Therefore we may say that the spirit cannot produce a voice without movement of the air, in it there is none and it cannot emit what it has not; and if it desires to move the air in which it is diffused it becomes necessary that the spirit should multiply itself, and that cannot multiply which has no quantity.

Leonardo da Vinci

Chapter Seven
Transplantation
In 2007, the most recent year of available data, 17,513 kidney transplants were performed in the United States — 3 percent fewer than in the previous year, marking the first time in nearly 20 years that transplant counts declined. This decline was seen in both deceased donor transplants (down 130 transplants, or 1 percent, from the prior year) and living donor transplants (down 391, or 6 percent). It also occurred among both pediatric recipients (down 14 percent) and adult recipients (down 2 percent). The fall in the number of transplants is contemporaneous with a 1 percent decline in the unadjusted rate of new cases of end-stage renal disease. The number of patients on the kidney transplant wait list, however, continues to increase sharply, growing 8 percent in 2007, and reaching more than 72,000 at the end of the year. The use of expanded criteria donors, thought to have contributed to the relative increase in the use of deceased donors observed during 2003–2006, has plateaued since 2005 at 20 percent of all deceased donations. The use of kidneys from donations after cardiac death, in contrast, has continued to increase, and these donations now constitute 11 percent of all donations from deceased donors. Living Donor Paired Donation was the only subgroup of living donor transplants that increased between 2006 and 2007, rising 125 percent to reach 216 transplants. Transplants from paired donations currently make up only 1 percent of transplants performed in the United States. The number of donations from living relations continues to decline, and is now 18 percent lower than the high observed in 2001. Donations from spouses or distant relatives have remained fairly constant. Wait times continue to increase nationwide. For patients entering the wait list in 2003, the median time to transplant — i.e., the time at which 50 percent of the patients have received a deceased donor transplant — was 2.8 years. Patients with blood type B wait the longest, with a median of 3.9 years for patients listed in 2003, while patients with blood type AB have the shortest waits, with a median of 1.4 years. Sensitized patients — with a panel-reactive antibody (PRA) of 10 percent or higher — tend to wait twice as long as unsensitized patients. Of patients added to the wait list in 2002, 17, 19, and 16 percent of white, African American, and Asian patients, respectively, died within five years awaiting a transplant, and 12, 22, and 23 percent were still waiting for a transplant at the end of that period. With one-year survival with a functioning transplant at 90 percent for recipients of deceased donor transplants and 96 percent for recipients of transplants from living donors, attention continues to focus on improving long-term transplant outcomes. Conditional on surviving the first year with a functioning transplant, 50 percent of recipients of deceased and living donor transplants, respectively, are projected to be alive with a functioning transplant at 13 and 23 years. The estimated glomerular filtration rate (eGFR) one year after transplant is associated with graft failure, with the risk increasing with eGFRs below 45 ml/min/1.73 m². Among recipients who die with a functioning transplant, cardiovascular disease continues to be the leading cause of death, accounting for 30 percent of deaths, followed by infectious causes at 21...
percent and malignancies at 9 percent. In the first year after transplant, recipients are hospitalized for transplant complications at a rate of 41 admissions per 100 patient years. The rate of reported acute rejections within the first year has fallen sharply since 1996, with approximately 10 percent of living donor transplant recipients reporting a rejection episode. Infectious hospitalizations in the first year occur at a rate of 32 admissions per 100 patient years; 16 percent are for a urinary tract infection. Cardiovascular hospitalizations occur at a rate of 15 admissions per patient year, with congestive heart failure accounting for 21 percent. And new-onset diabetes following transplant remains common, with over 40 percent of adult recipients having evidence of diabetes by the end of the third year after transplant.

