



kidney

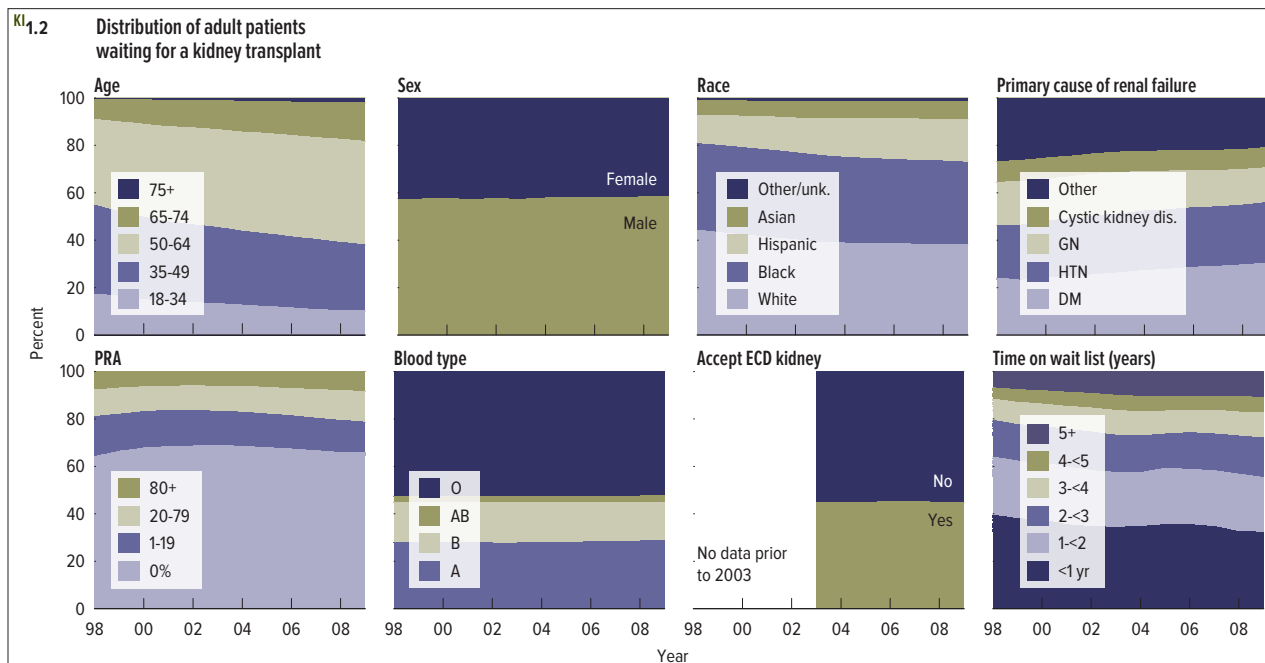
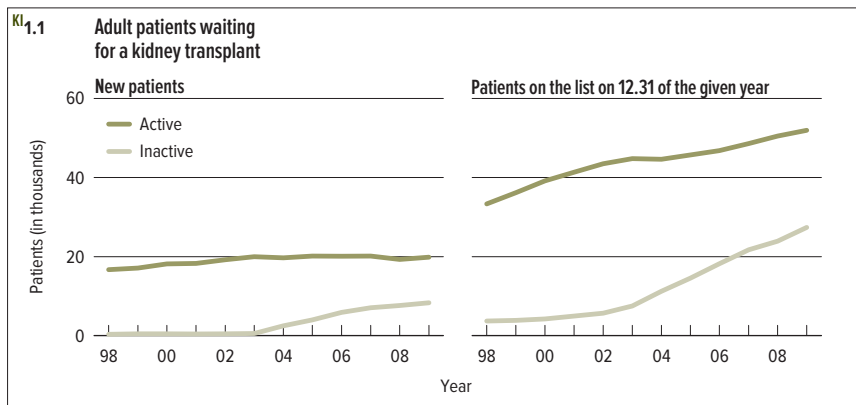
Kidney transplant highlights include the fact that the shortage of donor kidneys continues. Although 16,830 patients on the waiting list underwent kidney transplant in 2009, 5,412 listings were removed due to death (Figure 1.6). The shortage of kidneys has been accompanied by the use of deceased donor kidneys that are at increased risk to fail. Indeed, the Kidney Donor Risk Index (KDRI), which reflects the overall quality of deceased donor kidneys, has increased (Figure 2.6), and expanded criteria donor (ECD) kidneys comprised 16% of deceased donor kidneys in 2009 (Figure 2.7). At the same time, the discard rate for deceased donor kidneys has increased slightly (Figure 2.5).

Importantly, the number of kidney transplants was higher in 2009 than in 2008, reversing a trend. From 1998 to 2006, the total number of adult kidney transplants in the United States (US) increased annually (Figure 4.1), with a 34% increase during this period. Also during those years, the number of deceased donor transplants increased 26%, while the number of living donor transplants increased 51%. However, from 2006 to 2009, the total number of transplants fell 1.8%, with a 2.1% decline in deceased donor transplants and a 1.2% decline in living donor transplants. The decline in living donor transplants was first apparent in 2005; from 2004 to 2008 living donor transplants declined 9.4%. Thus, it is encouraging that in 2009 there was a 1.4% increase in total kidney transplants compared with 2008. This increase was entirely due to a 6.6% increase in living donor transplants; deceased donor transplants declined 1.4% between 2008 and 2009.

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*It's overwhelming what
human beings can do, and
to have the chance to
save someone else's life is
incredible.*

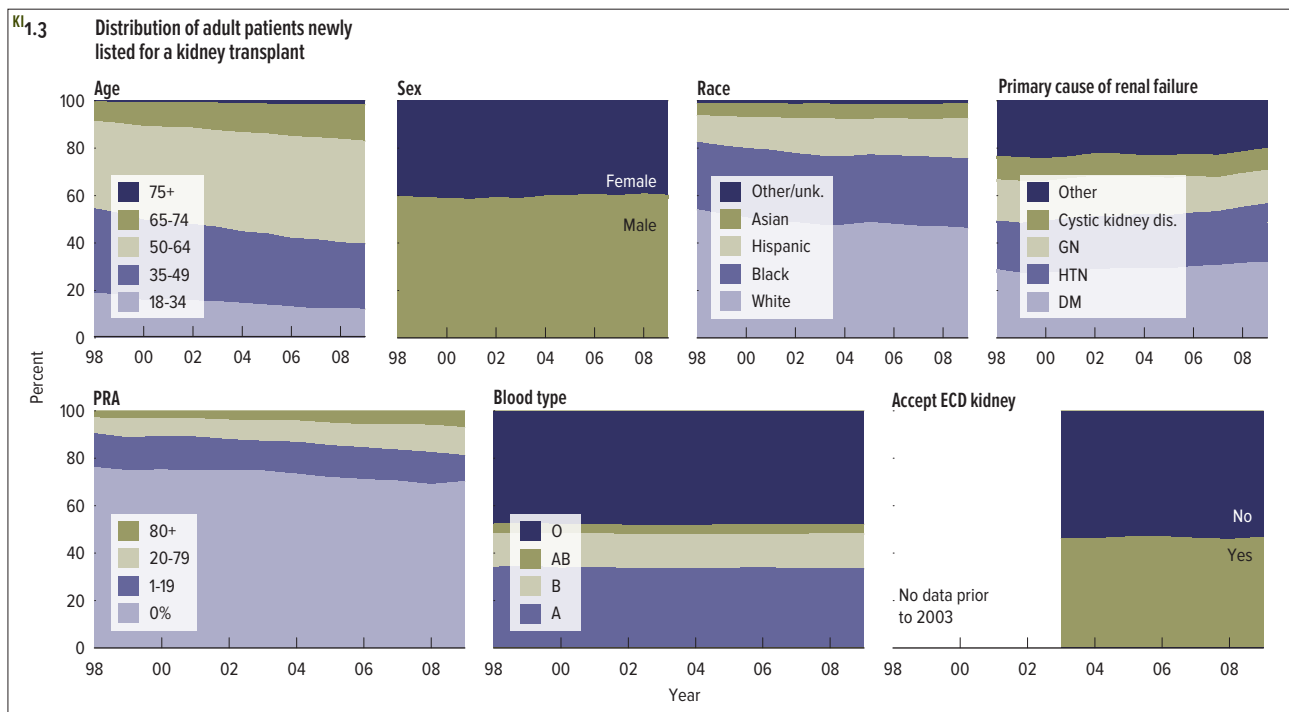
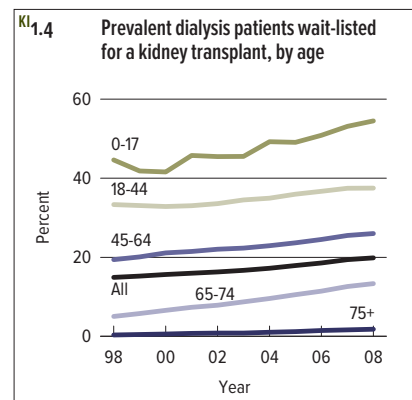
Andrea, kidney recipient



wait list Over the past 12 years, there has been a small but steady increase in the number of new patients added to the waiting list for a deceased donor kidney, contributing to an increase in the total number of patients on the waiting list (Figure 1.1). In 2003, a major Organ Procurement and Transplantation Network (OPTN) policy change (Policy 3.5.11.1; http://optn.transplant.hrsa.gov/PoliciesandBylaws2/policies/pdfs/policy_7.pdf) allowed patients on the list to accrue waiting time while inactive. Before 2003, an unknown number of patients on the list had been listed as active so they could accrue waiting time, even though they would not have accepted a kidney

offer. After 2003, without this incentive to list inactive patients as active, the number of patients listed as inactive grew incrementally (Figure 1.1). Nevertheless, the growth in the total number of patients on the waiting list has been almost linear, suggesting that the growth in inactive listings since 2003 is indeed an artifact of the OPTN policy change.

The demographic profile of the deceased donor kidney transplant waiting list has changed (Figure 1.2), as have the profiles of patients added to the waiting list (Figure 1.3). The proportions of men and women have remained relatively constant. However, the proportions of whites and blacks have declined slightly, while

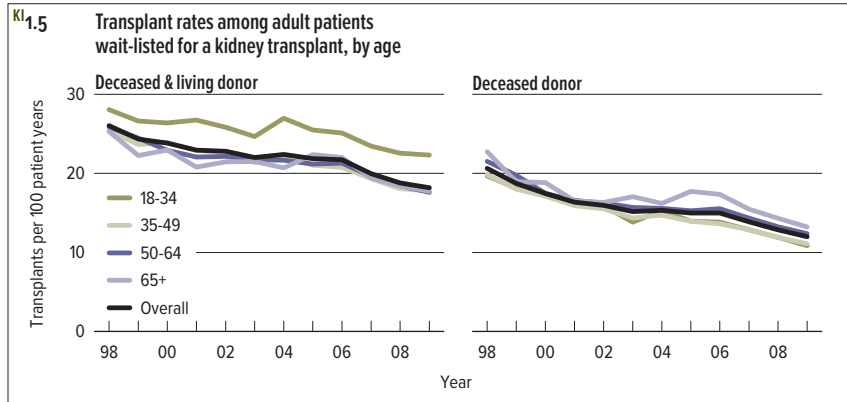


the proportion of Hispanics has grown. The proportions of patients on the waiting list due to end-stage renal disease (ESRD) from diabetes and hypertension have grown. The most striking demographic changes have been the increase in the proportion of older patients on the waiting list (Figure 1.2) and the proportion of newly listed patients who are older (Figure 1.3).

The proportions of waiting-list patients (Figure 1.2) and newly listed patients (Figure 1.3) with panel reactive antibody (PRA) higher than 0% have declined, but only slightly. The policy allowing individuals to accept an ECD kidney went into effect in 2004 (Policy 3.5.1; [http://optn.transplant.hrsa.](http://optn.transplant.hrsa.gov/PoliciesandBylaws2/policies/pdfs/policy_7.pdf)

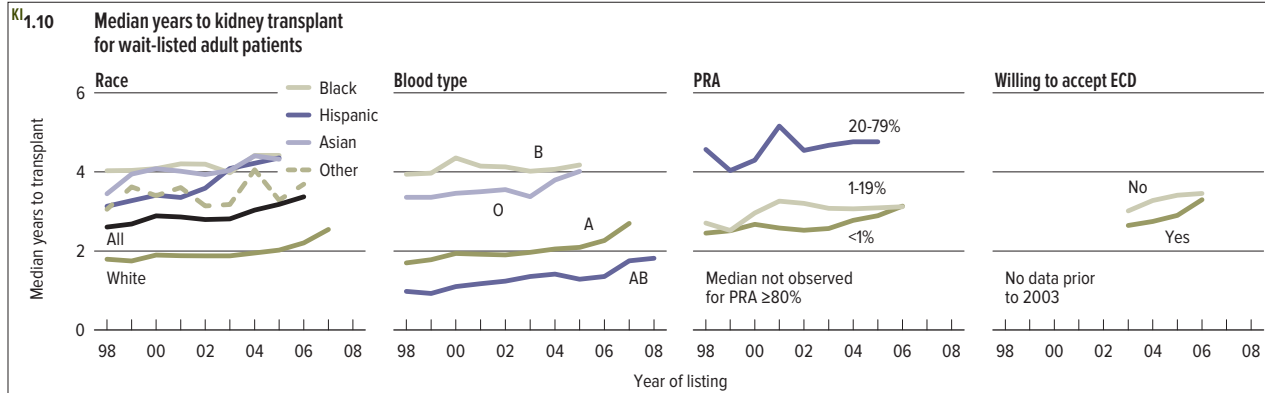
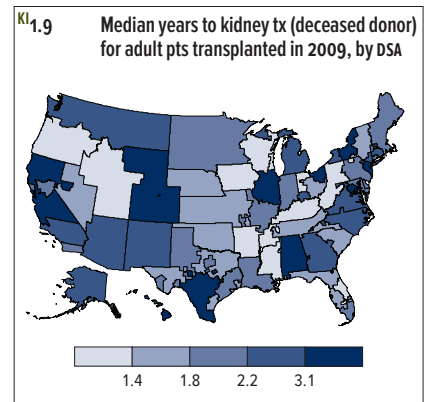
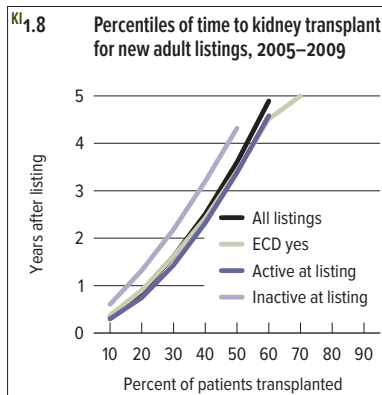
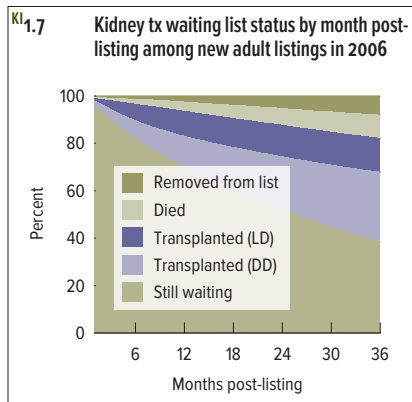
[gov/PoliciesandBylaws2/policies/pdfs/policy_7.pdf](http://optn.transplant.hrsa.gov/PoliciesandBylaws2/policies/pdfs/policy_7.pdf)). Since then, 45% of listed patients have agreed to accept an ECD kidney, if offered; that proportion has varied very little since 2004.

