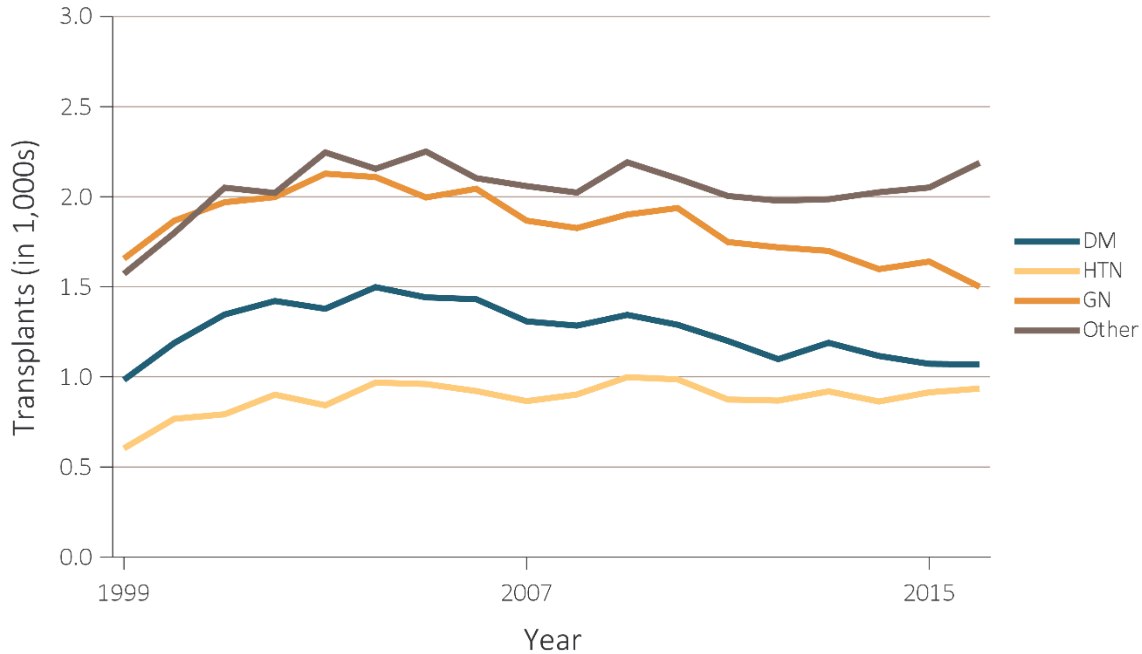
Data Source: Reference Tables E.8(3) and E.9(3). (a) Living-donor kidney transplant counts by recipient race. (b) Unadjusted living-donor kidney transplant rates by recipient race. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014. Abbreviations: AI/AN, American Indian or Alaska Native; Black/Af Am, Black/African American; NH/PI, Native Hawaiian or Pacific Islander; pt yrs, patient-years; tx, transplant.

The ranking of living-donor kidney transplantation counts by primary cause of ESRD has remained consistent over the past decade. Rankings from highest to lowest frequency were the Other causes, glomerulonephritis, DM, and HTN (Figure 6.17.a). This trend contrasts with the pattern among deceased-donor recipients (Figure 6.13.a), where the numbers with ESRD caused by DM and HTN have grown steadily in comparison to other causes.

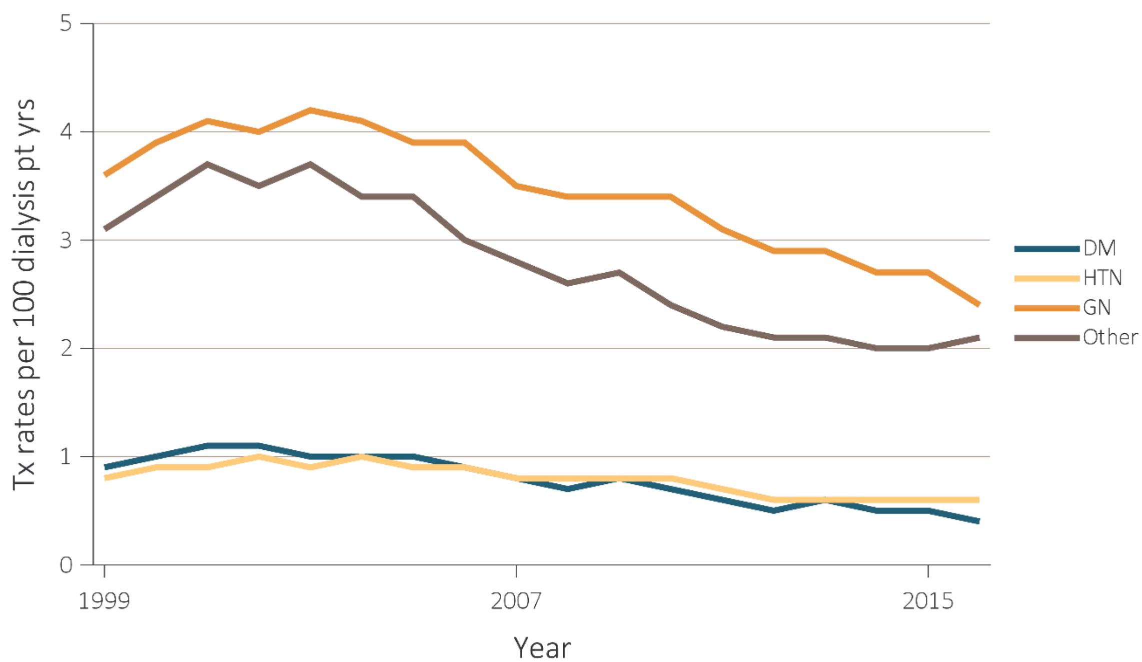
The rates of living-donor transplantation for all diagnosis groups have been declining over the past decade (Figure 6.17.b). Like the rates of deceased-donor transplants, those from living donors occur most often among patients with glomerular disease. In frequency, glomerular disease is followed by Other causes (including cystic disease), with rates lowest for those with HTN and DM.

vol 2 Figure 6.17 Number of living-donor transplants and unadjusted transplant rates among living-donor kidney recipients, by recipient primary cause of ESRD, 1999-2016

