CHAPTER I
Trends in Organ Donation and Transplantation in the United States, 1996-2005

INTRODUCTION

This chapter provides a brief overview of solid organ transplantation in the United States, and is produced as part of the 2006 *OPTN/SRTR Annual Report*. The *Annual Report* is prepared by the Scientific Registry of Transplant Recipients (SRTR) in collaboration with the Organ Procurement and Transplantation Network (OPTN) under contract with the Health Resources and Services Administration (HRSA). The report gathers a large amount of information on many aspects of solid organ transplantation in one publication, making it a valuable resource for patients, the transplant community, the public, and the Federal Government.

The text section of this report includes nine chapters devoted to specific topics in solid organ transplantation. Each chapter was written by a group of experts in the field of transplantation and provides a comprehensive look at the current state of transplantation and trends over the past decade. The text and figures in these chapters are based on recent SRTR analyses and the extensive reference tables of the 2006 *Annual Report*, which were prepared by the Arbor Research Collaborative for Health (formerly known as the University Renal Research and Education Association, or URREA), which with the University of Michigan has been the contractor for the SRTR since October 2000. These nine chapters and reference tables are included in the Annual Report and are available online, at the websites of the SRTR and OPTN (www.ustransplant.org and www.optn.org). All nine chapters of this report have undergone peer-review and are being published separately as stand-alone articles in the 2006 *SRTR Report on the State of Transplantation*, a special issue of the *American Journal of Transplantation*.

SUMMARY STATISTICS ON ORGAN TRANSPLANTATION IN THE UNITED STATES

As of the end of 2004 there were 153,245 persons living with a functioning organ transplant in the United States *[Table 1.14]*. This number reflects an increase by about 1.8% over the prior year and a 1.7-fold increase since 1996.

The total number of organs transplanted annually increased from 26,541 in 2004 to 27,527 in 2005, an increase of 986 (4%) *[Table 1.7]*. The transplanted organs with the highest percentage increases were intestine (31%) and lung (20%), as shown in Table I-1. These organs came from 14,488 organ donors in 2005, 335 more donors than in 2004 (2%) *[Table 1.1]*. The increase in the total number of donors resulted

Table I-1. Growth in Number of Transplanted and Recovered Organs, 2004-2005

Organs Transplanted				Organs Recovered from Deceased Donors			
Transplanted Organs	**2004**	**2005**	**Percent Change**	**Recovered Organs**	**2004**	**2005**	**Percent Change**
Total	26,541	27,527	3.7%	All DD organs	25,221	26,910	6.7%
Deceased donor	19,551	20,635	5.5%				
Living donor	6,990	6,892	-1.4%				
Kidney	15,674	16,072	2.5%	Kidney	12,570	13,313	5.9%
Deceased donor	9,027	9,509	5.3%				
Living donor	6,647	6,563	-1.3%				
Pancreas				Pancreas (all)	2,010	2,034	1.2%
PTA	130	129	-0.8%				
PAK	419	343	-18.1%				
Kidney-pancreas	880	896	1.8%				
Liver	5,779	6,000	3.8%	Liver	6,404	6,784	5.9%
Deceased donor	5,457	5,679	4.1%				
Living donor	322	321	-0.3%				
Intestine	52	68	30.8%	Intestine	168	185	10.1%
Heart	1,961	2,063	5.2%	Heart	2,096	2,220	5.9%
Lung	1,168	1,405	20.3%	Lung	1,973	2,374	20.3%
Deceased donor	1,153	1,404	21.8%				
Living donor	15	1	-93.3%				
Heart-lung	37	32	-13.5%	Heart-lung	NA	NA	NA

Source: *2006 OPTN/SRTR Annual Report*, Tables 1.2, and 1.7.

from a substantial increase of 443 (6%) deceased donors and a slight decrease of 108 (2%) living donors. This is the first time in the past decade that a decrease in the number of living donors was observed from one year to the next. A deceased donor usually provides several organs to benefit multiple patients with organ failure. The organ donation and transplantation collaborative initiatives of the Division of Transplantation at HRSA have successfully focused on increasing the number of deceased donors and on the number of organs per donor by working with professionals at organ procurement organizations, donor hospitals and transplant centers (1).

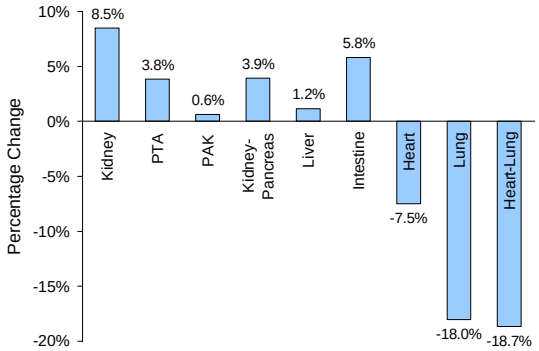
Table I-2. Waiting List Candidates (Active and Inactive Combined), 2004-2005

Organs	End of Year		Percent Change
	2004	2005	
Total	85,610	89,884	5.0%
Kidney	57,389	62,294	8.5%
PTA	502	521	3.8%
PAK	971	977	0.6%
Kidney-pancreas	2,381	2,474	3.9%
Liver	16,967	17,168	1.2%
Intestine	191	202	5.8%
Heart	3,210	2,970	-7.5%
Lung	3,828	3,139	-18.0%
Heart-lung	171	139	-18.7%

Source: *2006 OPTN/SRTR Annual Report*, Table 1.3.
PTA: Pancreas transplant alone. PAK: Pancreas after kidney.

Overall there were approximately 90,000 people registered on organ waiting lists at the end of 2005 (63,814 actively waiting and 26,053 with "inactive" status), a 5% increase over the number of people waiting for an organ at the end of 2004 *[Table 1.4]*. The overall percentage of wait-listed patients with inactive status rose from 14% in 1996 to 29% in 2005; percentages vary considerably by organ. The largest increase was in the number of people on the kidney transplant waiting list, increasing by 8% from 57,389 in 2004 to 62,294 in 2005, a net addition of 4,905 candidates (Table I-2). This large waiting list is in part due to the cumulative effect of the imbalance between supply of organs and demand (need) for organs over past years. The net change in the total number of candidates on the waiting list at year-end from one year to the next provides an indication of the balance between supply and demand during that year. A net growth indicates that the waiting time on average increases, whereas a decline in the number of patients on the waiting list projects a shortening of average waiting times. Figure I-1 shows that for 2004 to 2005, the organ supply fell short of the increasing need not only for kidneys but also to a lesser degree for livers (by 1%, or 117 livers) and pancreata. By contrast, there is good news for other organs, particularly for lungs and hearts, for which organs both the supply and demand increased and the size of the waiting list decreased.