The waiting time for prevalent patients on the deceased donor waiting list has also increased. Between 1998 and 2009, the percentage of patients waiting 2 or more years increased from 36.0% to 44.7% (Figure 1.2). Obviously, the increase in new listings has not been matched by an increase in transplants. Hence, the percentage of prevalent dialysis patients on the deceased donor kidney transplant waiting list has also increased slightly over the past 12 years (Figure 1.4). This increase has occurred in all age groups.



KI.1.6 Kidney transplant waiting list activity among adult patients

	2007	2008	2009
Listings at start of year	68,754	74,501	79,161
Listings added during year	31,988	32,097	33,215
Listings removed during year	26,241	27,437	27,762
Listings at end of year	74,501	79,161	84,614
Removal reason			
Deceased donor transplant	11,796	11,828	11,765
Living donor transplant	4,369	4,572	5,065
Patient died	5,041	5,306	5,412
Patient refused transplant	266	259	307
Transferred to another ctr	1,581	1,510	1,401
Improved, tx not needed	121	133	132
Too sick to transplant	992	1,243	1,475
Changed to kid.-pan. list	266	243	221
Other	1,809	2,343	1,984

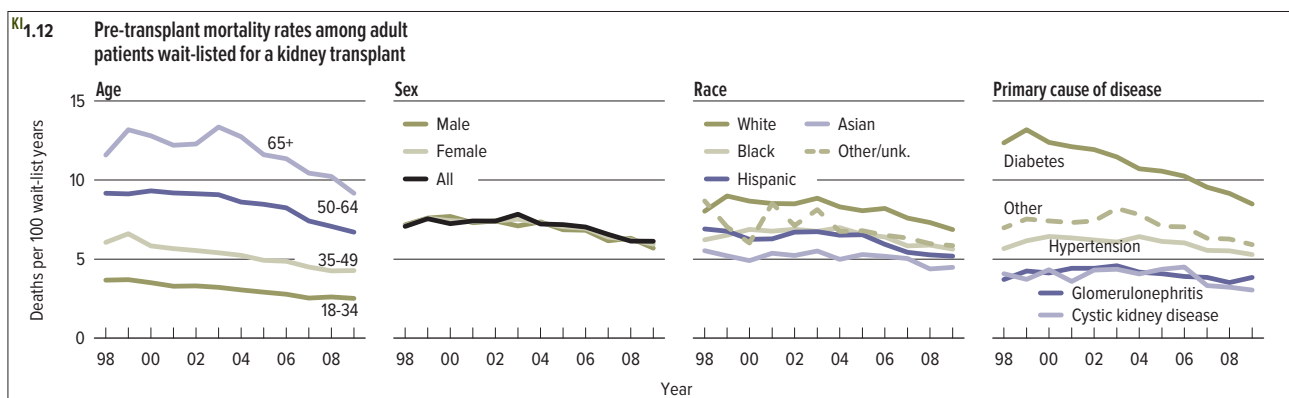
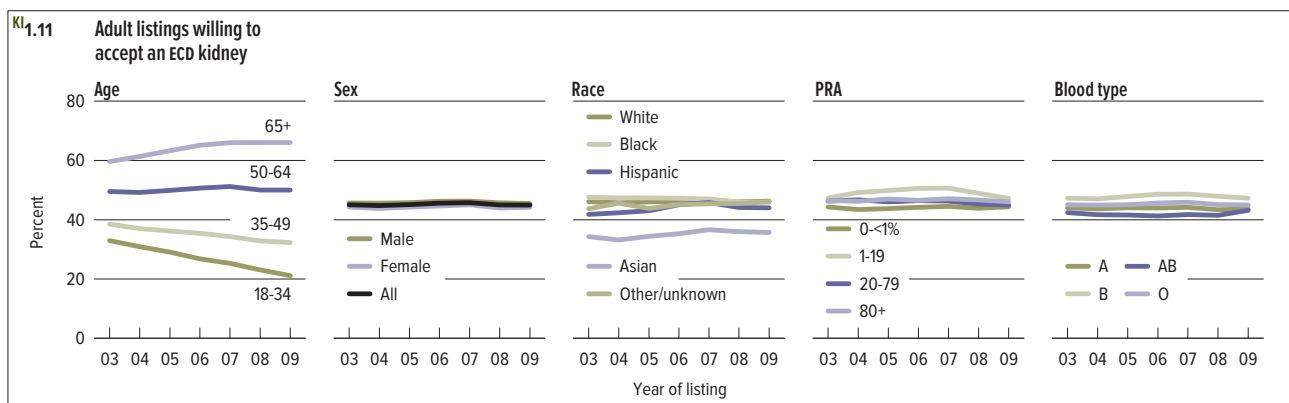


wait list Because the number of patients needing a kidney transplant has increased at a greater rate than the number of available organs, the rate of transplants per 100 patient-years on the waiting list has continued to decline (Figure 1.5). Rates are similar among age groups, but the overall rate is higher for patients aged 18 to 34 years, reflecting a higher living donor transplant rate in this group (Figure 1.5).

On January 1, 2009, there were 79,161 deceased donor listings. Patients listed at more than one center are counted once per listing. After additions and removals there were 84,614 listings at the end of 2009 (Figure 1.6). A kidney was received by 16,830 patients, but 5,412 listings were removed due to death, making death

the second most common reason for removal from the waiting list. The number of listings removed because the patient was too sick for transplant increased from 992 in 2007 to 1,243 in 2008 and 1,475 in 2009.

By 3 years after placement on the deceased donor waiting list, only 29.7% of listings had received a deceased donor kidney (Figure 1.7). The time from listing to transplant is longer for patients listed as inactive (Figure 1.8). The waiting time for a deceased donor kidney varies by region (Figure 1.9). Median waiting times are longer for minorities than for whites (Figure 1.10). Blood type and PRA strongly influence waiting time. Waiting times were slightly shorter for patients who agreed to accept an ECD kidney,



KI.1.13 Characteristics of adult patients on the kidney transplant wait list on December 31, 2009

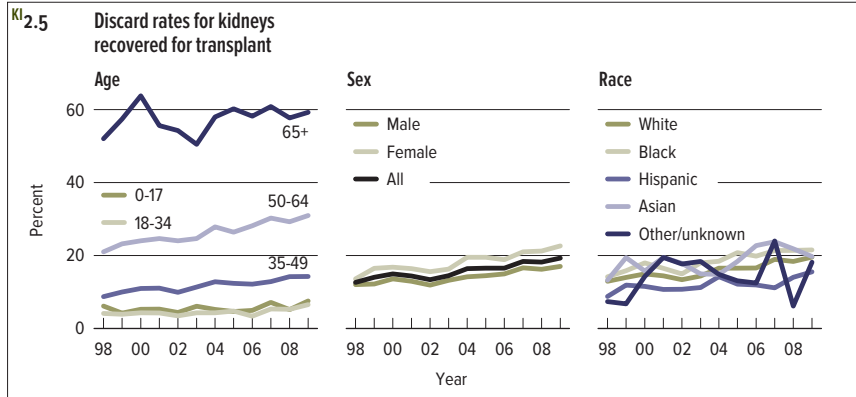
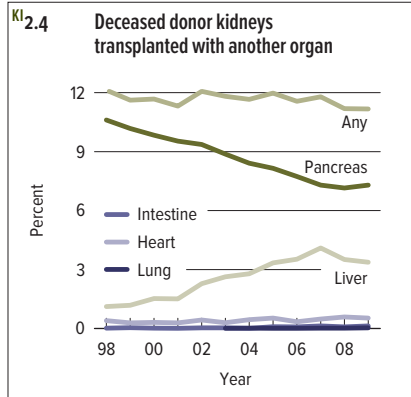
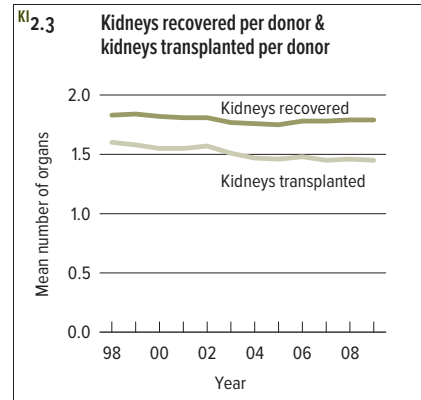
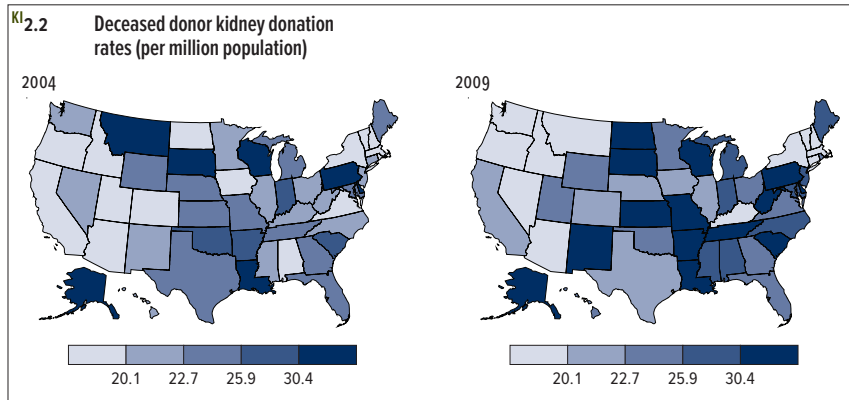
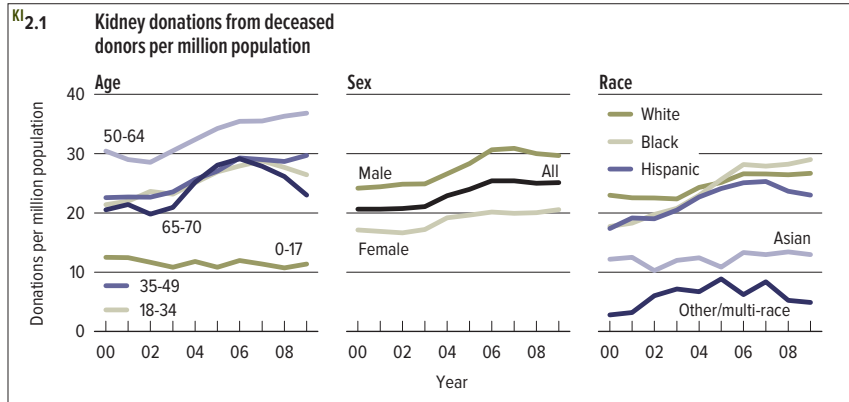
	Level	N	%		Level	N	%		Level	N	%
Age	18-44	20,893	26.3	Primary cause of disease	Diabetes	24,104	30.4	PRA	<10%	59,361	74.8
	45-64	43,999	55.4		Hypertension	20,326	25.6		10%+	19,999	25.2
	65-74	12,838	16.2		Glomerulonephritis	11,663	14.7		Unknown	1	0.0
	75+	1,631	2.1		Cystic kidney dis.	6,708	8.5	Time on list	<1 year	25,630	32.3
Gender	Male	46,446	58.5		Other/unknown	16,560	20.9		1-2	18,287	23.0
	Female	32,915	41.5	Tx history	Listed for first tx	66,802	84.2		2-3	13,259	16.7
Race	White	30,273	38.1		Listed for sub. tx	12,559	15.8		3-4	8,362	10.5
	Black	27,713	34.9	Blood type	A	22,715	28.6		4-5	5,088	6.4
	Hispanic	14,322	18.0		B	12,868	16.2		5+	8,735	11.0
	Asian	6,019	7.6		AB	2,348	3.0	ECD kidney	Will not accept	43,821	55.2
	Other/unk.	1,034	1.3		O	41,430	52.2		Will accept	35,540	44.8

but it is important to remember that these differences are not adjusted for other factors that may affect waiting time (Figure 1.10).

Since 2003, equal proportions of men and women have agreed to accept an ECD kidney (Figure 1.11). Older patients are more likely to be listed for an ECD kidney. Willingness to accept an ECD kidney is increasing slightly among patients aged 65 years or older and decreasing in those aged younger than 50 years (Figure 1.11). Interestingly, blood type and PRA influence waiting time dramatically (Figure 1.10) but do not seem to affect the proportions of patients listing for ECD kidneys (Figure 1.11). Mortality rates on the waiting list vary by age, as expected (Figure 1.12). Mortality rates are highest for whites compared with other groups. Mortal-

ity rates are highest for patients with ESRD caused by diabetes as opposed to other causes.

On December 31, 2009, 73.7% of wait-listed patients were aged 45 years or older and 18.3% were aged 65 years or older (Figure 1.13); 38.1% were white, 34.9% black, 18.0% Hispanic, and 7.6% Asian. Most (56.0%) had kidney disease caused primarily by diabetes or hypertension. There were 15.8% on the list for a repeat kidney transplant, and 44.8% were listed for an ECD kidney. Forty-five percent had been waiting at least 2 years, and 11.0% had been waiting at least 5 years.



