Chapter 7: Transplantation

- 17,914 kidney transplants were performed in the United States in 2014 (17,205 were kidney-alone) (Figure 7.3).
- Less than one-third of kidneys transplanted in 2014 were from living donors (Figure 7.3).
- From 2013 to 2014, the cumulative number of recipients with a functioning kidney transplant increased 2.9% to a total of 200,907 (Figure 7.4).
- On December 31, 2014, the kidney transplant waiting list had 88,231 candidates (dialysis patients only) with 50,692 active candidates. 83% of all candidates were awaiting their first transplant (Figure 7.2).
- Among candidates newly wait-listed for either a first-time or repeat kidney-alone transplant (living or deceased donor) in 2009, the median waiting time to transplant was 3.5 years (Figure 7.2). The waiting time among newly wait-listed candidates varies greatly by region of the country, from a low of 0.8 years in Utah to a high of 5.6 years in Mississippi (Reference Table E.2.2).
- The number of deceased kidney donors has risen from 6,231 in 2003 to 8,385 in 2014.
- The rate of donation among deceased Blacks/African Americans more than doubled from the year 2000 (4 donations/1,000 deaths) to 2014 (8 donations/1,000 deaths) (Figure 7.18.b).
- 16% of kidneys recovered from deceased donors were discarded in 2014, which has been stable since 2010.
- The counts of KPD transplants has risen sharply in recent years, with 552 performed in 2014, representing 10% of living donor transplants that year (Figure 7.15).
- In 2013, the probability of one-year graft survival was 92% and 97% for deceased and living donor kidney transplant recipients, respectively (Tables 7.3 and 7.4).
- The probability of patient survival within one year post-transplant was 96% and 99% in deceased and living donor kidney transplant recipients, respectively, in 2013 (Tables 7.3 and 7.4).
- Since 1997, the probabilities of graft survival and patient survival have steadily improved among recipients of both living and deceased donor kidney transplants (Tables 7.3 and 7.4).
- The one-year graft survival and patient survival advantage experienced by living donor transplant recipients persists at five and ten years post-transplant (Table 7.4).

Introduction

Kidney transplantation is the renal replacement therapy of choice for a 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. In addition, to further enhance our understanding of the donor pool, this year we report the trends and epidemiology of deceased kidney donations among deaths of all causes and traumatic deaths over the years.

Notably, there was a major overhaul of the kidney allocation system (KAS) that took effect on December 4, 2014, with the purpose 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

changes included: (1) a move to the more refined donor quality metric, the Kidney Donor Profile Index (KDPI) in place of the previous categories of standard criteria or extended criteria donors; (2) the calculation of an Expected Post-Transplant Survival (EPTS) score for all adult kidney candidates with preferential allocation of donor kidneys with the best KDPI scores of 20% or less to candidates with the best EPTS scores of 20% or less; (3) increased priority for sensitized candidates through a sliding scale point system based on calculated panel reactive antibodies (PRA); and (4) inclusion of pre-waiting list dialysis time in a candidate's waiting time (Organ Procurement and Transplantation Network [OPTN], Health Resources and Services Administration, U.S. Department of Health & Human Services, 2015). As this year's chapter only includes data through the end of 2014, we do not yet examine the potential effects of the new allocation policy. However, OPTN reports that the KAS has resulted in a bolus of transplants in highly sensitized patients and those with more than a decade of dialysis, with similar 6-month graft survival (Stewart et al., 2016). Not surprisingly, kidneys are being shipped over greater distances and the occurrence of delayed graft function has increased. The full impact of the allocation policy will be an increasing focus of this chapter in future Annual Data Reports.

Methods

This chapter uses multiple data sources including data from the Centers for Medicare & Medicaid Services (CMS), OPTN, the Centers for Disease Control and Prevention (CDC), and the U.S. Census. Details of data sources are described in the Data Sources section of the *ESRD Analytical Methods* chapter.

See the section on Chapter 7 in the *ESRD Analytical Methods* chapter for an explanation of analytical methods used to generate the figures and tables in this chapter.

Overview

During the year 2014, 17,914 kidney transplants, including 17,205 kidney-alone and 709 kidney plus at least one additional organ, were performed in the United States. Of these transplants, 5,574 were identified as coming from living donors and 12,328 from deceased donors. Overall, there were 145 (1%) more kidney transplants in the United States in 2014 than in 2013. Although the number of kidney transplants has, in general, remained stable since 2005, ranging from a high of 18,166 in 2006, to a low of 17,405 in 2012, the cumulative number of recipients living with a functioning kidney transplant continues to grow, reaching 200,907 in 2014, a 2.9% increase over 2013.

As of December 31, 2014, the kidney transplant waiting list increased by 3% over the previous year to 88,231 candidates (dialysis patients only), 83% of which were awaiting their first kidney transplant. Fifty-seven percent (50,692) of wait-listed candidates were in active status and 43% (37,539) were inactive. With less than 18,000 kidney transplants performed in 2014, the active waiting list was 2.8 times larger than the supply of donor kidneys, which presents a continuing challenge. An additional 15,498 (15%) of patients not yet on dialysis were on the waiting list as of December 31, 2014.

Among incident ESRD patients who started their dialysis in 2013, 12% were added to the waiting list or received a deceased or living donor transplant within one year of ESRD initiation. Among candidates newly wait-listed for either a first-time or repeat kidney-alone transplant in 2009, the median waiting time to transplant (deceased or living donor) was 3.5 years, i.e., 50% of patients had received a transplant within 3.5 years after being wait-listed for a transplant.

The probability of one-year graft survival for deceased donor kidney transplant recipients in 2013 was 92%, unchanged from 2012. Analyzing the separate components of graft failure, the probability of either returning to dialysis or undergoing repeat transplantation was 5%, while that of death was 4%. The probability of one-year graft survival for living donor transplant recipients was 97%. Analyzing the separate components of graft failure, the probability of either returning to dialysis or undergoing repeat transplantation was 2% and that of death was 1%.

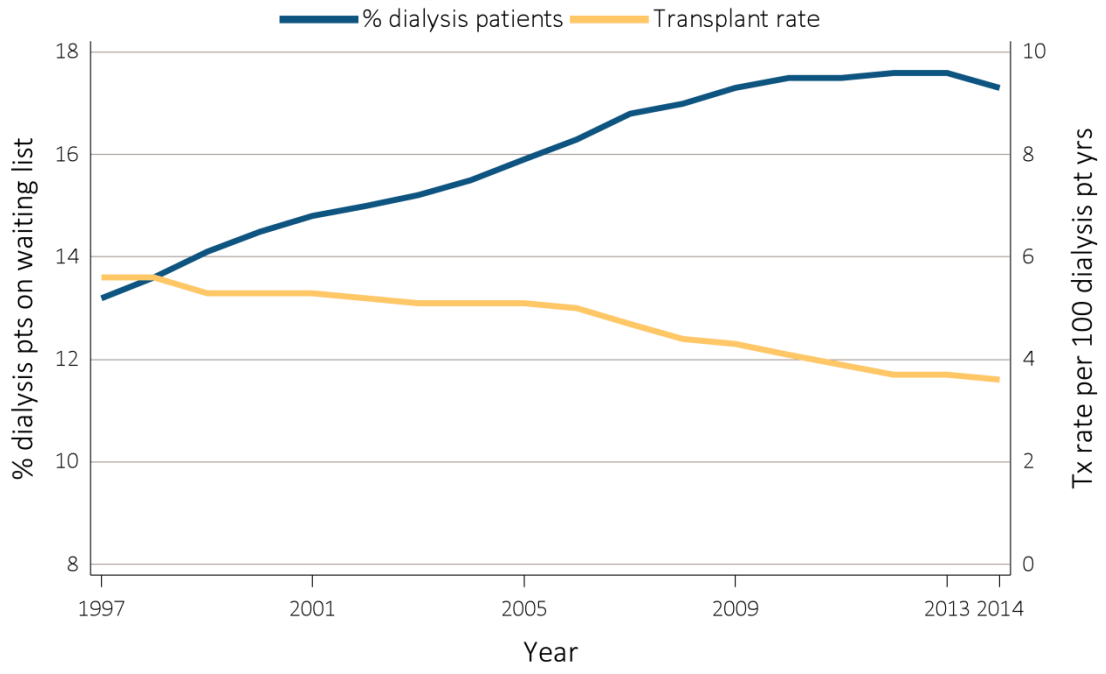
For recipients of deceased donor transplants in 2009, the probability of five-year graft survival remained unchanged from the prior year at 73%. Five-

year graft survival for living donor transplant

The unadjusted transplant rate per 100 dialysis patient years has been falling, while the percentage of prevalent dialysis patients wait-listed for a kidney has risen, though it appears to have plateaued in recent years (Figure 7.1). Probable contributing causes include a higher prevalent dialysis population, longer survival of ESRD patients on dialysis, and the growing imbalance between donor supply and demand, which in turn leads to longer kidney transplant waiting times. Waiting list counts and median waiting time to transplantation continue to grow for first-time listings (Figure 7.2). The number of candidates on the waiting list for repeat kidney transplant has plateaued at approximately 14,700 over the last five years, accounting for about 17% of the total wait-listed candidates. The median waiting time to transplantation (deceased or living donor) for first-time listings was 3.4 years in 2009, 11 months shorter than that for candidates listed for repeat transplants. Table 7.1 presents median waiting times over time, stratified by blood type and PRA at time of listing. Patients with blood types B and O have the longest waiting times. As expected, patients with higher PRA tend to have longer waiting times, although waiting times have been dropping over time in those with the highest levels of sensitization (PRA of 80% or greater). In addition to variations in waiting time as a function of blood type and level of sensitization, there are also large regional differences (Reference Table E.2.2). Two states (Louisiana and Mississippi) have waiting times in excess of five years. Eleven states have waiting times less than two years with the lowest times in Utah (0.8 years), Maine (1.2 years), and Iowa (1.3 years). The total number of kidney transplants has leveled off over the past decade (Figure 7.3). During this period, a modest rise in deceased donor kidney transplants has been balanced by a small decrease in living donor transplants. As noted above, the total number of recipients with functioning kidney transplants continues to grow (Figure 7.4).

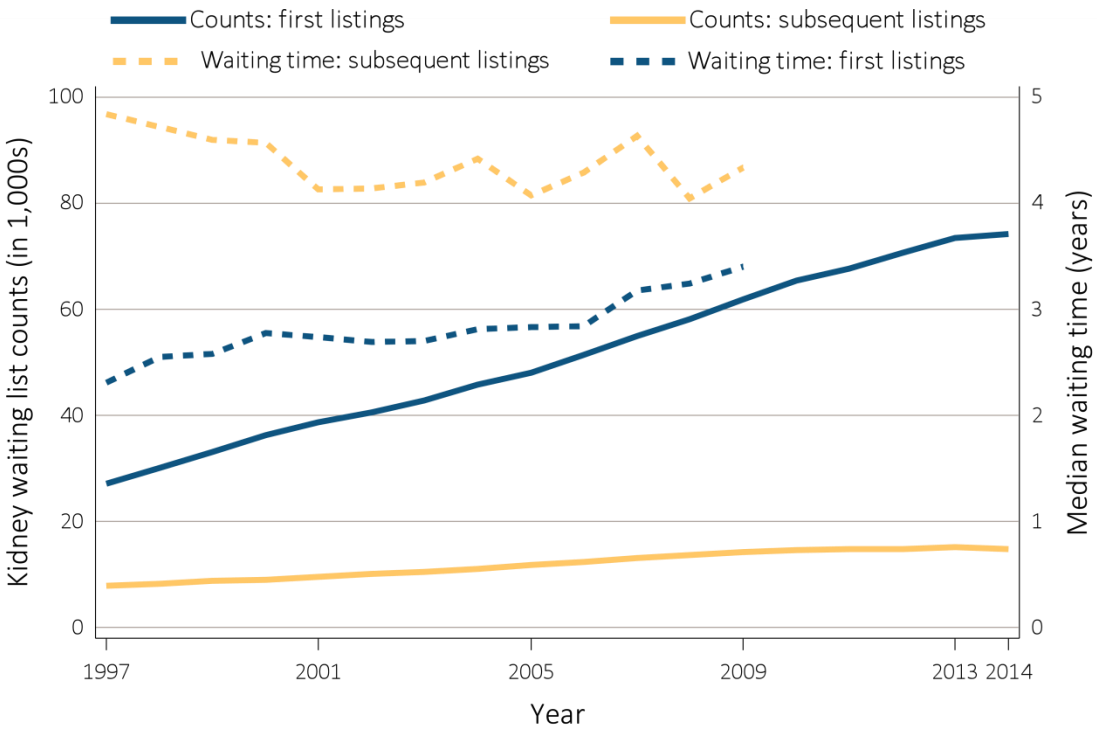
recipients also remained unchanged at 85%.

vol 2 Figure 7.1 Percentage of dialysis patients wait-listed and unadjusted kidney transplant rates, 1997-2014



Data Source: Reference Tables E.4 and E.9. Percentage of dialysis patients on the kidney waiting list is for all dialysis patients. Unadjusted transplant rates are for all dialysis patients. Abbreviations: Tx, transplant; pt yrs, patient years.

vol 2 Figure 7.2 Number of patients wait-listed for kidney transplant, 1997-2014, and median waiting time, 1997-2009