Figure I-1. Change in Numbers of Patients on Waiting Lists, 2004-2005

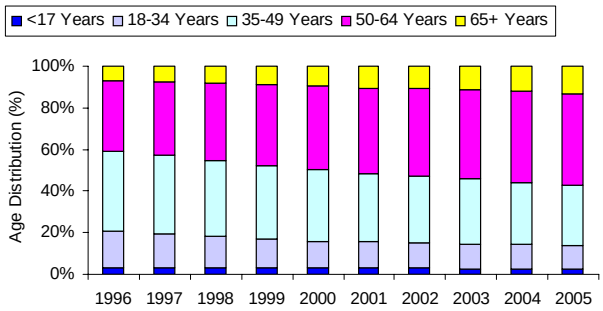


Source: *2006 OPTN/SRTR Annual Report*, Table 1.3.

From 2004 to 2005, the size of the heart, lung, and heart-lung waiting lists dropped by 8%, 18%, and 18%, respectively *[Table 1.3]*. The dramatic changes for lungs can be largely attributed to a new deceased donor lung allocation policy that was implemented in May 2005. The allocation policy was changed from a system based on waiting times to one based on net survival benefit from transplantation and medical urgency (waiting list mortality risk) (2).

Continuing a trend extending back more than 10 years, the transplant candidate population is increasingly older (Figure I-2) *[Table 1.4]*. In 1996, 7% of the overall waiting list candidates were 65 or older; in 2005, that percentage was 13%. The proportion of candidates age 50-64 rose as well, from 34% in 1996 to 44% in 2005. The percentages of candidates in every age group below 50 years, including pediatric candidates (under 18 years), have dropped over the decade.

Figure I-2. Age Distribution on Waiting Lists, All Organs, 1996-2005



Source: *2006 OPTN/SRTR Annual Report*, Table 1.3.

Key outcomes after transplantation include 1) survival of transplant recipients, and 2) the function of transplanted grafts. Table I-3 displays one- and five-year unadjusted

patient survival for all transplant recipients by organ, using the most recent cohort for which adequate follow-up exists. The cohort used to compute one-year survival consists of recipients transplanted in 2003-2004, while the cohort for five-year survival is based on recipients transplanted in 1999-2004. One-year patient survival rates were highest for kidney and pancreas recipients, ranging from about 95% to 98%; corresponding survival for liver, intestine, and heart recipients was approximately 87% to 91%, about 85% for lung, and lowest for the small number of heart-lung recipients with approximately 67% surviving at one-year *[Table 1.13]*.

Table I-4 shows the percentage of transplanted organs that are still functioning (graft survival) one and five years after transplantation by type of organ *[Table 1.13]*. Like patient survival, graft survival is calculated based on the same most recent cohorts for which sufficient follow-up was available.

Table I-3. Unadjusted One- and Five-Year Patient Survival by Organ

Organ Transplanted	1-Year Survival	5-Year Survival
Kidney		
Deceased donor	94.7%	80.7%
Living donor	98.0%	90.4%
Pancreas alone	94.9%	90.2%
Pancreas after kidney	95.5%	83.6%
Kidney-pancreas	95.1%	85.8%
Liver		
Deceased donor	86.9%	73.4%
Living donor	91.2%	76.8%
Intestine	87.5%	50.2%
Heart	88.1%	73.7%
Lung	84.9%	51.6%
Heart-lung	66.7%	43.6%

Source: *2006 OPTN/SRTR Annual Report*, Table 1.13.

Table I-4. Unadjusted One- and Five-Year Graft Survival by Organ

Organ Transplanted	1-Year Survival	5-Year Survival
Kidney		
Deceased donor	89.5%	67.1%
Living donor	95.1%	80.3%
Pancreas alone	72.8%	53.4%
Pancreas after kidney	78.7%	56.4%
Kidney-pancreas (kidney)	91.8%	76.3%
Kidney-pancreas (pancreas)	85.2%	71.1%
Liver		
Deceased donor	82.4%	67.4%
Living donor	84.0%	68.8%
Intestine	78.5%	40.1%
Heart	87.5%	72.6%
Lung	83.3%	48.9%
Heart-lung	64.1%	41.5%

Source: *2006 OPTN/SRTR Annual Report*, Table 1.13.

Graft survival rates are lower than corresponding patient survival rates because patients may survive a graft failure by receiving a second transplant or with an alternative therapy, such as dialysis for kidney transplant recipients or insulin therapy for pancreas transplant recipients.

TRANSPLANTATION AT A GLANCE

The full-page figures at the end of this chapter (Figures I-3 to I-10) offer "dashboard" views of the state of transplantation for different organs. Sets of summary graphics are included for six organs (kidney, pancreas, liver, intestine, heart, and lung) as well as two common multi-organ procedures (simultaneous pancreas-kidney and pancreas after kidney). For this overview, we have omitted separate figures for heart-lung transplants, given the extremely small numbers of these procedures. Below we describe the three graphs shown for each organ.

Number of Transplants and Size of Active Waiting List

These figures compare, for each of the last 10 years, the size of the active waiting list and the number of transplants performed. The size of the waiting list is a snapshot of the number of candidates active on the waiting list at the end of the year, although additional patients were listed or removed at some time during the year. The number of transplants includes all transplants performed over the year. This difference in ways of counting explains why for some organs (e.g., lung), the number of transplants performed during a certain year may exceed the number of people awaiting that organ on the last day of the same year. Other instances of the narrowing gap between waiting list size and number of transplant reflect changes in allocation policy and wait-listing practices.