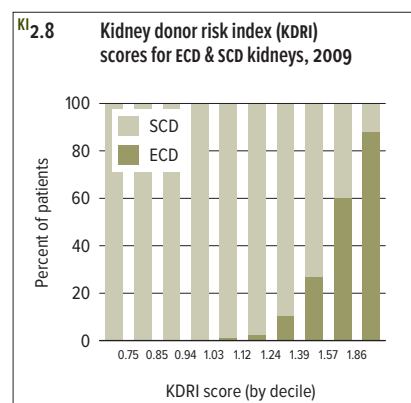
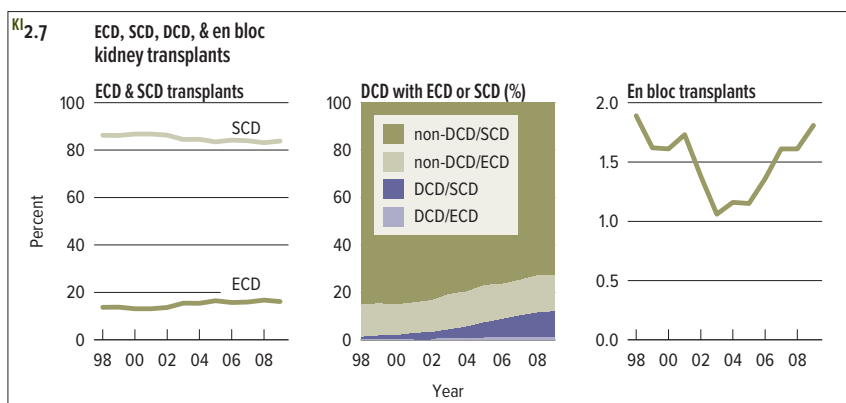
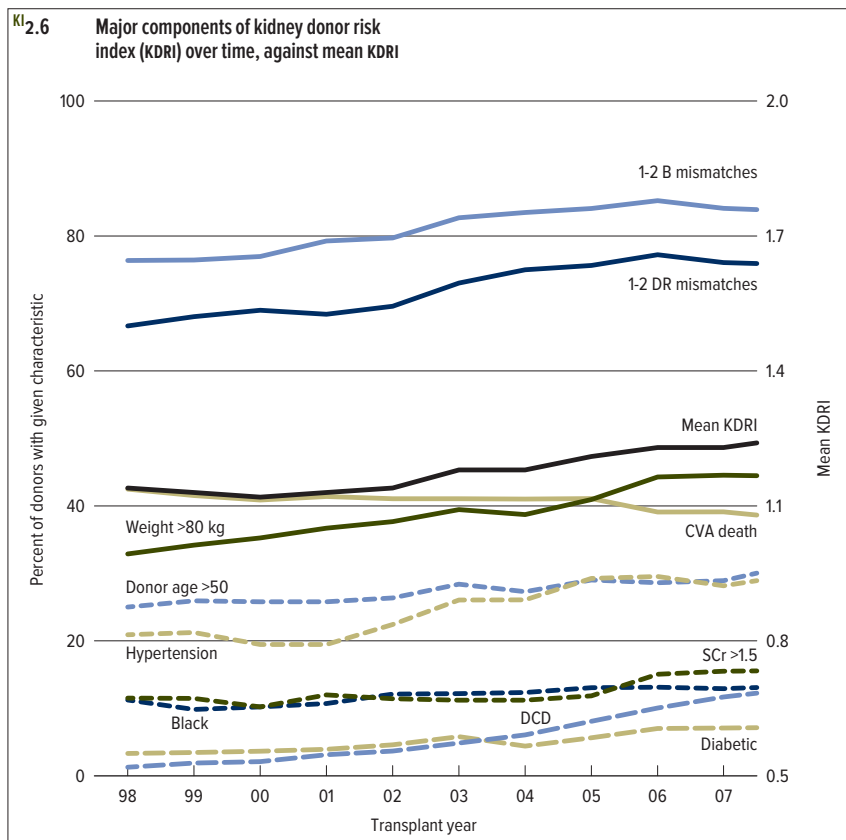
deceased donation

Ideally, the deceased donation rate should reflect donations among eligible donors. However, it is difficult to collect reliable data using uniform definitions of eligible deaths. Data on donations per million population (pmp), although crude, have been collected worldwide. Deceased donations pmp have increased over the past decade (Figure 2.1). Deceased donations pmp are similar for ages 18 to 49 and 65 to 70 years, higher for ages 50 to 64 years, and lowest for children and adolescents. Deceased donation rates tend to be higher for men than women. Donation rates are similar for whites, blacks, and Hispanics, but lower for Asians. There is substantial geographic heterogeneity in rates of deceased

kidney donation (Figure 2.2). The number of kidneys recovered and transplanted per donor has declined only slightly (Figure 2.3).

In 2009, 11.2% of deceased donor kidneys were transplanted with another organ; this has changed little over the past 12 years (Figure 2.4). However, the number of deceased donor kidneys transplanted with a pancreas declined, while the number transplanted with a liver increased, each plateauing in the past 2 to 3 years.

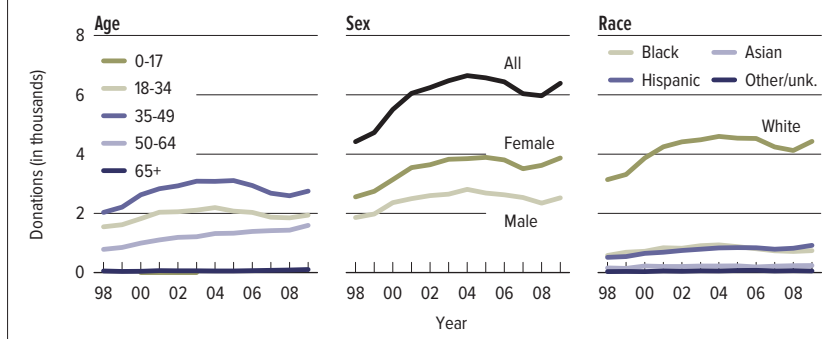
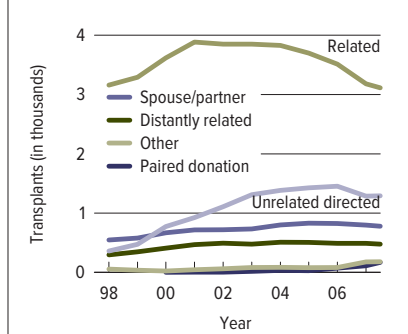
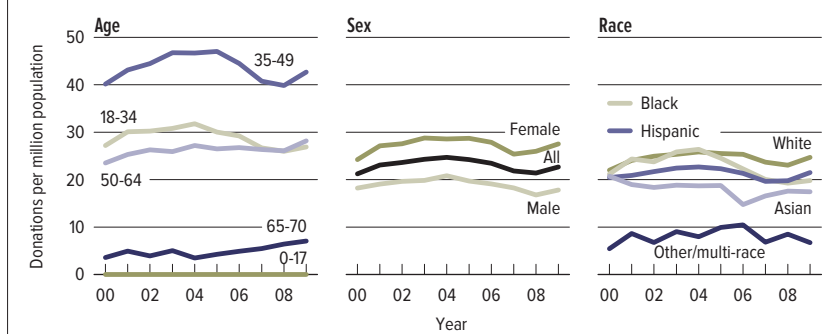
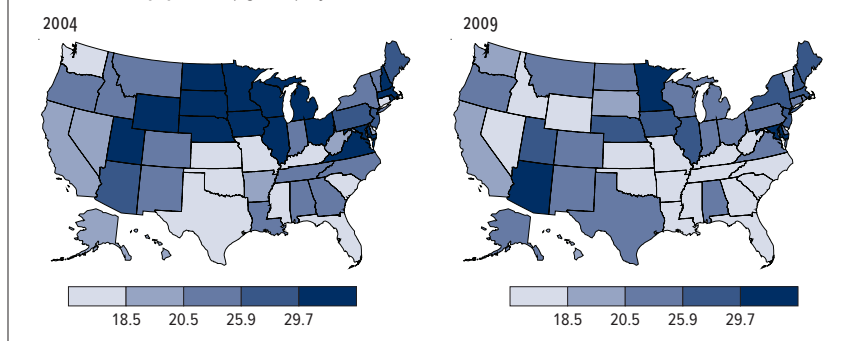
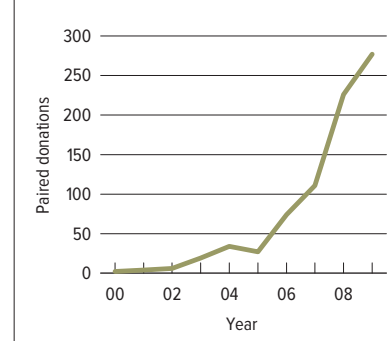
The discard rate for deceased donor kidneys has increased slightly over the past several years (Figure 2.5). Discard rates are proportionally higher for older donor age, and are as high as 60% for donors aged 60 years or older. The KDRI predicts kidney allograft survival based on characteristics of the deceased donor kid-



ney, adjusted for characteristics of the recipient and the transplant. A higher KDRI indicates a higher risk of graft failure than a lower KDRI. The mean KDRI for patients receiving a deceased donor kidney has increased (Figure 2.6). The components of the KDRI have changed at different rates over time.

An ECD kidney is a kidney from any brain-dead donor aged 60 years or older, or from a donor aged 50 to 59 years with 2 of the following: hypertension, terminal serum creatinine greater than 1.5 mg/dL, or death from a cerebrovascular accident (http://optn.transplant.hrsa.gov/PoliciesandBylaws2/policies/pdfs/policy_7.pdf). Donation after circulatory death (DCD) can yield ECD or standard criteria donor (SCD) kidneys. From 1998 to 2009, the overall percentage of non-DCD/ECD deceased donors

has remained relatively constant (13.6% in 1998 to 15.0% in 2009), whereas the percentage of DCD/SCD donors has risen over that time (from 1.1% in 1998 to 10.8% in 2009). Conversely, the overall percentage of non-DCD/SCD donors has fallen (85.2% in 1998 to 73.1% in 2009). DCD/ECD donors have become slightly more prevalent (0.1% in 1998 to 1.1% in 2009). Two kidneys can be transplanted *en bloc*; this strategy has been used to transplant kidneys that otherwise have a high risk of failure. Currently, only 1.8% of adult deceased donor kidneys are transplanted *en bloc* (Figure 2.7). Kidneys with higher KDRI scores are increasingly likely to be ECD kidneys and vice versa (Figure 2.8).

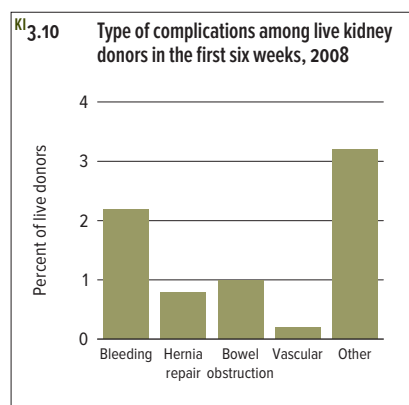
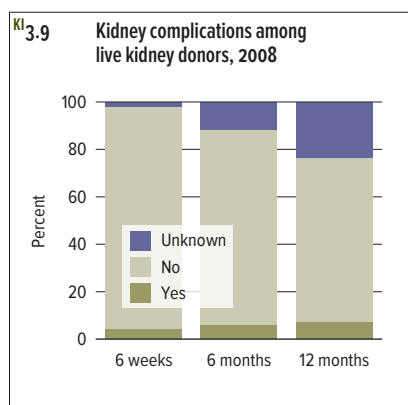
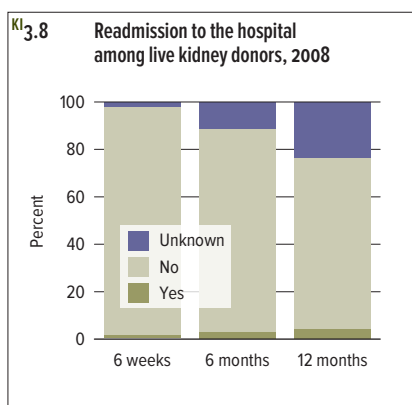
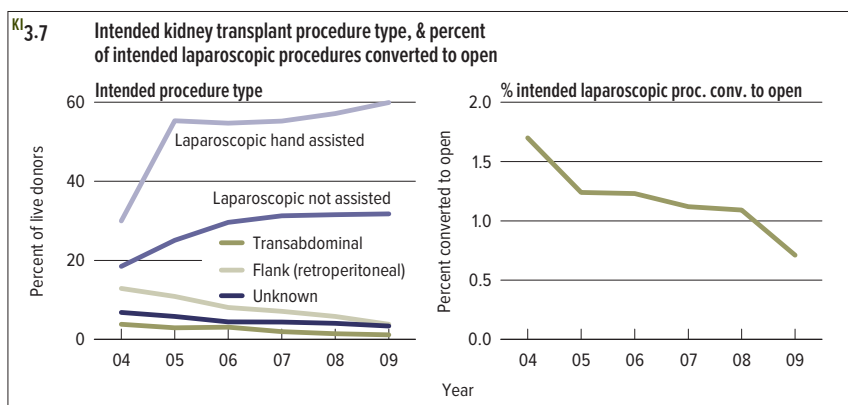
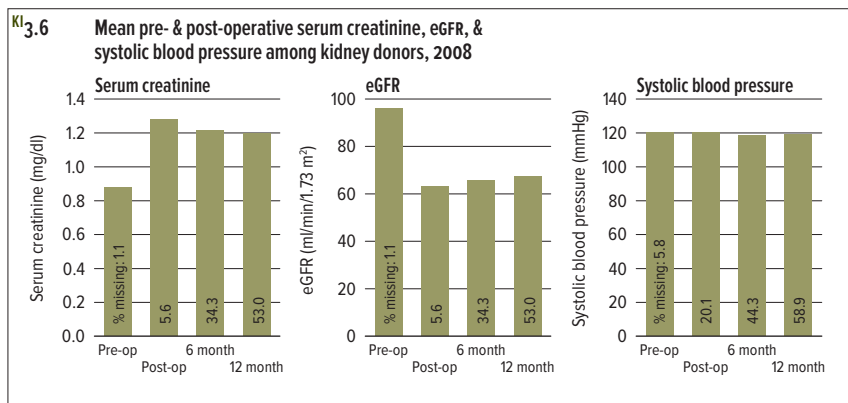
KI 3.1 Kidney donations from living donors**KI 3.2** Kidney transplants from living donors, by donor relation**KI 3.3** Living donor kidney donation rates per million population**KI 3.4** Living donor kidney donation rates per million population (age <70), by state**KI 3.5** Paired kidney donations

live donation Living kidney donations increased every year from 1998 to 2004, declined from 2005 to 2008, and increased by 7.0% in 2009 compared with 2008 (Figure 3.1). The 2009 increase in living donations was seen in all age groups and was greatest in Hispanics (12.0%). The increase in living donors in 2009 compared with 2008 was 3.3% for related donors, 8.4% for distantly related donors, 10.4% for spouses/partners, and 6.3% for unrelated donors (Figure 3.2).

Parallel increases occurred in the rates of living kidney donation pmp in 2009 compared with 2008 (Figure 3.3). The rate of living kidney donation was highest for patients aged 35 to 49 years and lowest for those aged 0 to 17 years. Rates were higher

for women than men, and were similar for whites, blacks, and Hispanics, and slightly lower for Asians. Substantial geographic variation remains in the rates of living kidney donation (Figure 3.4). Rates are high in New England and the north central US, and lowest in the southeast.

