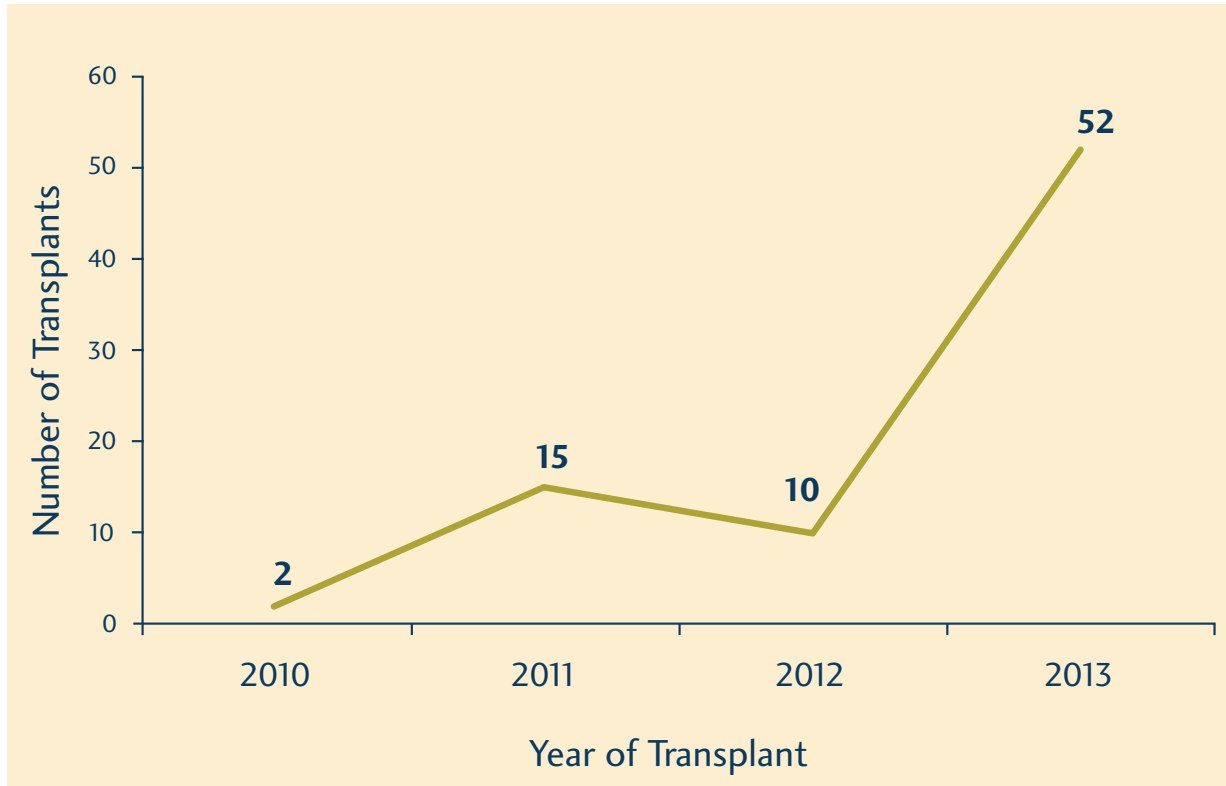


The State of the  
**OPTN/UNOS KPD Pilot Program**

## A Message from Kidney Paired Donation (KPD) Work Group

We are pleased to present this report to the transplant community and welcome the opportunity to share information and results of the OPTN/UNOS Kidney Paired Donation Pilot Program (KPDPP). The vision of the program is that every kidney transplant candidate with an incompatible but willing and approved living donor receives a living donor kidney transplant. To that end, the first match run was conducted in late 2010. Through March 31, 2014, 88 patients have received a life-saving kidney transplant through the program. In 2013 alone, 52 patients were transplanted, a 246% increase over the previous high of 15 in 2011.

