

Kidney and Pancreas Transplantation in the United States, 1998–2007: Access for Patients with Diabetes and End-Stage Renal Disease

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The articles in this report are based on the reference
tables in the 2008 OPTN/SRTR Annual Report. Table
numbers are noted in brackets and may be found online
at <http://ustransplant.org>.

Although the number of candidates on the kidney transplant waiting list at year-end rose from 40 825 to 76 070 (86%) between 1998 and 2007, recent growth principally reflects increases in the number of patients in inactive status. The number of active patients increased by 'only' 4510 between 2002 and 2007, from 44 263 to 48 773. There were 6037 living donor and 10 082 deceased donor kidney transplants in 2007. Patient and allograft survival was best for recipients of living donor kidneys, least for expanded criteria donor (ECD) deceased donor kidneys, and intermediate for non-ECD deceased donor kidneys. The total number of pancreas transplants peaked at 1484 in 2004 and has since declined to 1331. Among pancreas recipients, those with simultaneous pancreas-kidney (SPK) transplants experienced the best pancreas graft survival rates: 86% at 1 year and 53% at 10 years. Between 1998 and 2006, among diabetic patients with end-stage renal disease (ESRD) who were under the age of 50 years, 23% of all and 62% of those waitlisted received a kidney-alone or SPK transplant. In contrast, 6% of diabetic patients aged 50–75 years with ESRD were transplanted, representing 46% of those waitlisted from this cohort. Access to kidney-alone or SPK transplantation varies widely by state.

Key words: Access to transplantation, deceased donors, diabetes mellitus, expanded criteria donors, kidney transplantation, living donor, OPTN, pancreas

transplantation, simultaneous pancreas-kidney transplantation, SRTR, survival, waiting list

Introduction

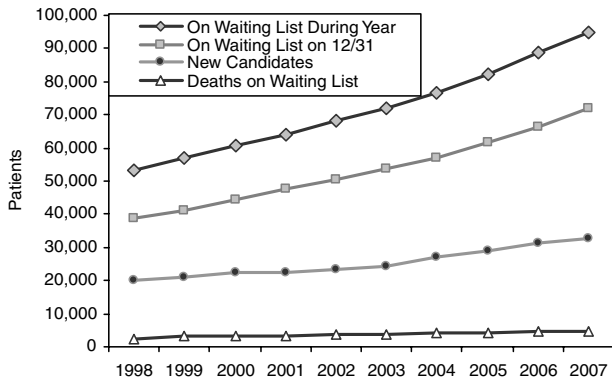
The first two sections of this article will review recent trends in kidney and pancreas transplant waiting list activity, transplant rates and outcomes. The remainder will focus on access for patients with diabetes and end-stage renal disease (ESRD) to the national Organ Procurement and Transplantation Network (OPTN) kidney or simultaneous pancreas–kidney (SPK) transplant waiting lists and on access by transplant candidates with diabetes to living donor, deceased donor kidney-alone and SPK transplantation. Both candidate age and geographic location contribute importantly to access to the waiting list and to transplantation opportunities for patients with diabetes. The influence of these variables on rates of wait-listing and transplantation will be examined.

Unless otherwise noted, the statistics in the sections on kidney and pancreas transplantation are drawn from the reference tables of the 2008 OPTN/SRTR Annual Report. Statistics for the third section about transplantation in patients with diabetes are drawn from both the reference tables and from special analyses prepared by the Scientific Registry of Transplant Recipients (SRTR). Additional information about the methods of data collection and analysis may be found in the data tables themselves and in the Technical Notes of the Annual Report, both online at <http://www.ustransplant.org>.

Kidney Transplantation

Number of transplants and size of active waiting list

Over the past 10 years, the annual number of kidney transplants performed nationally grew by 31%, from 12 318 transplants in 1998 to 16 119 transplants in 2007 [Table 1.7]. During this period, the total number of candidates listed for a kidney-alone transplant at any time during the calendar year increased by 78%, from 53 315 to 94 741 [Table 5.3], while the total number of candidates waitlisted for a kidney-alone transplant at year-end rose by 86%, from 38 690 to 71 862 [Table 1.3]; (Figure 1). Growth in the number of waitlisted patients has been accompanied by a

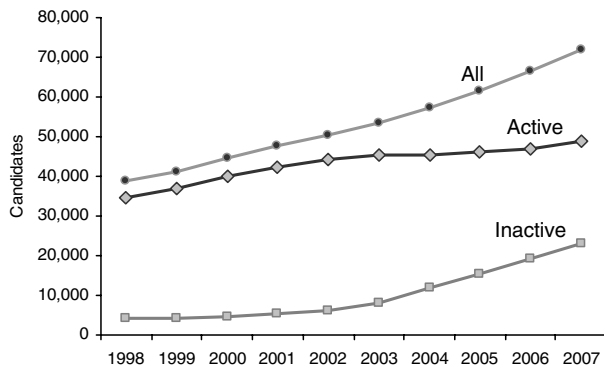


Source: 2008 OPTN/SRTR Annual Report, Tables 1.3, 5.2, 5.3

Figure 1: Number of new and prevalent kidney waiting list patients and deaths on the waiting list, 1998 to 2007.

similar increase of 76% in deaths on the waiting list, from 2528 in 1998 to 4452 in 2007 [Table 5.3]. However, while the absolute number of deaths has increased, it is notable that the annual death rate for waiting list candidates has decreased from a high of 84 deaths per 1000 patient-years at risk in 1999 to 65 deaths per 1000 patient-years at risk in 2007 [Table 5.3]. During this period, the annual death rate for waiting list candidates aged 50–64 years dropped from 100 deaths to 74 deaths per 1000 patient-years at risk, while the death rate for candidates aged 65 years or older dropped from 151 to 105. Most notably, the death rate for waiting list candidates with diabetes dropped from 149 in 1999 to 97 in 2007. While it is probable that these trends reflect improvements in dialysis outcomes, they may also reflect changes in transplant candidate selection and preparation.

Between December 31, 2002 and December 31, 2007, the total number of candidates on the national kidney transplant waiting list increased by nearly 50% (Figure 2). How-



Source: 2008 OPTN/SRTR Annual Report, Tables 5.1a, 5.1b.

Figure 2: Active/inactive status of kidney waiting list candidates at year-end, 1998–2007.

ever, not all of the components of the waiting list grew proportionally. While the number of active patients on the waiting list rose by 10% [Table 5.1a], most of the recent growth in the overall size of the waiting list reflects an increase in the use of Status 7 (inactive status), as the number of inactive patients on the waiting list grew by 282% [Table 5.1b]. Specifically, the number of active patients, 34 496 on December 31, 1998, rose to 44 263 at the end of 2002; but, by the end of 2007, only an additional 4510 patients had been added to the active candidate list, bringing the total number of active candidates on December 31, 2007 to 48 773. In contrast, the number of inactive patients on the kidney transplant waiting list increased slowly, from 4194 candidates at year-end in 1998 to 6038 candidates in 2002, and then nearly quadrupled to 23 089 patients by December 31, 2007. This increase in the use of Status 7 has been attributed to recent changes in OPTN policy that now allow waitlisted candidates to accrue waiting time during the entire period that they are listed, whether active or inactive (1).