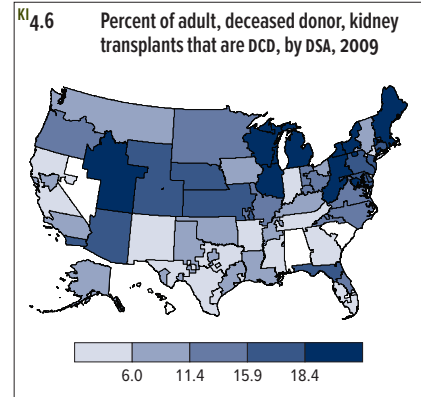
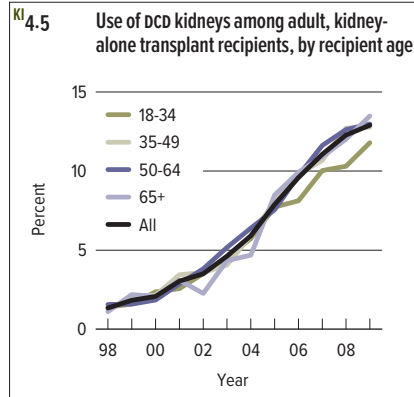
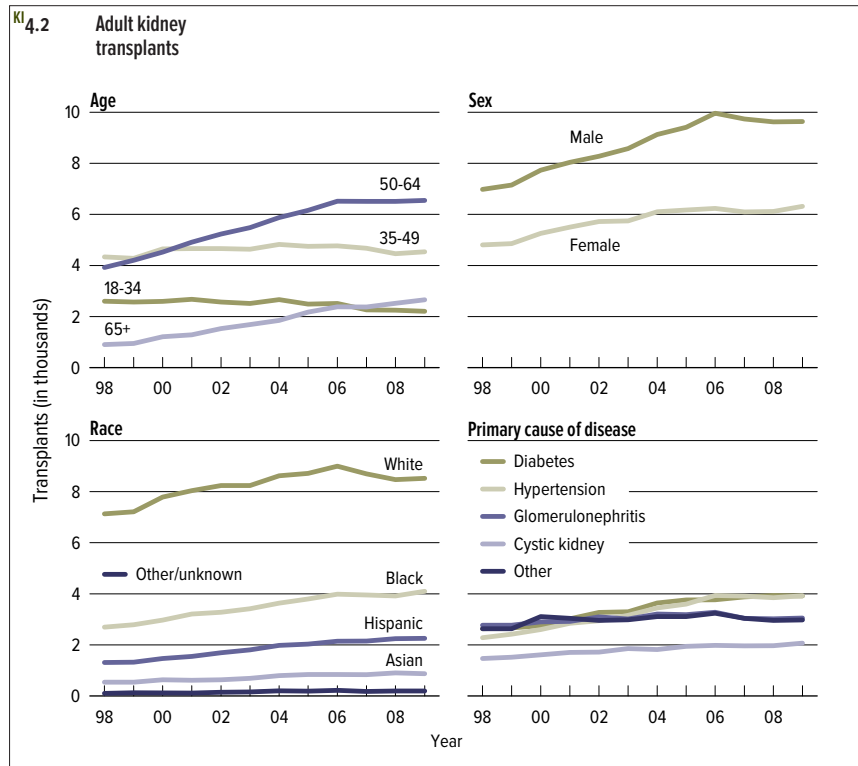
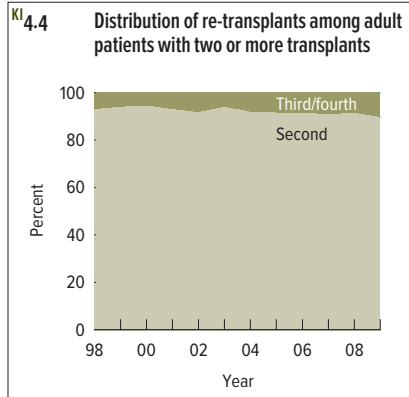
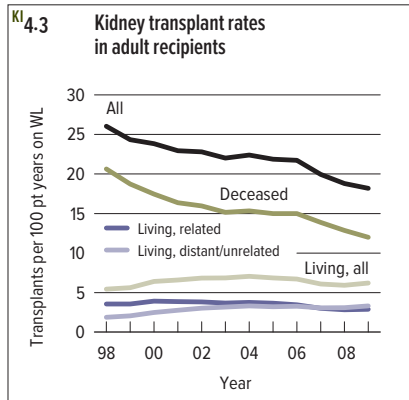
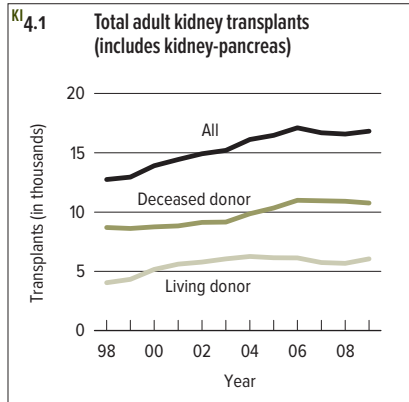
The use of kidney donations for paired exchange is relatively new in the US. The numbers, albeit small, are notable given that recipients are often patients for whom it is difficult to find an appropriate match (Figure 3.5). Despite an effort to improve reporting for living kidney donor follow-up, the number of donors without follow-up data remains high (Figure 3.6). For patients who donated a kidney in 2008, the proportions of serum creati-



nine values that were missing at post-op, 6 months, and 12 months were 5.6%, 34.3%, and 53.0%, respectively (Figure 3.6). The proportions with missing blood pressure values were even higher, missing at post-op, 6 months, and 12 months in 20.1%, 44.3%, and 58.9%, respectively.

Most donor nephrectomies are now performed laparoscopically, with almost twice as many hand-assisted as not (Figure 3.7). In 2009, only 4.9% of donor nephrectomies used a retroperitoneal flank (3.8%) or intra-abdominal (1.1%) approach. The proportion of intended laparoscopic donor nephrectomies that were converted to open procedures declined to less than 1% in 2009 (Figure 3.7).

Readmission rates (Figure 3.8) and complications (Figure 3.9) appear to be low for living kidney donors in the first year; some information is not known, however. In 2008, major complications included bleeding in 2.2%, need for wound hernia repair in 0.8%, and bowel obstruction in 1.0% (Figure 3.10). The numbers of living donor deaths occurring within 30 days of donation and thought to be donation-related were 0 in 2005, 1 in 2006, 0 in 2007, 1 in 2008, and 1 in 2009. The numbers (and percentages) of living donor deaths from any cause that occurred within 1 year of donation were 2 (0.03%) in 2005, 5 (0.08%) in 2006, 3 (0.05%) in 2007, 3 (0.05%) in 2008, and 2 (0.05%) in 2009.



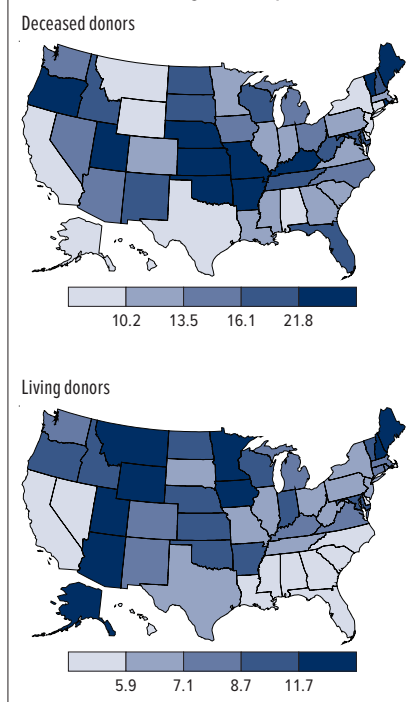
transplant From 1998 to 2006, the number of adult kidney transplants increased 34%; deceased donor transplants increased 26%, and living donor transplants increased 51% (Figure 4.1). However, from 2006 to 2009, the number of transplants fell 1.8%, with a 2.1% decline in deceased donor transplants and a 1.2% decline in living donor transplants. It is therefore encouraging that, between 2008 and 2009, there was a 1.4% increase in kidney transplants, which was entirely due to a 6.6% increase in living donor transplants, while deceased donor transplants declined 1.4%.

The largest increase in transplants between 2008 and 2009 was in patients aged 65 years or older (5.6%); transplants in patients

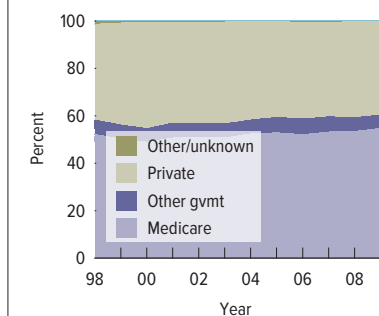
aged 18 to 34 years declined 2.1% (Figure 4.2). Most of the increase was in women (3.3%) versus men (0.1%). The 2009 increase was greatest in blacks (4.8%).

Unfortunately, the increase in 2009 was not enough to keep pace with the increase in the number of patients on the deceased donor waiting list. Hence, the rate of transplants per 100 patient-years on the waiting list declined 3.2% in 2009 (Figure 4.3). Since 1998, the rate of adult kidney transplants has declined by more than 30%. In 2009 12.1% of transplants were repeat transplants, and 89.5% of the repeat transplants were second, 9.5% third, and 1.0% fourth transplants (Figure 4.4). The proportion of deceased donor transplants using DCD kidneys has grown more than 8-fold, and

KI 4.7 Kidney transplant rates per 100 pt years on the waiting list, adult patients, 2009



KI 4.9 Insurance coverage among adult kidney transplant recipients at time of transplant



KI 4.8 Characteristics of adult kidney transplant recipients, 2009

Level	All		Deceased		Living	
	N	%	N	%	N	%
Age	18-34	2,208	13.8	1,000	1,208	20.0
	35-49	4,541	28.4	2,643	1,898	31.4
	50-64	6,556	41.1	4,363	2,193	36.2
	65+	2,659	16.7	1,906	753	12.4
Gender	Female	6,322	39.6	3,969	2,353	38.9
	Male	9,642	60.4	5,943	3,699	61.1
Race	White	8,525	53.4	4,530	3,995	66.0
	Black	4,105	25.7	3,259	846	14.0
	Hispanic	2,259	14.2	1,376	883	14.6
	Asian	874	5.5	602	272	4.5
	Other/unknown	201	1.3	145	56	0.9
Primary cause of disease	Diabetes	3,921	24.6	2,581	1,340	22.1
	Hypertension	3,931	24.6	2,759	1,172	19.4
	Glomerulonephritis	3,060	19.2	1,676	1,384	22.9
	Cystic kidney disease	2,070	13.0	1,126	944	15.6
	Other cause	2,982	18.7	1,770	1,212	20.0
Blood type	A	5,954	37.3	3,646	2,308	38.1
	B	2,096	13.1	1,294	802	13.3
	AB	768	4.8	534	234	3.9
	O	7,146	44.8	4,438	2,708	44.7
PRA	<10%	11,257	70.5	6,666	4,591	75.9
	10%+	3,667	23.0	2,631	1,036	17.1
	Unk.	1,040	6.5	615	425	7.0
History of renal replacement therapy	Preemptive transplant	2,639	16.5	905	1,734	28.7
	<1 year	2,169	13.6	687	1,482	24.5
	<3 years	4,056	25.4	2,536	1,520	25.1
	<5 years	2,856	17.9	2,371	485	8.0
	5+ years/unknown	4,244	26.6	3,413	831	13.7
Insurance	Private	6,270	39.3	2,677	3,593	59.4
	Medicare	8,729	54.7	6,581	2,148	35.5
	Other	965	6.0	654	311	5.1
HLA mismatches with donor	0	1,264	7.9	787	477	7.9
	1	371	2.3	87	284	4.7
	2	1,391	8.7	405	986	16.3
	3	2,904	18.2	1,301	1,603	26.5
	4	3,594	22.5	2,630	964	15.9
	5	4,221	26.4	3,117	1,104	18.2
	6	2,089	13.1	1,516	573	9.5
	Unk.	130	0.8	69	61	1.0
Kidney transplant history	First transplant	14,037	87.9	8,653	5,384	89.0
	Subsequent transplant	1,927	12.1	1,259	668	11.0
DCD status *	Non-DCD			8,633		
	DCD			1,279		
SCD/ECD status *	SCD			7,892		
	ECD			2,020		
Total	15,964	100.0	9,912	100.0	6,052	100.0

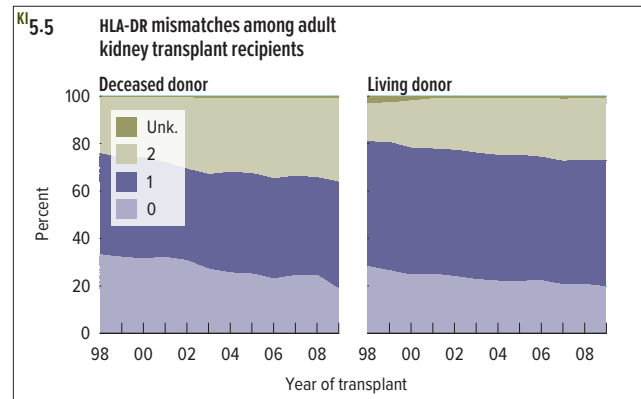
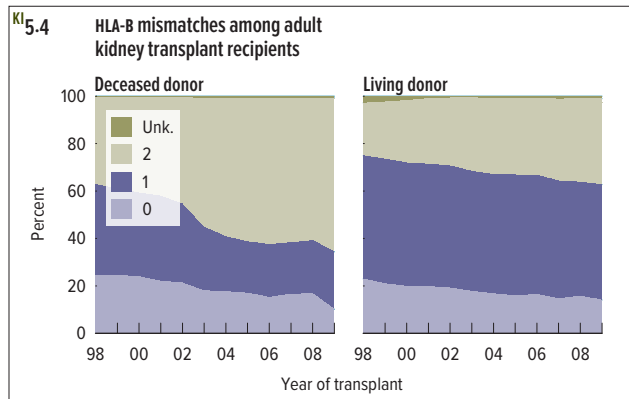
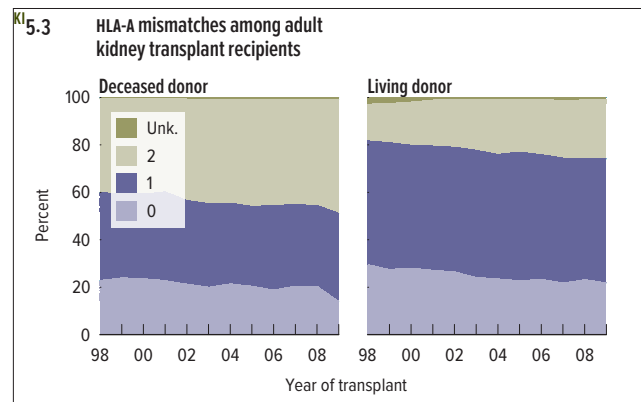
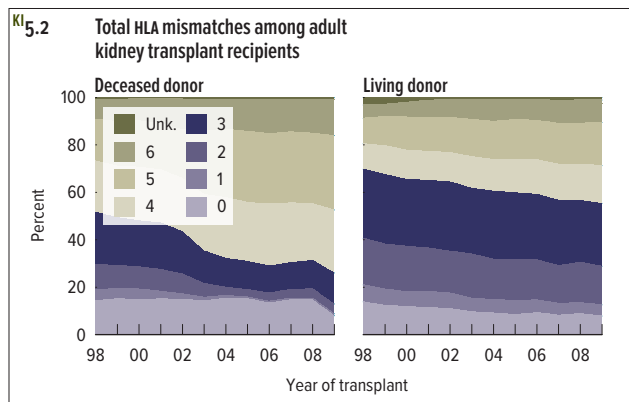
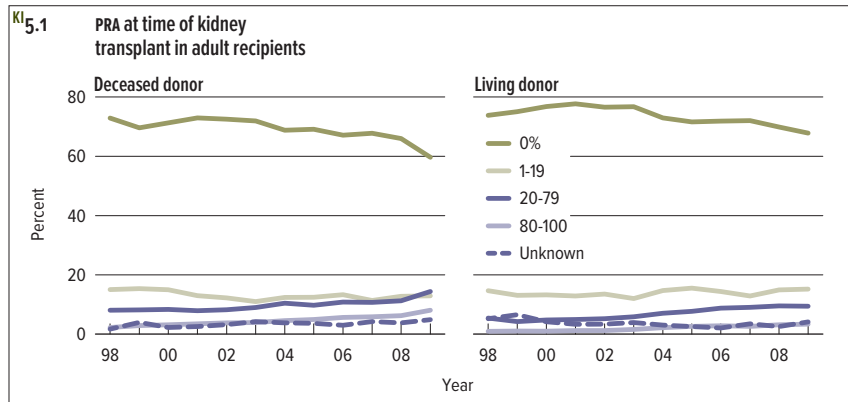
* for deceased donor transplant only

in 2009 DCD kidneys comprised 13% of deceased donor kidneys (Figure 4.5). There is remarkable heterogeneity among donor service areas (DSAs) in the proportion of deceased donor transplants using DCD kidneys, from 0% to 38% in 2009 (Figure 4.6).