(a) Number of transplants by primary cause of ESRD



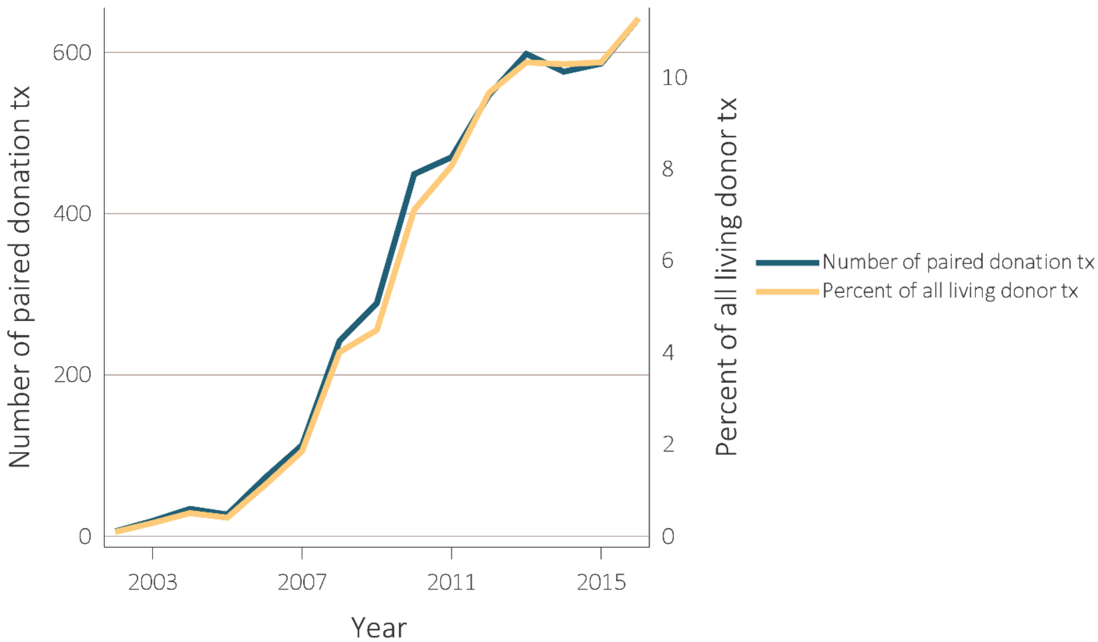
(b) Transplant rates by primary cause of ESRD



Data Source: Reference Tables E.8(3) and E.9(3). (a) Living-donor kidney transplant counts by recipient primary cause of ESRD. (b) Unadjusted living-donor kidney transplant rates by recipient primary cause of ESRD. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014. Abbreviations: DM, diabetes mellitus; ESRD, end-stage renal disease; GN, glomerulonephritis; HTN, hypertension; pt yrs, patient-years; tx, transplant.

A relatively recent initiative aimed at increasing the availability of living-donor transplants is the process of kidney paired donation (KPD). This approach typically occurs when an otherwise willing potential living donor is incompatible with their chosen recipient. In its simplest form, two living donors who are incompatible with their respective recipients agree to an exchange whereby their donated organs go to each other's compatible recipient. More complex chains involving exchanges among three or more recipient-donor pairs have also occurred. Altruistic, undirected donors have also initiated complex chains. The counts of KPD transplants rose sharply initially, appeared to plateau in 2012, but increased again in 2016, representing 11.3% of living-donor transplants that year (Figure 6.18).

vol 2 Figure 6.18 Number of paired donation transplants and percent of all living-donor transplants, 2002-2016



Data Source: Data are obtained from the Organ Procurement and Transplantation Network (OPTN). Paired donation transplant counts and percent of all living-donor transplants. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014. Abbreviation: tx, transplant.

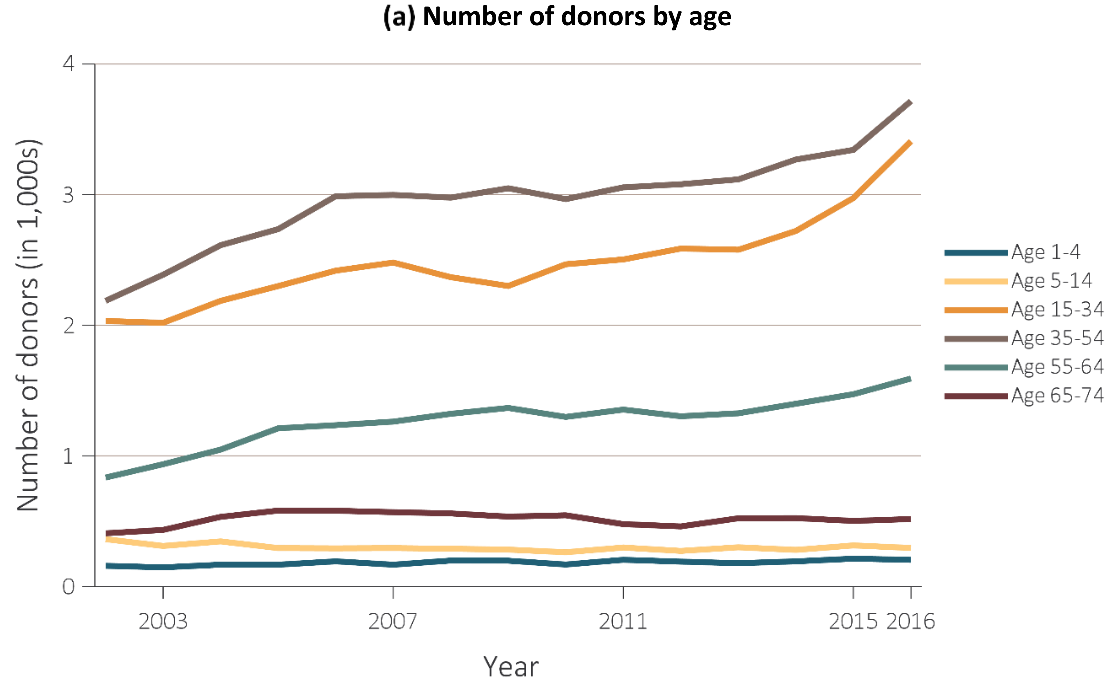
Deceased Donation Counts and Rates among All-cause Deaths

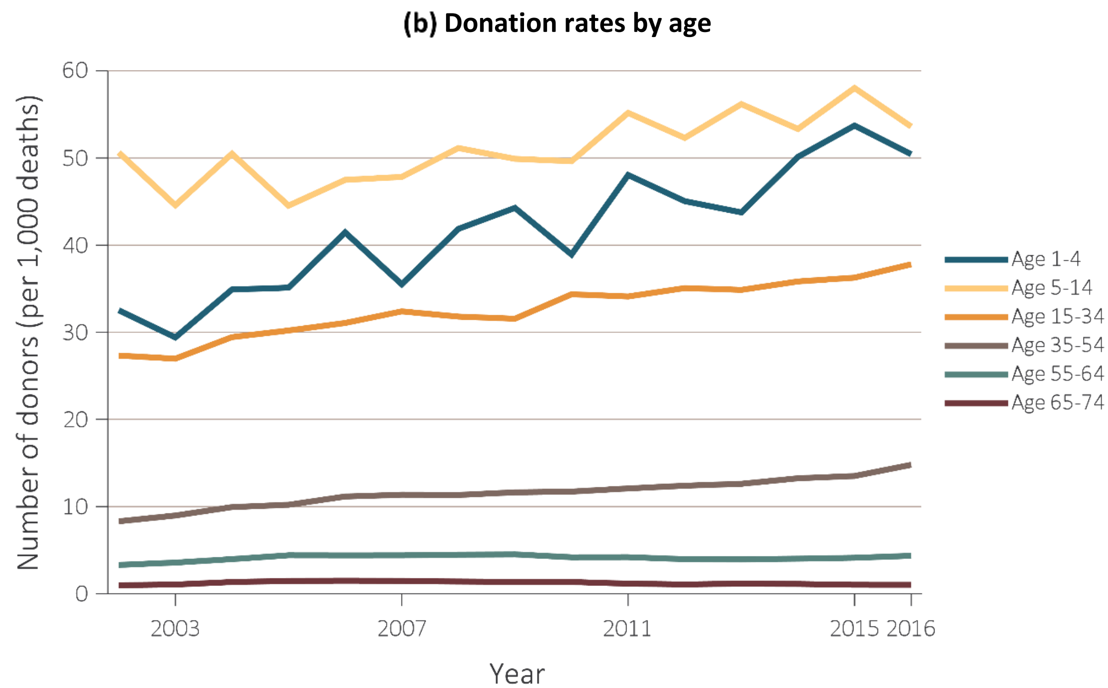
The number of deceased donors, aged 1-74 years, with at least one kidney retrieved increased from 5,981 in 2002 to 9,732 in 2016 (Figure 6.19.a). We do not report on those aged 75 years and older because of the small number of deceased organ donations from this age group. In 2016, among the 19,135 kidneys that were recovered from deceased donors, 3,423 (18%) were discarded for various reasons. During 2012-2016, the percentage of kidneys discarded ranged from 17%-18% (OPTN, 2017).