The proportion of candidates on the active kidney transplant waiting list over the age of 50 years has increased during the past decade from 44% to 58% [Table 5.1a]; (Table 1). This shift in the age distribution of the waiting list reflects changes in the rates of waitlisting of the different age groups. New waitlistings for candidates under 50 years increased 26%, from 11 469 to 14 407 during 1998–2007, whereas the number of candidates aged 50 years or older more than doubled, from 8704 in 1998 to 18 436 in 2007 [Table 5.2]. The number of active candidates younger than 50 years grew from 19 221 in 1998 to 21 245 in 2003 but remained between 20 349 and 20 579 over the next 4 years. The number of active candidates over age 50 years rose from 15 275 in 1998 to 24 234 in 2003, and then to 28 243 in 2008 [Table 5.1a]. In contrast, the number of inactive candidates younger than 50 years increased from 2187 in 1998 to 3553 in 2003, and then to 9029 by 2007. The number of inactive candidates over 50 years grew from 2007 in 1998 to 4498 in 2003, and then to 14 060 in 2007 [Table 5.1b]. As shown in Table 1, the percentage of candidates by age group on the waiting list in either active or inactive status is roughly proportional to their representation on the total waiting list.

The distribution of race among candidates active on the kidney waiting list has also changed over the past 10 years (Table 1). The number of white and African American active candidates grew from 15 113 and 12 493, respectively, in 1998 to 18 467 and 16 632 in 2007 [Table 5.1a]. At the same time, however, the percentage of white candidates on the active waiting list declined from 44% to 38% and the percentage of African American candidates decreased slightly from 36% to 34%. The total number of active Hispanic/Latino candidates more than doubled, from 4320 in 1998 to 8827 in 2007; Asian candidates also increased over the same time, from 2154 to 4148 [Table 5.1a]. These changes are reflected by a proportionate increase in the

Table 1: Annual number and distribution of kidney waiting list patients by patient characteristic and status at year-end, 1998–2007

Characteristic	Active (%)			Inactive (%)		
	1998	2003	2007	1998	2003	2007
N	34 496	45 479	48 773	4194	8051	23 089
<35 years	19	15	12	17	13	12
35–49 years	37	32	30	36	31	28
50–64 years	36	40	42	36	41	43
65+ years	9	13	16	12	15	18
White	44	39	38	48	41	39
African American	36	36	34	37	40	38
Hispanic/Latino	13	16	18	10	14	17
Asian	6	8	9	4	4	5
Other/multirace	1	1	1	2	2	2
Glomerular diseases	24	23	21	23	21	18
Diabetes	24	26	28	25	26	31
Hypertensive nephrosclerosis	17	20	22	12	18	21
Other	36	32	29	39	35	31

Source: Tables 5.1a and b and SRTR analysis, November 2008.

percentage representation of Hispanic/Latino and Asian candidates in both active and inactive status on the waiting list.

The pattern of diagnoses (glomerular diseases, hypertensive nephrosclerosis, diabetes and other diseases) of candidates on the active kidney waiting list has also evolved over the past 10 years (Table 1). Overall, the percentage of active candidates with diabetes and hypertension has increased, from 24% to 28% and from 17% to 22%, respectively, whereas the percentage with glomerular disease has declined, from 24% to 21%. In 2007, the distribution of diagnoses was roughly proportional between active and inactive candidates on the waiting list [Tables 5.1a and b]. Thus, it does not appear that the increased fractions of listed older, minority, diabetic or hypertensive candidates are driving the increased use of the Status 7 designation.

Among new candidates listed between 1998 and 2004, there has been relatively little change in the median time to receive any kidney transplant, that is, from either a deceased or living donor. In 1998, the median time to any kidney transplant was 1153 days; in 2004 (the most recent year for which this calculation is possible), the median time to any kidney transplant was 1219 days [Table 5.2].

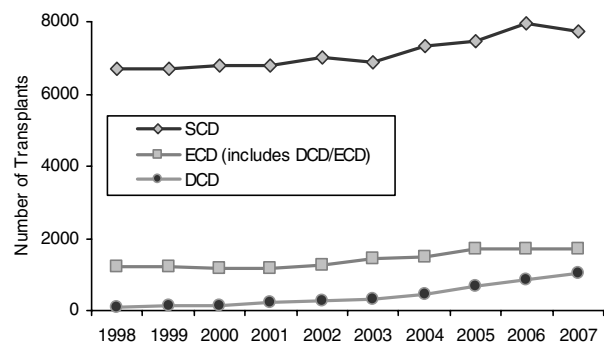
Kidney donation and transplant trends

The annual number of deceased donor kidney transplants, including multiorgan transplants but excluding SPK transplants, rose from 8032 transplants in 1998 to a peak of 10 659 in 2006, and then fell to 10 586 transplants in 2007 [Table 5.4]. Non-SPK multiorgan transplants doubled, from 252 in 2002 to 504 in 2007 [Table 1.8]. In 2007, kidney–liver (444) and kidney–heart (55) made up over 99% of these transplants.

During the same time interval, the number of standard criteria donor (SCD) transplants, expanded criteria

donor (ECD) transplants, and non-ECD transplanted kidneys recovered through donation after cardiac death (DCD) grew by 15%, 49%, and 929%, respectively [Table 5.4] (Figure 3).

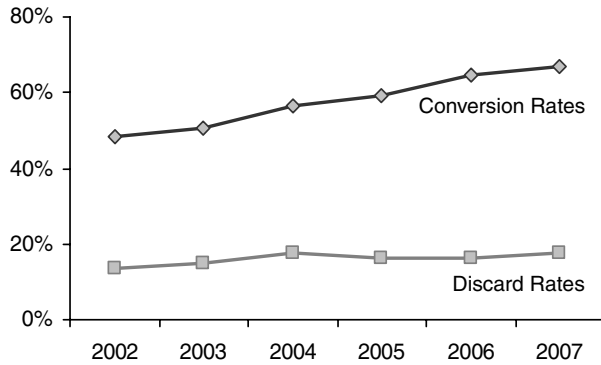
In these analyses, the ECD definition includes DCD kidneys that meet the OPTN ECD criteria. In 2007, there were 7729 SCD, 1828 ECD (101 of which were ECD/DCD) and 1029 DCD kidney transplants performed. The greatest numerical increment compared with 2002 has been in DCD transplants, with a gain of 765. SCD increased by 739, and ECD (includes ECD/DCD) by 543 [Table 5.4]. There were 73 fewer total transplants in 2007 (10 586) than in 2006 (10 659); this change represented 239 fewer SCD, 11 more ECD (includes ECD/DCD) and 155 more DCD transplants [Table 5.4]. Although the percentage of SCD kidneys allocated to candidates younger than 50 years has declined, from 59% in 1998 to 48% in 2007 [Table 5.4a], these younger candidates continued to receive SCD kidneys at a higher rate than their proportion on the waiting list, which was 56% in 1998 and 42% in 2007 [Table 5.1].



HRSA Collaboratives began in April 2003

Source: 2008 OPTN/SRTR Annual Report, Table 5.4

Figure 3: SCD, ECD and DCD kidney transplants, 1998–2007.