**Figure 1. OPTN/UNOS KPDPP Transplants per Year**



It is particularly encouraging to see that the KPDPP has increased transplant opportunities for candidates who tend to have difficulty finding a match on the deceased donor waiting list. More than a quarter of the candidates who received a kidney through the program had a calculated panel reactive antibody (CPRA) of 80% or higher (page 7), including 15 recipients with a CPRA of at least 95%. In addition, nearly 300 minority candidates have participated in KPDPP match runs, and minorities comprise one third of KPDPP transplant recipients (page 6).

We appreciate the dedicated transplant teams at 138 kidney programs (61% of the U.S. living donor kidney programs) who have agreed to participate in the KPDPP (page 4). We especially appreciate the hundreds of individuals who have contributed their expertise, time and attention to improving the program by serving on committees, finding solutions to problems and providing valuable feedback in surveys. Most importantly, we owe a debt of gratitude to the living donors who are willing to donate a kidney to a loved one, friend or someone they don't even know. They are the heroes that save lives.

During the past three years, we developed an increasingly user-friendly, online KPD system that is integrated with UNet<sup>SM</sup>, the computer system that manages the deceased donor waiting list. Candidate and donor data are shared among transplant centers to facilitate kidney exchanges, allowing users to view and respond to match offers and to see the donor information in one place. We continue to solicit and respond to user recommendations to make further system improvements.

The program was originally governed solely by operational guidelines. The first KPDPP policies were approved by the OPTN/UNOS Board of Directors in November 2012 and implemented in February 2013. At that time, many of the operational guidelines were converted to policy. The KPD Work Group, under the OPTN/UNOS Kidney Transplantation Committee, continues this conversion, with several policy proposals planned for 2014 and 2015. The program will be governed by both policy and operational guidelines until the transition is complete.

Several subcommittees have worked to improve KPDPP processes:

- The Finance Subcommittee developed financial tools to help transplant hospitals work through billing and paying for a KPD kidney that is recovered at one institution and transplanted at another. The tools include financial recommendations, a template contract and a financial checklist.
- The Histocompatibility Advisory Subcommittee developed KPD histocompatibility policies to improve the KPD system by decreasing the match offer decline rate related to unacceptable antigens. They routinely review the decline reasons related to HLA antibodies and continuously evaluate the policies to promote process improvement.
- The Design and Optimization Algorithm Subcommittee is evaluating alternative matching algorithms to optimize match pair efficiencies in order to increase the number of transplants. The subcommittee also ensures that both easy and difficult-to-match patients have access to matching opportunities.

To assist potential donors and candidates who are considering KPD as an option, we are creating educational videos and expanding online resources for patients, donors and transplant professionals.