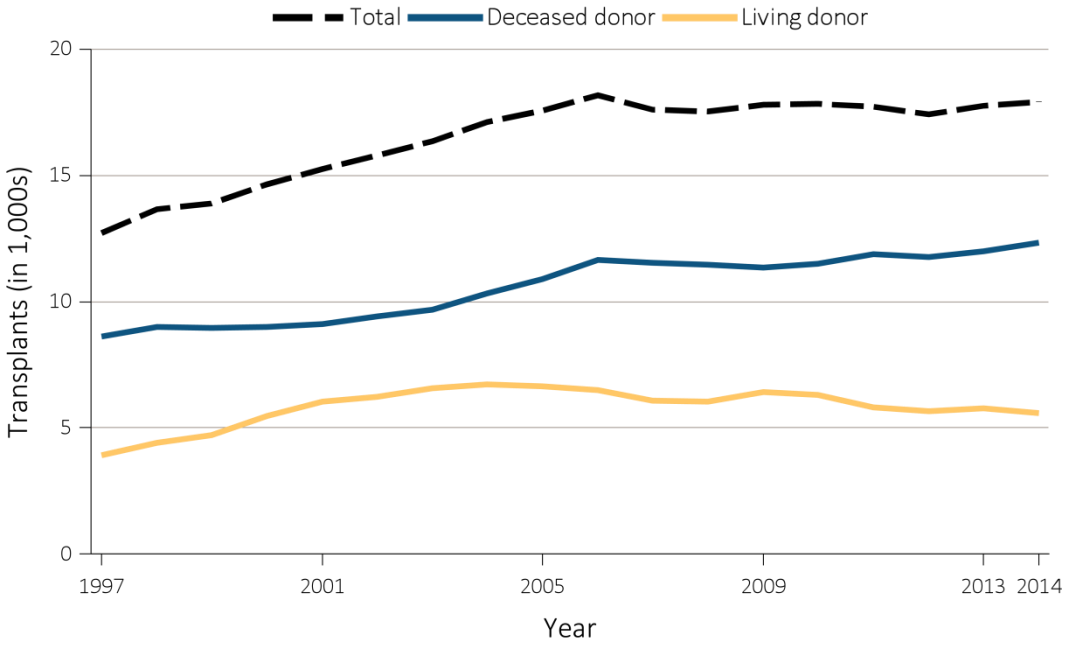
Data Source: Reference Tables E.2 and E.3. Waiting list counts include all candidates listed for a kidney transplant on December 31 of each year. Median waiting time is calculated for all candidates enrolled on the waiting list in a given year.

vol 2 Table 7.1 Median waiting time (in year) for kidney transplant, by blood type and PRA, 1997-2009

Blood type	PRA	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Blood type A	PRA = 0	1.0	1.1	1.1	1.4	1.2	1.3	1.3	1.3	1.2	1.4	1.8	1.8	2.0
	0 < PRA =< 20%	1.7	2.0	2.0	2.0	2.1	2.1	2.1	2.0	1.6	1.7	2.1	2.7	3.1
	20% < PRA =< 80%	3.3	3.1	2.9	2.8	3.0	3.2	2.6	2.8	2.9	3.0	2.8	2.5	3.0
	80% < PRA < 100%	6.2	5.2	6.4	5.6	4.6	4.7	5.1	5.1	3.9	3.8	4.9	3.2	3.4
Blood type B	PRA = 0	2.1	2.7	2.7	3.2	2.9	2.8	3.2	2.5	2.8	3.2	3.3	3.4	3.6
	0 < PRA =< 20%	3.6	3.7	4.1	4.2	4.0	4.1	3.4	3.3	3.8	3.9	3.7	4.4	5.2
	20% < PRA =< 80%	4.9	5.7	5.0	5.3	6.0	5.5	4.9	5.6	5.4	5.2	5.0	4.9	4.4
	80% < PRA < 100%	16.6	7.8	7.6	11.7	8.8	10.0	8.2	7.9	7.0	8.6	7.0	^	^
Blood type AB	PRA = 0	0.5	0.7	0.7	0.8	0.8	0.8	0.9	1.0	0.7	0.8	1.0	0.9	1.2
	0 < PRA =< 20%	0.9	1.1	1.1	1.0	1.3	1.3	1.4	1.1	1.1	1.0	1.1	1.8	2.6
	20% < PRA =< 80%	2.3	2.1	2.5	2.5	2.2	2.0	1.5	2.2	1.8	1.7	2.3	1.8	1.9
	80% < PRA < 100%	^	4.1	6.3	4.1	5.2	2.8	2.7	3.5	4.3	2.9	3.2	3.4	3.4
Blood type O	PRA = 0	2.0	2.2	2.3	2.4	2.4	2.4	2.4	2.7	2.8	2.9	3.6	3.7	3.8
	0 < PRA =< 20%	3.2	3.1	3.3	3.5	3.5	3.6	3.3	3.4	3.4	3.3	3.9	5.1	^
	20% < PRA =< 80%	4.8	4.8	4.8	4.8	4.9	4.5	4.2	4.5	4.3	4.2	4.2	4.7	4.4
	80% < PRA < 100%	5.0	6.6	6.0	6.6	6.5	6.2	5.8	5.9	6.0	5.0	6.9	4.8	4.1

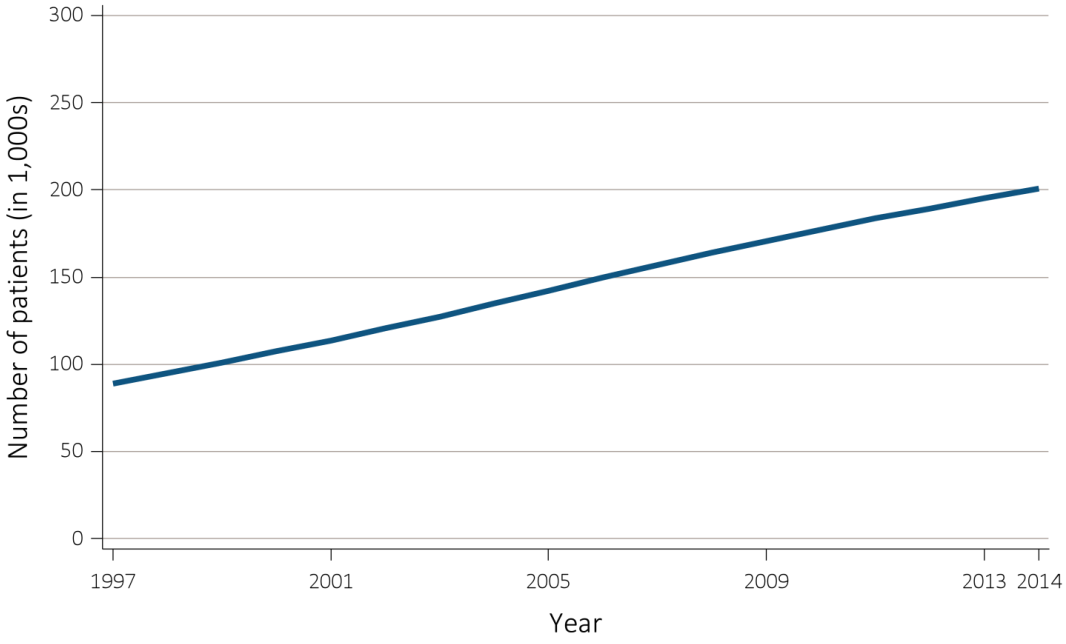
Data Source: Special analyses, USRDS ESRD Database. Abbreviation: PRA, panel reactive antibodies. ^ Value is missing since the estimated survival probability has not reached 50% and the corresponding data for that group were not sufficient to estimate median waiting time.

vol 2 Figure 7.3 Number of kidney transplants by donor type, 1997-2014



Data Source: Reference Tables E.8, E.8(2), and E.8(3). Counts of all transplants by year.

vol 2 Figure 7.4 Number of patients with a functioning kidney transplant, 1997-2014

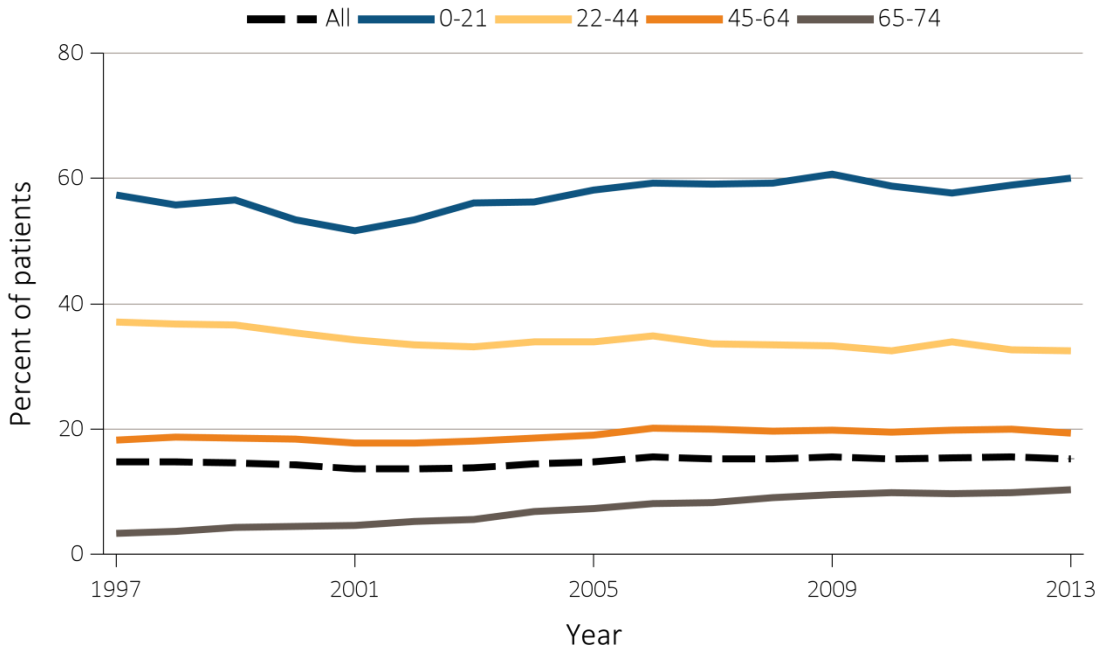


Data Source: Reference Table D.9. Prevalent counts of patients with a functioning kidney transplant as of December 31 of each year.

Kidney Transplant Waiting List

The percentage of patients wait-listed or receiving a transplant in their first ESRD-year has declined for those between the ages of 22 and 44 years, but has increased steadily since 2001 among those patients aged 0-21 years (Figure 7.5). There has been a consistent increase over time in the percentage of patients aged 65-74 years being wait-listed or receiving a kidney transplant within one year of ESRD initiation. However, older patients continue to comprise a minority of those being wait-listed or transplanted within one year of ESRD initiation.

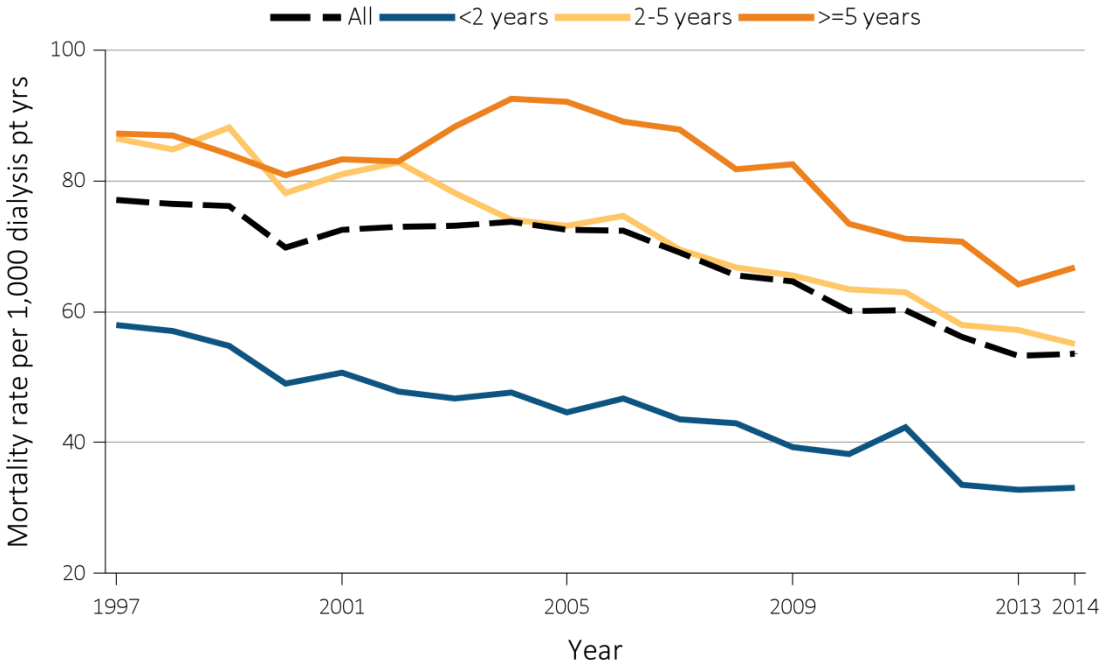
vol 2 Figure 7.5 Percentage of incident patients being wait-listed or receiving a kidney transplant within one year of ESRD initiation, by age, 1997-2013



Data Source: Reference Table E.5(2). Waiting list or transplantation among incident ESRD patients by age (0-74 years). Abbreviation: ESRD, end-stage renal disease.

There has been a 27% relative decline in the overall mortality rate for dialysis patients on the kidney transplant waiting list since 2004, likely reflecting similar trends observed in the overall dialysis population (Figure 7.6).

vol 2 Figure 7.6 Annual mortality rates for dialysis patients on the kidney transplant waiting list by time on the list, 1997-2014



Data Source: Reference Table H.6. Annual mortality rates of dialysis patients on the kidney transplant waiting list per 1,000 dialysis patient years at risk, by patient vintage. Abbreviation: pt yrs, patient years.