Since 2002, the number of donors among those aged 1-4, 5-14, and 65-74 years has been relatively stable, but the cohort of those aged 15-34 years has been increasing, particularly over the last five years. Donors aged 35-54 years have been the leading source of kidney donations during the past 15 years, with persons aged 15-34 years being the second highest source, and those aged 55-64 years the third highest.

Annual donation rates are the number of deceased donors with at least one retrieved kidney, per 1,000 deaths in the U.S. population (CDC, 2018). The overall donation rates ranged from 5.8 per 1,000 deaths in 2002 to 7.9 per 1,000 deaths in 2016 (Figure 6.19.b). The highest donation rates were among those aged 5-14 years, reaching 53.6 per 1,000 deaths in 2016, followed by those 15-34 years, from whom donations rose from 27 per 1,000 deaths in 2002 to 38 per 1,000 deaths in 2016.

vol 2 Figure 6.19 Number of deceased kidney donors and unadjusted kidney donation rates, by donor age, 2002-2016



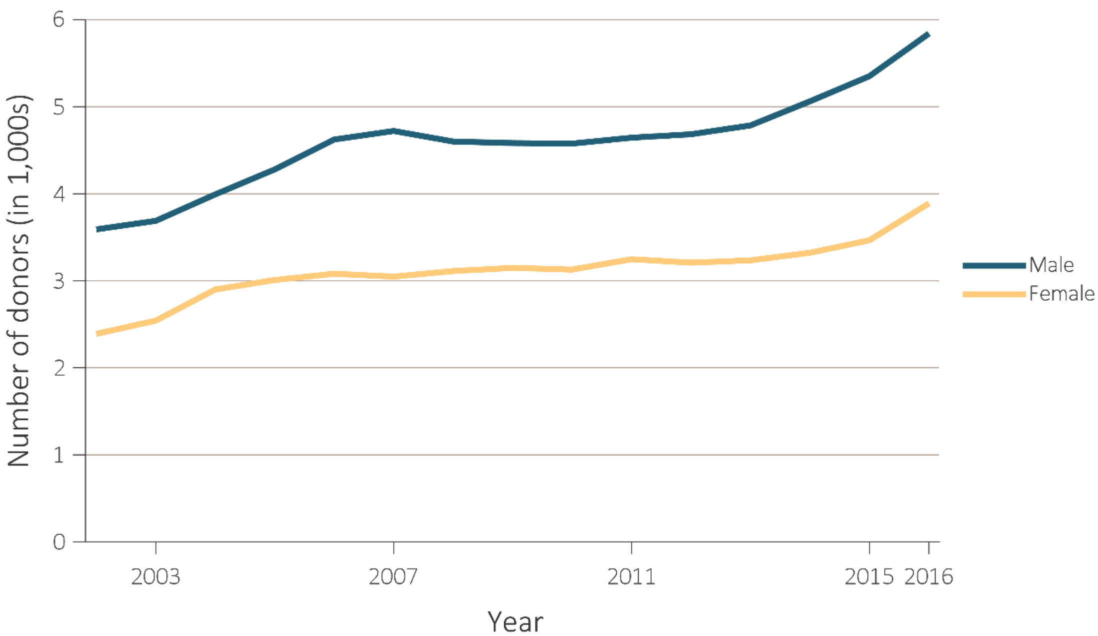


Data Source: Data on the annual number of deaths in the U.S. population are obtained from the Centers for Disease Control and Prevention; the deceased-donor data are obtained from the Organ Procurement and Transplantation Network (OPTN). Deceased-donor kidney donation counts and rates by donor age. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014.

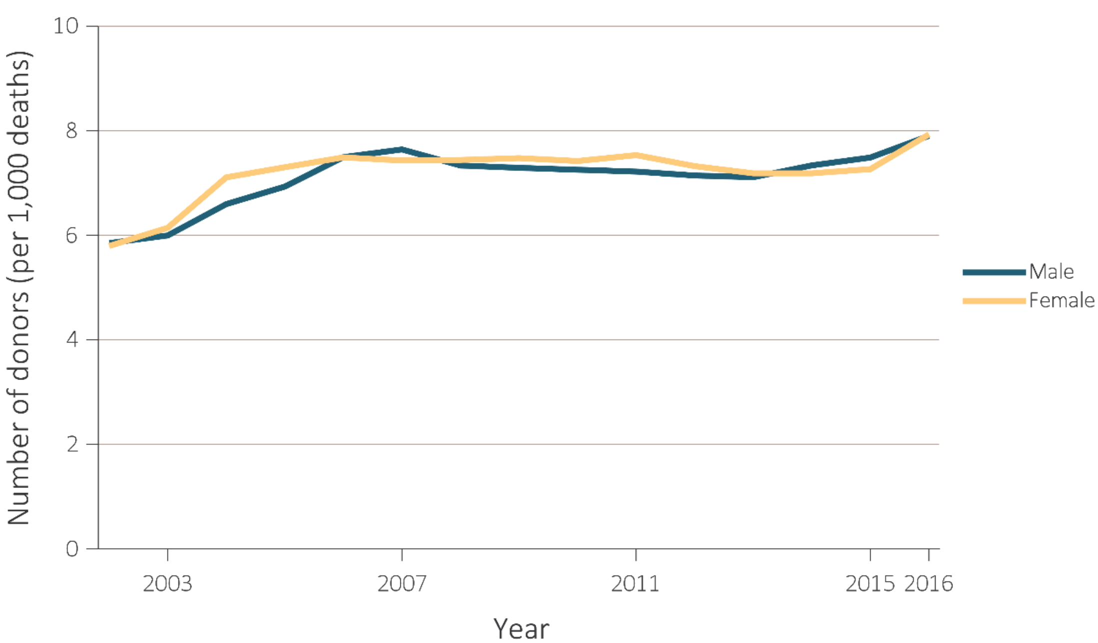
The number of deceased kidney donations by males has consistently been approximately 1.5 times greater than the number from females (Figure 6.20.a). However, the donation rates were similar between males and females (Figure 6.20.b). Both groups have demonstrated an increase in rates of donation, particularly over the last two years.