Age Distribution of Recipients and Active Waiting List

In this overview we have grouped all pediatric patients (<18 years) together, for ease of viewing. The *OPTN/SRTR Annual Report* data tables (and the accompanying chapters analyzing them) break this group out into several age groups: <1 year, 1-5 years, 6-10 years, and 11-17 years. See Chapter III for details. Here we have included only the data for 1996 and 2005; additional detail may be found in the organ-specific chapters of this report (Chapters IV to VI).

Unadjusted Patient and Graft Survival

These overview figures show survival of the transplanted organ (graft) and survival of transplant recipients (patient) at various time points following transplantation: three months, one year, three years, and five years. The figures are based on information about the most recent cohorts possible that still allow sufficient follow-up time for data collection and ascertainment.

CHAPTERS IN THE 2006 *OPTN/SRTR ANNUAL REPORT*

The graphics above give a quick view of the major trends addressed and analyzed in each of the organ-specific chapters of this report. Chapters on **kidney and pancreas** (Chapter IV), **liver and intestine** (Chapter V), and **heart and lung** (Chapter VI) provide detailed trends in donation, waiting time, allocation, posttransplant outcomes, and the demographics of both candidates and recipients. Additionally, these chapters supplement the reporting of 10-year trends with updates on recent changes in allocation policy, immunosuppression, clinical practice, and other areas relevant to the transplantation of different organ types.

In this year's report, the three organ-specific chapters are preceded by a review of trends in **organ donation and utilization** (Chapter II) including recent efforts to increase the number of donors, and a chapter devoted to the particular outcomes and policy concerns of **pediatric transplantation** (Chapter III).

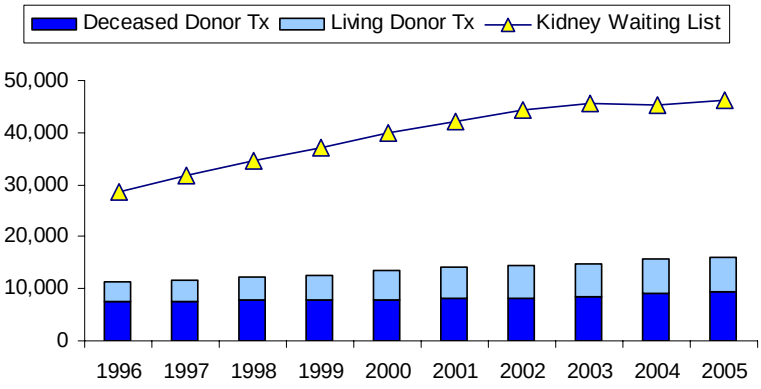
This year's report concludes with three "special-focus" chapters that look closely at issues of recent interest to the transplant community. A chapter on **organ acceptance rates** (Chapter VII) examines what happens when transplant centers turn down kidneys offered by an organ procurement organization, as low acceptance rates may contribute to inefficiency in organ distribution. A chapter on **geographic variability in access to kidney transplantation** (Chapter VIII) examines rates in wait-listing, receiving a living donor kidney transplant, and receiving a deceased donor kidney transplant after being placed on the waiting list, identifying wide disparities in access across the US. Lastly, a chapter on **repeat transplantation** (Chapter IX) focuses on the growing trend of same-organ retransplantation and its effects on the transplant community as a whole and on individual recipients, who are more likely to have inferior outcomes following retransplantation. These chapters all include special analyses performed by the SRTR and touch on topics that are timely and have implications for policy and clinical practice.

REFERENCES

1. Marks WH, Wagner D, Pearson TC, et al. *The 2005 SRTR Report on the State of Transplantation*: Organ Donation and Utilization, 1995-2004: Entering the Collaborative Era. *Am J Transplant* 6:1101-1110, 2006.

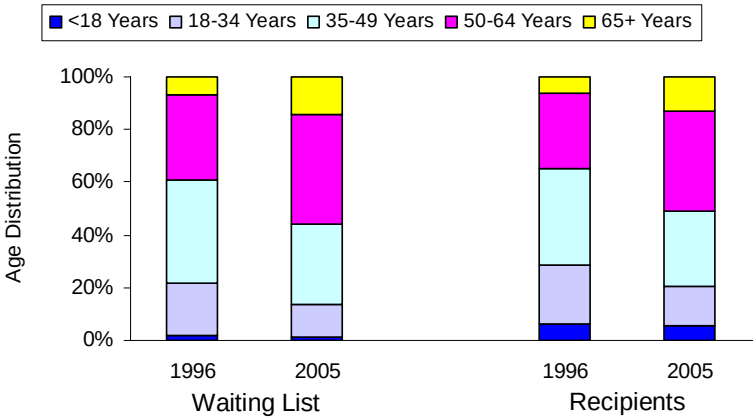
2. Egan TM, Murray S, Bustami RT, et al. *The 2005 SRTR Report on the State of Transplantation*: Development of the New Lung Allocation System in the United States. *Am J Transplant* 6:1212-1227, 2006.

Figure I-3. Kidney Transplantation at a Glance



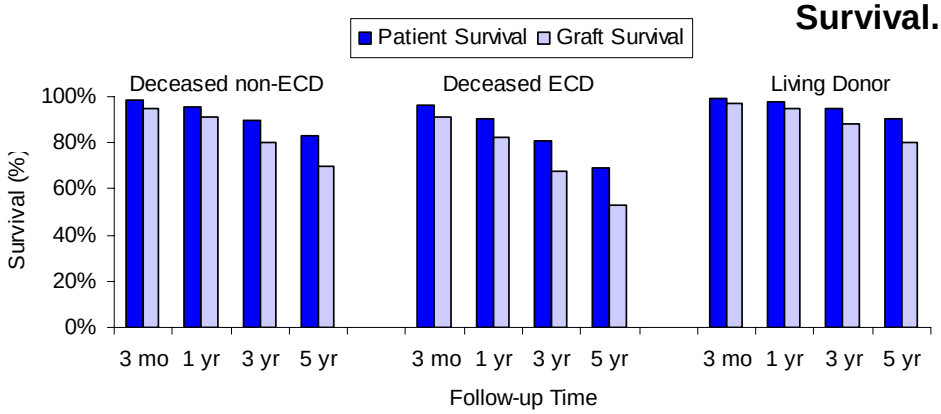
Number of Transplants and Size of Active Waiting List.