Transplant Counts and Rates

The overall number of annual kidney transplants has remained relatively stable since 2005, ranging from a high of 18,166 in 2006, to a low of 17,405 in 2012. However, as the dialysis population has expanded, the annual transplant rate among these dialysis patients has seen a continuous decline (Table 7.2). During 2005-2014, this trend was more pronounced in those aged 22-44 and 45-64 years. This decline is noticeable in both males and females, and across all racial groups and causes of ESRD. In subsequent sections, counts and rates of transplants are presented separately for deceased versus living donor sources as the trends differ substantially for certain subgroups. Most notably, transplant rates for ages 0-21 years have declined for living donor sources over the last decade but increased for deceased donor sources, resulting in overall stable transplant rates in recent years.

vol 2 Table 7.2 Unadjusted kidney transplant rates, all donor types, by age, sex, race, and primary cause of ESRD, per 100 dialysis patient years, 2005-2014

Age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
0-21	36.2	37	31.6	31.9	34.4	32.5	31.1	31.9	31	32.1
22-44	11.3	11	10.2	9.3	9.3	8.7	8.3	8.1	7.8	7.7
45-64	6.0	6.0	5.6	5.3	5.1	5.0	4.7	4.4	4.4	4.3
65-74	2.6	2.7	2.5	2.6	2.6	2.6	2.6	2.5	2.5	2.4
75 and up	0.3	0.3	0.4	0.3	0.4	0.4	0.4	0.4	0.3	0.4
Sex										
Male	5.6	5.6	5.2	4.9	4.7	4.5	4.3	4.0	4.0	3.9
Female	4.5	4.3	4.1	3.9	3.9	3.7	3.5	3.3	3.3	3.2
Race										
White	6.2	6.0	5.6	5.2	5.1	4.7	4.5	4.4	4.3	4.1
Black/African American	3.3	3.3	3.1	2.9	3.0	3.0	2.9	2.6	2.5	2.5
Native American	3.3	4.0	3.0	3.6	3.7	2.9	3.0	2.5	2.3	2.7
Asian	5.6	5.4	4.8	5.0	4.7	4.6	4.3	4.2	4.3	4.2
Primary Cause of ESRD										
Diabetes	3.4	3.2	3.1	2.9	2.8	2.6	2.5	2.3	2.3	2.2
Hypertension	3.2	3.2	3.1	3.0	2.9	2.8	2.6	2.6	2.5	2.5
Glomerulonephritis	9.8	10.1	9.1	8.8	8.7	8.8	8.3	7.9	7.8	7.6
All	5.1	5.0	4.7	4.4	4.3	4.1	3.9	3.7	3.7	3.6

Data Source: Reference Table E.9. Abbreviation: ESRD, end-stage renal disease.

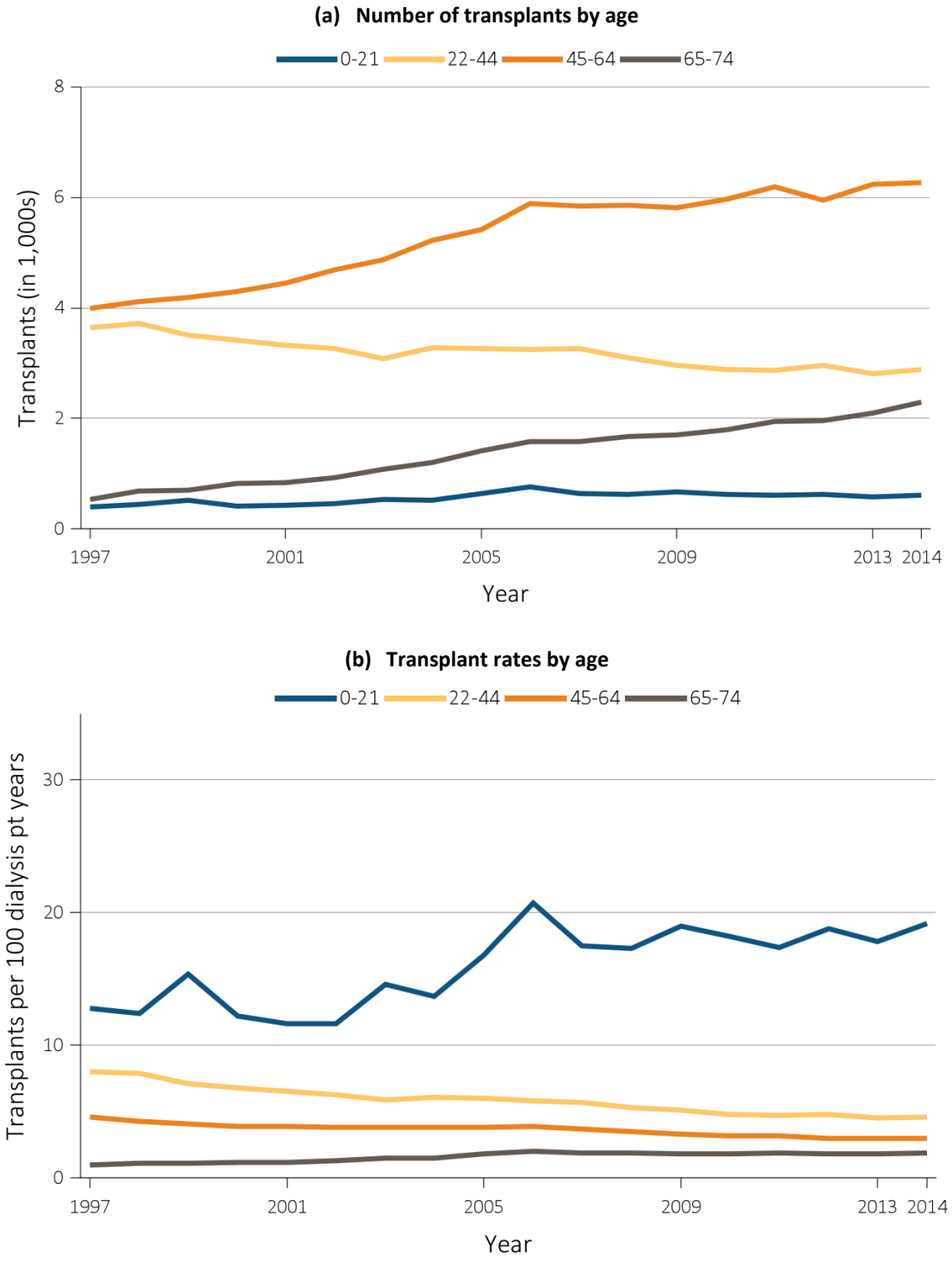
COUNTS AND RATES OF DECEASED DONOR TRANSPLANTS

The overall number of deceased donor transplants has leveled off since 2007 (Figure 7.3). In this section, we review trends in counts and rates of deceased donor transplants by age, sex, race, and primary cause of ESRD (Figures 7.7-7.10). As a general trend, while there are often increased transplant numbers (counts), there are decreased transplant rates, likely due to stagnation in the numbers of both deceased donor and living donor kidneys available for transplant coupled with a growing waiting list.

For patients aged 45-64 and 65-74 years, the number of deceased donor transplant recipients has continued to increase throughout the past two decades, although less markedly since 2006. The counts were highest for recipients aged 45-64 years, reaching 6,265 in 2014 (Figure 7.7.a, Number of transplants by age). In contrast, during this same time period, the number of deceased donor transplant recipients has decreased steadily to 2,886 for those aged 22-44 years.

Counts and rates of deceased donor transplantation per 100 dialysis patient years are presented in Figure 7.7 by age categories without statistical adjustment. The patterns for deceased donor transplant counts in Figure 7.7.a versus rates in 7.7.b look very different, as the number of dialysis patients varies, and increases markedly with age. Due to the small denominator for children on dialysis, and the pediatric allocation priority for kidneys from deceased donors under the age of 35 years, deceased donor transplant rates are highest in children (<22 years old); their rates increased in 2005-2007, stabilizing thereafter. While there has been a reduction in deceased donor kidney transplantation rates for those aged 22-44 and 45-64 years, the rates for those aged 65-74 years have stabilized at low levels.

vol 2 Figure 7.7 Number of deceased donor transplants and unadjusted transplant rates among deceased donor kidney recipients, by recipient age, 1997-2014



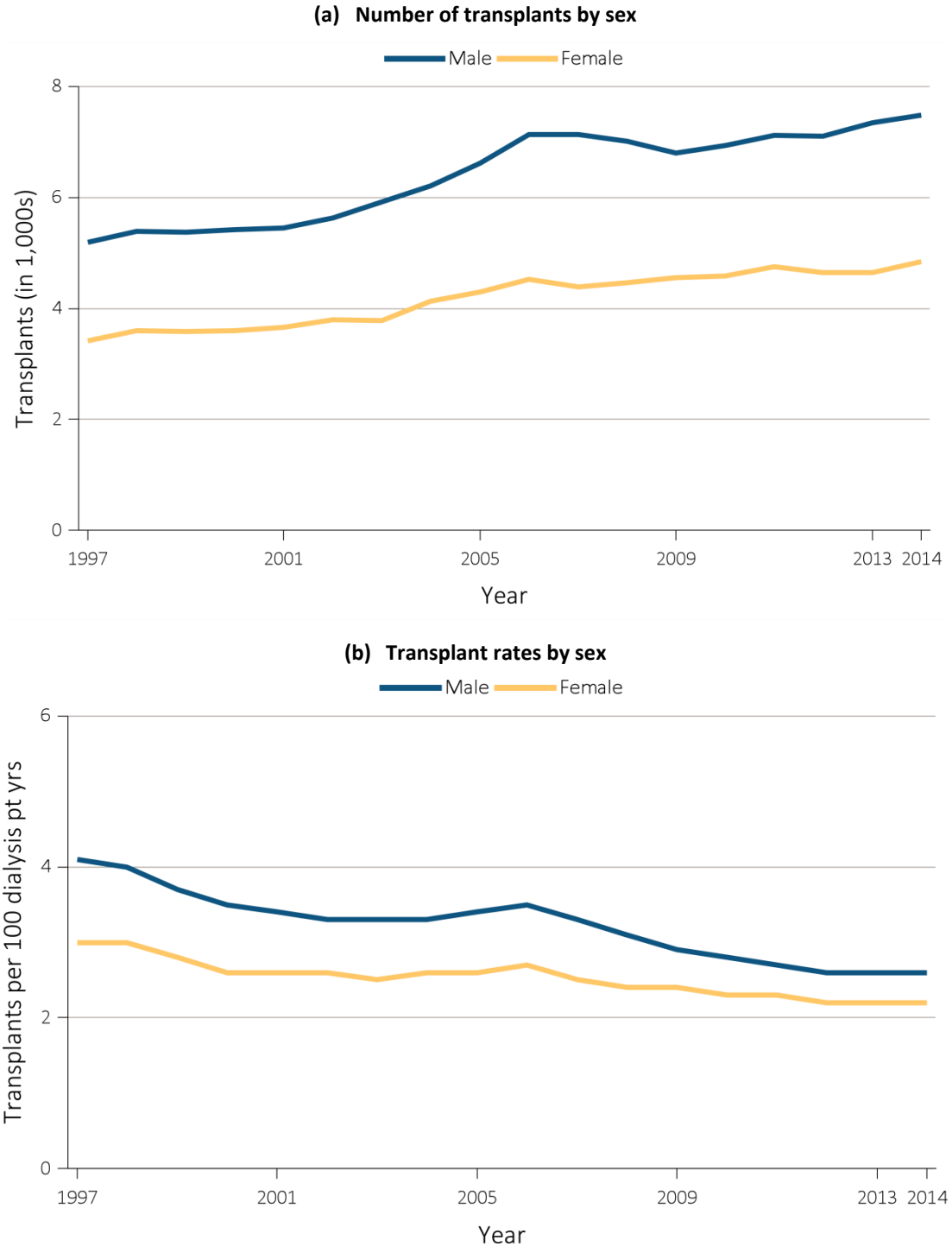
Data Source: Reference Tables E.8(2) and E.9(2). (a) Deceased donor kidney transplant counts by recipient age. (b) Unadjusted deceased donor kidney transplant rates by recipient age. Abbreviation: pt, patient.

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 (Figure 7.8.a, Number of transplants by sex). Males received substantially more transplants than females. This difference seems to be largely explained by the fact that males account for more than 60% of wait-listed candidates.