**Figure 7.1:** See page 372 for analytical methods. Unadjusted incident & transplant rates: limited to ESRD patients age 20 & older, thus yielding a computed incident rate higher than the overall rate presented elsewhere in this document. Wait list counts: patients age 20 & older listed for a kidney or kidney-pancreas transplant on December 31 of each year. Wait time: patients age 20 & older entering wait list in the given year. Transplant counts: patients age 20 & older as known to the USRDS.
More than 72,000 patients were listed for a kidney or kidney-pancreas transplant at the end of 2007, including almost 5,000 non-citizens (resident and non-resident aliens). Five percent of all patients on the list were listed at more than one transplant center. (Figure 7.2; see page 372 for analytical methods.) Patients age 18 & older listed for a kidney or kidney-pancreas transplant on December 31 of each year.

The median wait time for adults listed in 2004, the most recent observation year, was 3.0 years; for those listing in 2009, this is projected to reach 3.7 years. The longest wait times continue to occur among non-whites, patients with B and O blood types, and sensitized patients (those with a PRA of 10 percent or greater). (Figure 7.4; see page 372 for analytical methods.) Patients age 18 & older listed for a first-time kidney-only transplant in the given year.

In 2007, adults transplanted in Alabama had the longest wait times, at 5.2 years. Five states had a median of less than one year. (Data show the state in which the transplant occurred.) As wait times rise, the proportion of patients with higher PRAs rises as well. (Figures 7.5–6; see page 372 for analytical methods.) Patients age 18 & older receiving first deceased-donor kidney-alone transplant in 2007 (7.5); patients age 18 & older listed for a kidney or kidney-pancreas transplant between 1997 & 2002 (7.6).
Forty-five percent of both new and prevalent adult listings on the transplant wait list are willing to accept an expanded criteria donor (ECD) kidney. This varies widely by OPTN region, from 26 and 22 percent of those in Region 5 (the Southwest) to 80–82 percent of those in Region 9 (New York and western Vermont). Adults age 50–64 account for the greatest proportion of those willing to accept an ECD kidney, and those age 18–34 the lowest. Figure 7.7; see page 372 for analytical methods. Patients age 18 & older listed for a kidney or kidney-pancreas transplant.

In 2007, mortality rates per 100 person years for wait-listed patients averaged 10.3 in states represented by the upper quintile, and 7.5 nationwide. (Data indicate the state of residence of the transplant candidate.) Figure 7.9; see page 373 for analytical methods. Patients age 18 & older listed for a kidney or kidney-pancreas transplant on January 1, 2007.

For first-time, kidney-only transplant candidates, the likelihood of dying while awaiting a transplant has grown slightly since the early 1990s. For patients listed in 2002, for example, the probability of death was 0.04 in the first year after listing and 0.28 in the fifth — up from 0.02 and 0.22 in 1991. Figure 7.10; see page 373 for analytical methods. Patients age 18 & older listed for a first-time kidney or kidney-pancreas transplant.

Five years after a first listing on the kidney-only wait list in 2002, 68 percent of white patients have received a transplant, compared to 54 percent of non-white patients. The number still awaiting transplant at five years is nearly twice as high among non-whites, at 22.2 percent. Figure 7.11; see page 373 for analytical methods. Patients age 18 & older listed for a first-time kidney-only transplant, 2002.
Rates of kidney donation from deceased donors have consistently been greatest among those age 45–59 and among males — reaching 30 and 27 per million population, respectively, in 2007. Since 2005, donation rates in the African American population have become the highest by race, at almost 26 per million population in 2007, compared to 22 per million among whites.

After rising for nearly a decade, rates of living donor donations have been declining over the past several years — 15 percent since 2004 for donors age 20–44, and 21 percent for African Americans. Figure 7.12; see page 373 for analytical methods. Donors younger than 70, whose organs are eventually transplanted.

Deceased donor transplantation rates varied widely nationwide in 2007, averaging 29.5 per million in the upper quintile. The highest living donor transplantation rates are more localized, and in 2007 were 41.8, 36.4, 34.4, 34.2, and 31.6 per million, respectively, in Minnesota, South Dakota, North Dakota, New Hampshire, and Nebraska. Figure 7.13; see page 373 for analytical methods.