There is a very large gap between the number of patients waiting for a transplant and the number receiving a transplant. This gap has been widening, which means that the waiting times from listing to transplant continue to increase. Living donor transplants had increased until 2004 while deceased donor transplants increased gradually to 2005. Source: *2006 OPTN/SRTR Annual Report*, Tables 1.7, 5.1a.



Age Distribution of Recipients and Active Waiting List.

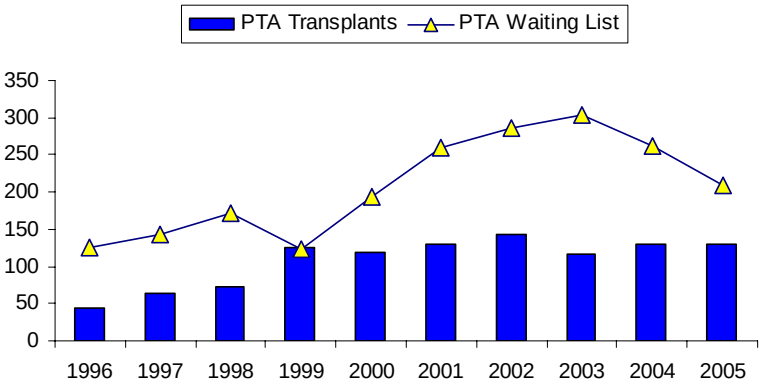
During the past decade the age distribution of candidates on the waiting list has changed such that older candidates now make up a much larger fraction of patients actively awaiting an organ. The same pattern is observed for transplant recipients except that ages <35 years show a greater representation than on the waiting list. Source: *2006 OPTN/SRTR Annual Report*, Tables 5.1a, 5.4a, 5.4b, 5.4c.



Unadjusted Patient and Graft Survival.

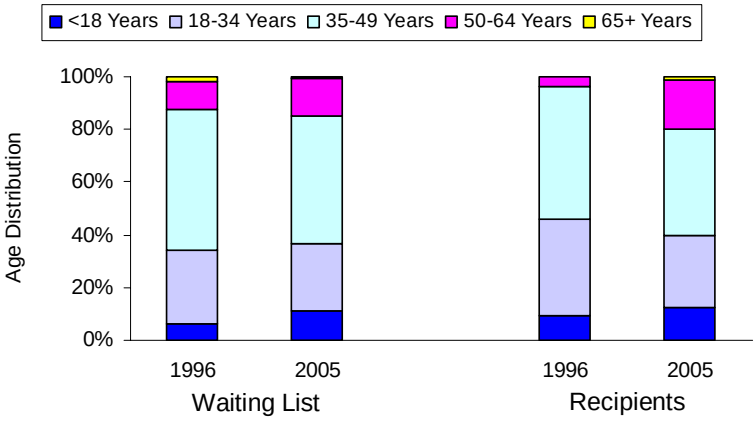
Patient survival in recent years has been improving. Five-year patient survival percentages based on transplants during 1999-2004 are clearly higher for living donors (90%) than for standard donor deceased donors (83%) and lowest among deceased donors (69%). Graft survival is lower since patients may live on dialysis or receive another transplant after graft failure. Source: *2006 OPTN/SRTR Annual Report*, Tables 5.10a, 5.10b, 5.10c, 5.14a, 5.14b, 5.14c.

Figure I-4. Pancreas Transplantation Alone (PTA) at a Glance



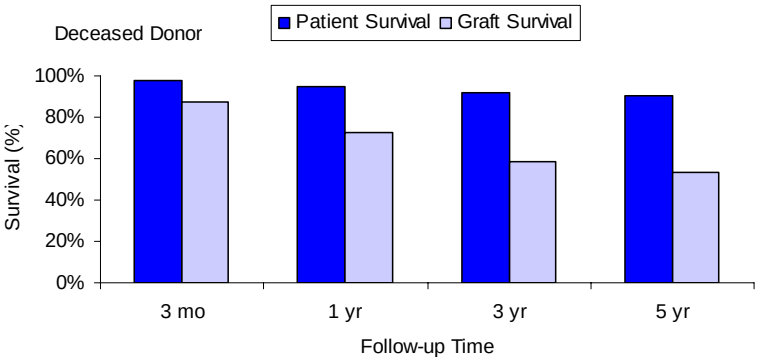
Number of Transplants and Size of Active Waiting List.

The number of patients on the waiting list for a pancreas transplant alone has decreased since 2003, which resulted in a narrowing gap between the number of patients waiting for a pancreas transplant alone (PTA) and the number receiving one. However, this gap was still present in 2005. The number of PTA per year has been stable in recent years. Source: *2006 OPTN/SRTR Annual Report*, Tables 1.7, 6.1a.



Age Distribution of Recipients and Active Waiting List.

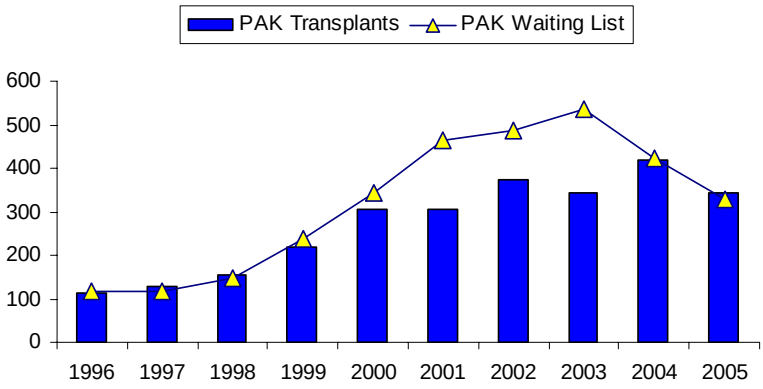
For PTA, more pediatric candidates were wait-listed and received a transplant in 2005 than in 1996. At the same time, the fraction of recipients over age 50 has grown. Pediatric diabetic patients rarely have kidney failure before age 18, but they are candidates for PTA. Source: *2006 OPTN/SRTR Annual Report*, Tables 6.1a, 6.4.



Unadjusted Patient and Graft Survival.