The rates of deceased donor kidney transplantation during 1997-2014 declined for both male and female

dialysis patients (Figure 7.8.b, Transplant rates by sex), although there has been some leveling off in the last year. This decline is explained partly by the growing number of dialysis patients. The difference in transplantation rates between males and females has been narrowing in recent years.

vol 2 Figure 7.8 Number of deceased donor transplants and unadjusted transplant rates among deceased donor kidney recipients, by recipient sex, 1997-2014

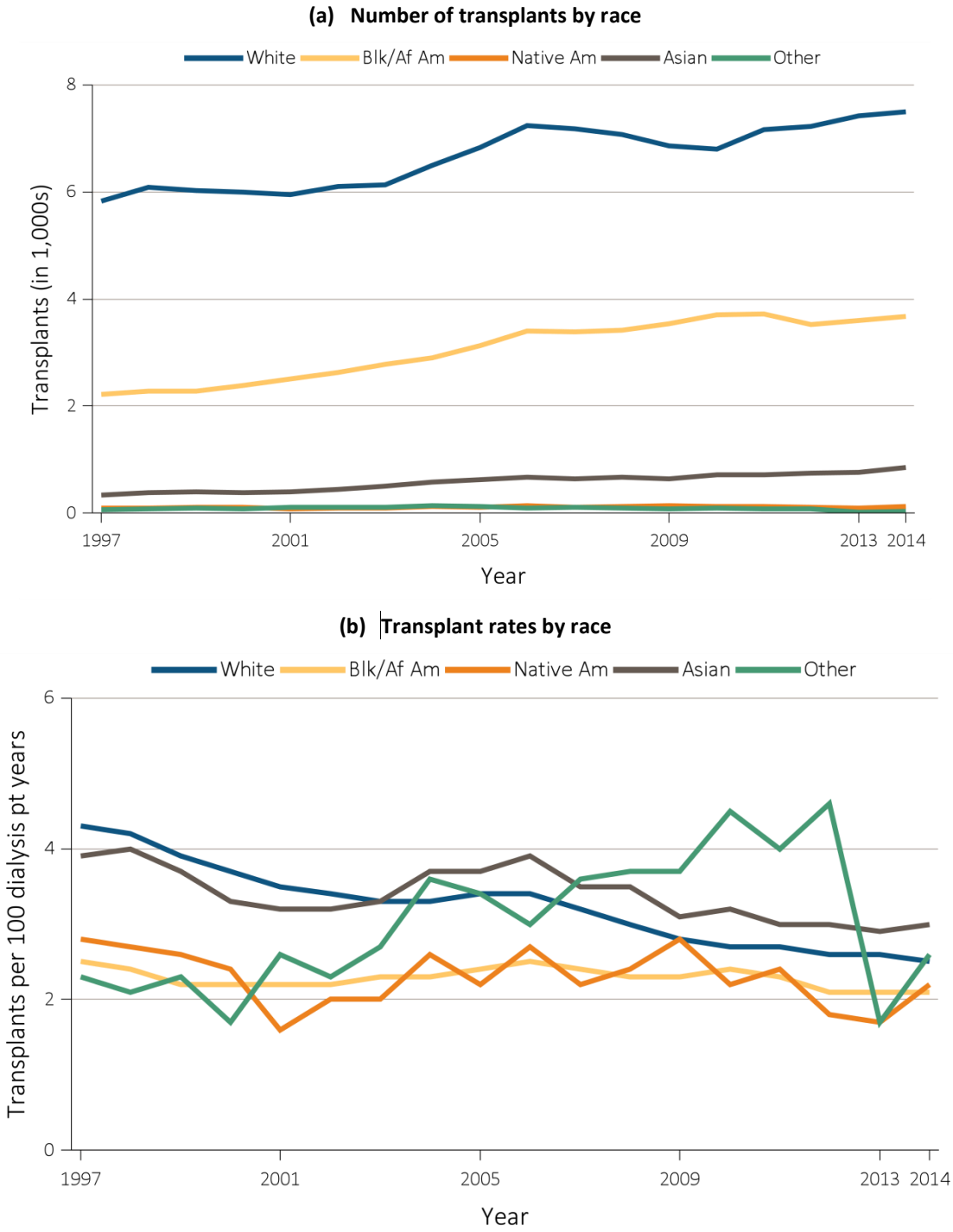


Data Source: Reference Tables E.8(2) and E.9(2). (a) Deceased donor kidney transplant counts by recipient sex. (b) Unadjusted deceased donor kidney transplant rates by recipient sex. Abbreviation: pt yrs, patient years.

Among Whites and Blacks/African Americans (hereafter, Blacks), the number of deceased donor transplants has grown substantially over the past decade, with smaller increases for Asians, and small decreases for Native American and Other races (Figure 7.9.a, Number of transplants by race).

Since 1996, deceased donor transplant rates for White dialysis patients have been declining. Since 2003, deceased donor transplant rates for Asians have been higher than for Whites (Figure 7.9.b, Transplant rates by race). The rates of deceased donor transplants for Blacks and Native Americans continue to remain low compared to Whites.

vol 2 Figure 7.9 Number of deceased donor transplants and unadjusted transplant rates among deceased donor kidney recipients, by recipient race, 1997-2014



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. Abbreviations: Blk/Af Am, Black/African American; Native Am, Native American; pt, patient.

The largest growth in deceased donor transplantation numbers has been among recipients with diabetes or hypertension (Figure 7.10.a, Number of transplants by primary cause). This growth is not surprising, as diabetes was the most common disease among the major causes of ESRD.

The rates of deceased donor transplants for all diagnosis groups have been declining since 2006 (Figure 7.10.b, Transplant rates by primary cause of ESRD).

Transplant rates among dialysis patients with glomerular disease exceeded those for any other causes, followed by the Other causes category (including cystic disease). Deceased donor transplant rates for candidates with ESRD attributed to hypertension and diabetes are similar to each other, but were lower than those observed for the glomerulonephritis and Other categories. This rank order is likely explained in part by differences in the suitability for transplantation of patients with these diagnoses as the primary cause of ESRD.

vol 2 Figure 7.10 Number of deceased donor transplants and unadjusted transplant rates among deceased donor kidney recipients, by recipient primary cause of ESRD, 1997-2014

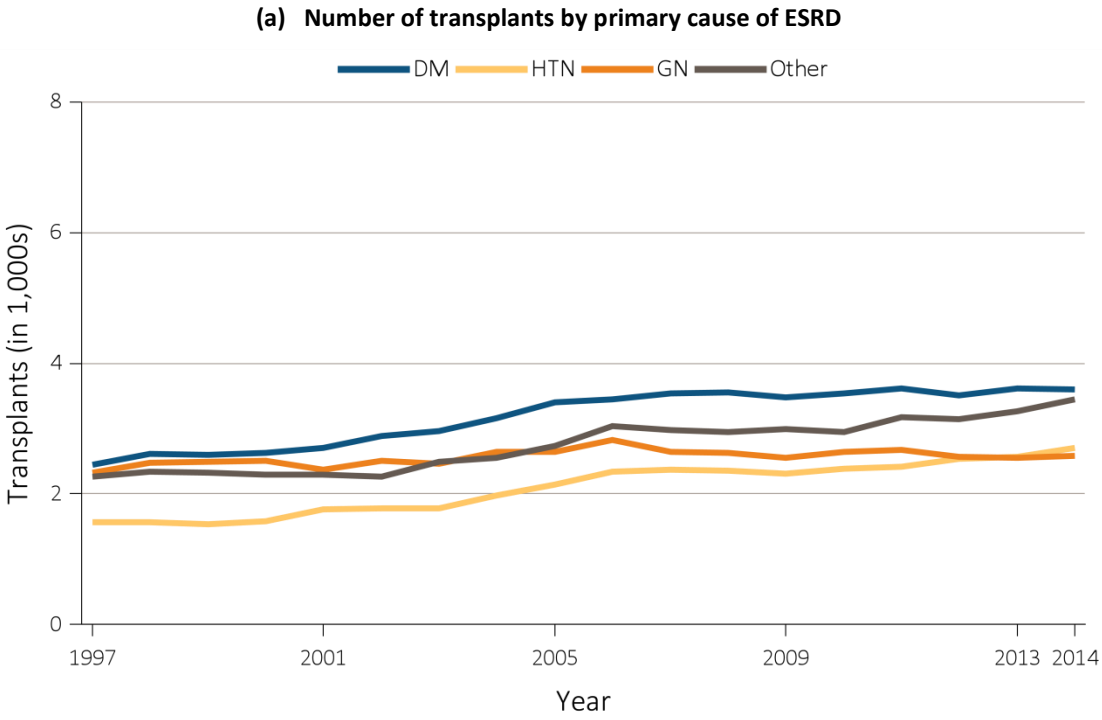
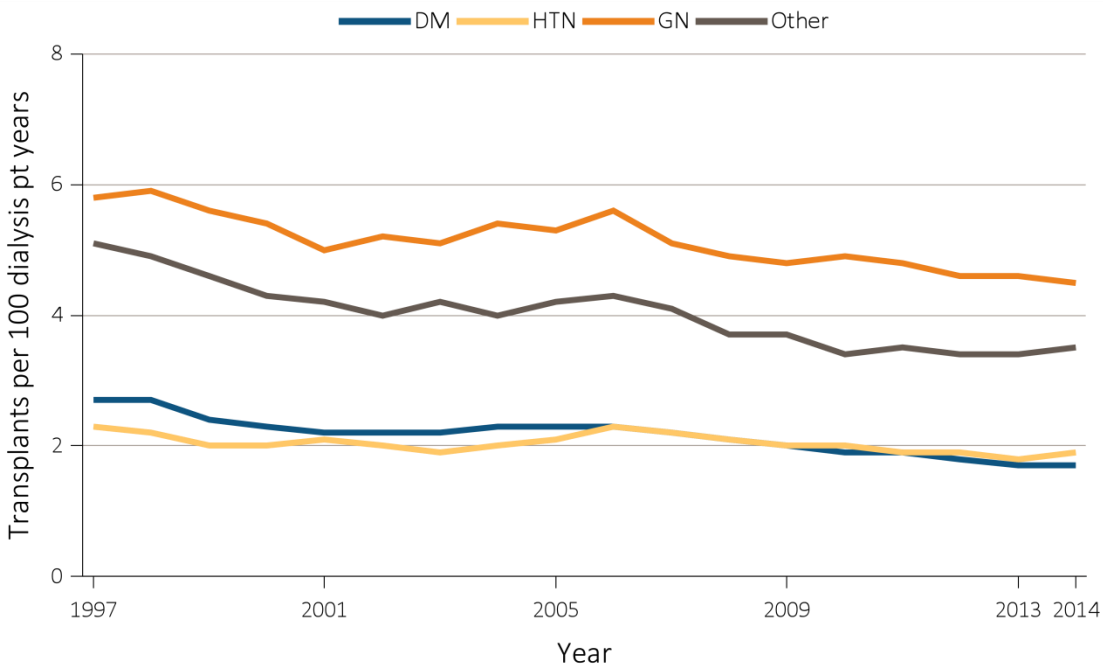


Figure 7.10 continued on next page.

vol 2 Figure 7.10 Number of deceased donor transplants and unadjusted transplant rates among deceased donor kidney recipients, by recipient primary cause of ESRD, 1997-2014 *(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. Abbreviations: DM, diabetes mellitus; ESRD, end-stage renal disease; GN, glomerulonephritis; HTN, hypertension; pt, patient.

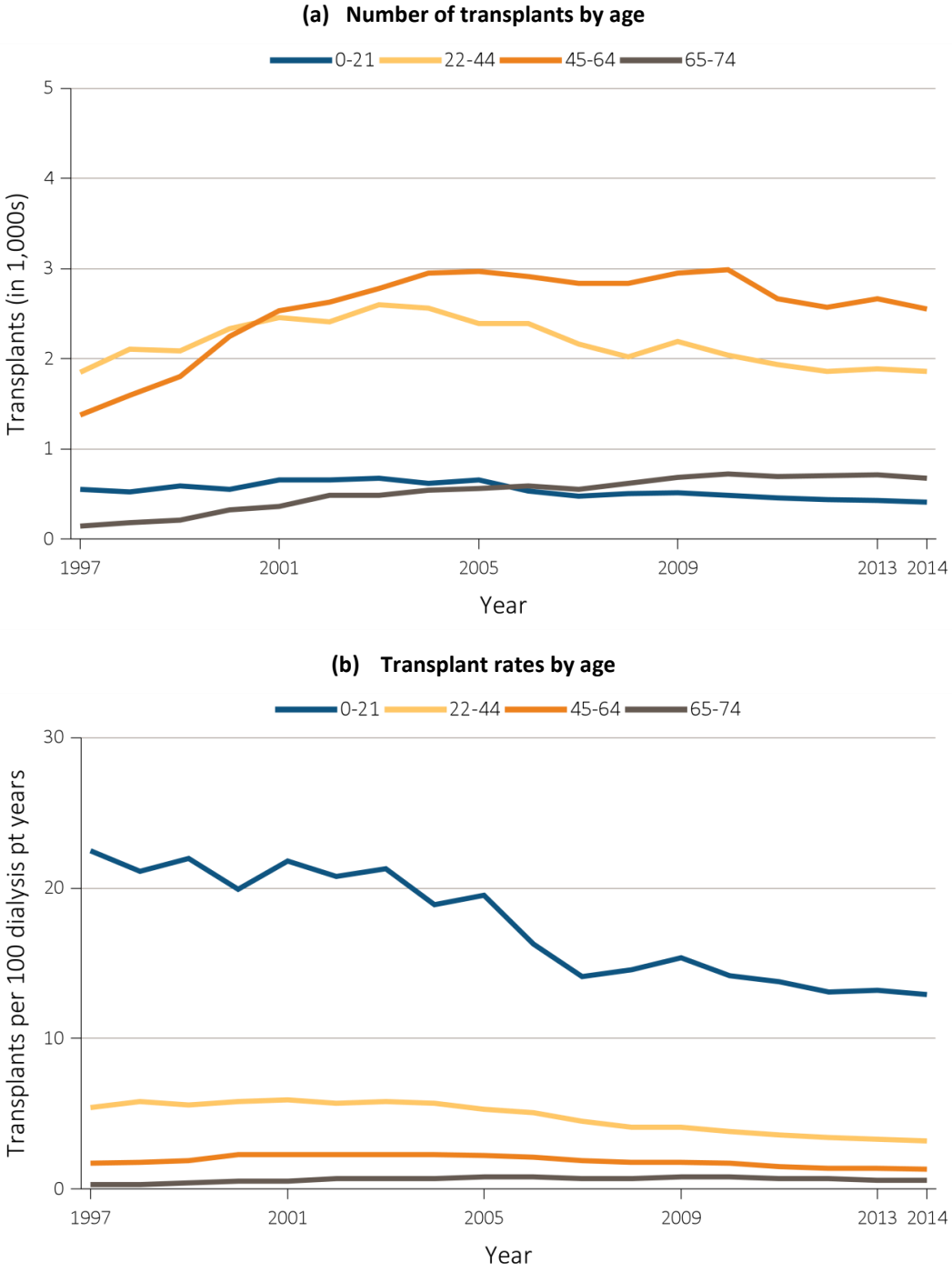
COUNTS AND RATES OF LIVING DONOR TRANSPLANTS

Though annual living donor kidney transplant counts rose steadily for adult recipients between 1996 and 2004, there has since been a steady but modest decline. In this section, we review trends in annual counts and rates of living donor kidney transplants by age, sex, race, and primary cause of ESRD (Figures 7.11-7.14).