vol 2 Figure 6.20 Number of deceased kidney donors and unadjusted kidney donation rates, by donor sex, 2002-2016

(a) Number of donors by sex



(b) Donation rates by sex

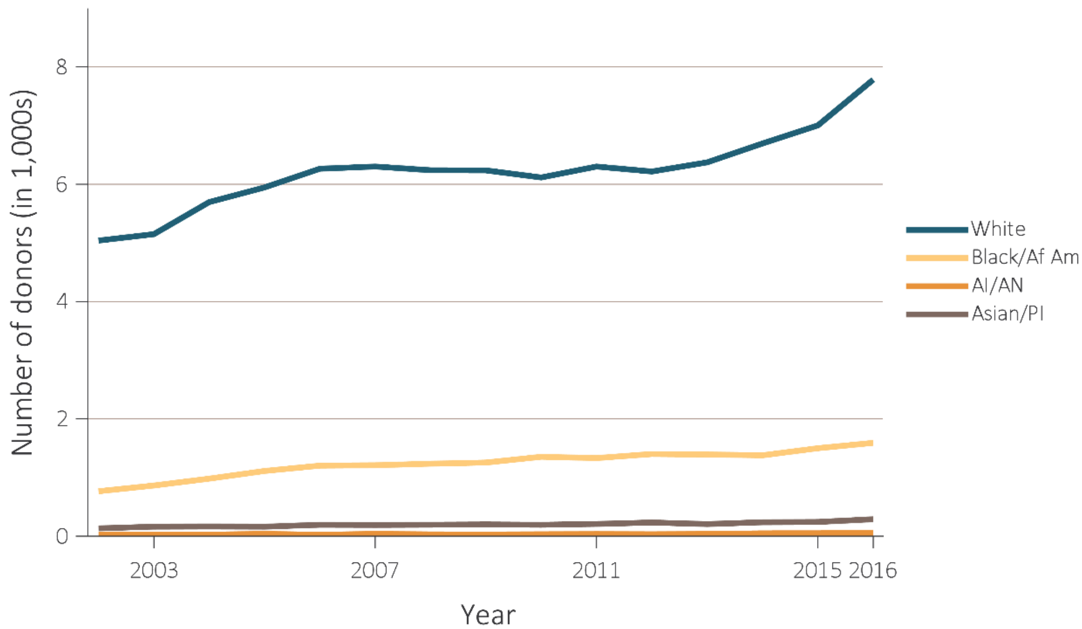


Data Source: Data on the annual number of deaths in the U.S. population are obtained from the Centers for Disease Control and Prevention; the deceased-donor data are obtained from the Organ Procurement and Transplantation Network (OPTN). Deceased-donor kidney donation counts and rates by donor sex. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014.

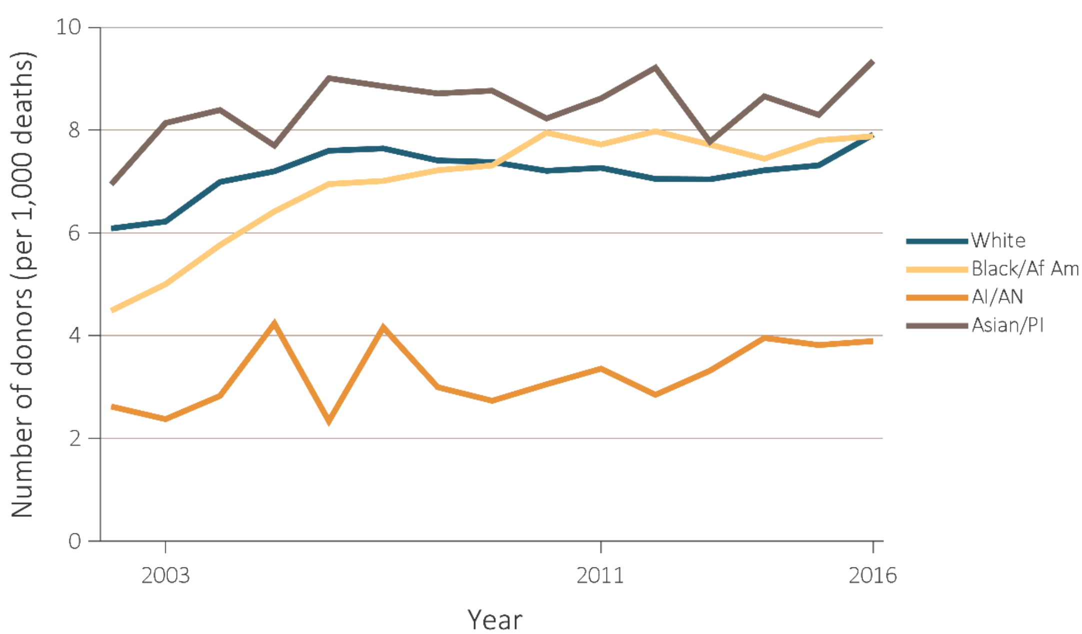
The number and rates of deceased organ donations has also varied by race. White persons have consistently accounted for the greatest absolute number of donations each year from 2002 to 2016 (Figure 6.21.a). The rate of deceased donors per 1,000 deaths among Blacks has almost doubled during this period (Figure 6.21.b), however, with current donation rates being similar among Blacks, Whites, and Asians or Pacific Islanders.

vol 2 Figure 6.21 Number of deceased kidney donors and unadjusted kidney donation rates, by donor race, 2002-2016

(a) Number of donors by race



(b) Donation rates by race



Data Source: The U.S. death population data are obtained from the Centers for Disease Control and Prevention; the deceased-donor data are obtained from the Organ Procurement and Transplantation Network (OPTN). Deceased-donor kidney donation counts and rates by donor race. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014. Abbreviations: AI/AN, American Indian or Alaska Native; Asian/PI, Asian/Pacific Islander; Black/Af Am, Black/African American.

Deceased Donation Counts and Rates among Traumatic Deaths

In this section, we focus on donors who had a traumatic cause of death, such as a motor vehicle accident, suicide, or homicide. Such occurrences represent a common source of donation, as these individuals may be less likely to have underlying health issues that would preclude use of their organs. The number of such donors, aged 1-74 years, with at least one kidney retrieved, has been relatively steady since 2006 (Figure 6.22.a). There were 2,770 such donations in 2016, representing 28% of all deceased donations.

For this specific group, annual donation rates were calculated as the number of deceased donors with a traumatic cause of death (motor vehicle accident, suicide, or homicide) from whom at least one kidney was retrieved, per 1,000 deaths in the U.S. population (CDC, 2018).