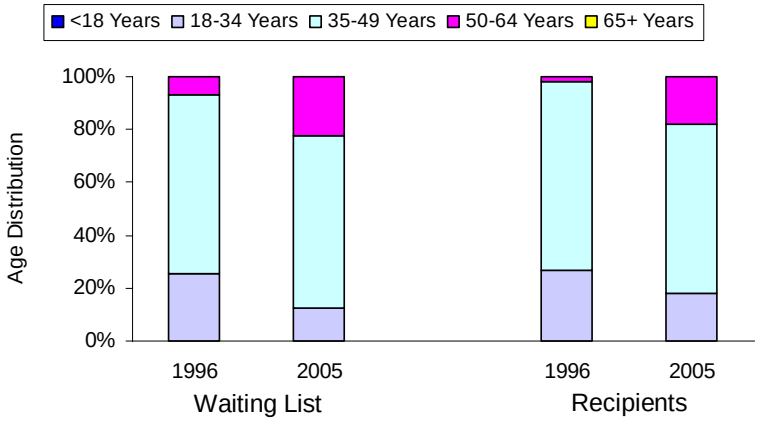
For PTA transplants, patient survival in recent years has been excellent; such patients do not usually have advanced kidney failure. The five-year patient survival is 90%. Graft survival is considerably lower since patients may live after graft failure through treatment with insulin. Source: *2006 OPTN/SRTR Annual Report*, Tables 6.10, 6.14.

Figure I-5. Pancreas After Kidney (PAK) Transplantation at a Glance



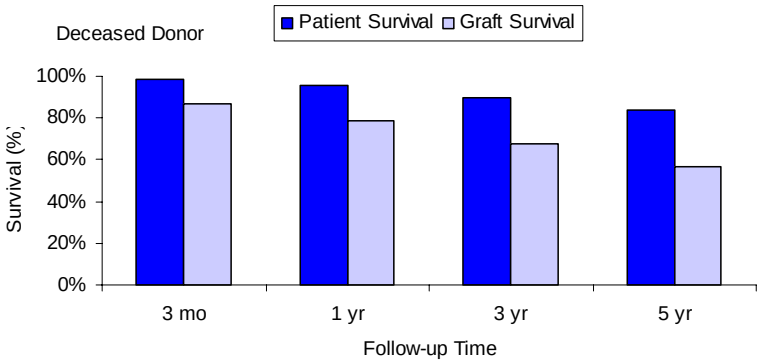
Number of Transplants and Size of Active Waiting List.

As with PTA, the number of patients on the waiting list for a PAK transplant has decreased since 2003. The gap between candidates and recipients decreased too. The number receiving a transplant matched the number of candidates at the end of 2004 and 2005. The number of PAK transplants has decreased in 2005 from its highest level of the decade in 2004. Source: *2006 OPTN/SRTR Annual Report*, Tables 1.7, 7.1a.



Age Distribution of Recipients and Active Waiting List.

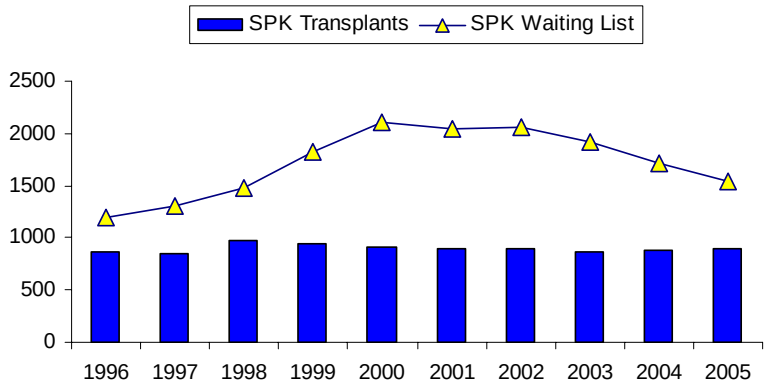
For PAK, more patients over 50 were wait-listed and received a transplant in 2005 than in 1996. At the same, time fewer candidates and recipients were in the age group of 18-34. Since recipients are mostly type 1 diabetics, the ages below 18 and above 65 are virtually unrepresented. Recipients include transplants from both living and deceased donors. Source: *2006 OPTN/SRTR Annual Report*, Tables 7.1a, 7.4.



Unadjusted Patient and Graft Survival.

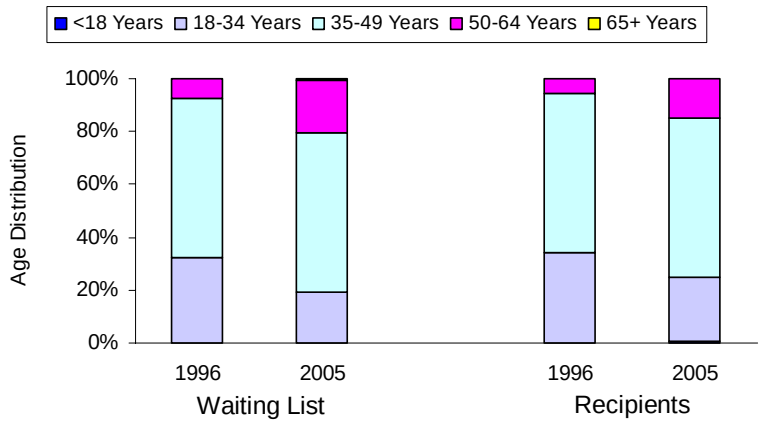
For PAK transplants, patient survival has been similar to that seen for simultaneous kidney-pancreas transplant recipients. Five-year patient survival is 84%. Graft survival is considerably lower since patients may live after graft failure through treatment with insulin. Source: *2006 OPTN/SRTR Annual Report*, Tables 7.10, 7.14.

Figure I-6. Simultaneous Pancreas-Kidney (SPK) Transplantation at a Glance



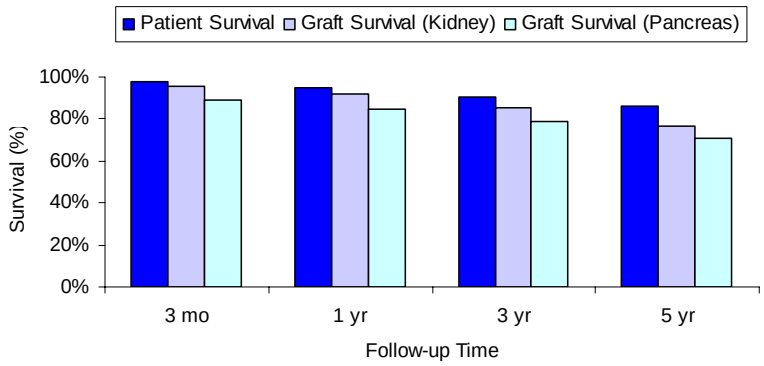
Number of Transplants and Size of Active Waiting List.