Counts for living donor transplants for those aged 22-44 years decreased from 2,603 in 2003 to 1,861 in 2014. The number of living donor transplants for the group aged 45-64 years has shown a more recent decline, falling from 2,993 in 2010 to 2,549 in 2014 (Figure 7.11.a, Number of transplants by age). While transplant counts for those over 65 years old increased between 1997 and 2010, they have subsequently remained relatively stable, at close to 800 per year.

Kidney transplantation rates from living donors per 100 dialysis patient years show that younger age groups have substantially higher annual rates (Figure 7.11.b, Transplant rates by age). However, there was a steep decline in these rates for the 0-21 year old group starting in 2003, with recent trends more static. 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 remained stable over the past decade.

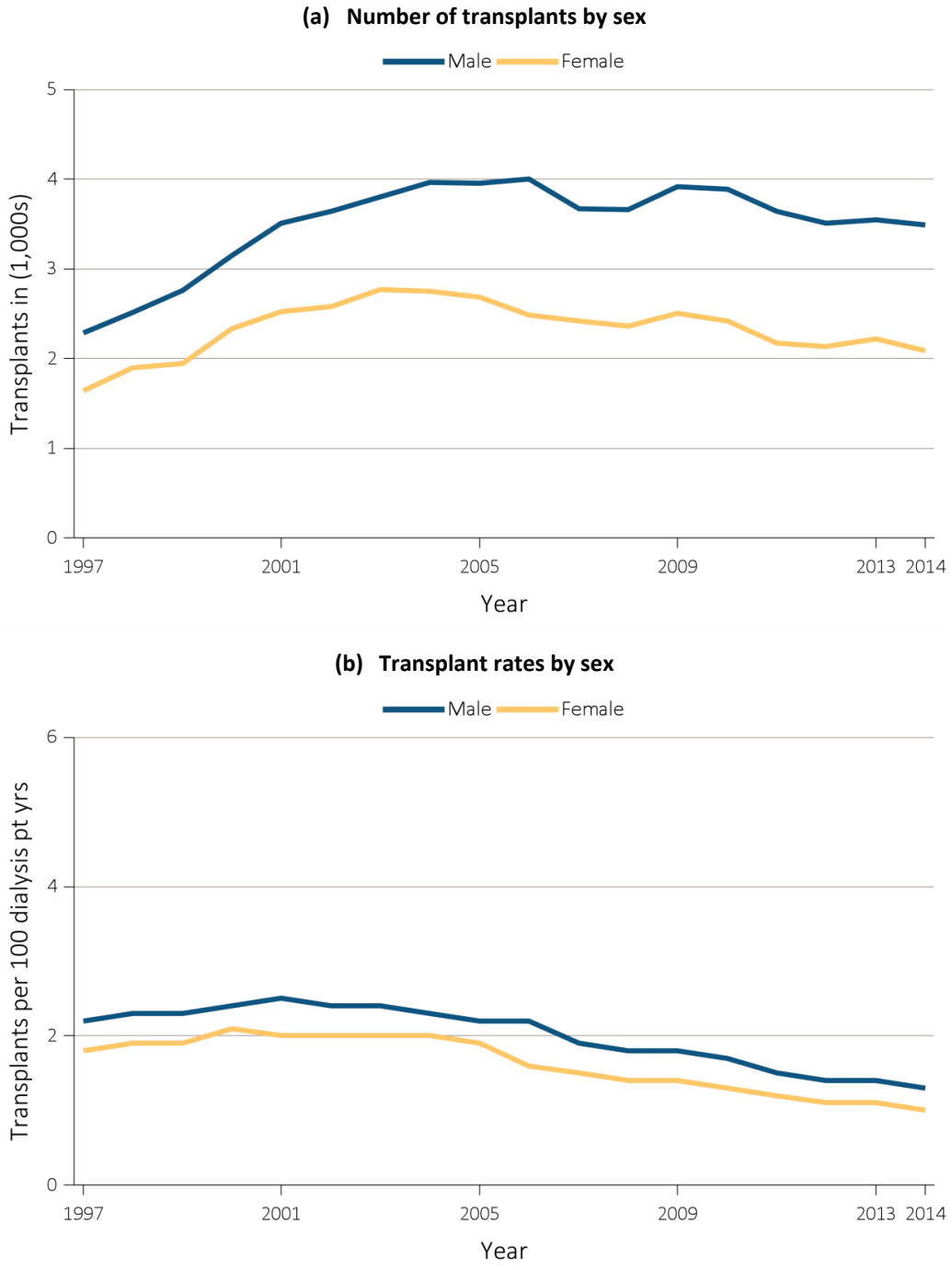
vol 2 Figure 7.11 Number of living donor transplants and unadjusted transplant rates among living donor kidney recipients, by recipient age, 1997-2014



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. Abbreviation: pt, patient.

The annual counts of living donor kidney transplantation show consistently higher numbers of male, compared to female, recipients (Figure 7.12.a, Number of transplants by sex). However, since 2009, living donor kidney transplant counts have decreased for both males and females. While the living donor transplant rates continue to remain higher for males than for females, the difference is relatively small (Figure 7.12.b, Transplant rates by sex).

vol 2 Figure 7.12 Number of living donor transplants and unadjusted transplant rates among living donor kidney recipients, by recipient sex, 1997-2014

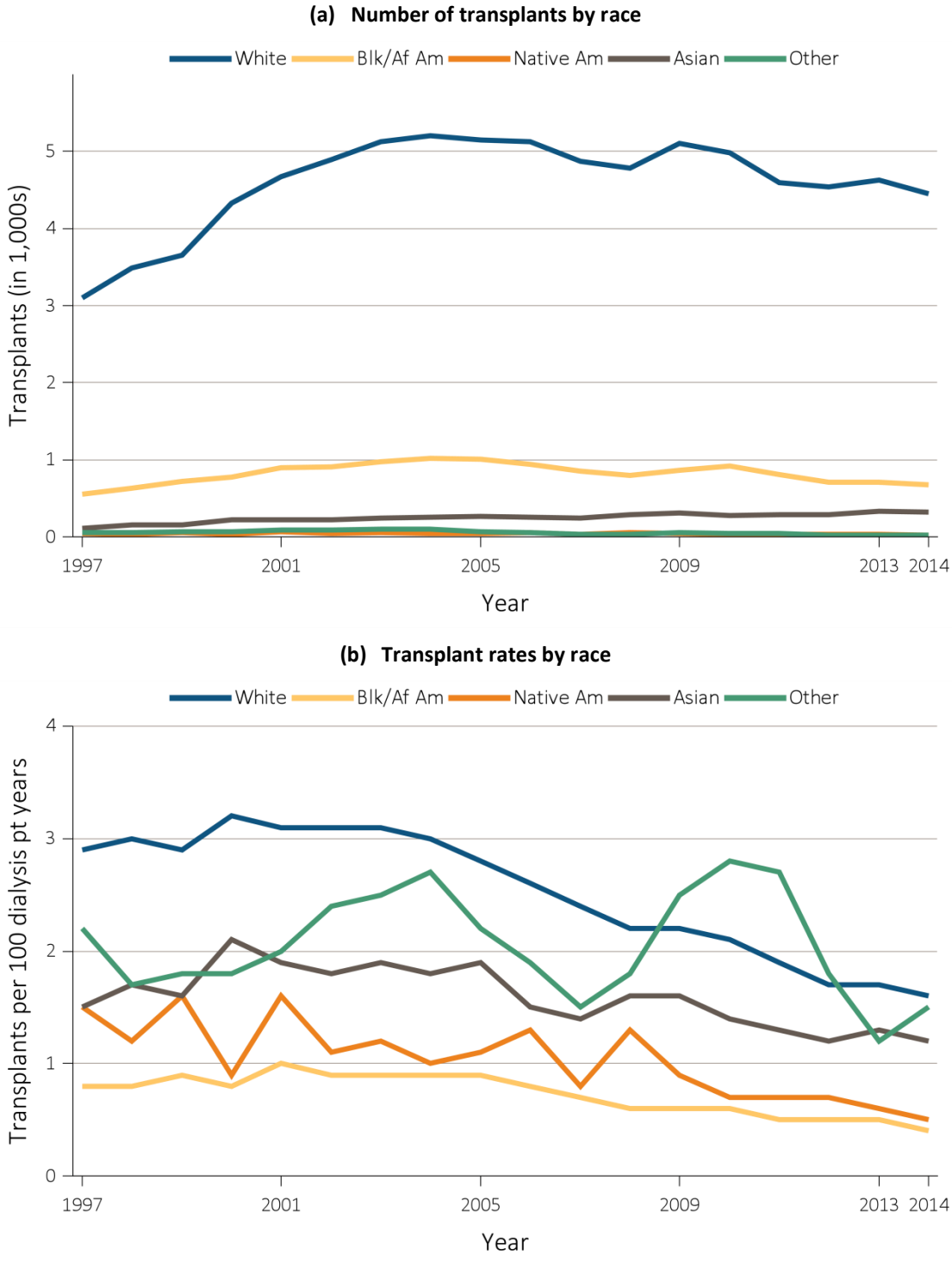


Data Source: Reference Tables E.8(3) and E.9(3). (a) Living donor kidney transplant counts by recipient sex. (b) Unadjusted living donor kidney transplant rates by recipient sex. Abbreviation: pt yrs, patient years.

Consistent with the overall trend, living donor kidney transplant counts steadily increased until 2004 for all races (Figure 7.13.a, Number of transplants by race). Since then, the annual number of living donor kidney transplants has decreased for Whites and Blacks, while the counts for Asians have shown a small increase.

Living donor transplant rates for Whites are the highest among all race groups, while rates among Native Americans are the lowest (Figure 7.13.b, Transplant rates by race), while the rate for Other races is quite variable by year. From 2013 to 2014, living donor transplant rates have declined slightly among all race groups except for Other among whom the transplant rate has increased.

vol 2 Figure 7.13 Number of living donor transplants and unadjusted transplant rates among living donor kidney recipients, by recipient race, 1997-2014



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. Abbreviations: Blk/Af Am, Black/African American; Native Am, Native American; pt, patient.

The ranking of living donor kidney transplantation counts by primary cause of ESRD has remained the same over the past decade, from highest to lowest frequency: other, glomerulonephritis, diabetes, and hypertension (Figure 7.14.a, Number of transplants by primary cause of ESRD). This trend contrasts with the

pattern among deceased donor recipients (Figure 7.10.a, Number of transplants by primary cause), where the numbers with ESRD caused by diabetes mellitus and hypertension 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 7.14.b, Transplant rates by primary cause of ESRD). Similar to the rates of deceased donor transplants, the rates of living donor transplants among patients with glomerular disease exceed those for any other causes, followed by other causes (including cystic disease), and are lowest for those with hypertension and diabetes.

vol 2 Figure 7.14 Number of living donor transplants and unadjusted transplant rates among living donor kidney recipients, by recipient primary cause of ESRD, 1997-2014

(a) Number of transplants by primary cause of ESRD

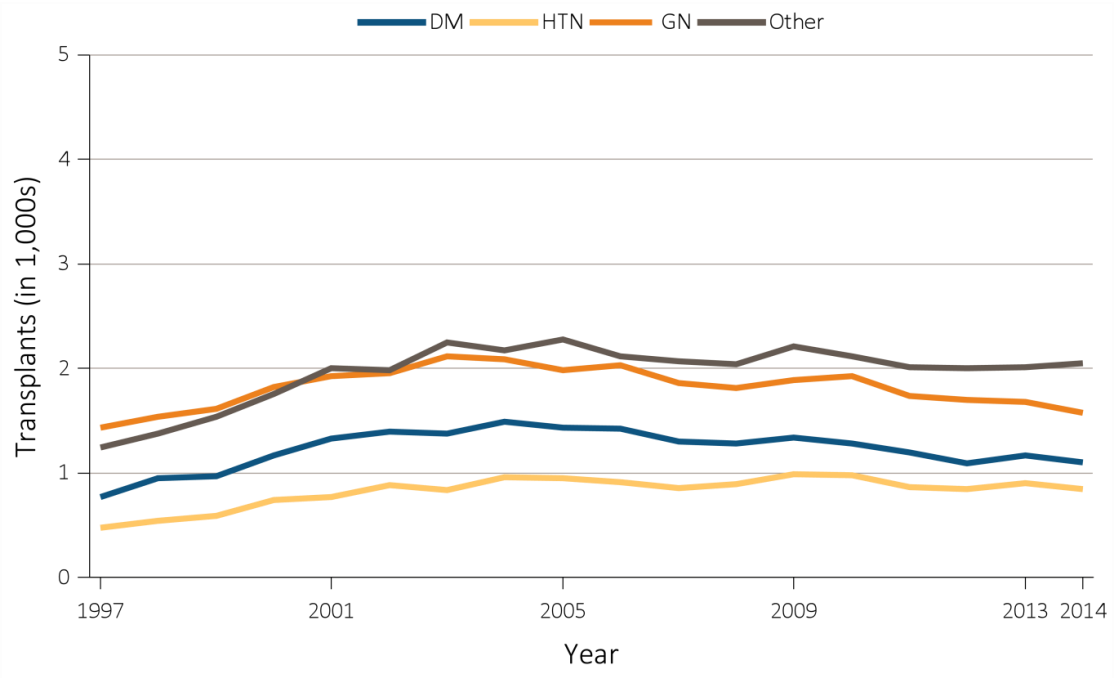
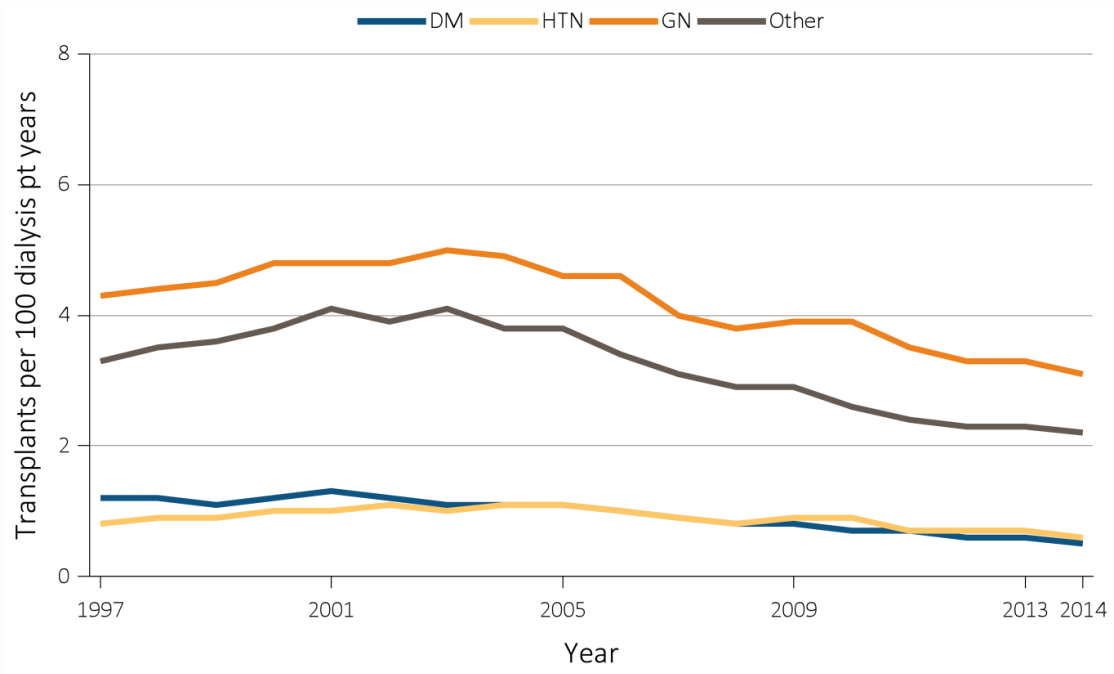