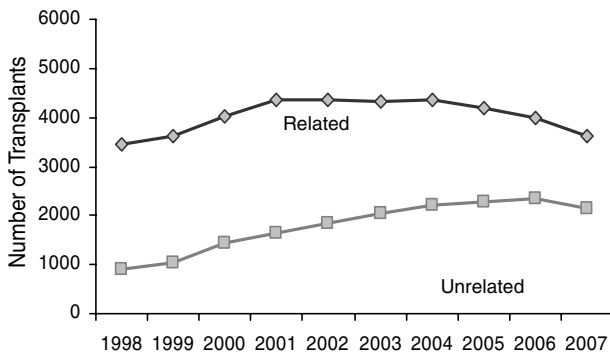


HRSA Collaboratives began in April 2003
Source: SRTR analysis, July 2008

Figure 4: Average conversion and discard rates for all organ procurement organizations, 2002–2007.

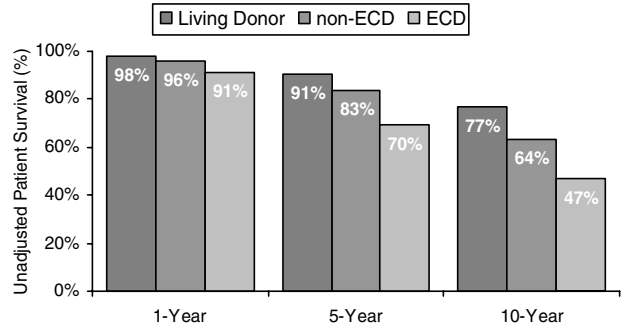
The 24% growth in deceased donor kidney transplantation since 2002 appears to be largely driven by the increase in conversion rates [Table 5.4]; (Figure 4). This rate is defined as the number of deceased donors who met eligibility criteria for donation divided by the number of eligible deaths defined as any ventilated death reported by a hospital that is evaluated and that meets organ donor eligibility requirements. Nationally, the average conversion rate grew from 48% in 2002 to 67% in 2007 (Figure 4). In contrast, the counterbalancing average discard rate was 13% in 2002 and 18% in 2007. Conversion rates may have been affected by the efforts of the Health Resources and Services Administration Transplant Growth and Management Collaboratives, which began in 2003.

There were 6037 living donor kidney transplants in 2007 [Table 5.4d]. This represents a 37% increase in the number of living donor transplants compared with 1998. Trends in living-related and living-unrelated kidney donors are in



Source: 2008 OPTN/SRTR Annual Report, Table 5.4d

Figure 5: Trends in living-related and living-unrelated donors, 1998–2007.



Source: 2008 OPTN/SRTR Annual Report, Tables 5.14a, b, d.

Figure 6: Unadjusted 1-year (2005–2006), 5-year (2001–2006) and 10-year (1996–2006) kidney recipient survival, by donor type.

shown in Figure 5. The number of living-related kidney donors grew from 3456 in 1998 to 4349 in 2001, where it remained roughly constant until 2004 at 4342. Since then, the number of living-related donors has decreased, falling to 3625 in 2007. From 1998 to 2006, the number of living-unrelated kidney donors grew steadily from 908 to 2348, with a decline in 2007 to 2154. The declines in living donation may reflect reconsideration by some kidney transplant programs of the use of older, hypertensive, diabetic, obese or minority living donors (2–7). The decrease in living donation does not appear to be related to donor sex or race [Table 2.9].

Kidney transplant patient and allograft survival trends

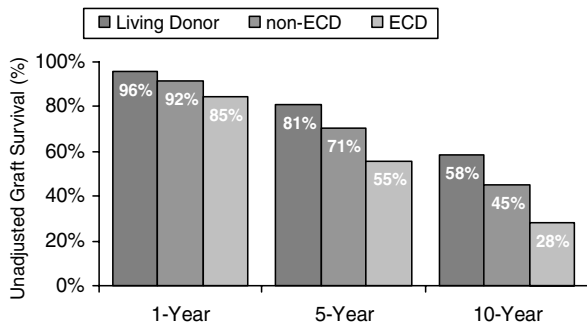
At the end of 2006, 103 312 patients had a functioning kidney transplant compared with 64 779 in 1998, an increase of 59% [Table 5.16]. For single kidney transplants (multiorgan and SPK transplants excluded) performed prior to 2006, 1-, 5- and 10-year patient survival was best for recipients of living donor kidneys, intermediate for non-ECD deceased donor recipients and lowest for those receiving ECD kidneys (Figure 6). Unadjusted patient survival rates at 5 years were 91% for recipients of living donor kidneys, 83% for non-ECD deceased donor kidneys and 70% for ECD kidney transplants (Table 2).

Kidney allograft survival followed the same pattern as that seen for recipient survival (Figure 7). Graft survival was

Table 2: Unadjusted graft and patient survival at 5 years among deceased donor (non-ECD and ECD) and living donor kidney transplant recipients, 1994–1999 and 2000–2005

Donor type	Graft survival (%)		Patient survival (%)	
	1994–1999	2000–2005	1994–1999	2000–2005
Living donor	79.4	81.1	90.1	90.6
Non-ECD	68.3	70.7	82.8	83.3
ECD	51.7	55.3	70.4	69.5

Source: Tables 5.10a, b and c and SRTR analysis, November 2008.



Source: 2008 OPTN/SRTR Annual Report, Tables 5.10a, b, d.

Figure 7: Unadjusted 1-year (2005–2006), 5-year (2001–2006) and 10-year (1996–2006) kidney graft survival (death is included as an event), by donor type.

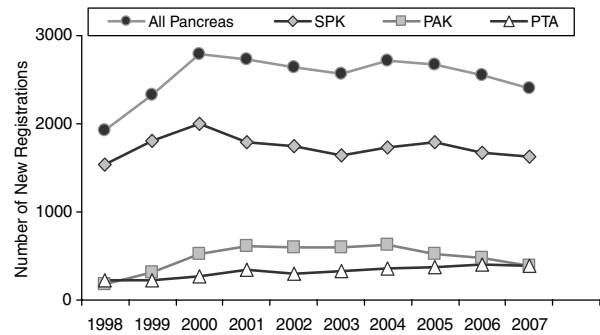
best for recipients of living donor kidneys, intermediate for non-ECD transplants and lowest for ECD transplants. At 5 years, the unadjusted graft survival rate was 81% for living donor, 71% for non-ECD and 55% for ECD transplants (Table 2). Although kidney transplant patient survival percentages were not different when the first 5 years of the decade were compared with the second half (all, $p > 0.05$), there was a significant trend toward improvement in allograft survival (all, $p < 0.05$).

Pancreas Transplantation

Pancreas transplant waiting list trends

The number of pancreata recovered peaked at 2045 in 2005, fell slightly in 2006 to 2032, and fell further in 2007 to 1927 [Table 1.1]. At the end of 2007, there were 3836 people waiting for a solid organ pancreas transplant, 2314 for an SPK, 932 for a pancreas after kidney (PAK) and 590 for a pancreas transplant alone (PTA). This was a 73% increase over the total number in 1998, indicating a growing discrepancy between the number of candidates waitlisted for pancreas transplantation and organs available [Table 1.3]. Correspondingly, there was an increase in waiting times for all types of pancreas candidates. The median waiting time for a PAK transplant has increased from about 220 days for candidates on the list in the late 1990s to 751 days for candidates placed on the list in 2005 [Table 1.5]. The median waiting time for an SPK transplant has risen from 404 days in 1998 to 448 days in 2007 [Table 1.5]. The greatest growth over the past decade in waitlisted patients has been among those waiting for a PAK transplant (415%) or a PTA (109%); in contrast, the number of SPK transplant candidates increased by 'only' 32% [Table 1.3].