The number of transplants from a paired donation rose from 96 in 2006 to 216 in 2007. Transplants from related donors, in contrast, have fallen 18 percent from their peak in 2001, to 3,181. In 2006–2007, donations from deceased donors were 2.5 per 1,000 deaths overall, and averaged 3.3 per 1,000 in the upper quintile. Figures 7.14–15; see page 373 for analytical methods. All patients receiving a living-donor kidney transplant (7.14); donations per 1,000 deaths (7.15).
The highest adjusted transplant rates by state occur primarily in the northern U.S., averaging 6.7 per 100 dialysis patient years in the upper quintile, and peaking at 10.4 in Vermont and 8.0 in Minnesota. Rates lower than 3.0, in contrast, are reported in Hawaii, the District of Columbia, and Oklahoma. See page 373 for analytical methods.

In 2007, the highest transplant ratios occurred in Minnesota, North and South Dakota, Nebraska, Utah, Massachusetts, Wisconsin, New Hampshire, and Vermont, averaging 1.61 in the upper quintile. Ratios in the lower quintile averaged 0.74. See page 373 for analytical methods. Adjusted for age, gender, race, & primary cause of ESRD.

Since 2000, the transplant rate per 100 dialysis patient years has fallen 27 and 22 percent for patients age 18–34 and 35–49, and 6.7 percent for those age 50–64; among those age 65 and older, in contrast, it has increased 48 percent. The transplant rate among whites is now 22 percent lower than in 2000, while in the African American population it has increased 6.1 percent. See page 373 for analytical methods.

Falling to 1.5 per 100 dialysis patient years in 2007, the rate of transplants from living donors has declined slightly each year since 2004. One in five deceased donor transplants in 2007 was from an expanded criteria donor (ECD); one in nine was a donation after cardiac death (DCD). See page 373 for analytical methods.
One in four transplant recipients in 2007 had received renal replacement therapy for five or more years, up from 13–14 percent in the early 1990s. Preemptive transplants also account for a larger share of the current transplant population, increasing from 9–10 percent in the early 1990s to 15 percent in 2007. Figure 7.21; see page 373 for analytical methods. Patients age 18 & older.

Seventy-two percent of transplant recipients in 2007 had a PRA of 0 percent at transplant, up from 64 percent in 1991, but down from a peak of 77 percent in 2001. The percentage of patients with a PRA of 20 percent or higher has increased from 10.6 to 15.7; 5.1 percent now have a PRA of 80 percent or above. Figure 7.22; see page 373 for analytical methods. Patients age 18 & older.

The distribution of transplant recipients by their number of transplants has remained consistent since 1991. Patients with a first transplant account for 87–89 percent of the population, while 10–11 percent have had a second transplant, and 1.5–1.9 percent have received three or more transplants. Figure 7.23; see page 373 for analytical methods. Patients age 18 & older.

Rising since 2001, the number of kidney-liver transplants reached 412 in 2007. Kidney-pancreas transplants have remained relatively stable since the late 1990s. Nearly 500 patients receiving a kidney transplant in 2007 had received a prior organ transplant. Figures 7.25–26; see page 373 for analytical methods. Patients age 18 & older receiving multiple simultaneous organs (7.25); patients age 18 & older reporting a prior organ transplant (7.26).
Differences in the occurrence of delayed graft function (DGF) vary by donor type. In 2007, DGF was reported in only 3.3 percent of transplants from living donors, compared to 21.3, 29.6, and 42.0 percent of those from standard criteria donors (SCDs), expanded criteria donors (ECDs), and donations after cardiac death. [Figure 7.27; see page 373 for analytical methods. Patients age 18 & older with a functioning graft.]