Figure 7.14 continued on next page.

vol 2 Figure 7.14 Number of living donor transplants and unadjusted transplant rates among living donor kidney recipients, by recipient primary cause of ESRD, 1997-2014 *(continued)*

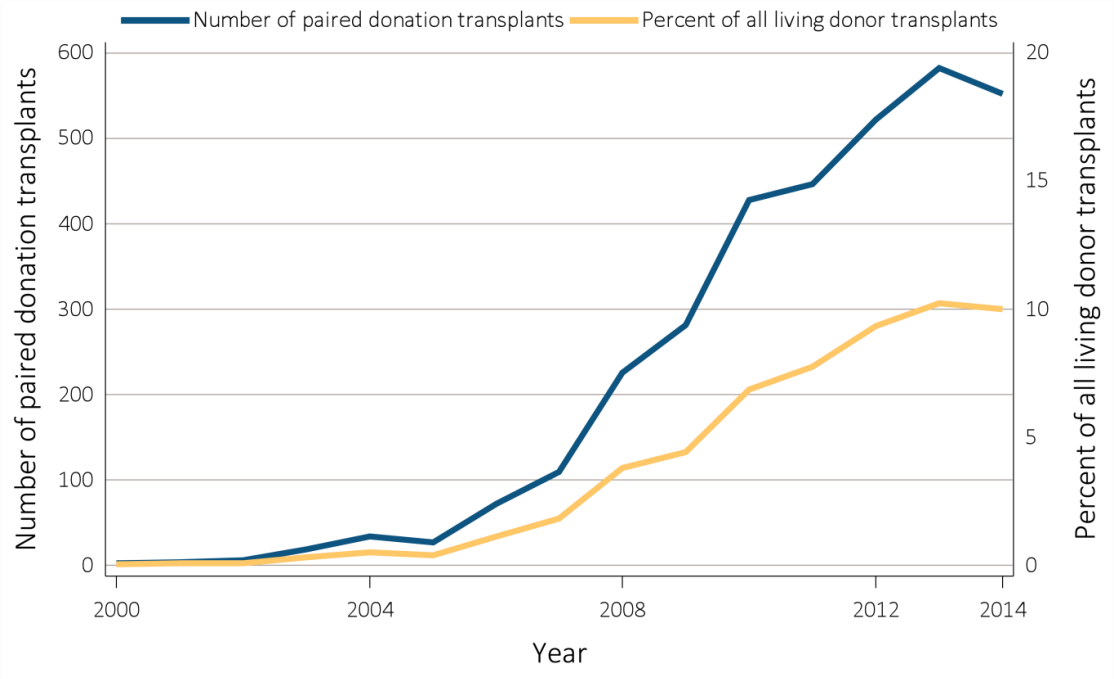
(b) Number of transplants by primary cause of ESRD



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. Abbreviations: DM, diabetes mellitus; ESRD, end-stage renal disease; GN, glomerulonephritis; HTN, hypertension; pt, patient.

A relatively recent initiative aimed at increasing the availability of living donor transplants is the process of kidney paired donation (KPD). This typically applies when an otherwise willing potential living donor is incompatible with the recipient. In its simplest form, two living donors who are incompatible with their respective recipients perform an exchange whereby the donation goes to each other's compatible recipient. More complex chains involving exchanges among three or more recipient-donor pairs are possible and have been performed. The counts of KPD transplants have risen sharply in recent years, with 552 performed in 2014, representing 10% of living donor transplants that year (Figure 7.15).

vol 2 Figure 7.15 Number of paired donation transplants and percent of all living donor transplants, 2000-2014



Data Source: Data are obtained from the Organ Procurement and Transplantation Network (OPTN). Paired donation transplant counts and percent of all living donor transplants.

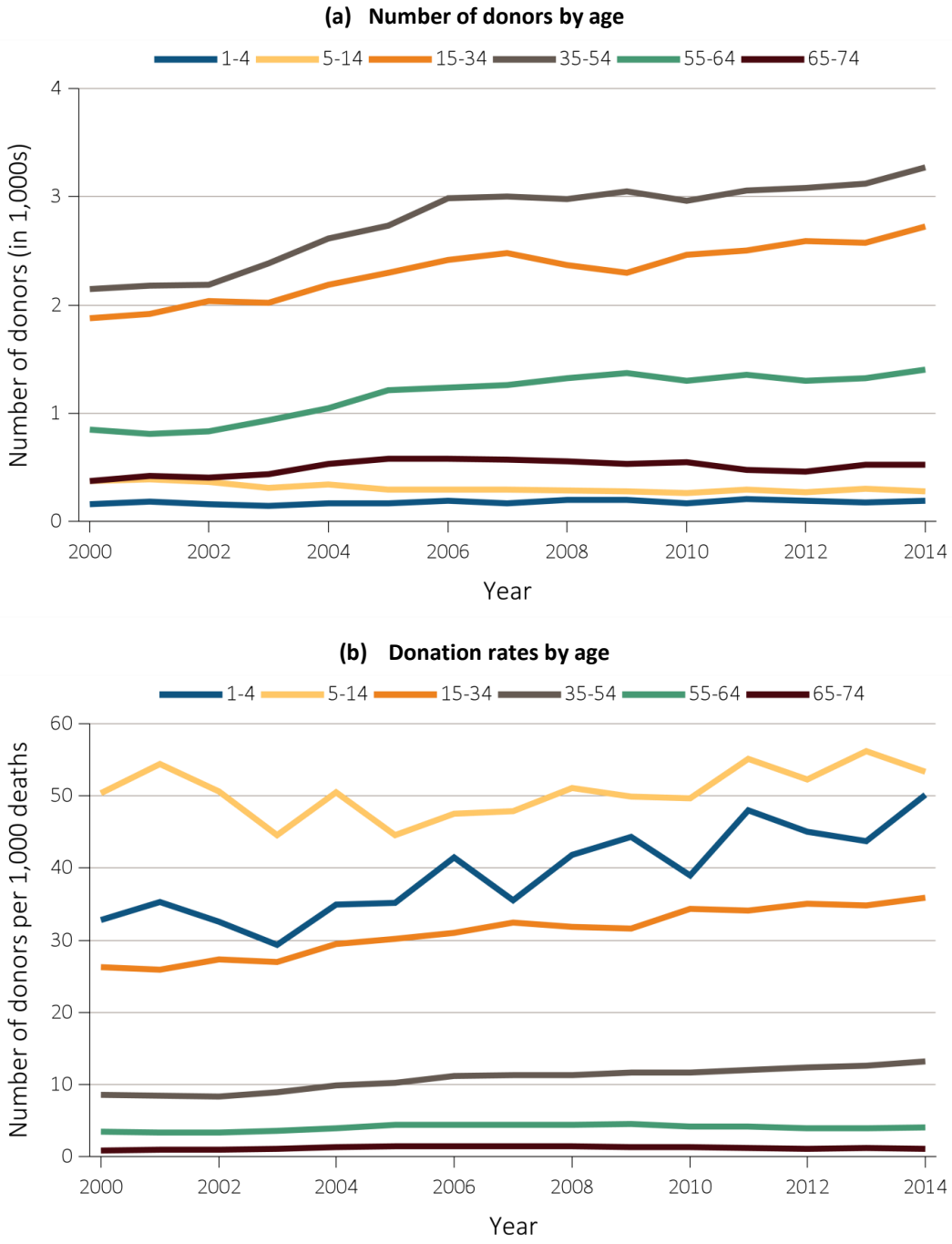
Deceased Donation Counts and Rates among All-cause Deaths

The number of deceased donors, aged 1-74 years, with at least one kidney retrieved has been increasing from 6,231 in 2003 to 8,385 in 2014 (Figure 7.16.a, Number of donors by age).

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

Annual donation rates were calculated as the number of deceased donors from whom at least one kidney was retrieved per 1,000 deaths in the U.S. population (Centers for Disease Control and Prevention, 2016). The overall donation rates ranged from 5.7 per 1,000 deaths in 2000 to 7.3 per 1,000 deaths in 2014. Donation rates among those aged younger than 55 years have increased from 14 per 1,000 deaths in 2003 to 20 per 1,000 deaths in 2014 (Figure 7.16.b, Donation rates by age). The highest donation rates were among those aged 1-4 (rising from 33 per 1,000 deaths in 2000 to 50 per 1,000 deaths in 2014) and 5-14 years (rising slightly from 50 per 1,000 deaths in 2000 to 53 per 1,000 deaths in 2014).

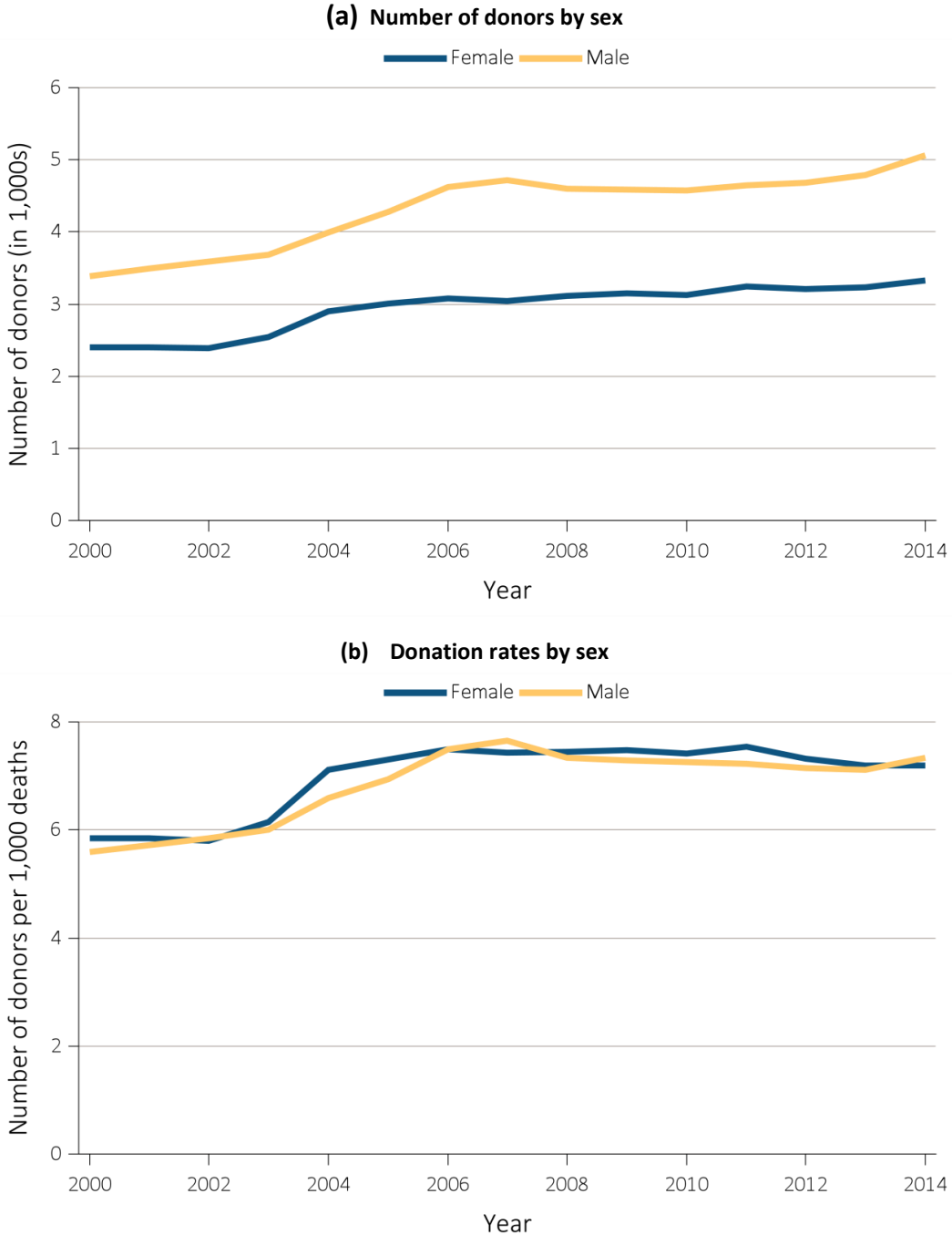
vol 2 Figure 7.16 Number of deceased kidney donors and unadjusted kidney donation rates, by donor age, 2000-2014



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.