As expected, due to the underlying cause of death, donors in the age range of 15-54 years were over-represented, with only small numbers from other age categories (Figure 6.22.a). Donation rates from traumatic deaths were highest among those aged 5-34 years (46 per 1,000 deaths, Figure 6.22.b). In 2016, overall organ donations from those with a traumatic death were 3.9 times the rate of those who died from any cause (28.6 versus 7.3 donations per 1,000 deaths).

vol 2 Figure 6.22 Number of deceased kidney donors and unadjusted kidney donation rates, for traumatic deaths, by donor age, 2002-2016

(a) Number of donors by age

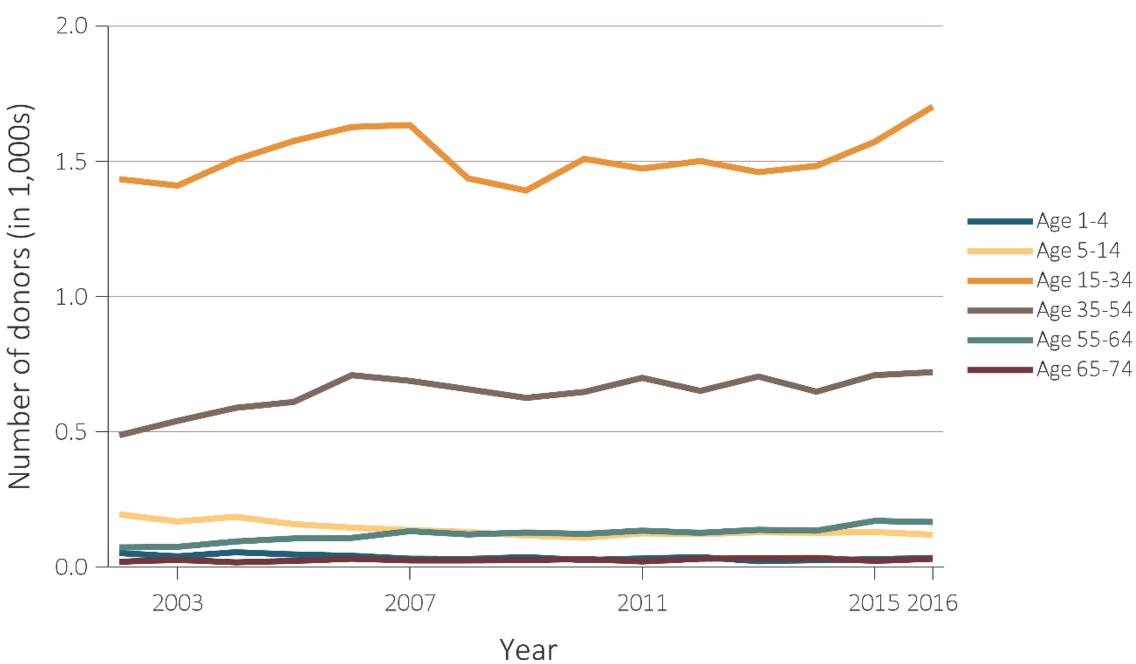
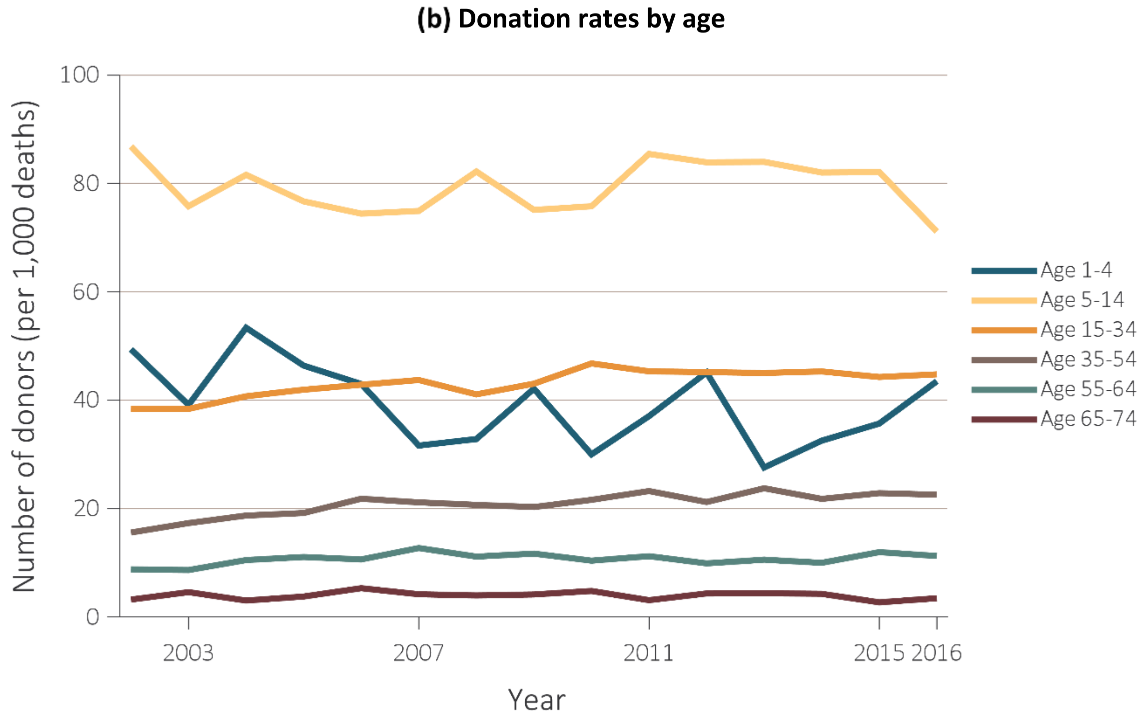


Figure 6.22 continued on next page.