The rates of deceased and living donor kidney transplants per 100 patient-years on the waiting list also show remarkable geographic variation (Figure 4.7). Rates of deceased donor kidney transplants were 6.5 and 9.7 per 100 patient-years on the waiting list in California and Texas, respectively, but in neighboring states Oregon and Oklahoma, the rates were more than 2-fold higher, 32.8 and 21.8 per 100 patient-years on the waiting list, respectively. Rates for living donor transplants were lowest in California, Nevada, and

the southeastern states and were 2- to 3-fold higher in Minnesota, Iowa, New England, and some western states (Figure 4.7).

In 2009, 54.7% of kidney transplant recipients had Medicare as their primary insurance provider (Figures 4.8 and 4.9). In 2009, 16.5% of kidney transplants were preemptive (transplant before beginning maintenance dialysis), but 12.1% were repeat transplants, and 26.6% were for patients who had been on renal replacement therapy for 5 or more years before transplant (Figure 4.8). Also in 2009, 12.9% of deceased donor kidney transplants used DCD kidneys, and 20.4% used ECD kidneys (Figure 4.8).



donor-recipient matching

In general, the immunological risk of kidney transplant has increased over the past 12 years. For recipients of deceased donor kidneys, the proportion with a PRA level of 0% at the time of transplant has declined from 72.9% in 1998 to 59.7% in 2009 (Figure 5.1). Over the same period, the proportion with a PRA level of 80% to 100% has increased from 2.2% to 8.1%. For recipients of living donor kidneys, the proportion with a PRA level of 0% at the time of transplant declined only slightly, from 73.8% in 1998 to 67.9% in 2009, while the proportion with a PRA level of 80% to 100% increased from 0.9% to 3.4%.

In general, the immunological risk of kidney transplant has increased over the past 12 years.

Over the past several years, the proportion of patients with 3 or fewer donor/recipient human leukocyte antigen (HLA) mismatches has been decreasing (Figure 5.2). For example, the percentage of 0 HLA mismatches declined from 14.3% in 1998 to 7.9% in 2009 for deceased donor transplants, and from 13.9% to 7.9% for living donor transplants. Similar declines in the degree of HLA matching are seen for HLA-A (Figure 5.3), HLA-B (Figure 5.4), and HLA-DR mismatches (Figure 5.5).

The risk for cytomegalovirus (CMV) infection after transplant is largely determined by the donor and recipient antibody status (indicating prior CMV infection). The highest risk for transmission of CMV occurs when the donor has had CMV infection and the recipient has not. Between 2005 and 2009, 17.4% of deceased

KI 5.6 Adult kidney donor-recipient cytomegalovirus (CMV) serology matching, 2005–2009

RECIPIENT	DECEASED DONOR				LIVING DONOR			
	Neg.	Pos.	Unk.	Total	Neg.	Pos.	Unk.	Total
Negative	11.4	17.4	0.1	29.0	20.9	14.4	3.3	38.6
Positive	23.1	42.8	0.3	66.1	18.9	32.6	4.9	56.4
Unknown	1.8	3.0	0.0	4.9	1.3	1.4	2.3	5.0
Total	36.3	63.2	0.5	100	41.1	48.4	10.6	100

KI 5.7 Adult kidney donor-recipient Epstein-Barr virus (EBV) serology matching, 2005–2009

RECIPIENT	DECEASED DONOR				LIVING DONOR			
	Neg.	Pos.	Unk.	Total	Neg.	Pos.	Unk.	Total
Negative	0.6	7.7	2.7	11.0	2.1	5.8	3.1	10.9
Positive	3.0	40.1	17.1	60.3	3.9	46.1	11.6	61.5
Unknown	1.2	16.5	11.1	28.8	0.9	5.9	20.8	27.5
Total	4.8	64.3	30.9	100	6.8	57.7	35.5	100

KI 5.8 Adult kidney donor-recipient hepatitis B core antibody (HBcAb) serology matching, 2005–2009

RECIPIENT	DECEASED DONOR				LIVING DONOR			
	Neg.	Pos.	Unk.	Total	Neg.	Pos.	Unk.	Total
Negative	68.1	2.9	0.2	71.2	61.1	1.4	12.1	74.6
Positive	7.2	1.0	0.0	8.3	3.1	0.5	1.0	4.6
Unknown	19.6	0.9	0.0	20.6	6.1	0.1	14.6	20.8
Total	95.0	4.8	0.2	100	70.3	2.1	27.6	100

KI 5.9 Adult kidney donor-recipient hepatitis B surface antigen (HBsAg) serology matching, 2005–2009

RECIPIENT	DECEASED DONOR				LIVING DONOR			
	Neg.	Pos.	Unk.	Total	Neg.	Pos.	Unk.	Total
Negative	87.8	0.0	0.2	88.0	77.7	0.0	12.1	89.7
Positive	2.3	0.0	0.0	2.3	1.3	0.0	0.2	1.5
Unknown	9.7	0.0	0.0	9.8	3.9	0.0	4.9	8.8
Total	99.7	0.0	0.3	100	82.8	0.0	17.2	100

KI 5.10 Adult kidney donor-recipient hepatitis C serology matching, 2005–2009

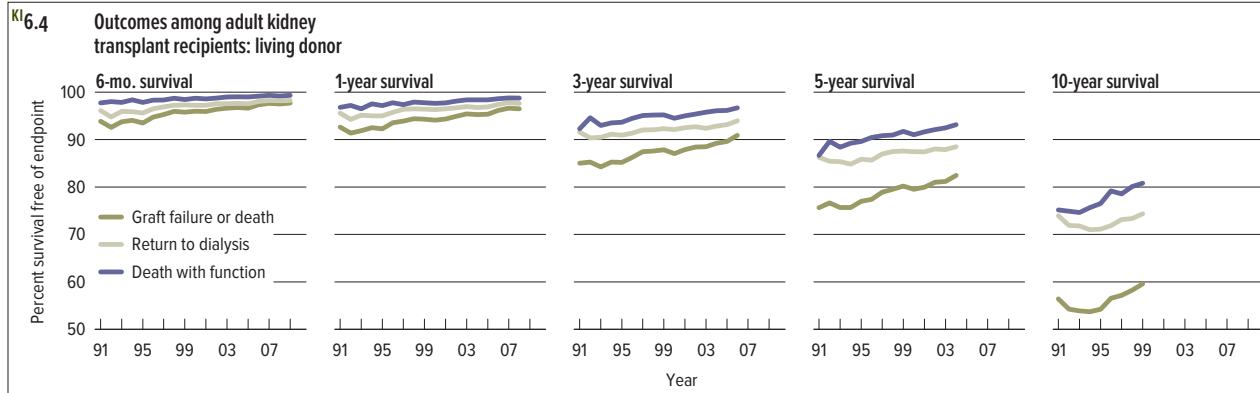
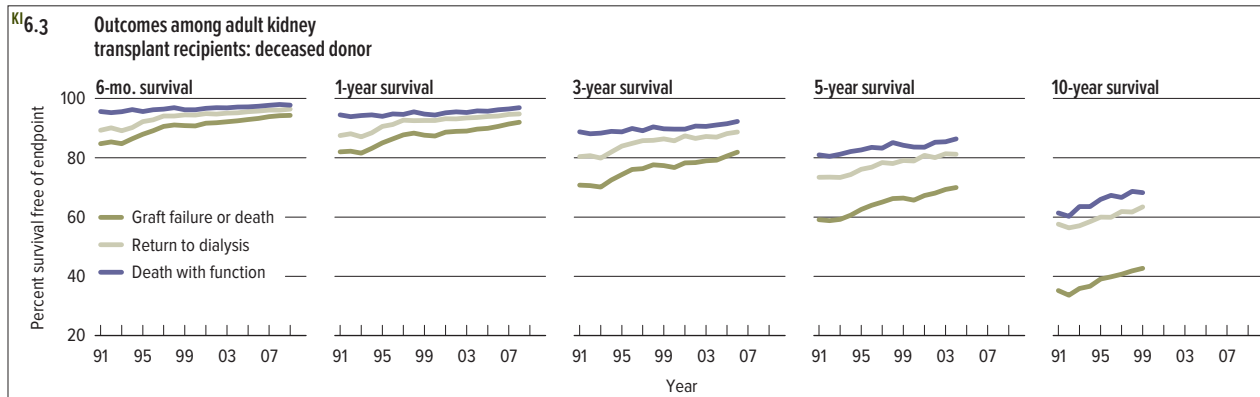
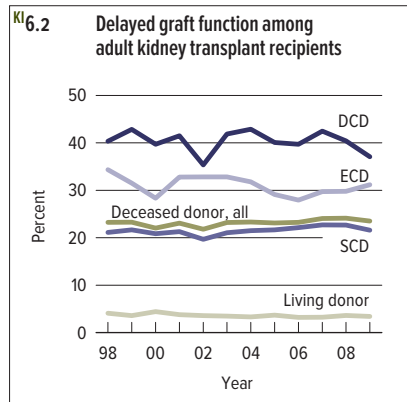
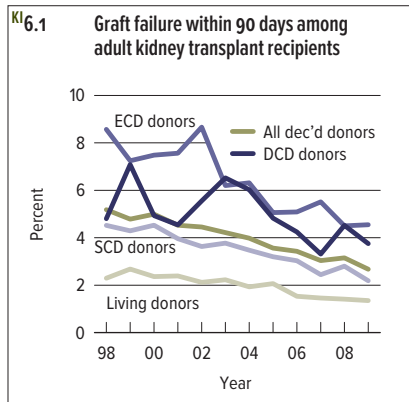
RECIPIENT	DECEASED DONOR				LIVING DONOR			
	Neg.	Pos.	Unk.	Total	Neg.	Pos.	Unk.	Total
Negative	82.8	0.3	0.2	83.2	78.4	0.5	9.5	88.4
Positive	4.7	1.9	0.0	6.6	2.7	0.0	0.3	3.0
Unknown	9.8	0.3	0.0	10.1	4.2	0.0	4.4	8.6
Total	97.3	2.5	0.2	100	85.3	0.6	14.2	100

KI 5.11 Adult kidney donor-recipient human immunodeficiency virus (HIV) serology matching, 2005–2009

RECIPIENT	DECEASED DONOR				LIVING DONOR			
	Neg.	Pos.	Unk.	Total	Neg.	Pos.	Unk.	Total
Negative	80.3	0.0	0.1	80.4	72.9	0.0	9.1	82.0
Positive	0.5	0.0	0.0	0.5	0.2	0.0	0.1	0.3
Unknown	19.2	0.0	0.0	19.2	3.9	0.0	13.8	17.7
Total	99.9	0.0	0.1	100	77.0	0.0	23.0	100

donor recipients were in this high-risk category, as indicated by a serology match between a donor positive and a recipient negative (D+/R-) for CMV. Among living donor transplant recipients, 14.4% were D+/R- (Figure 5.6). Of even more concern is transmission of Epstein-Barr virus (EBV) infection, which can cause PTLD. At increased risk (D+/R-) for EBV and PTLD were 7.7% of adult deceased donor kidney recipients and 5.8% of living donor kidney recipients (Figure 5.7). Few patients appeared to be at risk for hepatitis B virus (HBV) infection from the transplanted kidney; 2.9% of deceased donor recipients were cases of D+/R- for hepatitis B core antibody (HBcAb; indicating prior HBV infection); for living donor recipients, the percentage was 1.4% (Figure 5.8). Interestingly, only 2.3% of deceased and 1.5% of living donor

recipients were HBV surface antigen (HBsAg) positive, indicating either prior infection or immunization (recommended in guidelines) (Figure 5.9). Only 0.3% of deceased donor recipients were cases of D+/R- for hepatitis C virus (HCV) antibody, and 1.9% were D+/R+ for HCV. There were 0.5% living donor kidney recipients D+/R- for HCV and 0.0% D+/R+ for HCV (Figure 5.10). Fortunately, there were no recorded instances of recipients receiving kidneys from donors positive for human immunodeficiency virus (HIV) antibody (Figure 5.11).



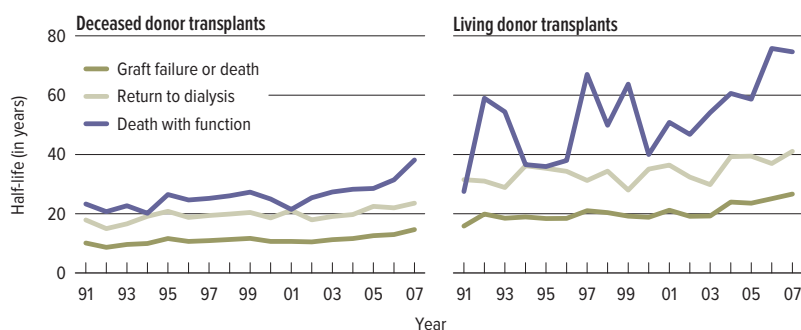
outcomes Outcomes have continued to improve after kidney transplant. The loss of a kidney graft within 90 days of transplant declined from 5.2% in 1998 to 2.7% in 2009 (Figure 6.1). In 2009, the proportion of patients with primary non-function was 1.4% for living donor kidneys and 2.7% for deceased donor kidneys (4.6% for ECD, 3.8% for DCD, and 2.2% for SCD).