Deceased kidney donor counts of males have been consistently around 1.5 times greater than those of females (Figure 7.17.a Number of donors by sex), but the donation rates are similar between males and females (Figure 7.17.b Donation rates by sex). Both groups have demonstrated an increase in the donor numbers and rates after 2003, but have been stable since 2008.

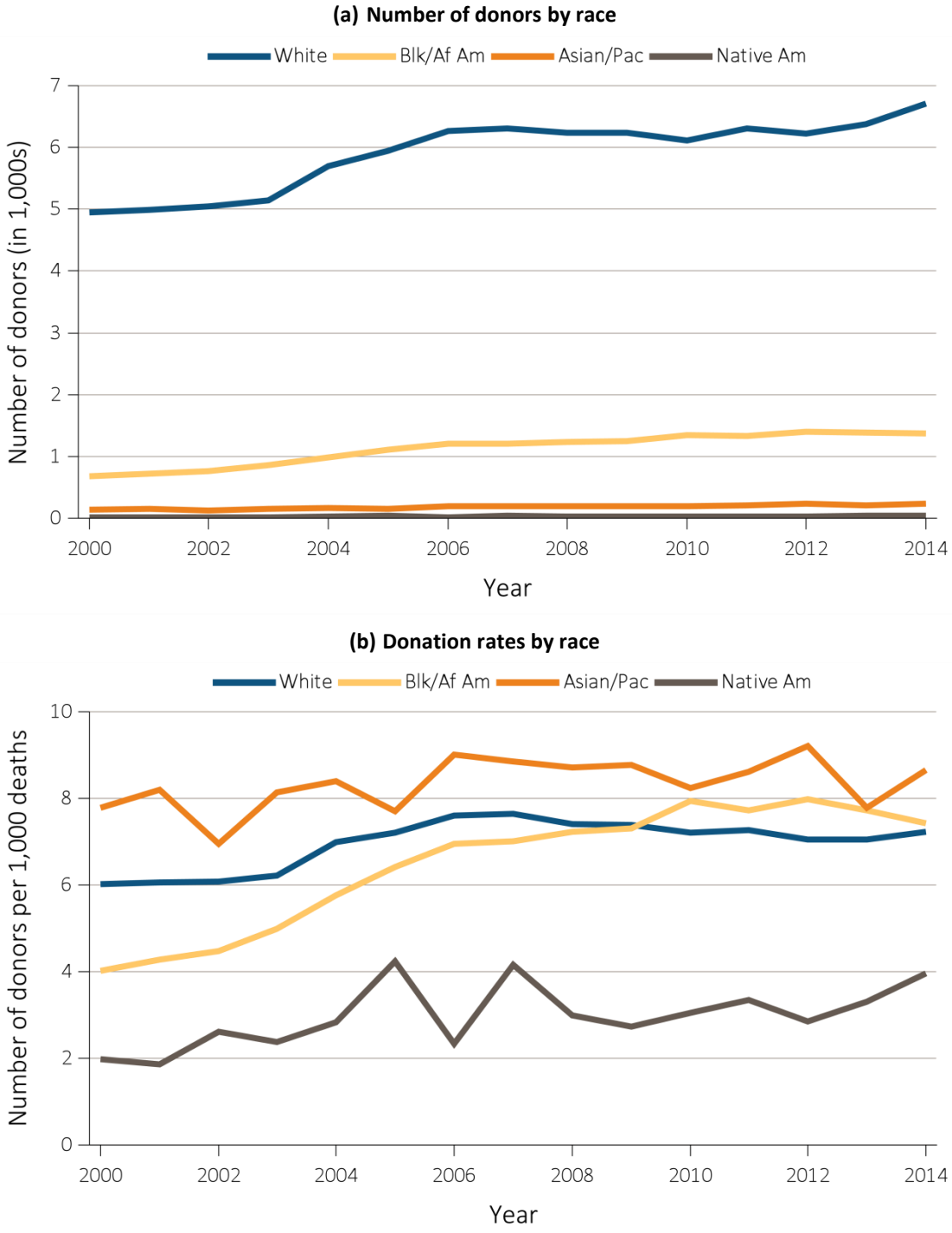
vol 2 Figure 7.17 Number of deceased kidney donors and unadjusted kidney donation rates, by donor sex, 2000-2014



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.

Whites have contributed the most to the number of deceased donors each year during 2000-2014 (Figure 7.18.a Number of donors by race), but Blacks have surpassed Whites in donation rates since 2009 (Figure 7.18.b Donation rates by race). The rate of deceased donors per 1,000 deaths among Blacks almost doubled from 2000 to 2014. Since 2000, Asian or Pacific Islanders have had the highest donation rate, and Native Americans have had the lowest donation rates.

vol 2 Figure 7.18 Number of deceased kidney donors and unadjusted kidney donation rates, by donor race, 2000-2014



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. Abbreviations: Asian/Pac, Asian/Pacific Islander; Blk/Af Am, Black/African American; Native Am, Native American.

In 2014, among 16,404 kidneys that were recovered from deceased donors, 2,703 (16%) were discarded due to various reasons. During 2010-2014, the percent of kidneys discarded has ranged between 16%-17% (OPTN, 2015).

Deceased Donation Counts and Rates Among Traumatic Deaths

In this new section, counts and rates of deceased donations are presented focusing on donors with traumatic causes of death (motor vehicle accident, suicide, or homicide). Such cases represent a common source of donation, as they may be less likely to have other underlying health issues that would preclude use of the organs. The number of such donors, aged 1-74 years, with at least one kidney retrieved, has been relatively steady since 2006, with 2,449 donations in 2014 (which represents 29% of all deceased donations).

As expected, due to the underlying cause of death, donors in the age range of 15-54 years are over-represented, with only small numbers of donors in the other age categories (Figure 7.19.a, Number of donors by age).

Annual donation rates were calculated as the number of deceased donors with a traumatic cause of death from whom at least one kidney was retrieved per 1,000 deaths (with cause being motor vehicle accident, suicide, or homicide) in the U.S. population (Centers for Disease Control and Prevention, 2016). In 2014, overall donation rates among those with traumatic deaths (28.5 per 1,000 deaths) were 4.1 times as high as donation rates among those with death from any cause (7.3 per 1,000 deaths). Donation rates for traumatic deaths were highest among those aged 5-34 years (47 per 1,000 deaths, Figure 7.19.b, Donation rates by age).

vol 2 Figure 7.19 Number of deceased kidney donors and unadjusted kidney donation rates, for traumatic deaths, by donor age, 2000-2014

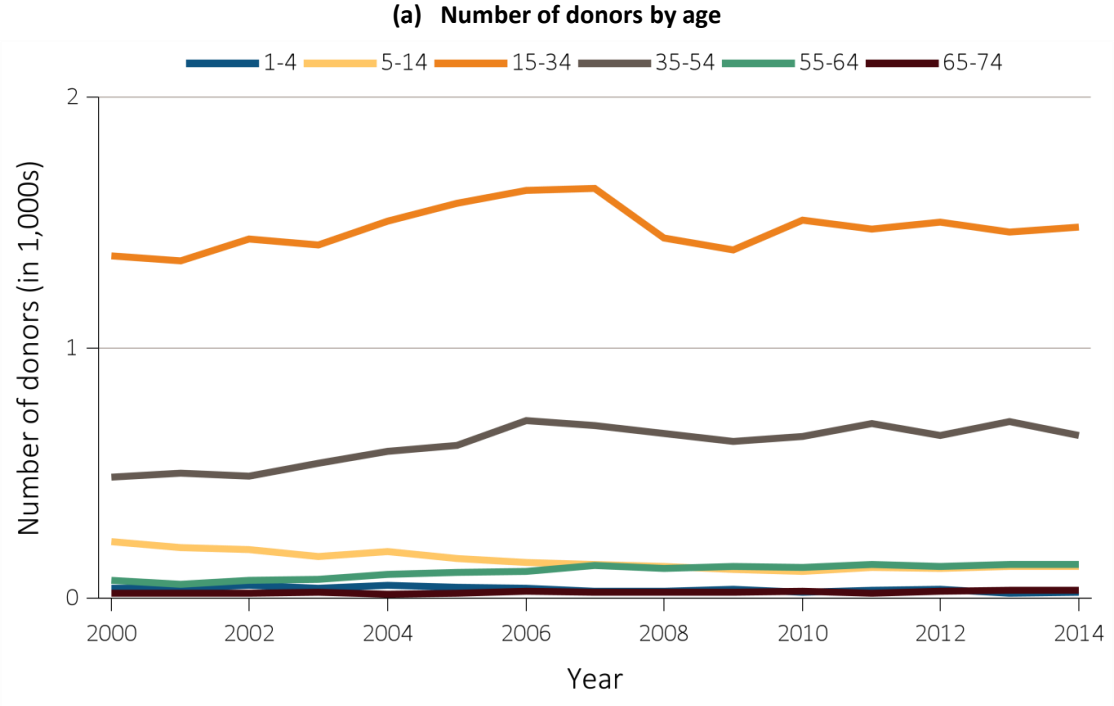
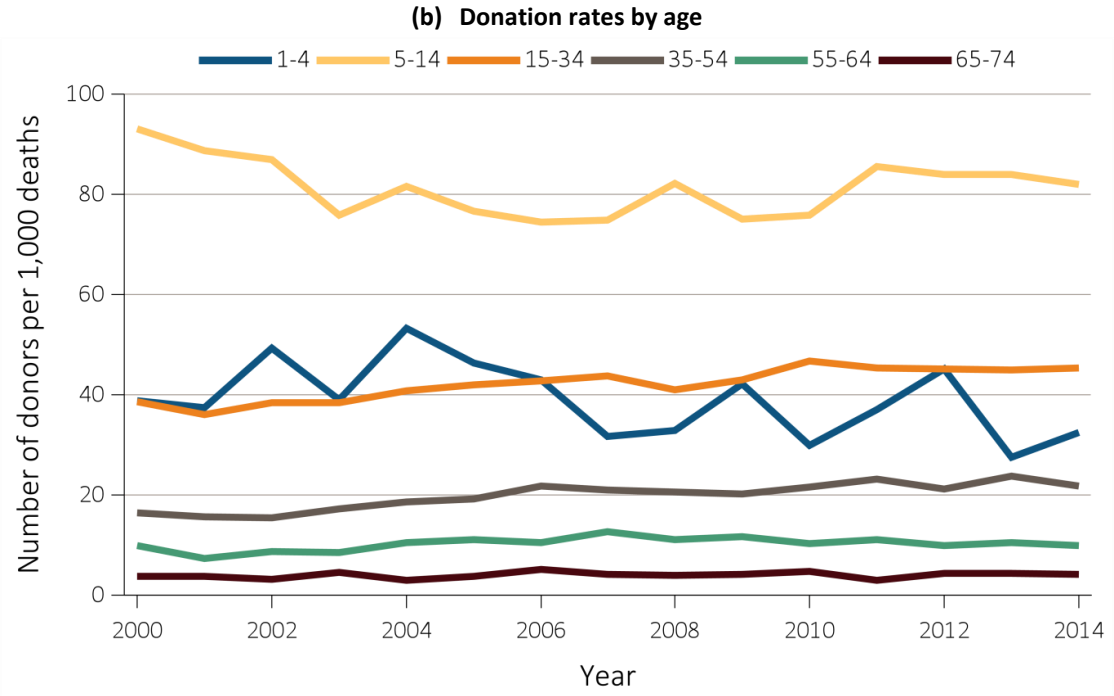


Figure 7.19 continued on next page.