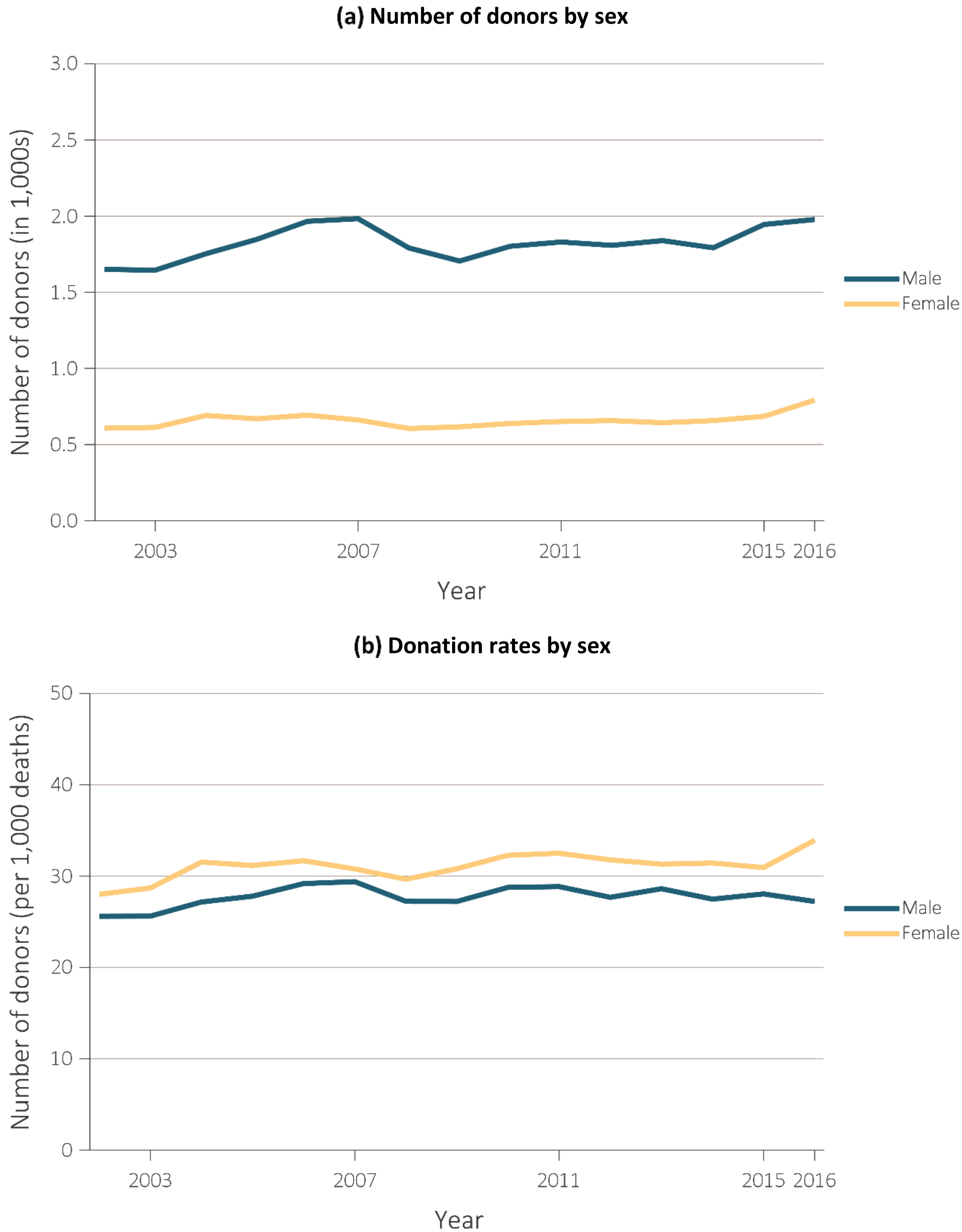
vol 2 Figure 6.22 Number of deceased kidney donors and unadjusted kidney donation rates, for traumatic deaths, by donor age, 2002-2016 (continued)



Data Source: Data on the annual number of deaths in the U.S. population are obtained from the Centers for Disease Control and Prevention; the deceased-donor data are obtained from the Organ Procurement and Transplantation Network (OPTN). Deceased-donor kidney donation counts and rates by donor age. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014.

Within this subgroup of donors, although counts for males have been consistently about double those of females (Figure 6.23.a), donation rates by sex were similar (Figure 6.23.b).

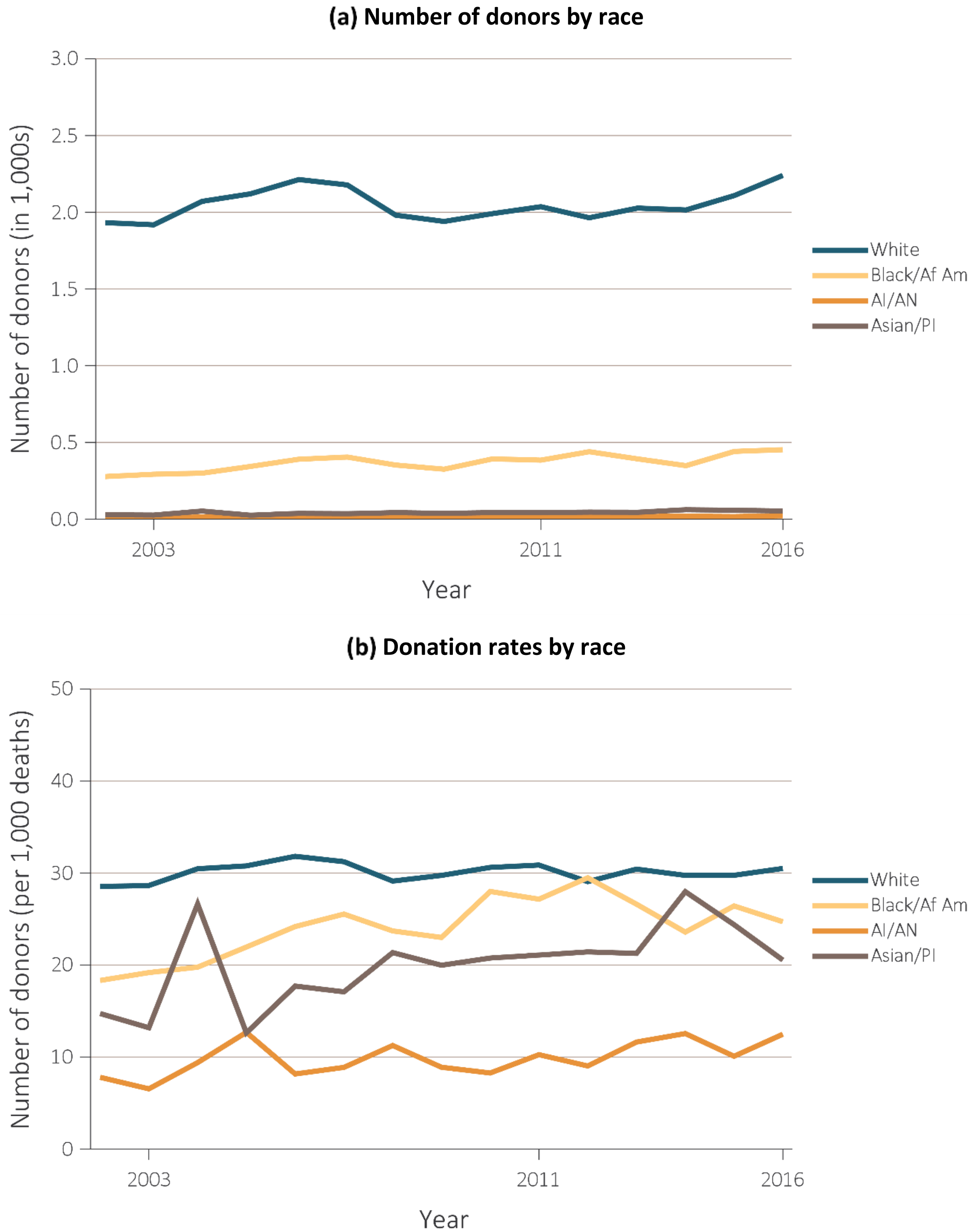
vol 2 Figure 6.23 Number of deceased kidney donors and unadjusted kidney donation rates, for traumatic deaths, by donor sex, 2002-2016



Data Source: Data on the annual number of deaths in the U.S. population are obtained from the Centers for Disease Control and Prevention; the deceased-donor data are obtained from the Organ Procurement and Transplantation Network (OPTN). Deceased-donor kidney donation counts and rates by donor sex. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014.