It is notable, however, that there have been recent downward trends in registrations for SPK, PAK and total pancreas transplant (Figure 8). The total number of new pancreas waiting list registrations grew from 1931 in 1998 to a high of 2796 in 2000, but fell to 2399 by 2007. New



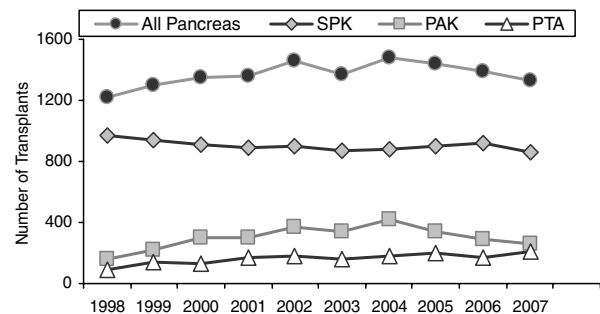
Source: 2008 OPTN/SRTR Annual Report, Table 1.5.

Figure 8: New registrations on pancreas waiting list, by transplant type, 1998–2007.

PAK waiting list registrations rose from 179 in 1998 to a high of 623 in 2004, falling to 385 in 2007. New SPK registrations rose from 1535 in 1998 to a high of 2007 in 2000, and then declined to 1622 in 2007. PTA registrations show continued—albeit modest—growth between 1998 and 2007, from 217 to 392 [Table 1.5].

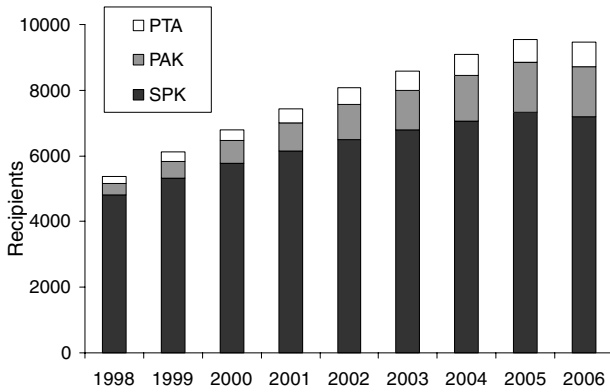
Pancreas transplant trends

The overall number of pancreas transplants rose from 1216 in 1998, peaked at 1484 in 2004 and has since declined to 1331 (Figure 9). The number of SPK transplants peaked in 1998 and the number of PAK transplants in 2004. The cause of this decrease in pancreas transplant numbers is uncertain, but has been attributed to several factors: kidney payback debts precluding SPK transplantation within 'debtor' organ procurement organizations (OPOs), an uneven distribution of pancreas transplant programs across the United States, caution by many transplant programs in the acceptance of pancreata recovered outside their own donor service area, and age and obesity trends in the donor population (8). The preponderance of pancreas transplants are SPK, accounting for 65% of all pancreas transplants in 2007.



Source: 2008 OPTN/SRTR Annual Report, Tables 6.4, 7.4, 8.4.

Figure 9: Pancreas transplants, by transplant type, 1998–2007.



Source: 2008 OPTN/SRTR Annual Report, Tables 6.16, 7.16, 8.16.

Figure 10: Number of recipients living with a functioning pancreas transplant at end of year, 1998–2006.

Pancreas transplant patient and allograft survival trends

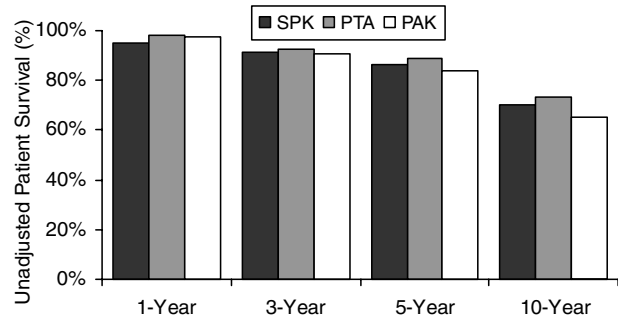
Despite trends toward fewer pancreas transplants and waiting list registrations, the total number of patients alive with a functioning pancreas allograft increased 78%, from 5364 in 1998 to 9556 in 2005, but then declined slightly to 9453 in 2006 (Figure 10). The largest relative increases over the past 9 years occurred in the PAK and PTA populations, both of which experienced roughly 4-fold increases. Nonetheless, SPK recipients represent by far the largest cohort of patients alive with a functioning pancreas allograft.

Patient survival rates were similar for SPK, PAK and PTA recipients at 1 year (ranging from 95% to 98%) and 3 years (ranging from 91% to 93%; Figure 11). The 5- and 10-year unadjusted patient survival rates were statistically ($p \leq 0.05$) lowest for PAK recipients at 84% and 65%, respectively, and higher for SPK (87% and 70%, respectively) and PTA recipients (89% and 73%, respectively) [Table 1.13]. Among pancreas recipients, those with SPK transplants experienced the best unadjusted pancreas graft survival rates: 86% at 1 year ($p = 0.08$) and 53% at 10 years ($p < 0.001$; Figure 12). Graft survival rates for PAK and PTA recipients were lower than for SPK recipients, with 1-year rates of 77% and 81%, respectively, and 10-year rates of 35% and 26%, respectively [Table 1.13].

Kidney Transplantation in Patients with Diabetes

Trends in diabetes among patients with end-stage renal disease

In 2007 compared with 1999, the percentage of patients with diabetes among all, among active and among newly waitlisted adult kidney-alone candidates increased (Table 3). Among all waitlisted candidates, the highest percentage of patients with diabetes by race is seen in Native

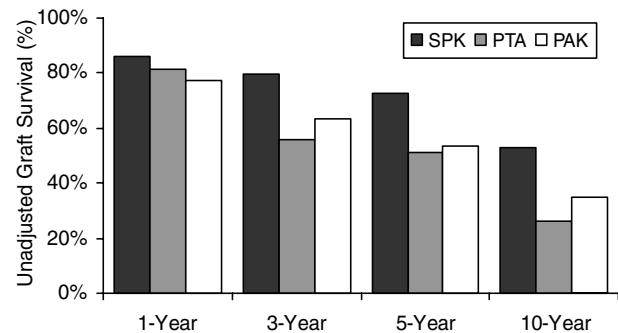


Source: 2008 OPTN/SRTR Annual Report, Table 1.13.

Figure 11: Unadjusted 1-, 3-, 5- and 10-year pancreas patient survival, by transplant type.

Americans and the lowest percentages within the white and African American populations (Figure 13). The greatest rates of increase are seen in African Americans, Hispanic/Latinos and Asians. However, much of the overall increase can be explained by the increase in the average age of waitlisted kidney transplant candidates (Figure 14). The average slope for the increase in patients with diabetes on the waiting list is 0.79 percentage points/year, whereas the average slope for the increase in this group when adjusted for age is 0.37 percentage points/year. Thus, the increasing age of waitlisted candidates explains roughly more than half of the growth in the percentage of patients with diabetes on the waiting list.