SPK accounts for the large majority of all pancreas transplants and has been stable over the last decade. The gap between the number of patients waiting for a transplant and the number receiving a transplant has been large, but has substantially decreased since 2000. Source: *2006 OPTN/SRTR Annual Report*, Tables 1.7, 8.1a.



Age Distribution of Recipients and Active Waiting List.

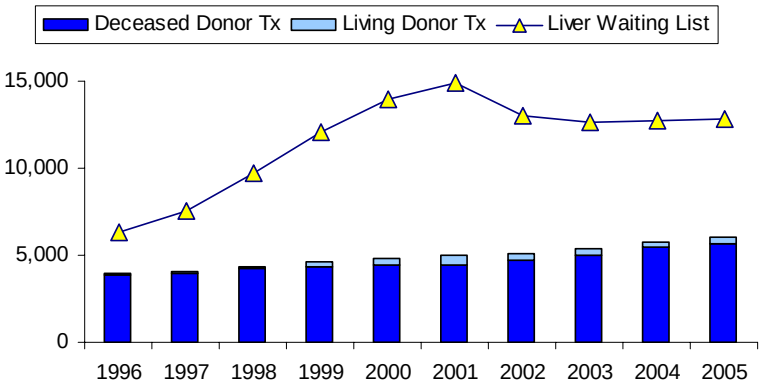
For SPK transplantation, a greater fraction of patients over age 50 were wait-listed and received a transplant in 2005 than in 1996. At the same time, fewer candidates and recipients were in the 18-34 age group. Since recipients are mostly type 1 diabetics, the ages below 18 and above 65 are virtually unrepresented. Recipients include transplants from both living and deceased donors. Source: *2006 OPTN/SRTR Annual Report*, Tables 8.1a, 8.4.



Unadjusted Patient and Graft Survival.

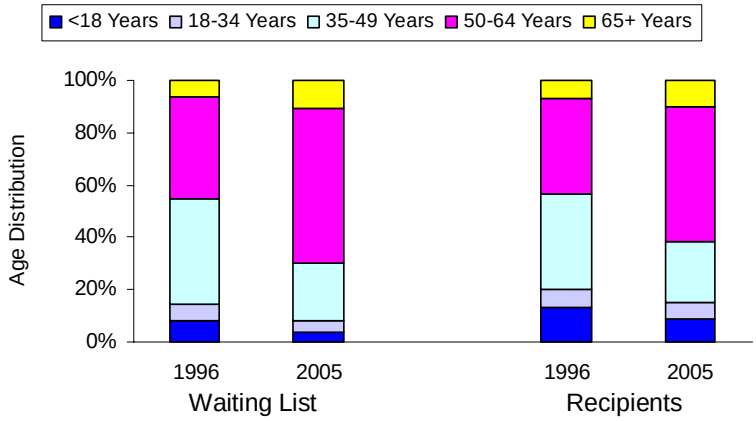
Patient survival has improved for SPK recipients in recent years. All SPK transplants are from deceased donors and their five-year patient survival is 86%. Graft survival is lower since patients may live after graft failure through treatment with insulin. Source: *2006 OPTN/SRTR Annual Report*, Tables 8.10, 8.14.

Figure I-7. Liver Transplantation at a Glance



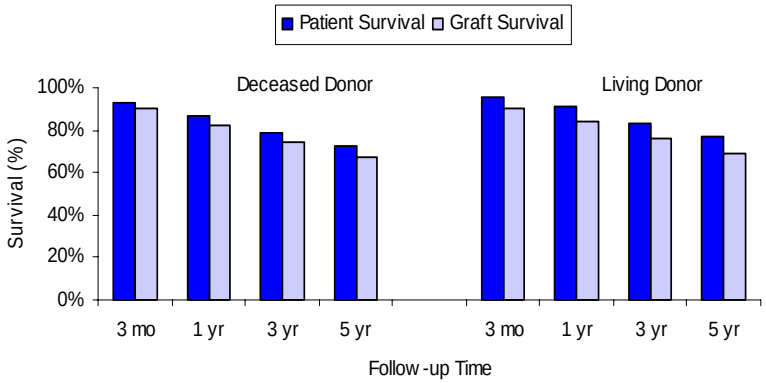
Number of Transplants and Size of Active Waiting List.

The large increase in the number of patients awaiting a liver transplant has stabilized since 2002, when the MELD/PELD system began. The number receiving a deceased donor liver transplant has gradually increased, more steeply in 2004 and 2005. The gap between the numbers of candidates and recipients has been slowly shrinking since 2002. Source: *2006 OPTN/SRTR Annual Report*, Tables 1.7, 9.1a, 9.1b.



Age Distribution of Recipients and Active Waiting List.

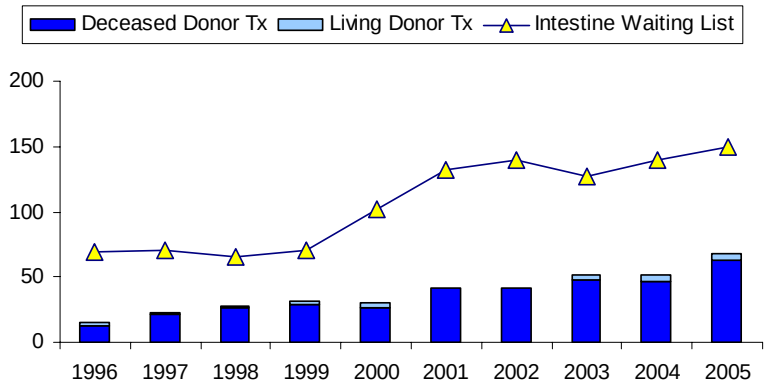
The numbers of candidates and recipients age 35-49 have remained fairly constant over the decade, but the age group's proportion by both measures has declined. Recipients include transplants from both living and deceased donors. Source: *2006 OPTN/SRTR Annual Report*, Tables 9.1a, 9.4a, 9.4b.