Whites have contributed most to the absolute number of traumatic deceased donors each year from 2002-2016 (Figure 6.24.a). This was consistent with patterns of all-cause deceased donations and the U.S. racial/ethnic population distribution. Actual rates of donation in the most recent years, however, have been similar for Whites, Blacks, and Asians or Pacific Islanders (Figure 6.24.b).

vol 2 Figure 6.24 Number of deceased kidney donors and unadjusted kidney donation rates, for traumatic deaths, by donor race, 2002-2016



Data Source: The U.S. death population data are obtained from the Centers for Disease Control and Prevention; the deceased-donor data are obtained from the Organ Procurement and Transplantation Network (OPTN). Deceased-donor kidney donation counts and rates by donor race. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014. Abbreviations: AI/AN, American Indian or Alaska Native; Asian/PI, Asian/Pacific Islander; Black/Af Am, Black/African American.

Transplant Outcomes

For more than a decade, there has been a progressive improvement in the health outcomes of kidney transplant recipients. In this section, we review trends in the probability of graft survival (not censored for death) and patient survival, at one, five, and ten years post-transplant.

During 1999-2015, kidney transplant patients generally experienced improved graft outcomes (Figure 6.25). It has frequently been stated that improvements in short-term (one-year) graft survival have not been accompanied by improvements in longer term outcomes. However, for the most recent years available, improvements in long-term (five- and ten-year) survival, although not contemporaneous, have been similar to improvements in short-term graft survival. Among the recipients of deceased-donor kidney transplants, the 2015 probability of one-year graft survival was 93%, improved from 87% in 1999. The 2011 probability of five-year graft survival for deceased-donor kidney transplants was 75%, improved from 66% in 1999. The 2006 probability of ten-year graft survival for deceased-donor kidney transplants was 48%, improved from 44% in 1999. Similar patterns of improvement over time are evident for living-donor kidney transplants, though across the board outcomes are better than for deceased-donor transplants. For the most recent years of data available, the probability of graft survival for living-donor transplants was 98%, 85%, and 65%, for one-, five-, and ten-year periods post-transplant, respectively.

vol 2 Figure 6.25 Trends in 1-, 5-, & 10-year kidney transplant graft survival, 1999-2015

(a) Deceased donor

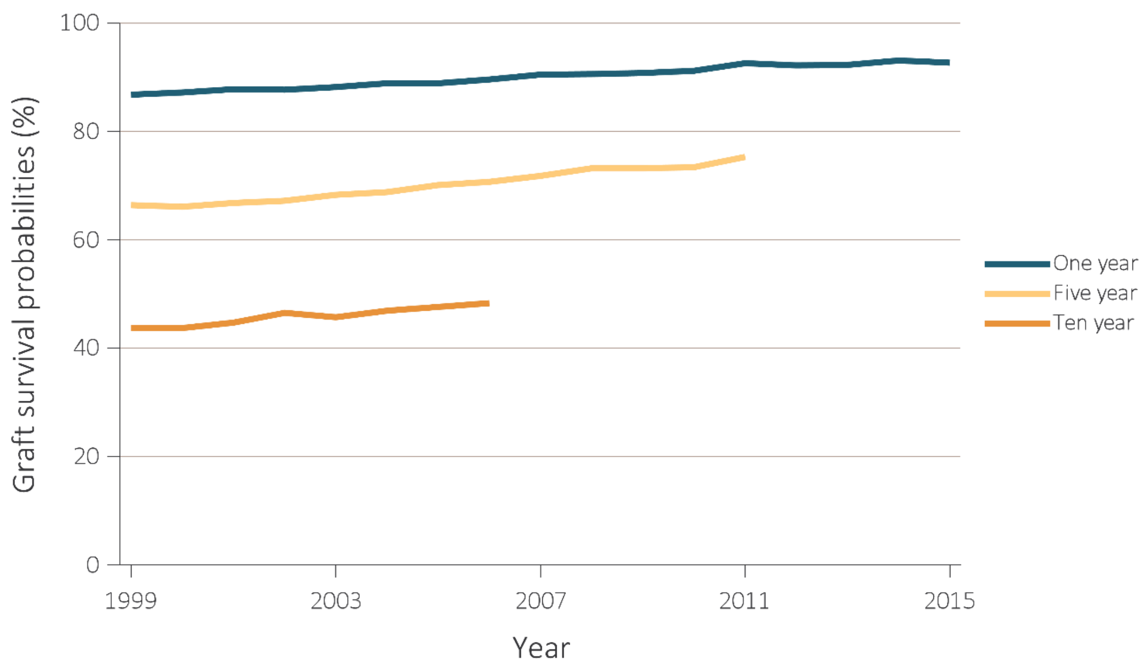
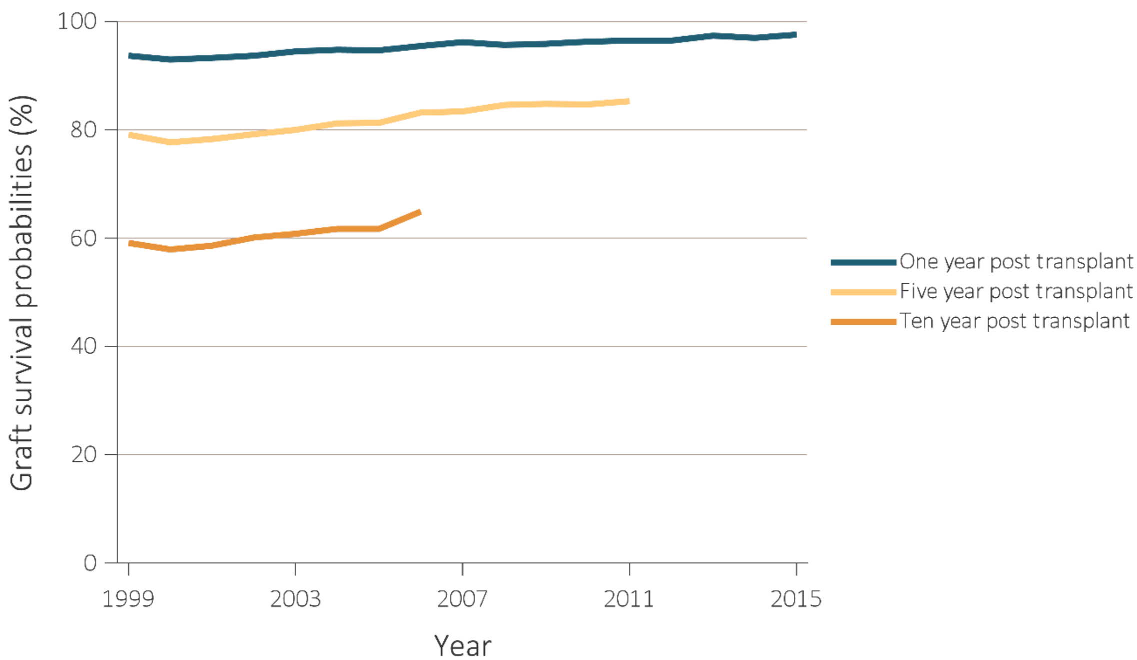


Figure 6.25 continued on next page.