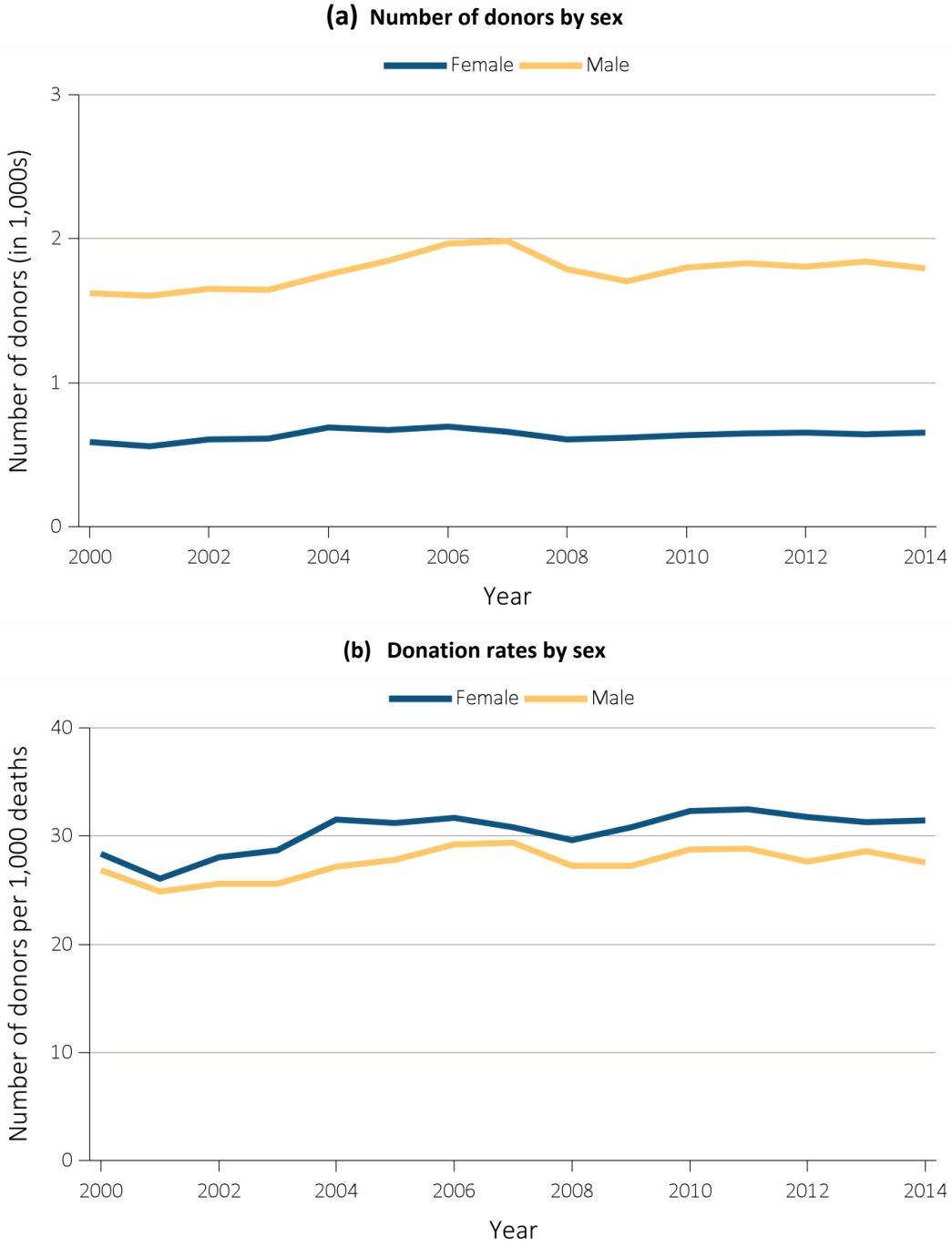
vol 2 Figure 7.19 Number of deceased kidney donors and unadjusted kidney donation rates, for traumatic deaths, by donor age, 2000-2014 *(continued)*



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.

While deceased kidney donor counts of males have been consistently around double those of females (Figure 7.20.a Number of donors by sex), male and female donation rates are similar (Figure 7.20.b Donation rates by sex). Both counts and rates of kidney donation among males and females with traumatic deaths have been stable for the last several years.

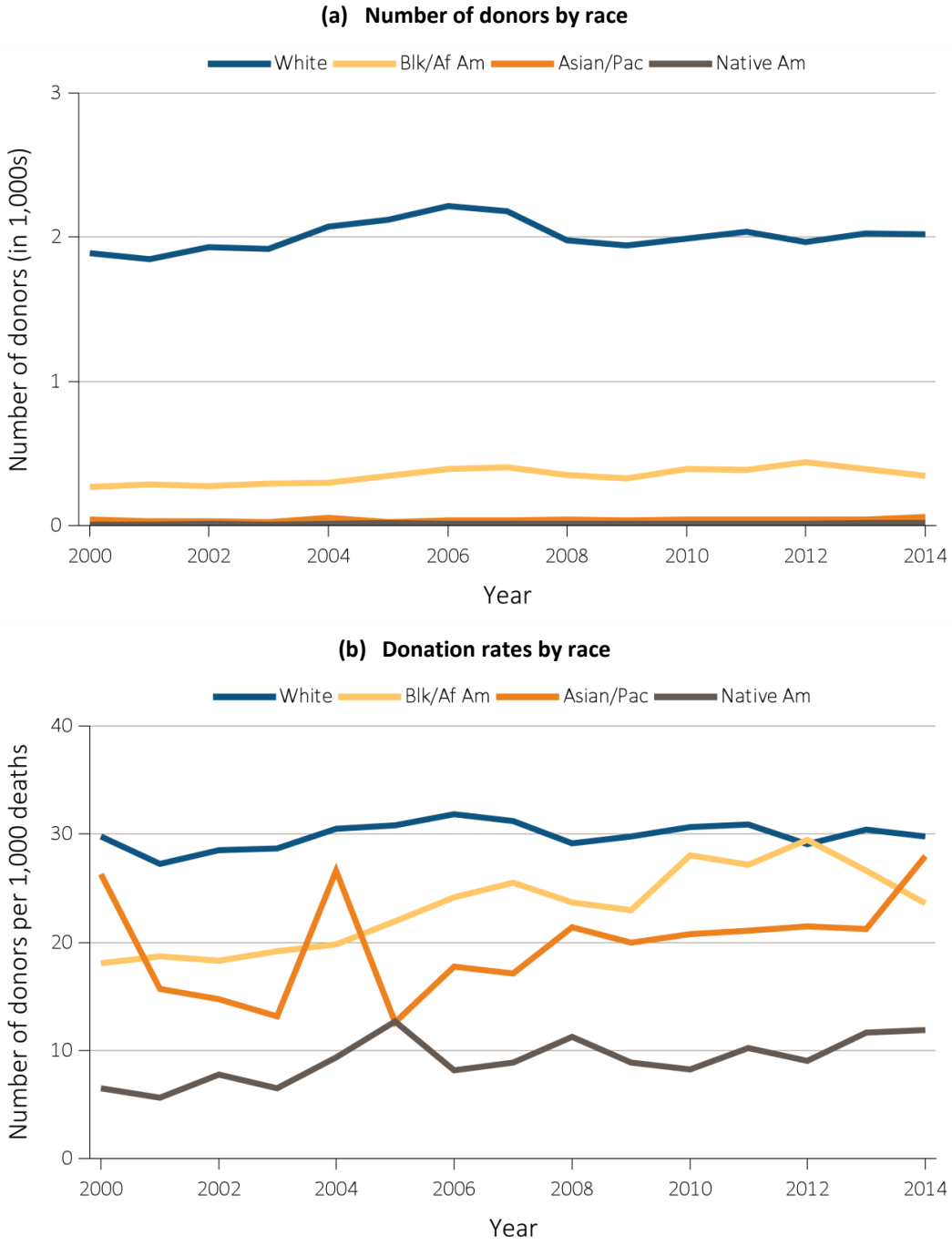
vol 2 Figure 7.20 Number of deceased kidney donors and unadjusted kidney donation rates, for traumatic deaths, by donor sex, 2000-2014



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.

Whites have contributed the most to the number of deceased donors each year during 2000-2014 (Figure 7.21.a Number of donors by race), although rates of donation in the most recent years have been similar across Whites, Blacks, and Asian or Pacific Islanders (Figure 7.21.b Donation rates by race).

vol 2 Figure 7.21 Number of deceased kidney donors and unadjusted kidney donation rates, for traumatic deaths, by donor race, 2000-2014



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. Abbreviations: Asian/Pac, Asian/Pacific Islander; Blk/Af Am, Black/African American; Native Am, Native American.

Transplant Outcomes

There has been a progressive improvement in outcomes of kidney transplant recipients in the last few years. In this section, we review the trends in probability of all-cause graft failure, probability of returning to dialysis or retransplantation, and probability of death at one, five, and ten years post-transplant. All-cause graft failure is defined as any graft failure, including death with graft function as a graft failure. The probability of return to dialysis or retransplantation represents death-censored graft failure.

During 1997-2013, kidney transplant patients experienced improved health outcomes, with decreases in deaths and all-cause graft failure at one year post-transplantation. Among the recipients of deceased donor kidney transplants, the probability of all-cause graft failure in the first year following transplant decreased from 14% in 1997 to 8% in 2013, while the probability of death decreased from 6% in 1997 to 4% in 2013. Similarly, among those who received living donor kidney transplants, the probability of all-cause graft failure in the first year following transplant decreased from 7% in 1997 to 3% in 2013, while probability of death decreased from 3% to 1% over the same period.

Improvements in patient and graft survival probabilities have persisted for most of the five- and ten-year outcomes as well. Among deceased donor kidney transplant recipients, the probability of all-cause graft failure by the fifth year improved, dropping from 34% in 1997 to 27% in 2009, and by the tenth year post-transplant it also decreased from 58% in 1997 to 53% in 2004. Probability of death by the fifth year post-transplant improved by dropping from 19% in 1997 to 16% in 2009, and for tenth year post transplant improved by decreasing from 39% in 1997 to 37% in 2004. Similarly, for living donor kidney transplant recipients, the probability of all-cause graft failure by the fifth year decreased from 22% in 1997 to 15% in 2009, while in the tenth year it decreased from 43% in 1997 to 38% in 2004. The probability for death by fifth year post-transplant also improved by falling from 11% in 1997 to 8% in 2009, while in the tenth year it decreased from 24% in 1997 to 22% in 2004. Overall, the outcomes have been consistently more advantageous in living donor kidney transplant recipients in comparison to deceased donor transplant recipients (Tables 7.3 and 7.4).

vol 2 Table 7.3 Trends in 1-, 5-, & 10-year deceased donor kidney transplant outcomes, 1997-2013

	One year post-transplant			Five years post-transplant			Ten years post-transplant		
Year	Prob. of all-cause graft failure	Prob. of return to dialysis or repeat transplant	Prob. of death	Prob. of all-cause graft failure	Prob. of return to dialysis or repeat transplant	Prob. of death	Prob. of all-cause graft failure	Prob. of return to dialysis or repeat transplant	Prob. of death
1997	13.9%	8.1%	6.1%	34.2%	23.4%	19.2%	57.9%	41.0%	39.3%
1998	13.5%	8.3%	5.5%	33.2%	23.5%	18.2%	56.4%	40.3%	38.0%
1999	14.3%	8.4%	5.9%	33.4%	22.7%	18.8%	56.3%	39.2%	38.2%
2000	13.7%	7.9%	6.4%	34.0%	22.7%	19.7%	56.7%	38.6%	39.2%
2001	12.7%	7.6%	5.7%	32.9%	21.1%	19.8%	55.2%	36.7%	38.6%
2002	12.7%	7.8%	5.6%	32.5%	21.8%	18.8%	53.5%	35.8%	37.1%
2003	12.4%	7.3%	5.6%	31.7%	20.3%	18.4%	54.4%	35.8%	37.6%
2004	11.8%	7.1%	5.4%	31.2%	20.5%	18.3%	53.1%	35.4%	36.7%
2005	11.5%	6.9%	6.0%	29.9%	19.1%	17.8%			
2006	10.8%	6.6%	5.1%	29.3%	18.7%	17.1%			
2007	9.8%	5.9%	4.6%	28.2%	17.7%	16.9%			
2008	9.6%	6.0%	4.5%	26.8%	16.1%	16.3%			
2009	9.4%	5.6%	4.9%	26.8%	16.3%	16.1%			
2010	8.8%	5.4%	4.4%						
2011	7.3%	4.3%	3.9%						
2012	7.8%	4.8%	3.8%						
2013	7.7%	4.8%	3.5%						

Data Source: Reference Tables F.2, F.14, I.26; F.5, F.17, I.29; F.6, F.18, I.30. Outcomes among recipients of a first-time deceased donor kidney transplant; unadjusted. Abbreviation: Prob., probability.

vol 2 Table 7.4 Trends in 1-, 5-, & 10-year living donor kidney transplant outcomes, 1997-2013

	One year post-transplant			Five years post-transplant			Ten years post-transplant		
Year	Prob. of all-cause graft failure	Prob. of return to dialysis or repeat transplant	Prob. of death	Prob. of all-cause graft failure	Prob. of return to dialysis or repeat transplant	Prob. of death	Prob. of all-cause graft failure	Prob. of return to dialysis or repeat transplant	Prob. of death
1997	6.7%	4.8%	2.7%	22.1%	15.7%	10.5%	43.1%	31.0%	24.3%
1998	5.9%	4.3%	2.3%	20.7%	14.5%	10.1%	42.1%	30.4%	23.3%
1999	6.0%	4.2%	2.1%	20.8%	14.6%	9.5%	41.0%	28.9%	22.5%
2000	6.5%	4.4%	2.6%	21.7%	14.7%	10.5%	41.9%	28.9%	23.7%
2001	6.1%	4.0%	2.5%	21.2%	14.2%	10.2%	41.0%	27.6%	23.7%
2002	5.7%	3.8%	2.4%	20.3%	13.5%	10.2%	39.7%	26.1%	24.4%
2003	5.5%	4.0%	1.8%	20.1%	13.8%	9.4%	39.3%	26.0%	23.0%
2004	5.2%	3.6%	2.1%	18.8%	12.7%	8.8%	38.3%	24.7%	22.4%
2005	5.4%	3.7%	2.0%	18.7%	12.7%	8.8%			
2006	4.5%	3.1%	1.7%	16.8%	11.2%	8.0%			
2007	3.8%	2.5%	1.3%	16.6%	10.6%	7.9%			
2008	4.3%	2.9%	1.6%	15.4%	10.1%	7.4%			
2009	4.0%	2.7%	1.3%	15.1%	9.3%	7.6%			
2010	3.7%	2.4%	1.4%						
2011	3.5%	2.0%	1.8%						
2012	3.5%	2.1%	1.4%						
2013	2.6%	1.5%	1.2%						

Data Source: Reference Tables F.8, F.20, I.32; F.11, F.23, I.35; F.12, F.24, I.36. Outcomes among recipients of a first-time living donor kidney transplant; unadjusted. Abbreviation: Prob., probability.

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