In 2009, delayed graft function (DGF), defined as the need for dialysis during the first week after transplant, occurred in 23.5% of recipients of deceased donor kidneys and 3.4% of recipients of living donor kidneys (Figure 6.2). In 2009, DGF occurred in 21.6% of SCD kidney recipients, 31.2% of ECD kidney recipients, and 37.1%

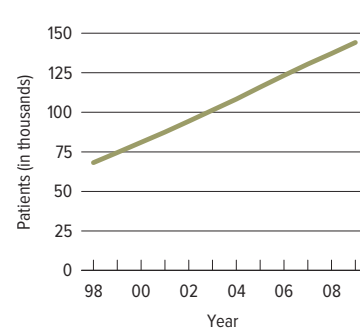
of DCD kidney recipients. The incidence of DGF has changed little over the past 12 years.

Graft survival (i.e., survival with a functioning graft) has continued to improve. Graft survival for deceased donor kidneys in 2009 was 94.4% at 6 months; for transplants in 2008, 92.0% at 1 year; for transplants in 2006, 81.9% at 3 years; for transplants in 2004, 70.0% at 5 years; and for transplants in 1999, 42.7% at 10 years (Figure 6.3). Graft survival for living donor transplants in 2009 was 97.7% at 6 months; for transplants in 2008, 96.5% at 1 year; for transplants in 2006, 90.9% at 3 years; for transplants in 2004, 82.5% at 5 years; and for transplants in 1999, 59.6% at 10 years (Figure 6.4). One-year graft survival will be difficult to

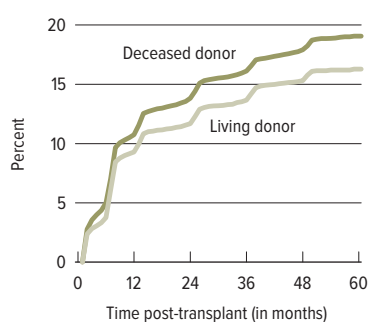
KI 6.5 Half-lives for adult kidney transplant recipients surviving with a functioning graft for at least one year



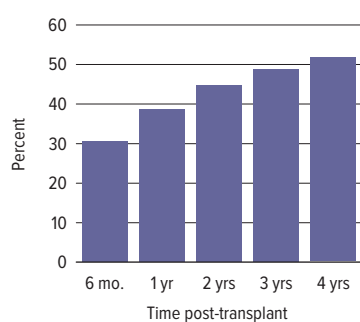
KI 6.6 Adult recipients alive & with a functioning kidney transplant on June 30 of the year



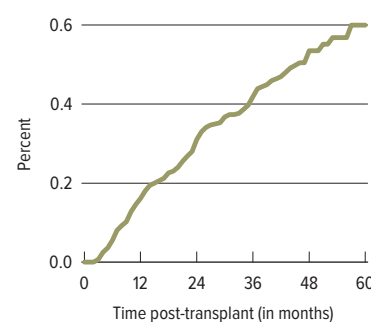
KI 6.7 Incidence of first acute rejection among adult pts receiving a kidney tx in 2005–09



KI 6.8 Reported hospitalizations among adult pts receiving a kidney transplant in 2005–2009



KI 6.9 Incidence of PTLTD among adult pts receiving a kidney transplant in 2005–2009

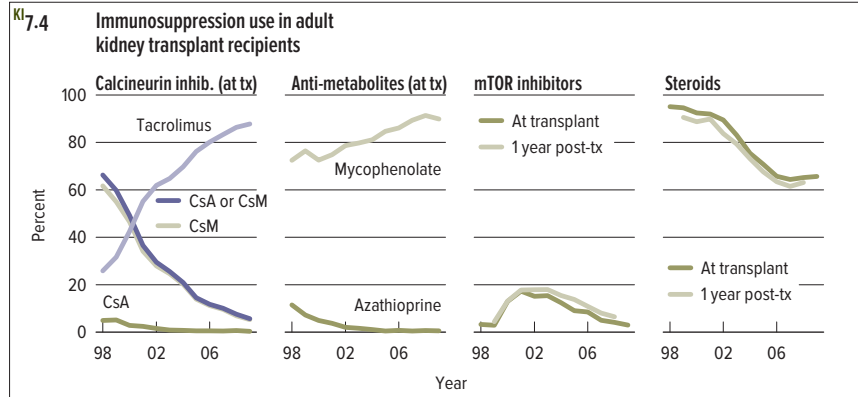
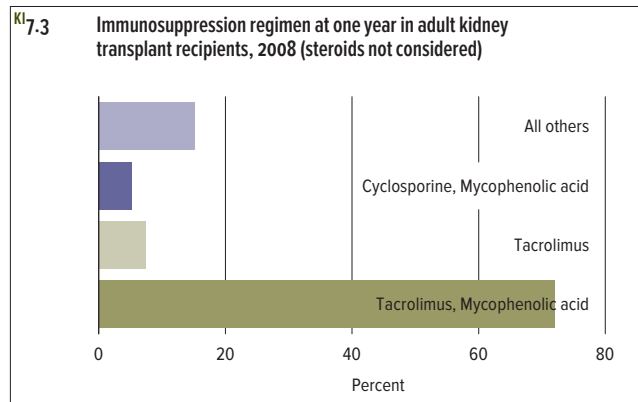
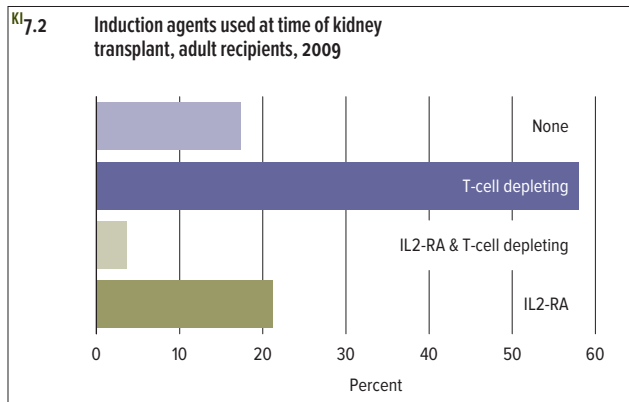
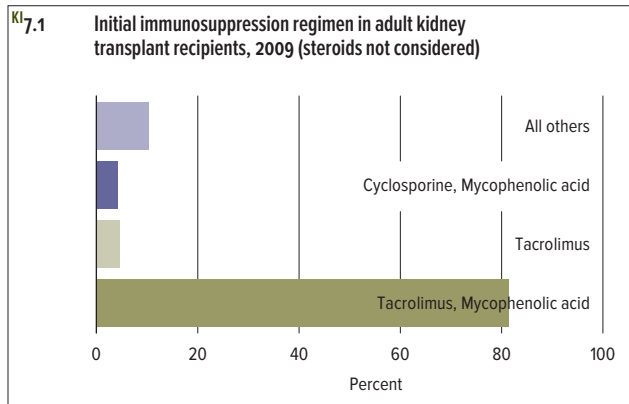


improve on, but there is much room for improvement in 10-year graft survival.

The rate of late graft failure is traditionally measured by the graft half-life conditional on 1-year survival, defined as the time to when half of grafts surviving at least 1 year are still functioning. Graft half-lives for deceased and living donor kidneys have increased (Figure 6.5). For deceased donor kidneys, the half-life increased 45%, from 10.1 years for transplants in 1991 to 14.7 years for transplants in 2007. For living donor kidneys, the half-life increased 68.2%, from 15.8 years for transplants in 1991 to 26.6 years for transplants in 2007. Remarkably, the half-life of a deceased donor kidney in 2007 (14.7 years) is substantially less than the

half-life of a living donor kidney in 1991 (26.6 years). This suggests there is substantial room to improve the rate of late graft failure, at least for recipients of deceased donor kidneys.

The number of patients with a functioning kidney graft has doubled, from 68,200 in 1998 to 144,180 in 2009 (Figure 6.6). The proportion of patients with acute rejection has declined. For transplants in 2005–2009, only 11.6% of patients with deceased donor kidneys and 10.0% of patients with living donor kidneys experienced acute rejection by 1 year post-transplant (Figure 6.7). Hospitalization is common (Figure 6.8). PTLTD is an uncommon but potentially lethal complication (Figure 6.9).



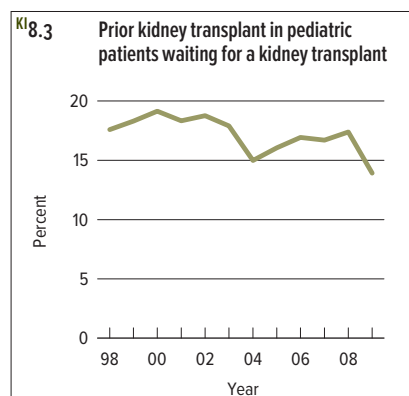
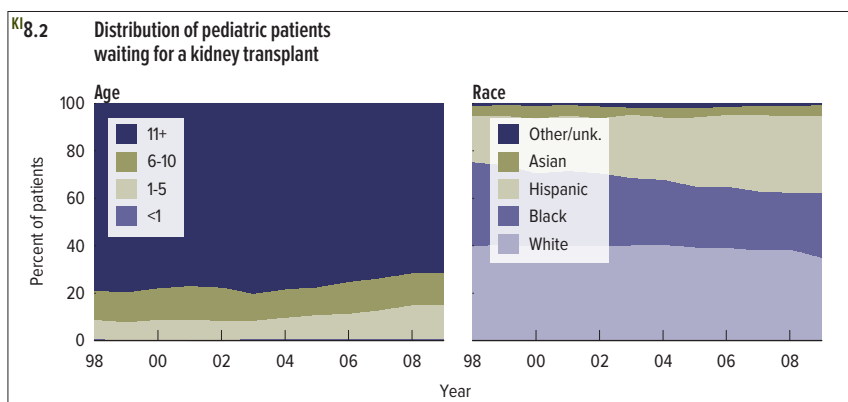
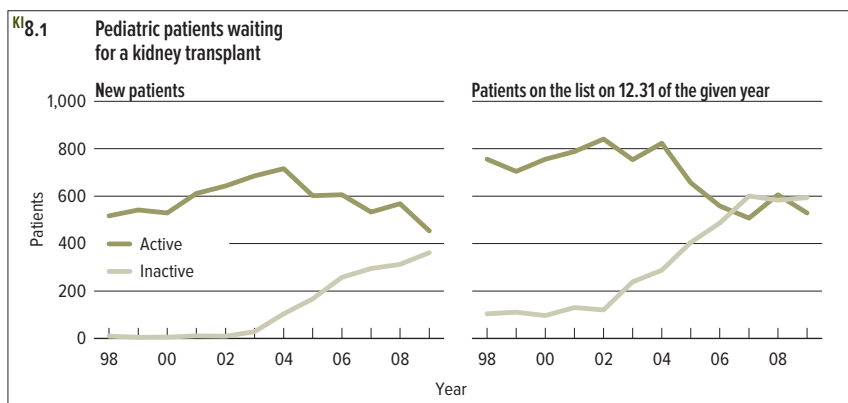
immunosuppression

In 2009, 81% of kidney transplant recipients' initial maintenance immunosuppression included tacrolimus and mycophenolate (Figure 7.1). Use of an induction antibody has grown; in 2009, 58% of patients received a T-cell depleting antibody, 21.2% an interleukin-2 receptor antagonist (IL2-RA), and 3.6% both a T-cell depleting antibody and an IL2-RA; only 17.2% did not receive induction (Figure 7.2). At 1 year after transplant, 72.1% of patients were receiving tacrolimus and mycophenolate, and only 5.3% were receiving cyclosporine A and mycophenolate (Figure 7.3).

Use of cyclosporine for initial immunosuppression has declined from 66.3% in 1998 to 5.7% in 2009 (Figure 7.4). During this

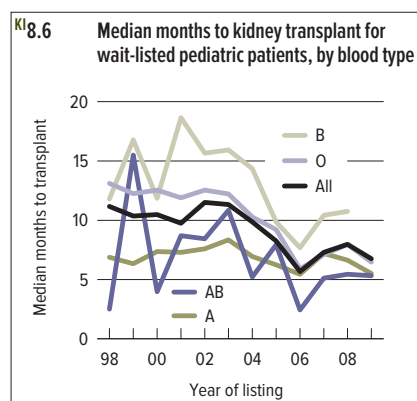
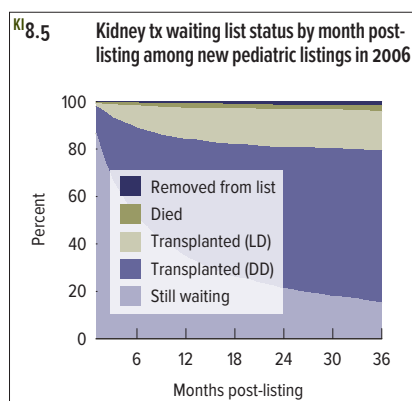
time, use of tacrolimus increased from 25.9% to 87.8%. From 1998 to 2009, use of azathioprine declined from 11.5% to 0.6%, while use of mycophenolate as initial immunosuppression increased from 72.5% to 89.9%. Use of mammalian target of rapamycin (mTOR) inhibitors peaked in 2001, being used in 17.2% of patients as initial immunosuppression and 17.8% at 1 year after transplant. However, use of mTOR inhibitors declined to 3.0% at the time of transplant in 2009, and 6.5% at 1 year post-transplant in 2008.

Use of corticosteroids for initial maintenance immunosuppression was as high as 95.1% in 1998, declined to 65.8% in 2006, and was almost unchanged at 65.7% in 2009. Use of corticosteroids at 1 year post-transplant declined from 90.6% in 1999 to 63.5% in 2006, and remained unchanged at 63.1% in 2008.