vol 2 Figure 6.25 Trends in 1-, 5-, & 10-year kidney transplant graft survival, 1999-2015 (continued)

(b) Living donor

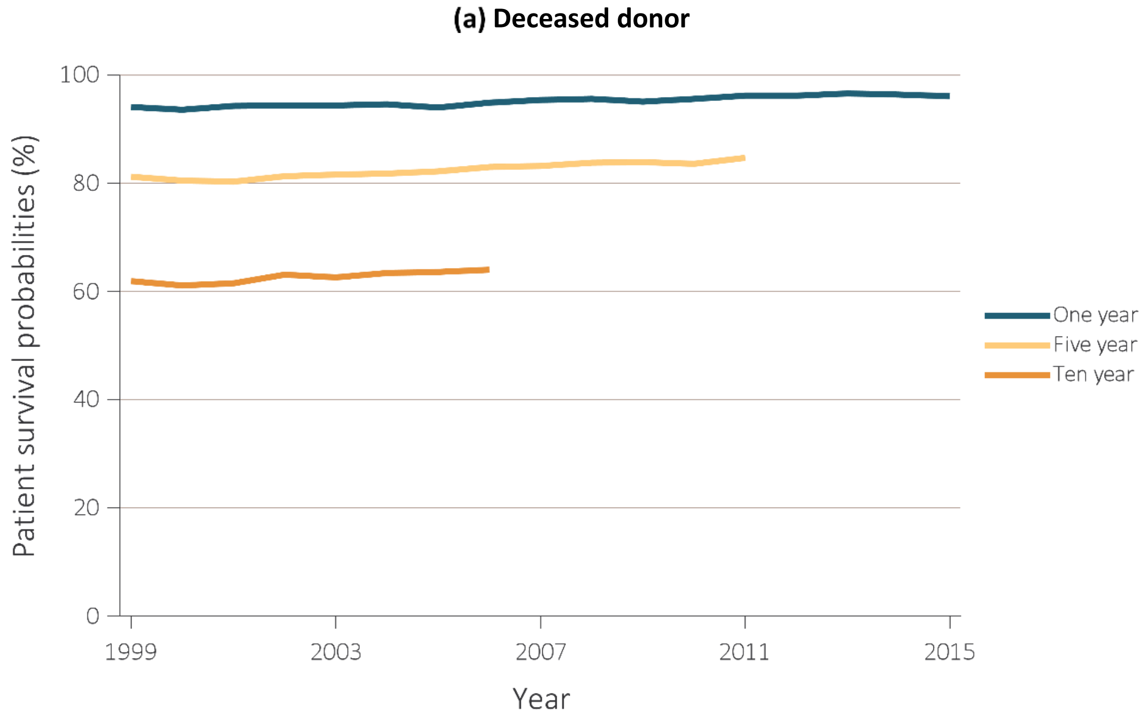


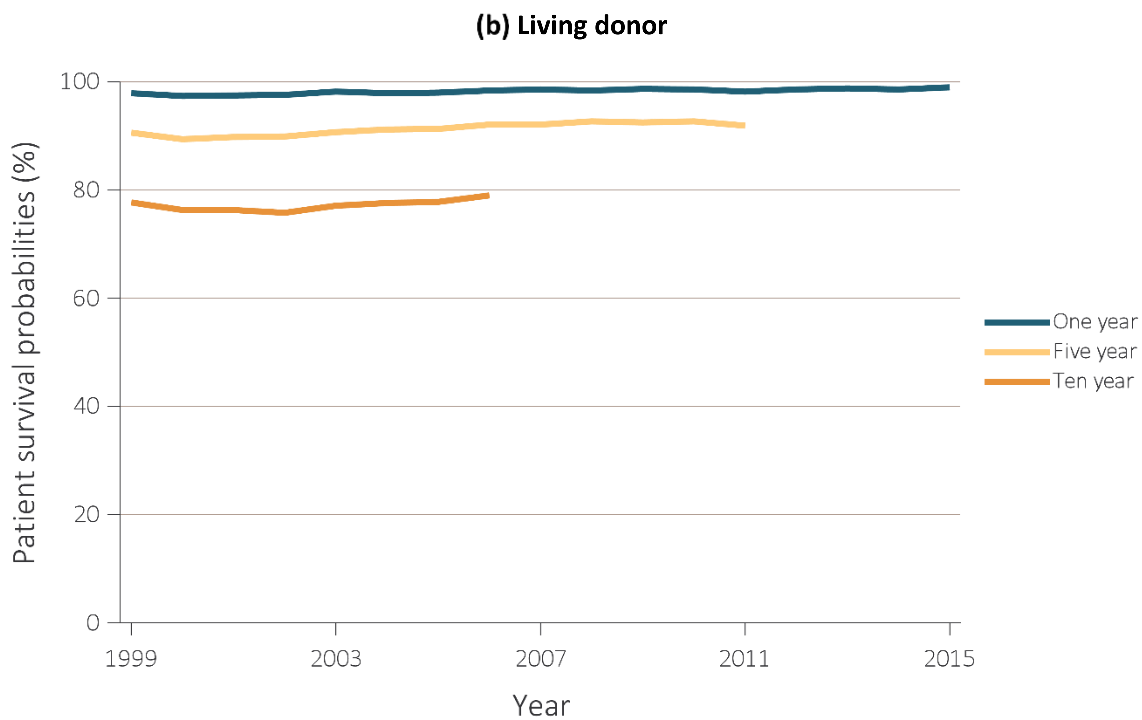
Data Source: Reference Tables F.2, F.14, F.5, F.17, F.6, F.18. Outcomes among recipients of a first-time deceased-donor kidney transplant, unadjusted. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014.

With respect to patient survival, there has also been an overall improvement in outcomes over time although more modest, and not as consistent, when compared to changes in graft survival (Figure 6.26). Among the recipients of deceased-donor kidney transplants, the 2015 probability of one-year patient survival was 96%, improved from 94% in 1999. The 2011 probability of five-year patient survival for deceased-donor kidney transplants was 85%, improved from 81% in 1999. The 2006 probability of ten-year graft survival for deceased-donor kidney transplants was 64%, improved from 62% in 1999. Similar patterns of improvement over time are evident for living-donor kidney transplants, though across the board outcomes are better than for deceased-donor transplants. For the most recent years of data available, the probability of graft survival for living-donor transplants was 99%, 92%, and 79%, for one-, five- and ten-year periods post-transplant, respectively.

Overall, outcomes have been consistently more advantageous for living-donor kidney transplant recipients in comparison to deceased-donor transplant recipients. Dissemination of information on the advantages of living-donor kidney transplant is a valuable component of informed decision-making and transplant education, for both recipients and potential organ donors.

vol 2 Figure 6.26 Trends in 1-, 5-, & 10-year kidney transplant patient survival, 1999-2015





Data Source: Reference Tables I.26, I.29, I.30, I.32, I.35, I.36. Survival probabilities among recipients of a first-time living-donor kidney transplant, unadjusted. Note that trends may be influenced by changes to the kidney allocation system (KAS) policy that were implemented in December 2014.

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