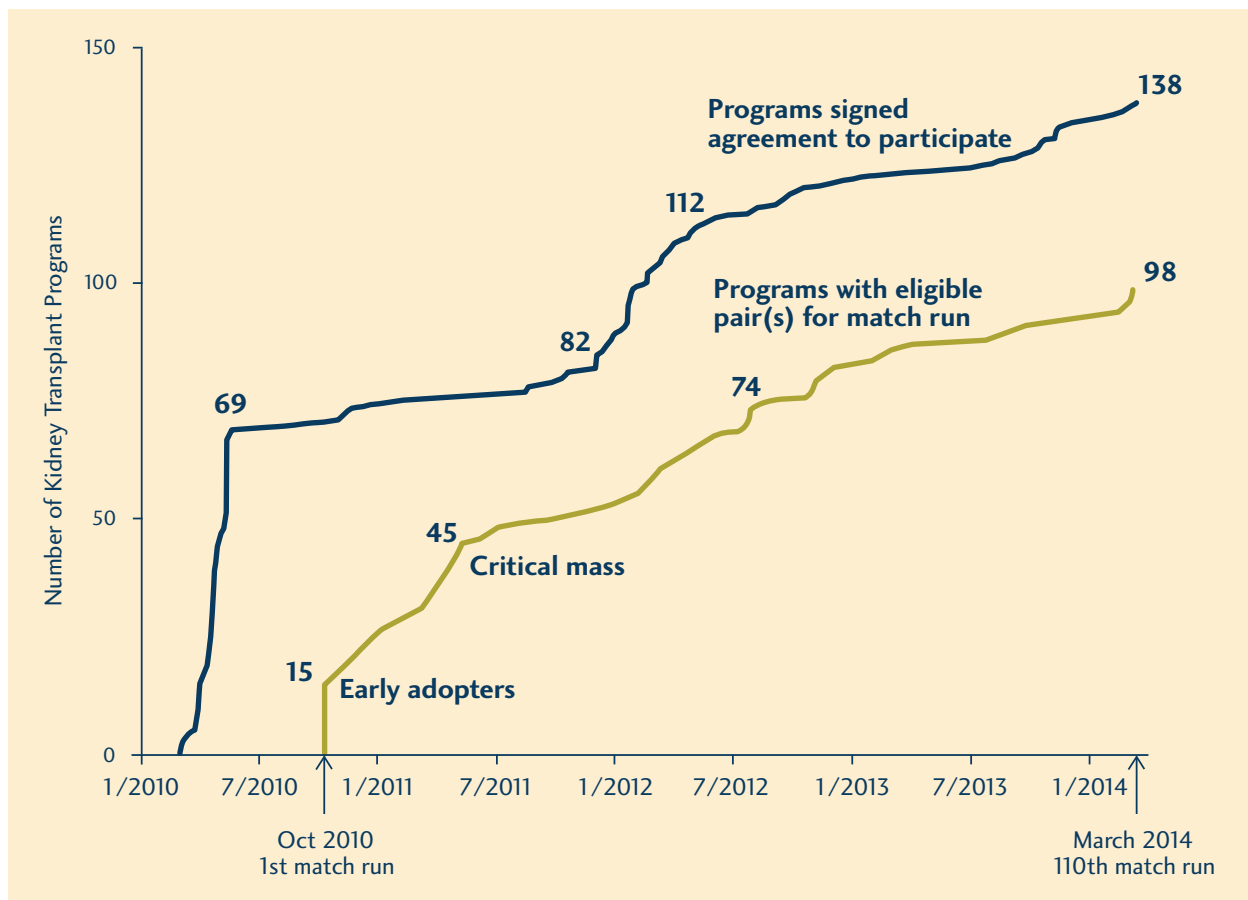
We welcome the remaining living donor kidney transplant hospitals to participate in the KPDPP and to suggest system improvements to optimize all aspects of the program. We look forward to continuing to help transplant candidates receive the gift of life through kidney paired donation.

Sincerely on behalf of the OPTN/UNOS KPD Work Group,  
Mark Aeder, M.D.  
Chair

## Participating Transplant Programs

Of the 228<sup>1</sup> active U.S. kidney programs approved to perform living donor transplants in the U.S., 138 (61%) have agreed to participate in the KPDP, and 98 centers have entered at least one donor/candidate pair into a match run (**Figure 2A**). In early 2010, an initial wave of 69 transplant programs agreed to participate by way of four coordinating centers, central hubs that provided data directly to UNOS to operate the program. Fifteen “early adopter” programs provided data on a total of 43 pairs that were included in the very first match run on October 28, 2010, leading to matching opportunities for seven patients. By mid-2011, a “critical mass” of 45 centers had entered match run-eligible pairs into the system, resulting in a pool of well over 100 donors and candidates in each match run. Since then the number of candidates entered has steadily increased (**page 7**).