Unadjusted Patient and Graft Survival.

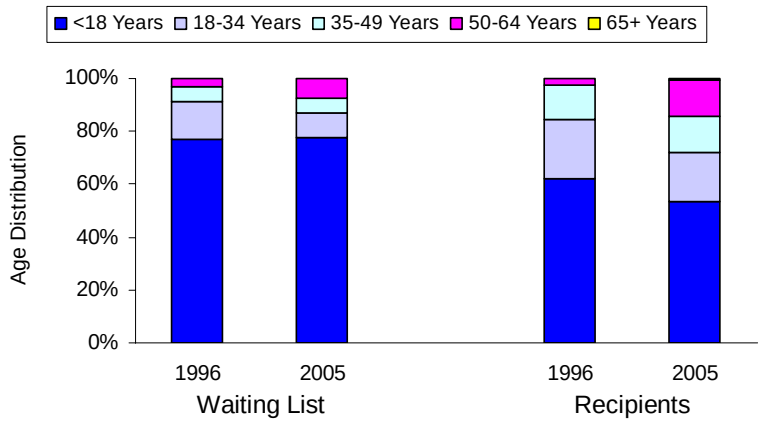
Patient survival in recent years has been improving for both deceased donors and living donors, with 73% and 77% of patients, respectively, alive five years following transplantation. Graft survival is lower since patients may live after graft failure through repeat liver transplantation. Source: *2006 OPTN/SRTR Annual Report*, Tables 9.10a, 9.10b, 9.14a, and 9.14b.

Figure I-8. Intestine Transplantation at a Glance



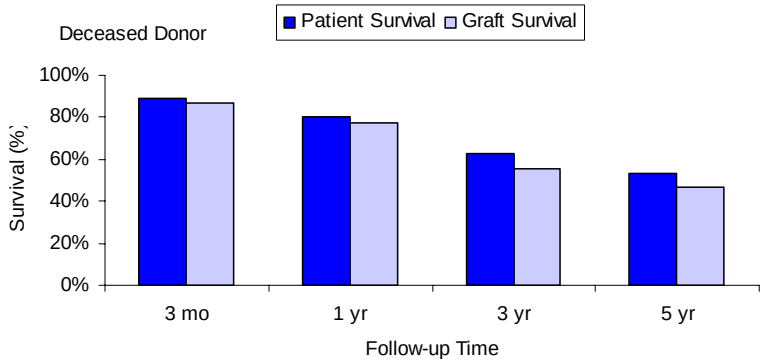
Number of Transplants and Size of Active Waiting List.

The numbers of patients on the intestine waiting list and the number receiving a transplant both approximately doubled between 1996 and 2005. The difference between the number of candidates and transplant recipients has been increasing through the second half of the decade. Source: *2006 OPTN/SRTR Annual Report*, Tables 1.7, 10.1a.



Age Distribution of Recipients and Active Waiting List.

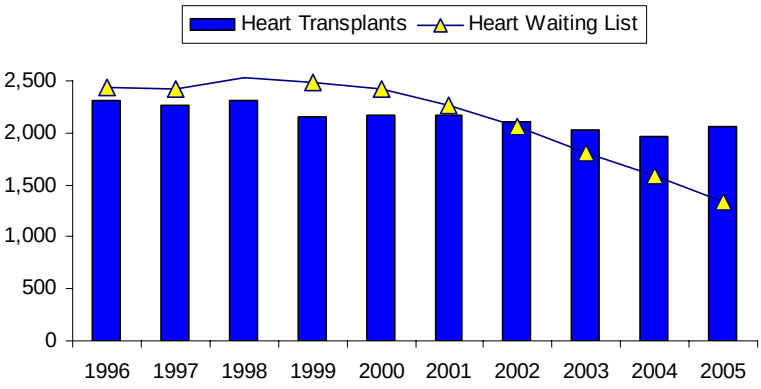
About 75% of intestine candidates have been in the pediatric age group. The small group of candidates in the age group >50 years doubled during the decade. Adult recipients make up a greater portion of recipients than candidates. The age group older than 50 shows a large increase during the decade in both categories. Source: *2006 OPTN/SRTR Annual Report*, Tables 10.1a, 10.4.



Unadjusted Patient and Graft Survival.

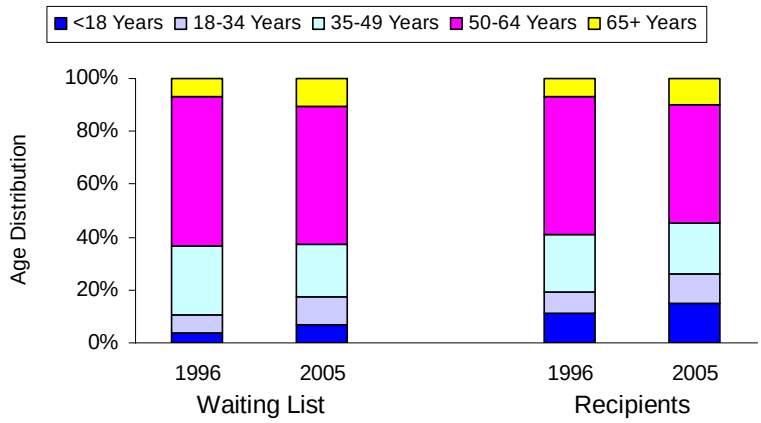
One-year patient survival reached 80% in 2005; however, longer-term survival at 5 years is 53%. Graft survival is lower, as patients may survive graft failure through parenteral alimentation or retransplantation. Source: *2006 OPTN/SRTR Annual Report*, Tables 10.10, 10.14.