Of transplant patients with private or other types of insurance, 32–33 percent have an eGFR of 60 ml/min/1.73 m² or greater at discharge, compared to just 22 percent of those with Medicare coverage. An eGFR less than 15 is reported in 21 percent of Medicare patients, but only 11 percent of those covered by private insurance. [Figure 7.28; see page 373 for analytical methods. Patients age 18 & older, discharged with graft function within 15 days of transplant.]

Since 1999, the distribution of patients by estimated glomerular filtration rate (eGFR) at discharge from the transplant hospitalization has changed little. In 2007, 46 percent of deceased donor recipients, compared to only 11 percent of living donor recipients, had an eGFR of less than 30 ml/min/1.73 m² at discharge. [Figure 7.29; see page 373 for analytical methods. Patients age 18 & older, discharged with graft function within 15 days of transplant.
The most common immunosuppression regimen for adults transplanted in 2005–2007 was the combination of tacrolimus and mycophenolate (MPA, including mycophenolate mofetil and mycophenolate sodium). Steroid use has continued to decline, both at the time of transplant and at one year post-transplant. Induction antibodies are used in two of three adult transplant patients, with thymoglobulin being the most common agent. **Figures 7.30–35; see page 373 for analytical methods.** Patients age 18 & older receiving a first kidney-alone transplant. CsA: cyclosporine A; CsM: cyclosporine microemulsion. Cyclo includes CsA & CsM. MMF: mycophenolate mofetil & mycophenolate sodium. Tac: tacrolimus; includes traditional & modified release formulations. mTOR: mammalian target of rapamycin; includes sirolimus & everolimus.
Primary non-function — graft failure within seven days of transplant — is now reported in fewer than 2 percent of deceased donor adult transplant recipients, and just 0.84 percent of transplants from living donors. See Figure 7.36 for analytical methods. Patients age 18 & older.

At one year following their transplant, 35 percent of 2006 recipients had an estimated glomerular filtration rate of 60–<90 ml/min/1.73 m² — up from 21.5 percent in 1991. More than 5 percent had an eGFR of 90 or greater. See Figure 7.37 for analytical methods. Patients age 18 & older receiving a kidney-alone transplant.

Estimated GFR at one year post-transplant is a strong predictor of five-year graft survival. Only 15 percent of patients with an eGFR less than 15 ml/min/1.73 m² at one year still have graft function at five years, compared to 85–86 percent of those with an eGFR at one year of 45 or higher. See Figure 7.38 for analytical methods. Patients age 18 & older receiving a kidney-alone transplant, 2000–2005.

Long-term transplant outcomes continue to be a focus of attention. Five-year survival with a functioning graft was 68 and 82 percent for recipients of kidneys from deceased and living donors, respectively, in 2002, up from 57 and 76 percent in 1992. Ten-year survival with a functioning graft was 39 and 57 percent in 1997, compared to 31 and 53 percent in 1992. Conditional on surviving the first year with a functioning transplant, at 13 years 50 percent of deceased donor transplant recipients are projected to have a functioning graft. For recipients of living donor transplants, this projected half-life is 23 years. See Figures 7.39–40 for analytical methods. Patients age 18 & older receiving a first kidney-alone transplant.
n 2007, transplant recipients were hospitalized for transplant complications at a rate of 41 admissions per 100 patient years; among African Americans, the rate exceeded 48 per 100. Infectious complications occur at twice the rate of cardiovascular complications during the first year post-transplant, at 32 compared to 15 hospitalizations per 100 patient years. Figure 7.41; see page 374 for analytical methods. All patients transplanted in 2006.

The rate of reported acute rejections within the first post-transplant year has fallen sharply since 1996, with 12 and 10 percent of deceased donor and living donor recipients having a rejection episode reported, respectively, in 2006. The vast majority of these were listed as biopsy-proven. Figure 7.43; see page 374 for analytical methods. Patients age 18 & older receiving a first kidney-alone transplant & discharged with a functioning graft.