**Figure 2A: Trends in Participation— as of March 21, 2014**

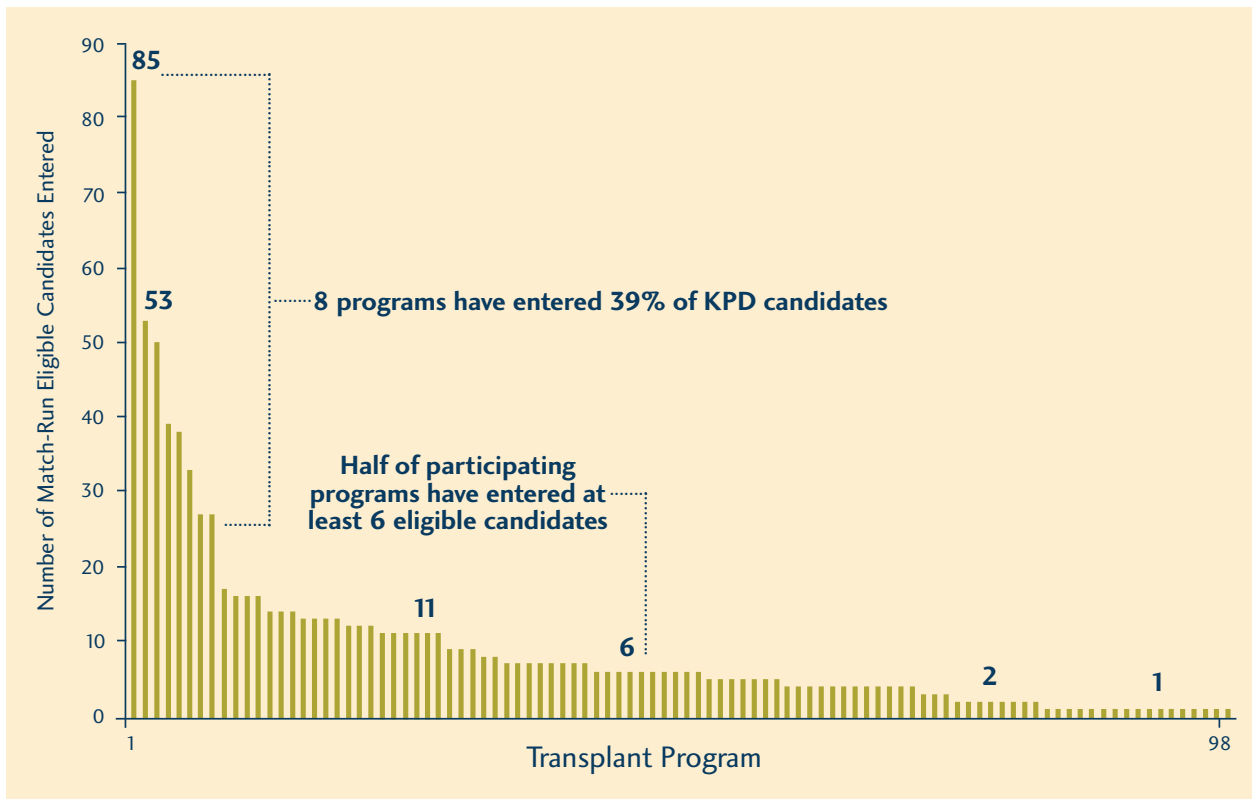


<sup>1</sup> Includes all kidney transplant programs with active OPTN membership status, active living donor program status and active deceased kidney program status, as of March 21, 2014.

The number of candidates entered into the system varies greatly among participating hospitals. Since 2010, one program has entered 85 match run-eligible candidates (along with their paired donors), or 9% of the total of 904 match run-eligible candidates. The eight most actively participating programs account for 39% of the total number of candidates entered, while half of participating programs have entered at least six candidates (**Figure 2B**).

As the KPD Work group continues to encourage additional living kidney donor programs to join the pilot program, it also seeks ways to incentivize programs to enter *all* of their candidate/donor pairs, not just hard-to-match pairs, to create more matching opportunities for all participants.