Age and geography appear to contribute importantly to differences in access to waitlisting and kidney transplantation among diabetic subpopulations. Data from the Centers for Medicare and Medicaid Services (CMS) and the OPTN/SRTR are used in the following analyses of these factors. The CMS database includes information on all dialysis patients in the United States. The OPTN/SRTR database includes data on all waitlisted kidney transplant



Source: 2008 OPTN/SRTR Annual Report, Table 1.13.

Figure 12: Unadjusted 1-, 3-, 5- and 10-year pancreas graft survival (death is included as an event), by transplant type.

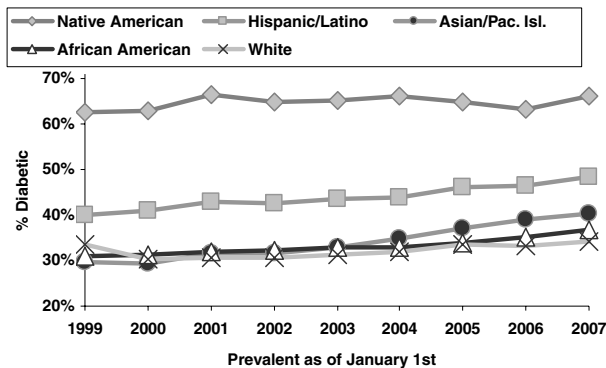
Table 3: Change in the percentage of patients with diabetes among waitlisted adult kidney-alone candidates by race, from 1998 to 2007

Candidate race	Change in % diabetics		
	On waiting list January 1st	Active on waiting list January 1st	New listings throughout year
African American	+6	+5	+8
Hispanic/Latino	+8	+7	+9
Native American	+4	+4	+5
White	+1	-1	+3
Asian/Pacific Islander	+11	+9	+14

Source: SRTR analysis, November 2008.

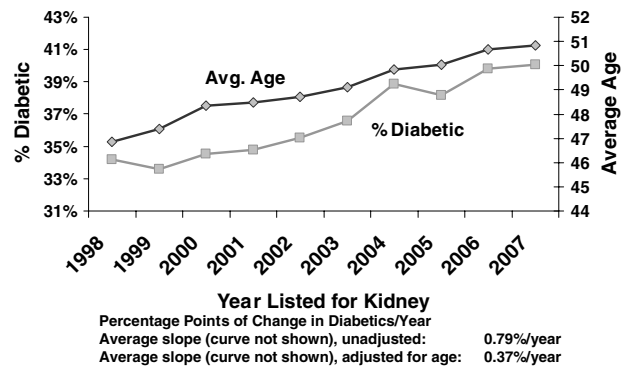
candidates and recipients in the United States. Both data sources were supplemented with vital status information from the Social Security Death Master File (9). Since kidney transplants are rarely performed on patients older than 75 years, the following waitlisting and transplant data discussions are limited to patients younger than 75 years at time of entry into the study. Information on type I versus type II diabetes was not available for all subsets of candidates and recipients included in these analyses. Therefore, for patients with diabetes, access to the waiting list and transplantation was analyzed in the context of two age cohorts: younger (<50 years old) and older (50–75 years of age).

Nationally, between 1998 and 2006, the total number of patients between 0 and 75 years with ESRD from diabetes mellitus (DM; n = 313 061)—defined as beginning dialysis (n = 303 666), being preemptively waitlisted (n = 8492), or receiving a preemptive living donor transplant without prior placement on the waiting list (n = 903)—has grown steadily for patients both under and over the age of 50 years (Table 4). In 1998, the incident number of patients with ESRD from diabetes who were under the age of 50



Source: SRTR analysis, using data as of November 2008.

Figure 13: Percentage of diabetics among all waitlisted adult kidney-alone candidates by race.



Source: SRTR analysis, using data as of November 2008.

Figure 14: Percentage of diabetics and average age among newly waitlisted adult kidney-alone candidates by year listed.

years or between 50 and 75 years were 6090 and 24 828, respectively. By 2006 those numbers had grown to 7143 and 30 704, increases of 17% and 24%, respectively.

Access to the waiting list and to transplantation for patients with diabetes and end-stage renal disease

Between 1998 and 2006, 22 046 (38%) of the 58 617 U.S. patients with diabetes and ESRD who were under the age of 50 years were waitlisted and 13 693 were transplanted with either a living or deceased donor kidney-alone or an SPK transplant (Table 5). Thus, 23% of the total younger diabetic ESRD population and 62% of the younger diabetic waitlisted cohort received a kidney transplant. Within this cohort, 3509 patients with diabetes were preemptively waitlisted; among that group, 2596 (74%) were eventually transplanted. Of the younger patients with diabetes who were preemptively waitlisted, 792 were also preemptively transplanted: 486 from a living donor and 306 from a deceased donor. An additional 1804 transplants occurred among these preemptively waitlisted candidates after they began dialysis: 447 from living donor and 1357 from deceased donor sources. In addition, during this period, 449 patients with diabetes under age 50 years were transplanted preemptively from a living donor without ever being waitlisted. This brings the total number of preemptive transplants among younger patients with diabetes to 1241, of which 75% were, not surprisingly, from living donors.

Transplant rates were lower among non-preemptively waitlisted diabetics under the age of 50 years, and the ratio of living to deceased donation among these patients was nearly the inverse of that seen among those who were preemptively transplanted. Some 18 537 patients with diabetes under the age of 50 years were waitlisted after beginning dialysis; of these, 10 648 (57%) received a kidney transplant: 3162 (30%) from a living donor and 7486 (70%) from a deceased donor.

Table 4: Number of patients aged 0–75 years with diabetes as the primary cause of ESRD: (a) beginning dialysis; (b) preemptively waitlisted and (c) receiving a preemptive living donor kidney transplant who were never waitlisted

Entry criterion		1998–2006	1998	1999	2000	2001	2002	2003	2004	2005	2006
Age < 50 years											
Began dialysis	N	54 659	5657	5732	5999	5922	5985	6145	6233	6245	6741
Preemptively waitlisted	N	3509	390	401	436	365	376	349	373	438	381
Received preemptive living donor transplant, never waitlisted	N	449	43	53	47	57	68	55	66	39	21
Total	N	58 617	6090	6186	6482	6344	6429	6549	6672	6722	7143
Age 50+ years											
Began dialysis	N	249 007	24 472	25 748	26 822	27 977	27 890	28 460	28 768	29 049	29 821
Preemptively waitlisted	N	4983	337	372	445	474	483	607	658	779	828
Received preemptive living donor transplant, never waitlisted	N	454	19	34	30	52	44	61	74	85	55
Total	N	254 444	24 828	26 154	27 297	28 503	28 417	29 128	29 500	29 913	30 704

Source: SRTR analyses, November 2008 using OPTN and CMS data.

Of 306 preemptively waitlisted, younger patients with diabetes who received a preemptive deceased donor kidney transplant, 132 (43%) received an SPK transplant. In contrast, 934 (69%) of the 1357 preemptively waitlisted, younger diabetic recipients who were transplanted with a deceased donor kidney after beginning dialysis received SPK transplants and 3643 (49%) of the 7486 non-preemptively waitlisted, younger diabetic recipients who underwent deceased donor kidney transplantation received an SPK transplant. Thus, preemptively waitlisted, younger diabetic kidney transplant recipients who were preemptively transplanted were more likely to receive a living donor kidney transplant and less likely to receive an SPK transplant than were those who were not preemptively transplanted, whether preemptively waitlisted or not.