Figure I-9. Heart Transplantation at a Glance



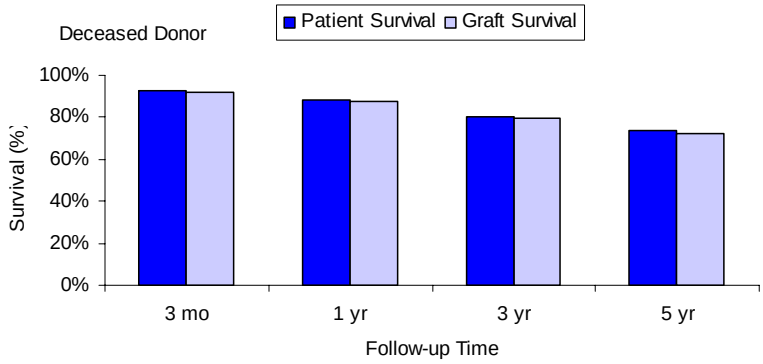
Number of Transplants and Size of Active Waiting List.

The number of heart transplants increased in 2005 after several years of gradual reduction. The number of patients awaiting a heart has decreased steeply since 2000, likely reflecting improvements in medical therapy. Source: *2006 OPTN/SRTR Annual Report*, Tables 1.7, 11.1a.



Age Distribution of Recipients and Active Waiting List.

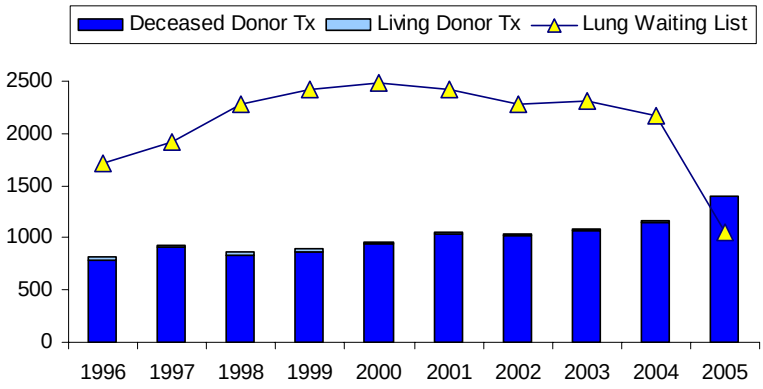
Trends in the age distribution of wait-listed candidates show that the ages below 34 and above 65 years have increased, while ages 35-64 years are less represented. The pattern of trends for transplant recipients is similar although the ages below 35 years have larger percentages than on the waiting list. Source: *2006 OPTN/SRTR Annual Report*, Tables 11.1a, 11.4.



Unadjusted Patient and Graft Survival.

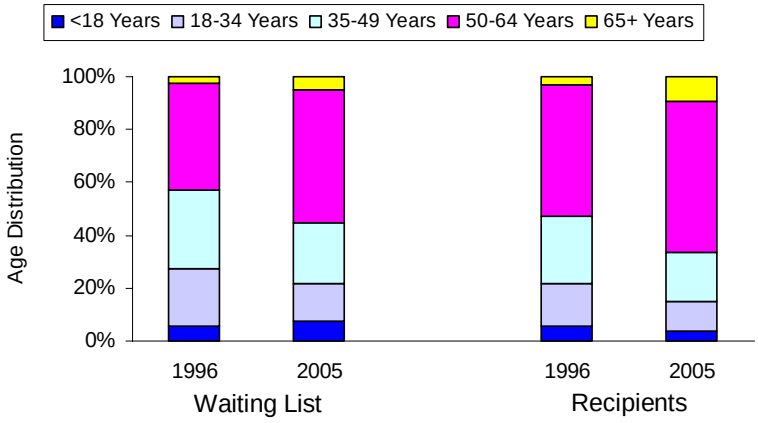
Patient survival has been improving in recent years for heart recipients. At one and five years following heart transplantation 88% and 74% of patients, respectively, are alive. Graft survival is very similar because very few patients may receive a second heart transplant after graft failure. Source: *2006 OPTN/SRTR Annual Report*, Tables 11.10, 11.14.

Figure I-10. Lung Transplantation at a Glance



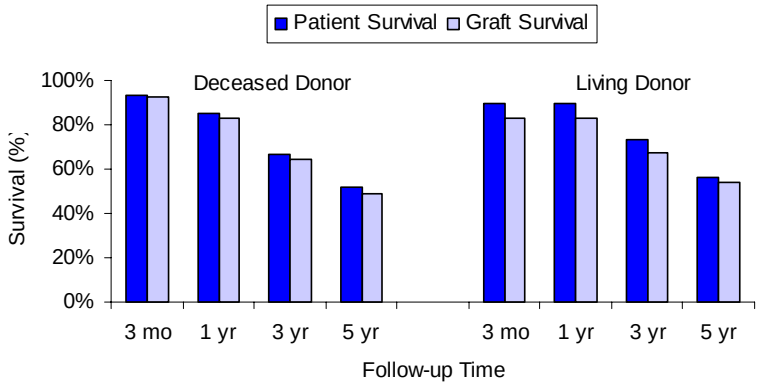
Number of Transplants and Size of Active Waiting List.

The number of lung transplants has increased steeply in the last year. The number of patients awaiting a transplant dropped steeply in 2005 after a stable pattern during the prior seven years. This sharp reduction is largely attributable to changes in allocation policy, which now considers urgency and benefit rather than time spent waiting. Source: *2006 OPTN/SRTR Annual Report*, Tables 1.7, 12.1a.



Age Distribution of Recipients and Active Waiting List.

The lung waiting list shows a mixed trend in age distribution, with increasing percentages of candidates who are pediatric or older than 50. Candidates 18-49 years old show a corresponding reduction in the percentage of the waiting list. The pattern for transplant recipients shows similarly a strong increase for ages above 50 years, but the decrease in percentages for younger ages includes pediatric ages. Recipients include transplants from both living and deceased donors. Source: *2006 OPTN/SRTR Annual Report*, Tables 12.1a, 12.4a, 12.4b.



Unadjusted Patient and Graft Survival.

Patient survival has been improving in recent years for both deceased and living donor lung transplant recipients. At one year following deceased donor and living donor lung transplantation 85% and 89% of patients, respectively, were alive. With the recent good results at one year, it is hoped that longer term patient survival will improve. Graft survival is very similar because very few patients may live after graft failure through a second lung transplant. Source: *2006 OPTN/SRTR Annual Report*, Tables 12.10a, 12.10b, 12.14a, 12.14b.