Kl 8.4 Kidney transplant waiting list activity among pediatric patients

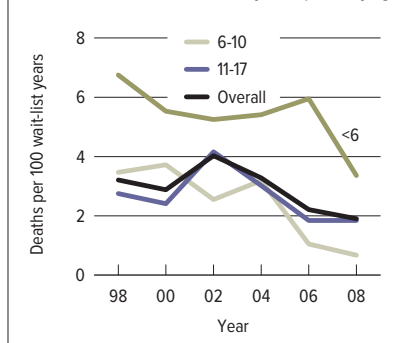
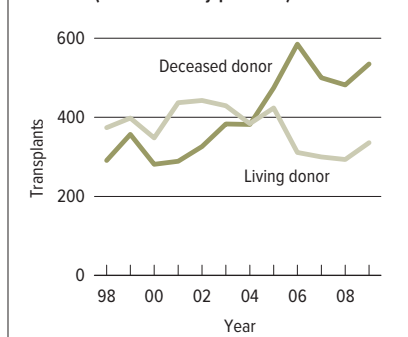
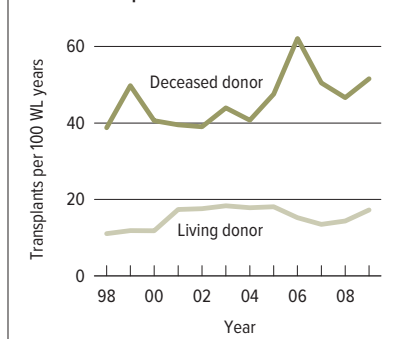
	2007	2008	2009
Listings at start of year	1,068	1,126	1,225
Listings added during year	874	955	876
Listings removed during year	816	856	957
Listings at end of year	1,126	1,225	1,144
Removal reason			
Deceased donor transplant	575	571	641
Living donor transplant	148	170	203
Patient died	22	26	24
Patient refused transplant	1	0	3
Transferred to another ctr	43	50	58
Improved, tx not needed	5	13	5
Too sick to transplant	1	5	2
Changed to kid.-pan. list	1	2	0
Other	20	19	21



pediatric transplant

Beginning in 2003, the number of children listed as inactive on the kidney transplant waiting list increased dramatically; as for adults (Figure 1.1), this was likely a result of the change in policy allowing waiting time accrual while inactive on the list. The number of active patients on the waiting list declined between 1998 and 2009 (Figure 8.1). The age and race distribution of the waiting list has changed little (Figure 8.2). In 2009, 13.9% of patients on the waiting list were waiting for re-transplants (Fig 8.3). Fortu-

nately, few children and adolescents die on the waiting list (Figure 8.4). For children and adolescents who were listed for a deceased donor kidney in 2006, by 3 years after listing, 64.6% had undergone deceased donor transplant, 16.7% had undergone living donor transplant, 2.3% had died, 1.7% had been removed from the list, and only 14.7% were still waiting for a transplant (Figure 8.5). The median waiting time for children and adolescents declined from 11.2 months in 1998 to 6.8 months in 2009 (Figure 8.6). The decline in waiting time was mostly for individuals with blood type O.

KI 8.7 Pre-tx mortality rates among pediatric pts wait-listed for a kidney transplant, by age**KI 8.8** Pediatric kidney transplants (includes kidney-pancreas)**KI 8.9** Pediatric kidney transplant rates**KI 8.10** Characteristics of pediatric kidney transplant recipients, 2007–2009

	Level	All		Deceased		Living	
		N	%	N	%	N	%
Age	<1	7	0.3	3	0.2	4	0.4
	1-5	478	19.6	245	16.3	233	25.1
	6-10	446	18.3	274	18.2	172	18.5
	11-17	1,504	61.8	984	65.3	520	56.0
Sex	Female	1,019	41.8	640	42.5	379	40.8
	Male	1,416	58.2	866	57.5	550	59.2
Race	White	1,262	51.8	630	41.8	632	68.0
	Black	439	18.0	352	23.4	87	9.4
	Hispanic	629	25.8	455	30.2	174	18.7
	Asian	72	3.0	46	3.1	26	2.8
	Other/unknown	33	1.4	23	1.5	10	1.1
Primary cause of disease	Diabetes	2	0.1	1	0.1	1	0.1
	Hypertension	56	2.3	45	3.0	11	1.2
	Glomerulonephritis	495	20.3	330	21.9	165	17.8
	Cystic kidney dis.	852	35.0	505	33.5	347	37.4
	Other cause	1,030	42.3	625	41.5	405	43.6
Blood type	A	791	32.5	465	30.9	326	35.1
	B	285	11.7	171	11.4	114	12.3
	AB	90	3.7	56	3.7	34	3.7
	O	1,269	52.1	814	54.1	455	49.0
PRA	<10%	1,990	81.7	1,233	81.9	757	81.5
	10%+	272	11.2	177	11.8	95	10.2
	Unk.	173	7.1	96	6.4	77	8.3
History of renal replacement therapy	Preemptive tx	715	29.4	346	23.0	369	39.7
	<1 year	673	27.6	397	26.4	276	29.7
	<3 years	669	27.5	480	31.9	189	20.3
	<5 years	170	7.0	130	8.6	40	4.3
	5+ years	208	8.5	153	10.2	55	5.9
Insurance	Private	1,006	41.3	498	33.1	508	54.7
	Medicaid	592	24.3	419	27.8	173	18.6
	Medicare	648	26.6	480	31.9	168	18.1
	Other public	160	6.6	92	6.1	68	7.3
	Other	29	1.2	17	1.1	12	1.3
HLA mismatches with donor	0	83	3.4	40	2.7	43	4.6
	1	82	3.4	6	0.4	76	8.2
	2	284	11.7	34	2.3	250	26.9
	3	523	21.5	151	10.0	372	40.0
	4	523	21.5	453	30.1	70	7.5
	5	587	24.1	514	34.1	73	7.9
	6	331	13.6	302	20.1	29	3.1
Transplant history	Unknown	22	0.9	6	0.4	16	1.7
	First transplant	2,221	91.2	1,353	89.8	868	93.4
	Subsequent	214	8.8	153	10.2	61	6.6
DCD status *	Non-DCD			1,441	95.7		
	DCD			65	4.3		
SCD/ECD status *	SCD			1,506	100.0		
	ECD						
All patients		2,435	100	1,506	100	929	100

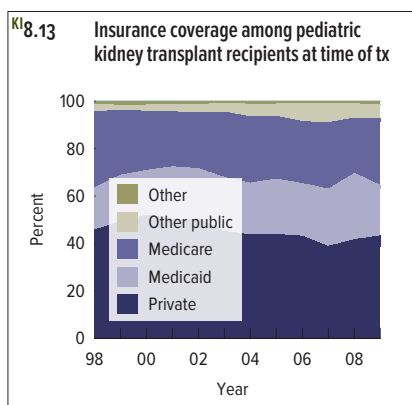
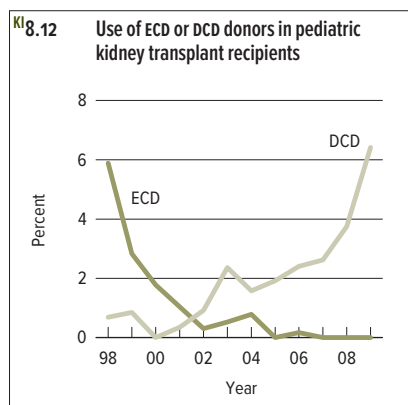
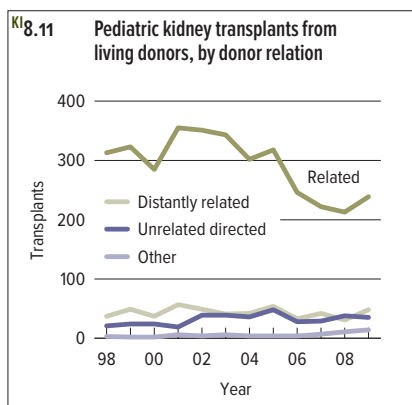
* for deceased donor tx only

pediatric transplant

Death rates on the waiting list vary by age, but have declined since 1998 (Figure 8.7). Overall, from 1998 to 2009, the number of transplants increased 31.0%. However, the increase was due to an 83.8% increase in deceased donor transplants; living donor transplants declined 10.2% (Figure 8.8). In 2005, pediatric patients began to receive additional priority in the deceased donor kidney allocation system. It is interesting, therefore, that between 1998 and 2004, the rate of deceased donor kidney transplants (per 100 ESRD patient-years) increased 5.0%, from 38.8 to 40.7, but from 2004 to 2009 the rate increased an additional 26.6%, to 51.6 (Figure 8.9).

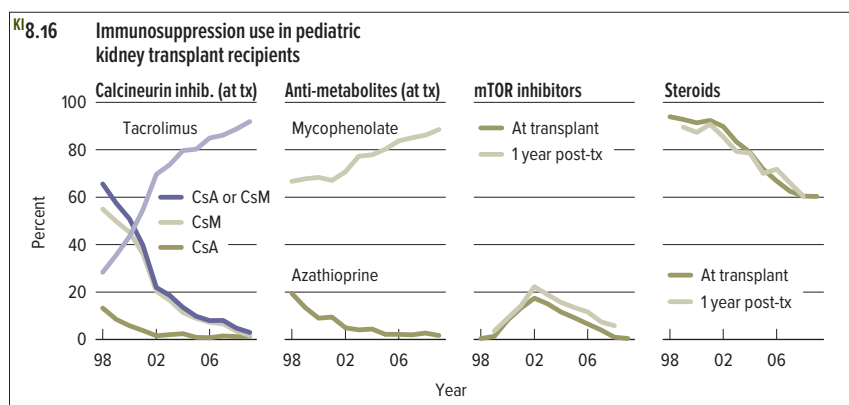
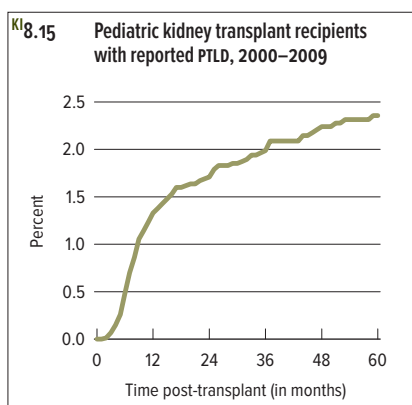
In contrast, between 1998 and 2004, the rate of living donor transplants (per 100 wait list patient-years) increased 61.4%, from 11.1 to 17.8, while from 2004 to 2009 the rate declined 3.5%, to 17.2 (Figure 8.9). The apparent shift from living donor to deceased donor transplants may have been partly due to the allocation policy change. Between 2007 and 2009, 29.4% of transplants were preemptive, and 27.6% of patients were on renal replacement therapy for less than 1 year before transplant (Figure 8.10). Only a small number of deceased donor kidneys were from DCD donors.

Among living donor transplants, 85.4% of patients received kidneys from related or distantly related donors in 2009 (Figure 8.11). However, the number of living related or distantly related donors



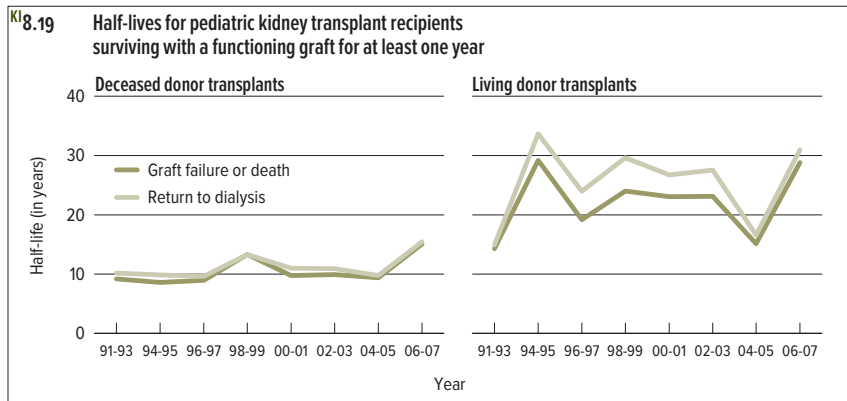
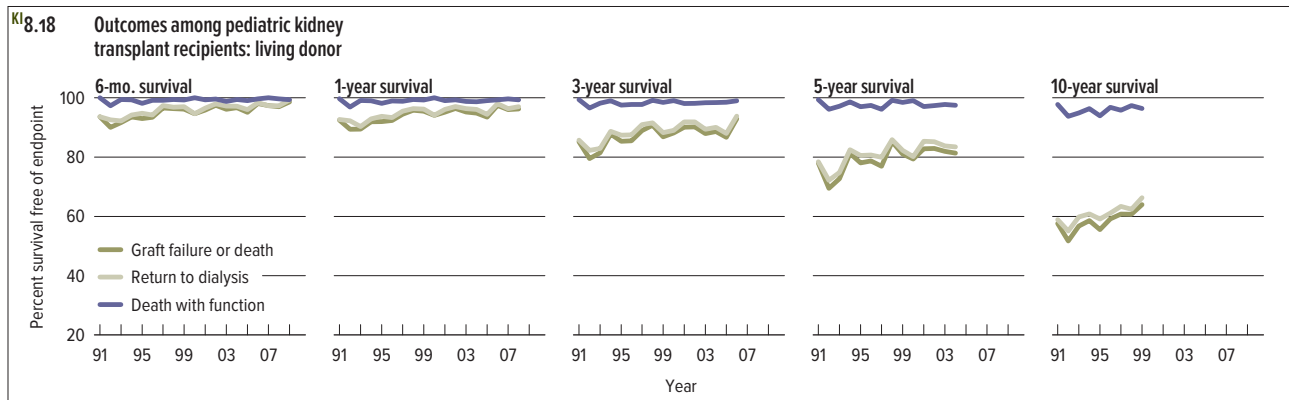
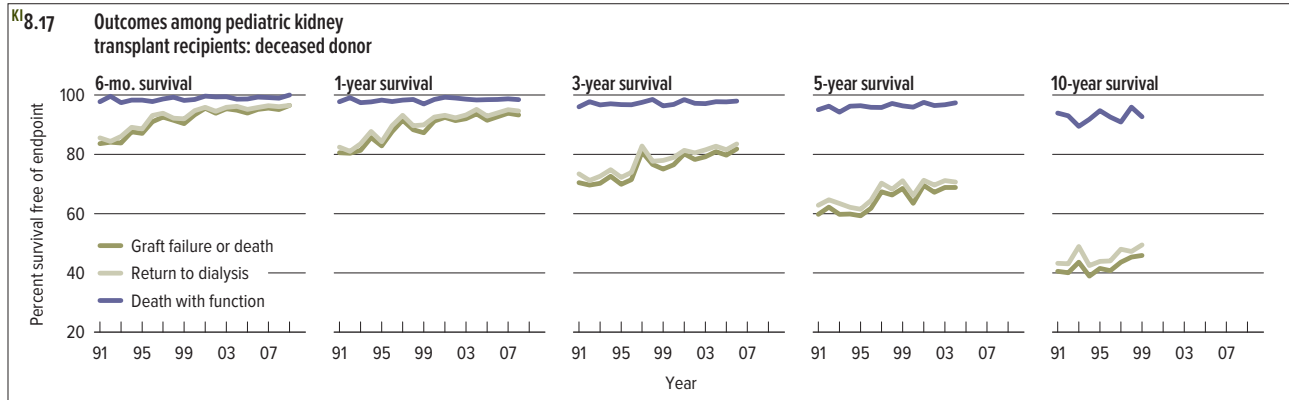
KI 8.14 Kidney donor-recipient Epstein-Barr virus (EBV) serology matching for pediatric transplant recipients, 2005–2009