During this same period, a comparatively smaller percentage (35 897/254 444, 14%), of older ESRD patients with

diabetes, aged 50–75 years, were waitlisted (Table 5). Of those waitlisted candidates, 16 427 (46%) were transplanted, representing 6% of all patients with diabetes and ESRD in this age group. Among older patients with diabetes, 4983 were preemptively waitlisted; within this group of candidates, 2788 (56%) were eventually transplanted. Of the older patients with diabetes who were preemptively waitlisted, 1057 were also preemptively transplanted: 569 from a living donor and 488 from a deceased donor. An additional 1731 transplants occurred among these preemptively waitlisted candidates after they began dialysis: 453 from living donor and 1278 from deceased donor sources. Furthermore, during this period, 454 older patients with diabetes were transplanted preemptively from a living donor without ever being placed on the waiting list. This brings the total number of preemptive transplants among older diabetics to 1511, of which 68% were from living donors.

Table 5: Allocation outcomes of study population by entry criterion: patients with diabetes aged 0–75 years whose first ESRD treatment was during 1998–2006

Entry criterion, age < 50	N	Waitlisted			All transplants	Preemptive transplants			Not preemptive transplants		
		Waitlisted KI	Waitlisted SPK	Waitlisted KI		Living donor	Deceased donor	Deceased donor KI	Living donor	Deceased donor KI	Deceased donor SPK
Began dialysis	54 659	13 182	5355	10 648	–	–	–	3162	3843	3643	
Preemptively waitlisted	3509	1 852	1657	2596	486	174	132	447	423	934	
Received preemptive living donor transplant never waitlisted	449	–	–	449	449	–	–	–	–	–	
Total	58 617	15 034	7012	13 693	935	174	132	3609	4266	4577	
Entry criterion, age 50–75											
Began dialysis	249 007	30 132	782	13 185	–	–	–	4290	8418	477	
Preemptively waitlisted	4983	4657	326	2788	569	456	32	453	1149	129	
Received preemptive living donor transplant never waitlisted	454	–	–	454	454	–	–	–	–	–	
Total	254 444	34 789	1108	16 427	1023	456	32	4743	9567	606	

Source: SRTR analyses, November 2008 (KI = kidney-alone transplant; SPK = simultaneous pancreas–kidney transplant).

Table 6: Allocation outcomes by entry criterion: patients with diabetes waitlisted for SPK transplantation aged 0–75 years whose first ESRD treatment was during 1998–2006

	Waitlisted SPK	All transplants	Preemptive transplants			Not preemptive transplants		
			Living donor	Deceased donor KI	Deceased donor SPK	Living donor	Deceased donor KI	Deceased donor SPK
Entry criterion, age < 50, SPK waiting list								
Began dialysis	5355	3730	—	—	—	492	326	2912
Preemptively waitlisted	1657	1349	214	0	132	184	117	702
Total	7012	5079	214	0	132	676	443	3614
Entry criterion, age 50–75, SPK waiting list								
Began dialysis	782	490	—	—	—	72	61	357
Preemptively waitlisted	326	248	57	0	32	21	42	96
Total	1108	738	57	0	32	93	103	453

Source: SRTR analyses, November 2008 (KI = kidney-alone transplant; SPK = simultaneous pancreas–kidney transplant).

As was seen in younger patients with diabetes, transplantation rates and the ratio of living to deceased donation were lower among older diabetic patients who were not preemptively waitlisted compared with those who were. Some 30 914 older patients with diabetes were waitlisted after beginning dialysis and 13 185 (43%) received a kidney transplant: 4290 (33%) from a living donor and 8895 (67%) from a deceased donor.

Simultaneous pancreas–kidney transplantation rates were much lower among older compared with younger patients with diabetes. Of the 488 preemptively waitlisted, older diabetic patients who received a preemptive deceased donor kidney transplant, 32 (7%) received an SPK transplant; 129 (7%) of the 1731 preemptively waitlisted, older diabetic patients who were transplanted after beginning dialysis received SPK transplants and 477 (5%) of the 8895 non-preemptively waitlisted, older patients with diabetes who underwent deceased donor kidney transplantation received an SPK transplant.

Access to the simultaneous pancreas–kidney waiting list and to SPK transplantation for diabetic patients with end-stage renal disease

More than 7000 younger patients with diabetes were listed for SPK transplantation: 1657 were listed preemptively and 5355 were listed after beginning dialysis (Table 6). Of those preemptively listed, 1349 (81%) received transplants, as did 3730 (70%) of those not listed preemptively. Of these recipients, 834 (62%) of those who were preemptively listed received SPK transplants; however, only 132 of those SPK transplants were preemptive. An additional 2912 (54%) SPK transplants went to the 5355 candidates who were listed after the initiation of chronic maintenance dialysis. Of the preemptively waitlisted recipients, 398 ultimately received living donor kidney transplants; the number of living donor transplants for non-preemptively waitlisted recipients was 492. Respectively, 117 and 326 of the preemptively and non-preemptively waitlisted candidates ultimately received deceased donor kidney-alone transplants.

Far fewer older candidates with diabetes were listed for SPK and received either SPK or kidney-alone transplants. Overall, 1018 older patients with diabetes were listed, 326 preemptively and 782 after beginning dialysis. Transplants were performed in 248 (76%) of the preemptively listed candidates; 490 (63%) of those not listed preemptively received transplants. Of preemptively listed candidates, 128 (39%) received SPK transplants but only 32 of those transplants were preemptive. An additional 357 (46%) SPK transplants went to the 782 candidates who were listed after the initiation of chronic maintenance dialysis. Ultimately, 78 of the preemptively waitlisted candidates and 72 of those not preemptively waitlisted received living donor kidneys. Respectively, 42 and 61 of the preemptively and non-preemptively waitlisted candidates ultimately received deceased donor kidney-alone transplants.

Geographic variation in access to kidney and to simultaneous pancreas–kidney transplantation for patients with diabetes and end-stage renal disease

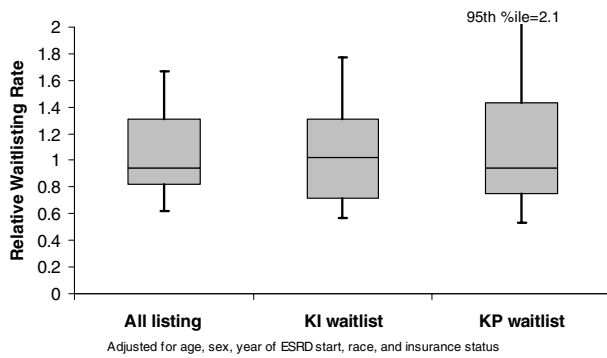
Table 7 shows by state of residence the number and percentage of patients who were waitlisted and the percentage of patients who received a transplant during the study period. Among younger patients with diabetes were the following findings. The percentage of ESRD patients per state who were waitlisted for either a kidney or an SPK transplant ranged over twofold, from 23% to 57%, with a national mean of 38%. The percentage receiving a living donor kidney transplant ranged more than tenfold, from 3% to 36%, with a mean of 8%. The percentage receiving a kidney-alone deceased donor transplant ranged twelvefold, from 2% to 19%, with a mean of 8%. And the percentage of SPK transplants ranged more than sevenfold, from 3% to 22%, with a mean of 8%. Overall, the ratio between deceased and living donor transplants was 2.0.