Twenty-one percent of cardiovascular hospitalizations among transplanted patients have a primary diagnosis of congestive heart failure, and 11.2 percent are due to hypertension. For infectious hospitalizations, the most common diagnoses are urinary tract infection, at 16.4 percent, and pneumonia and septicemia, at 13.9 and 12.2 percent, respectively. Figure 7.42; see page 374 for analytical methods. All patients transplanted in 2003–2005.
Forty-one percent of adult recipients have evidence of diabetes by three years post-transplant. In the same period, post-transplant lymphomas are reported to the OPTN in 0.5 and 2.4 percent of adult and pediatric recipients, and 0.6 and 3.5 percent of the subset of Medicare patients. Medicare claims show rates of 1.0 and 3.7. (Figures 7.44–45; see page 374 for analytical methods. All patients receiving a first kidney-alone transplant, 2000–2004 (7.44–45).

Graft failure rates continue to improve, falling from 9.3 per 100 patient years in 1991 to 6.6 in 2007. Both the rate of a failure necessitating dialysis or retransplantation, and that of death with function, have fallen to 3.3. Cardiovascular disease is the primary cause of death for 30 percent of adult patients who die with a functioning graft. (Figures 7.46–47; see page 374 for analytical methods. Pts age 18 & older (7.46); pts age 18 & older, 2003–2007 (7.47).

The number of transplanted kidneys failing during a calendar year (excluding death with function) fell 5.1 percent in 2007; 4.1 percent of patients starting dialysis in this year did so after a transplant failure. Of those age 35–49 with a graft failure, 54 percent were relisted or retransplanted within a year, compared to 28 percent of those age 65 or older. (Figures 7.48–49; see page 374 for analytical methods. Pts age 18 & older (7.48); pts age 18 & older at graft failure (7.49).

The median time to retransplant for patients with a graft failure in 1999 was 7.5 years, little changed from 1991. Of those with a graft failure in 2007, 72 percent were then treated with hemodialysis, and 5.2 percent with peritoneal dialysis — down from 10.1 percent in 1991. The percentage preemptively retransplanted has remained at 9–10 since 1991. (Figures 7.50–51; see page 374 for analytical methods. Patients age 18 & older at graft failure (7.50–51).
In 2007, **17,513** kidney transplants were performed, 543 fewer than the previous year, marking the **FIRST DECLINE** in nearly 20 years. • 7.1

The **WAIT LIST** continues to grow, with more than 72,000 patients at the end of 2007. • 7.2

Of deceased donor transplants, **20%** & **11%**, respectively, are from donations from expanded criteria donors & donations after cardiac death. • 7.20

The proportion of patients **PREEMPTIVELY** transplanted continues to rise, & is now **15%** of all renal transplants. • 7.21

The proportion of patients spending **5+ YEARS** on dialysis prior to transplant continues to rise, reaching 25% in 2007. • 7.21

**MEDICARE** is the primary payor for 52% of deceased donor transplants; **PRIVATE INSURANCE** covers 56% of living donor transplants. • 7.24

Approximately 23% of deceased donor recipients, & 3% of living donor recipients, have **DELAYED GRAFT FUNCTION**. • 7.27

Nearly **THREE IN FOUR** transplant recipients are placed on an initial immunosuppressive regimen of tacrolimus & mycophenolate. • 7.35

Risk of **GRAFT LOSS** increases exponentially with eGFR levels of **<45 ml/min/1.73 m²**. • 7.38

Five- & ten-year **GRAFT SURVIVAL** continues to improve. • 7.39–40

First-year **ACUTE REJECTIONS** have declined dramatically, to 12% of deceased donor recipients & 10% of living donor recipients. • 7.43

Post-transplant **LYMPHOMAS** were reported to the OPTN in 2.4% & 0.5% of pediatric & adult recipients within three years post-transplant. • 7.45

**summary**