RECIPIENT	DECEASED DONOR				LIVING DONOR			
	Neg.	Pos.	Unk.	Total	Neg.	Pos.	Unk.	Total
Negative	2.6	22.6	8.2	33.4	5.2	29.7	9.2	44.1
Positive	4.0	32.4	15.8	52.2	3.8	31.7	7.6	43.1
Unknown	0.9	8.1	5.5	14.5	0.8	6.4	5.7	12.9
Total	7.4	63.1	29.4	100	9.7	67.8	22.5	100



declined 18.0% between 1998 and 2009. In 2009, no ECD donor kidneys were transplanted into pediatric patients; however, 6.4% of deceased donor kidneys were DCD kidneys (Figure 8.12). Among pediatric patients who underwent transplants in 2009, the primary insurance was private for 43.3%, Medicare for 28.3%, Medicaid for 21.2%, other public source for 5.8%, or other for 1.4% (Figure 8.13). Pediatric patients are at higher risk for PTLD than adults because they are less likely to have antibodies to EBV. The highest risk for EBV infection and PTLD occurs for EBV(-) recipients of EBV(+) donor kidneys. For transplants in 2005–2009, this was the case in 22.6% of recipients of deceased donor kidneys and 29.7% of recipients of living donor kidneys (Figure 8.14), that is, much more

often than in adults (Figure 5.7). For pediatric patients who underwent transplants in 2000–2009, the incidence of PTLD was 0.49% at 6 months, 1.3% at 1 year, 1.7% at 2 years, 2.0% at 3 years, 2.2% at 4 years, and 2.4% at 5 years post-transplant (Figure 8.15). Trends in maintenance immunosuppressive medications for pediatric patients (Figure 8.16) are similar to trends for adults (Figure 7.4). In 2009, 91.9% of pediatric patients received tacrolimus as part of the initial maintenance immunosuppressive medication regimen, and 88.6% received mycophenolate. Steroids were used in 60.4% of transplant recipients at 1 year post-transplant; 79% of patients receiving kidneys received induction therapy: IL2-RA, 33%; T-cell depleting antibody, 42%; no induction therapy, 21%.

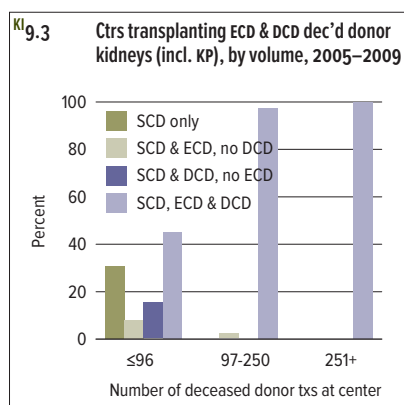
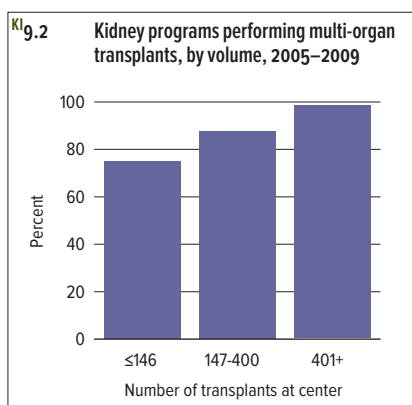
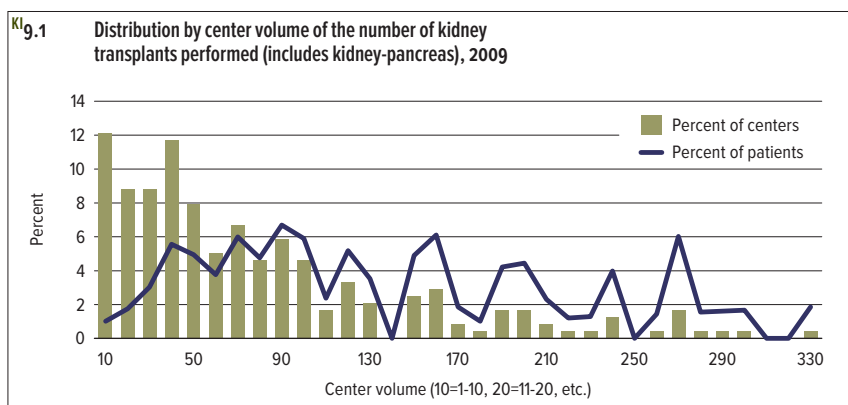


pediatric transplant

Graft survival (i.e., survival with a functioning graft) has continued to improve over the past decade. Graft survival for deceased donor kidneys in 2009 was 96.5% at 6 months; for transplants in 2008, 93.3% at 1 year; for transplants in 2006, 81.8% at 3 years; and for transplants in 2004, 68.8% at 5 years (numbers were too small to calculate 10-year graft survival) (Figure 8.17). Graft survival for living donor kidneys in 2009 was 98.6% at 6 months; for transplants in 2008, 96.3% at 1 year; for transplants in 2006, 92.9% at 3 years; for transplants in 2004, 81.4% at 5 years; and for transplants

in 1999, 64.0% at 10 years (Figure 8.18). These graft survival numbers are almost identical to those for adults (Figure 6.3 and 6.4).

The rate of late graft failure is traditionally measured by the graft half-life conditional on 1-year survival, defined as the time to when half of grafts surviving at least 1 year are still functioning. Graft half-lives for deceased and living donor kidneys have changed little over the past 17 years, although from year to year there is substantial variability due to the small numbers used in these calculations (Figure 8.19). For transplants in 2006–2007, the half-life was 15.1 years for deceased donor kidneys and 28.8 years for living donor kidneys.

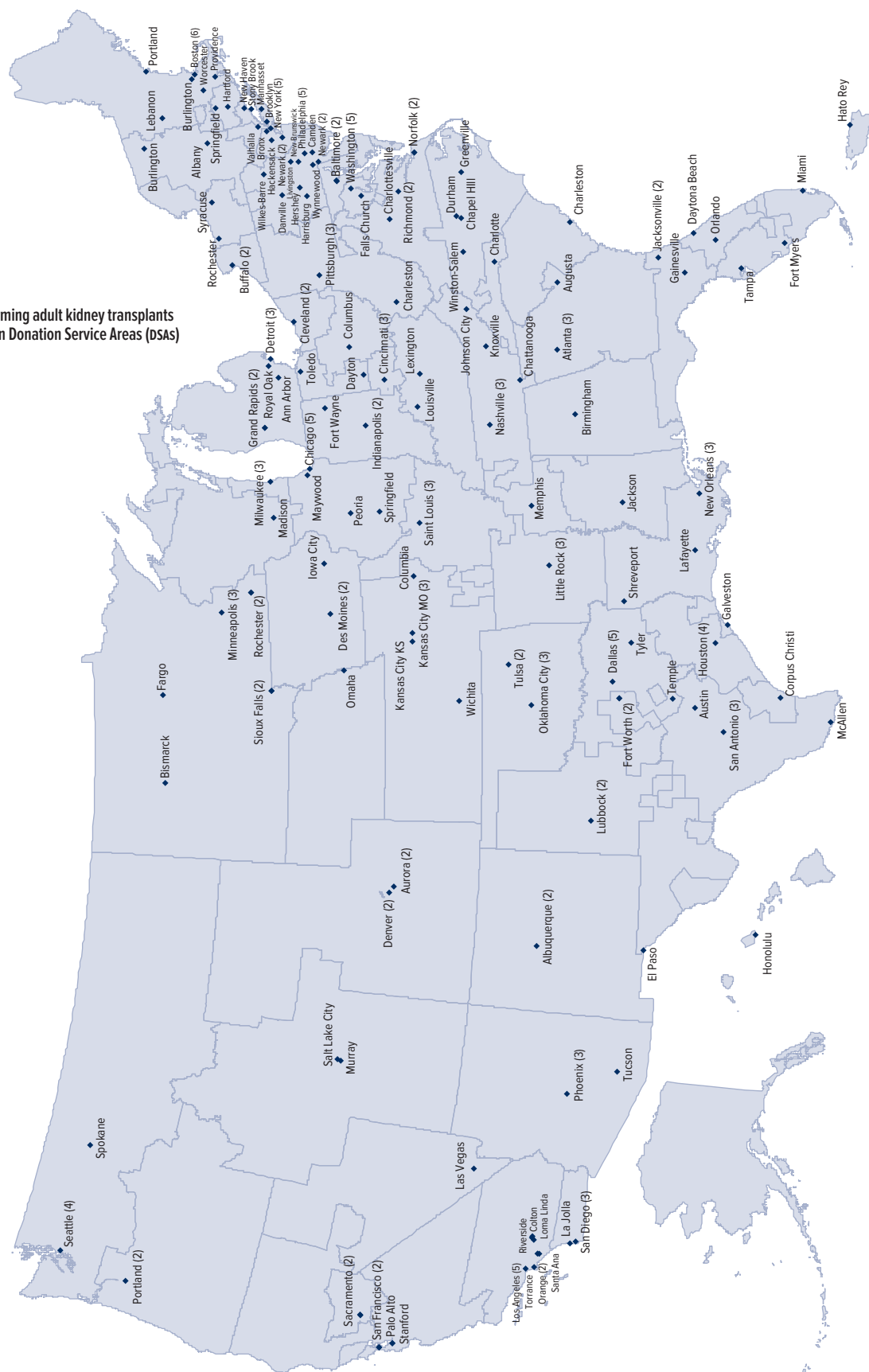


center characteristics

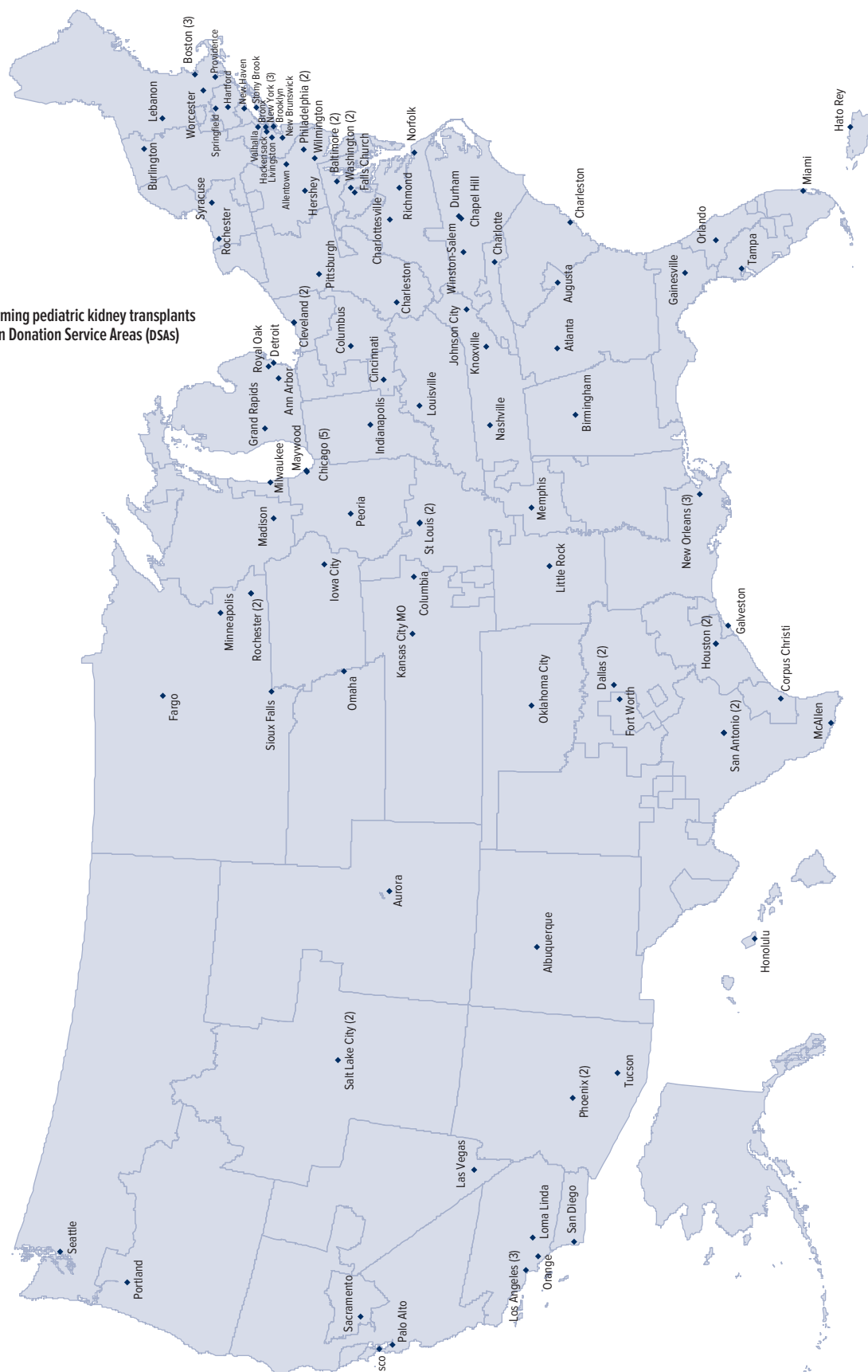
In 2009, 12.1% of transplant centers performed 10 or fewer adult and pediatric kidney transplants (Figure 9.1). In contrast, 9 centers transplanted more than 250 kidneys in 2009, including 1 center that transplanted 330 kidneys. Half of all centers performed fewer than 50 kidney transplants in 2009. In 2005–2009, one-third of centers performed 146 transplants or fewer (i.e., less than approximately 30 transplants per year), one-third performed more than 400 (i.e., more than approximately 80 per year), and one-third performed 147 to 400. Among low-volume centers, 25.0%

transplanted kidneys alone, that is, did not perform kidney transplants along with other organs (Figure 9.2). In contrast, among high-volume centers, only 1.4% transplanted kidneys only. Thus, multi-organ transplants that include kidneys are more likely at high-volume centers than at low-volume centers. Similarly, among low-volume centers, 31.0% performed deceased donor kidney transplants using only SCD kidneys in 2005–2009, while none of the high-volume centers performed only SCD deceased donor kidney transplants (Figure 9.3). Of low-volume centers, 60.7% used DCD kidneys, but all high-volume centers used at least some DCD kidneys in 2005–2009.

KI 10.1 Centers performing adult kidney transplants in 2009, within Donation Service Areas (DSAs)



KI 10.2 Centers performing pediatric kidney transplants in 2009, within Donation Service Areas (DSAs)



KL 10.3

Centers performing adult kidney
transplants in 2009, within OPTN regions