Among older patients with diabetes, the following findings were observed. The percentage of ESRD patients per state who were waitlisted for either a kidney or an SPK transplant ranged more than fourfold, from 6% to 24%, with a mean of 14%. The percentage receiving a living donor kidney

Table 7: Percentage of patients with diabetes (by age) placed on the kidney waiting list and receiving a transplant by state, 1998–2006

State	Age < 50 years					Age 50–75 years				
	N	Waitlisted for KI or or SPK (%)	Living donor transplants (%)	Deceased donor KI transplants (%)	Deceased donor SPK transplants (%)	N	Waitlisted for KI or SPK (%)	Living donor transplants (%)	Deceased donor KI transplants (%)	Deceased donor SPK transplants (%)
AK	66	40.9	13.6	1.5	12.1	241	14.5	3.3	5.4	0.4
AL	1272	39.1	8.2	5.1	4.2	4611	13.9	1.8	2.0	0.0
AR	635	26.5	6.9	10.1	4.6	2211	7.0	1.8	3.6	0.2
AZ	1345	33.4	7.8	5.9	6.3	5448	14.0	3.1	3.5	0.2
CA	6532	50.5	5.0	6.4	8.5	30788	21.8	1.7	3.6	0.3
CO	626	47.3	11.5	8.3	11.5	2358	19.6	3.3	4.7	0.1
CT	447	33.8	12.8	6.5	2.9	2275	10.8	2.5	2.5	0.0
DC	252	30.2	5.6	4.8	5.2	1065	15.4	2.0	3.2	0.4
DE	197	39.6	8.6	7.6	3.0	757	20.1	2.1	6.2	0.4
FL	2972	28.9	3.4	7.1	10.1	13876	10.2	1.2	4.3	0.3
GA	2149	23.2	2.8	4.4	7.6	8344	8.5	0.9	3.0	0.3
HI	401	31.4	2.7	6.5	4.0	1986	15.4	1.4	2.7	0.0
IA	400	46.0	12.3	10.0	16.5	1712	15.4	4.3	6.7	0.2
ID	192	34.9	13.5	10.9	9.9	546	13.7	3.8	6.8	0.2
IL	2258	45.2	7.7	7.9	11.5	10289	15.5	2.9	4.0	0.4
IN	1185	37.6	7.6	8.4	14.1	5048	10.2	2.0	3.9	0.5
KS	405	29.9	5.4	8.1	10.1	1756	7.9	1.6	3.6	0.6
KY	875	28.3	4.0	6.3	11.1	3489	8.4	1.3	3.9	0.5
LA	1347	26.9	3.9	5.0	8.2	5771	8.2	1.1	2.3	0.3
MA	738	48.5	21.4	10.8	3.9	3647	19.7	3.6	6.2	0.2
MD	1088	40.2	10.4	9.4	7.4	5269	17.7	3.1	5.2	0.4
ME	135	41.5	16.3	7.4	8.9	755	11.1	3.0	4.8	0.0
MI	2145	42.3	13.8	8.8	6.0	8845	15.1	3.8	4.2	0.1
MN	683	51.2	36.0	9.4	7.5	2377	24.0	10.1	7.5	0.9
MO	1117	32.6	6.6	8.1	6.9	4937	11.0	2.1	4.3	0.3
MS	836	31.2	3.1	7.7	4.7	3146	8.7	1.0	1.7	0.0
MT	153	45.1	19.6	9.8	11.8	543	20.6	6.8	9.0	0.4
NC	2070	28.9	4.6	5.0	7.6	8246	10.4	1.6	2.7	0.3
ND	146	43.8	26.0	7.5	9.6	469	21.7	7.9	9.2	0.2
NE	284	36.6	10.6	8.8	13.7	1205	12.6	3.5	5.1	0.2
NH	156	41.7	14.7	14.1	5.1	586	14.8	2.2	7.2	0.3
NJ	1439	46.8	11.9	8.7	6.8	7671	17.3	3.0	3.9	0.2
NM	527	31.5	7.4	8.3	3.6	2133	11.3	2.2	3.4	0.0
NV	375	40.0	5.1	11.2	7.7	1799	16.0	2.0	3.6	0.2
NY	3176	41.0	10.3	8.6	4.3	16098	16.5	2.6	3.7	0.2
OH	2416	35.4	10.0	7.3	12.4	11557	10.4	3.0	3.4	0.3
OK	880	25.1	3.6	7.4	5.2	3157	10.0	1.2	4.4	0.2
OR	512	30.5	10.0	12.1	8.8	1842	11.4	3.9	6.8	0.1
PA	2238	50.8	8.8	10.5	12.6	11131	17.3	1.9	6.5	0.4
PR	965	22.7	4.1	5.0	4.9	4761	5.6	0.8	1.4	0.0
RI	146	56.8	24.7	18.5	4.1	643	11.7	4.2	4.5	0.0
SC	1073	26.8	4.4	5.6	7.5	4695	8.6	0.7	3.4	0.2
SD	164	50.6	18.9	15.2	9.1	660	24.1	4.4	10.2	0.6
TN	1397	33.5	7.5	8.4	8.9	5222	10.2	1.8	3.4	0.2
TX	6127	31.9	4.4	7.8	4.4	23951	12.6	1.5	3.6	0.1
UT	342	30.7	18.1	9.4	12.9	1039	11.7	6.5	7.3	0.3
VA	1541	40.6	9.2	6.1	7.1	6565	14.9	3.3	3.1	0.1
VT	50	44.0	18.0	8.0	12.0	175	17.7	2.9	9.1	0.0
WA	852	38.7	9.0	8.0	12.8	3357	14.0	3.1	5.2	0.3
WI	827	52.5	9.4	8.7	21.6	3355	18.1	4.5	6.3	0.8
WV	405	34.8	9.1	13.1	6.7	1859	9.1	1.8	3.4	0.1
WY	58	48.3	19.0	8.6	6.9	178	15.2	3.4	6.7	0.0
All	58 617	37.6	7.8	7.6	8.0	254 444	14.1	2.3	3.9	0.3

Source: SRTR analysis, November 2008 (KI = kidney-alone transplant; SPK = simultaneous pancreas–kidney transplant).

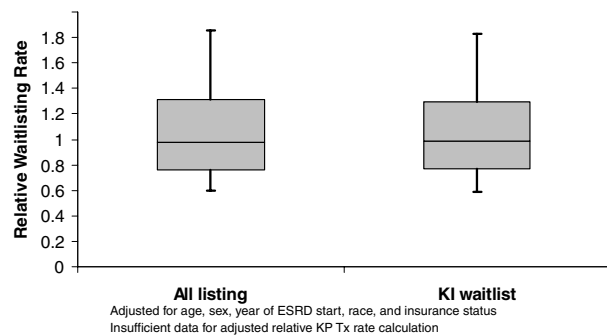


Source: SRTR analysis, November 2008.

Figure 15: Percentiles (5th, 25th, 50th, 75th, 95th) of adjusted relative access rates compared with national average, 1998–2006, diabetes mellitus (DM) as cause, age < 50 years.

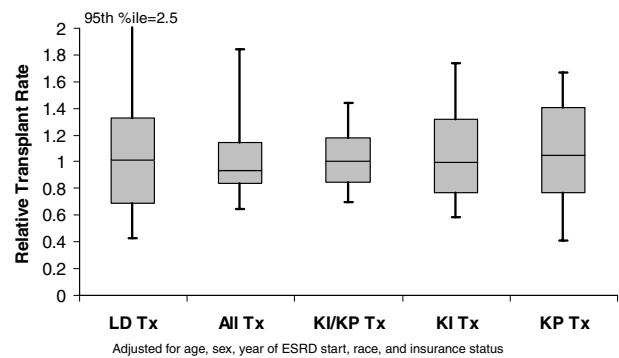
transplant ranged more than tenfold, from 0.7% to 10.1%, with a mean of 2.3%. The percentage receiving a kidney-alone deceased donor transplant ranged sevenfold, from 1.4% to 10.2%, with a mean of 4%. And the percentage of SPK transplants ranged from 0.0% to 0.9%, with a mean of 0.3%. Overall, the ratio between deceased and living donor transplants was 1.8.

These geographic differences in the rates of waitlisting (Figures 15 and 16) and transplantation (Figures 17 and 18) persisted even after adjusting for candidate age, race, sex, insurance status and year of ESRD. There was considerable geographic variation in listing rates for both younger and older patients with diabetes. Table 8 presents some of the correlations in the outcomes shown in Table 7 across states. Transplant rates for various subgroups tended to correlate with each other. In general, a high concordance was seen between the listing rates of the two age groups within a state; that is, states with high listing rates for younger diabetic patients also had higher listing rates for



Source: SRTR analysis, November 2008.

Figure 16: Percentiles of adjusted relative access rates compared with national average, 1998–2006, DM as cause, age ≥ 50 years.



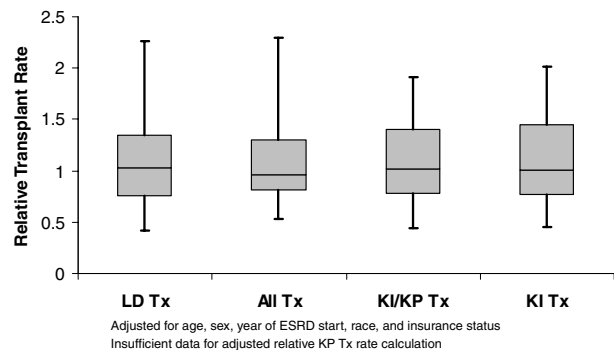
Source: SRTR analysis, November 2008.

Figure 17: Percentiles of adjusted relative access rates compared with national average, 1998–2006, DM as cause, age < 50 years.

older such patients and visa versa (between-state Pearson correlation coefficient = 0.78). Correlations were also seen in transplantation rates between various subgroups. States with high transplant percentages for patients with diabetes tended to have high transplant percentages for candidates without the disease. And, states with high transplant percentages for younger candidates (age less than 50 years) tended to have high transplant percentages for older candidates. No distinction was made in the table between kidney-alone and SPK when calculating correlations between listing rates, but transplant rates are based on kidney-alone transplants.

Summary

Over the past decade, the total number of candidates on the kidney transplant waiting list at any time during the calendar year increased by 78%, from 53 315 to 94 741. However, the number of candidates active on the kidney



Source: SRTR analysis, November 2008.

Figure 18: Percentiles of adjusted relative access rates compared with national average, 1998–2006, DM as cause, age ≥ 50 years.

Table 8: Between-state correlation coefficients (r) for outcomes in Table 7

Donor	ESRD cause	Age	Transplant (KI)/listing rate	Distinction	Correlation (r)
N/A	DM		Listing	<50 vs. ≥50 years	0.78
Kidney		0–75	Transplant	DM vs. non-DM	0.86
Kidney	DM		Transplant	<50 vs. ≥50 years	0.90
Kidney	Non-DM		Transplant	<50 vs. ≥50 years	0.88

Source: SRTR analysis, November 2008 (ESRD = end-stage renal disease; KI = kidney-alone transplant; N/A = not applicable).

transplant waiting list grew more slowly, increasing by only 16% since 2001. In contrast, the number of inactive patients on the kidney transplant waiting list nearly quadrupled since 2002 to 23 089. The annual number of deceased donor kidney-alone transplants peaked at 10 212 in 2006 and then fell to 10 082 transplants in 2007. Similarly, the number of living-related kidney donors reached 4349 in 2001 but decreased to 3625 in 2007; the number of living-unrelated donor transplants peaked at 2348 in 2006 but declined in 2007 to 2154. Unadjusted kidney transplant recipient survival rates at 5 years were 91% for living donor kidneys, 83% for non-ECD deceased donor kidneys and 70% for ECD kidney transplants; unadjusted graft survival was 81% for living donor, 71% for non-ECD and 55% for ECD transplants. There is a significant trend toward improvement in allograft survival (all $p < 0.05$) when the first 5 years of the last decade are compared with the second half.

The overall number of pancreas transplants peaked at 1484 in 2004 and has since declined to 1331 by 2007. There were also recent downward trends in SPK, PAK and total pancreas transplant registrations. The total number of new pancreas waiting list registrations peaked at 2796 in 2000 and then fell to 2399 in 2007. Patient survival rates were similar for PAK, SPK and PTA through the first three posttransplant years, but the 5- and 10-year patient survival rates were lower for PAK recipients: 65% at 10 years compared with 70% and 73% for SPK and PTA recipients, respectively. The best pancreas allograft survival rates, 86% at 1 year and 53% at 10 years, were achieved with SPK transplants. One-year graft survival rates for PAK and PTA were 77% and 81%, respectively, and 10-year rates were 35% and 26%, respectively.

The age of candidates and the percentage of patients with diabetes among all, among active and among newly waitlisted adult kidney-alone candidates are increasing. The increasing age of waitlisted candidates explains roughly half of the growth in the percentage of diabetics on the waiting list. Nationally, between 1998 and 2006, 23% of the total population of patients with diabetes and ESRD who were under the age of 50 years and 62% of the waitlisted population of these patients, received a kidney or an SPK transplant. During this same interval, 6% of such patients aged 50–75 years, representing 46% of those waitlisted, were transplanted. Among those preemptively waitlisted,

74% of candidates under the age of 50 years and 56% of candidates between the ages 50 and 75 years were eventually transplanted. Among younger patients with diabetes: the percentage of ESRD patients per state who were waitlisted for either a kidney or an SPK transplant varied more than twofold, the percentage receiving a living donor kidney transplant more than tenfold, the percentage receiving a kidney-alone deceased donor transplant twelvefold and the percentage of SPK transplants more than sevenfold. Among older patients with diabetes: the percentage of ESRD patients per state who were waitlisted for either a kidney or an SPK transplant ranged more than fourfold, the percentage receiving a living donor kidney transplant more than tenfold, the percentage receiving a kidney-alone deceased transplant sevenfold and the percentage of SPK transplants from 0.0% to 0.9%.

Overall, the percentage of patients with diabetes and ESRD is increasing at a rate that is only partially explained by the aging of the ESRD population. Age and geography have emerged as powerful determinants of kidney and SPK transplantation for this patient population. Based upon these variables, marked variation among patients with diabetes is observed in living donor transplantation, waitlisting and deceased donor transplantation rates. Preemptive waitlisting is associated with better access to transplantation for both younger and older diabetic ESRD cohorts.

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