**Figure 2B: Number of match Run-Eligible Candidates<sup>2</sup> per Program — as of March 21, 2014**

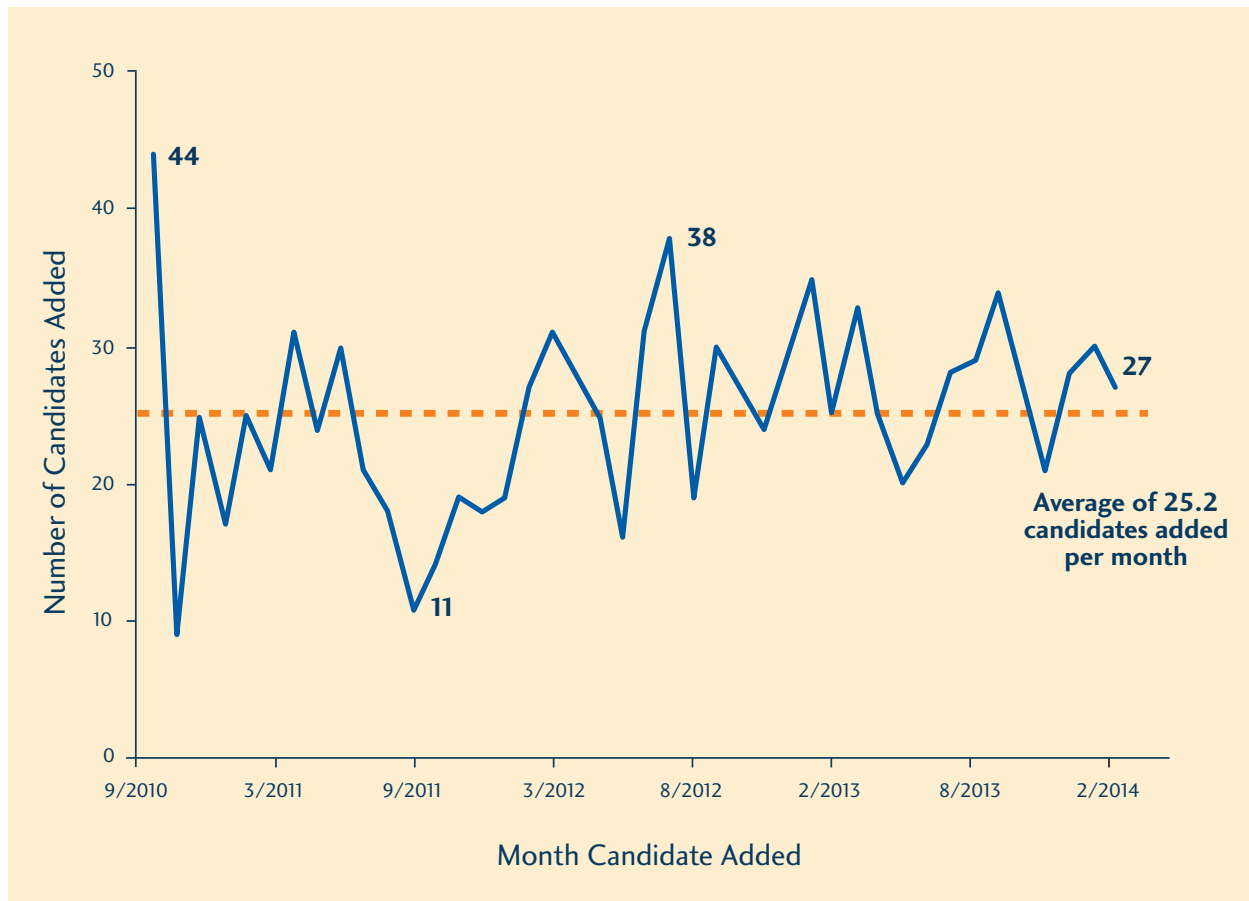


<sup>2</sup> A candidate can be entered into the KPDPP without being match run eligible. To be match run eligible, a candidate must have all required data elements entered and be set to “active” status in the KPD system.

## Candidates and Donors Added to the KPD System

On average, 25.2 candidates were added to the program each month since October 2010. In the first quarter of 2014, there has been an average monthly addition of over 28, reflecting the continued growth of the KPDP. In total, 1,046 candidates have been added as of March 31, 2014. A total of 1,135 donors<sup>3</sup> have been added, including 52 non-directed donors (NDDs). A NDD is a donor who enters the program without a paired candidate, with the intent of starting a NDD chain.

**Figure 3: Number of Candidates Added, by Month — through March 31, 2014**



<sup>3</sup> While most candidates entered the program with one paired donor, some candidates had more than one donor.

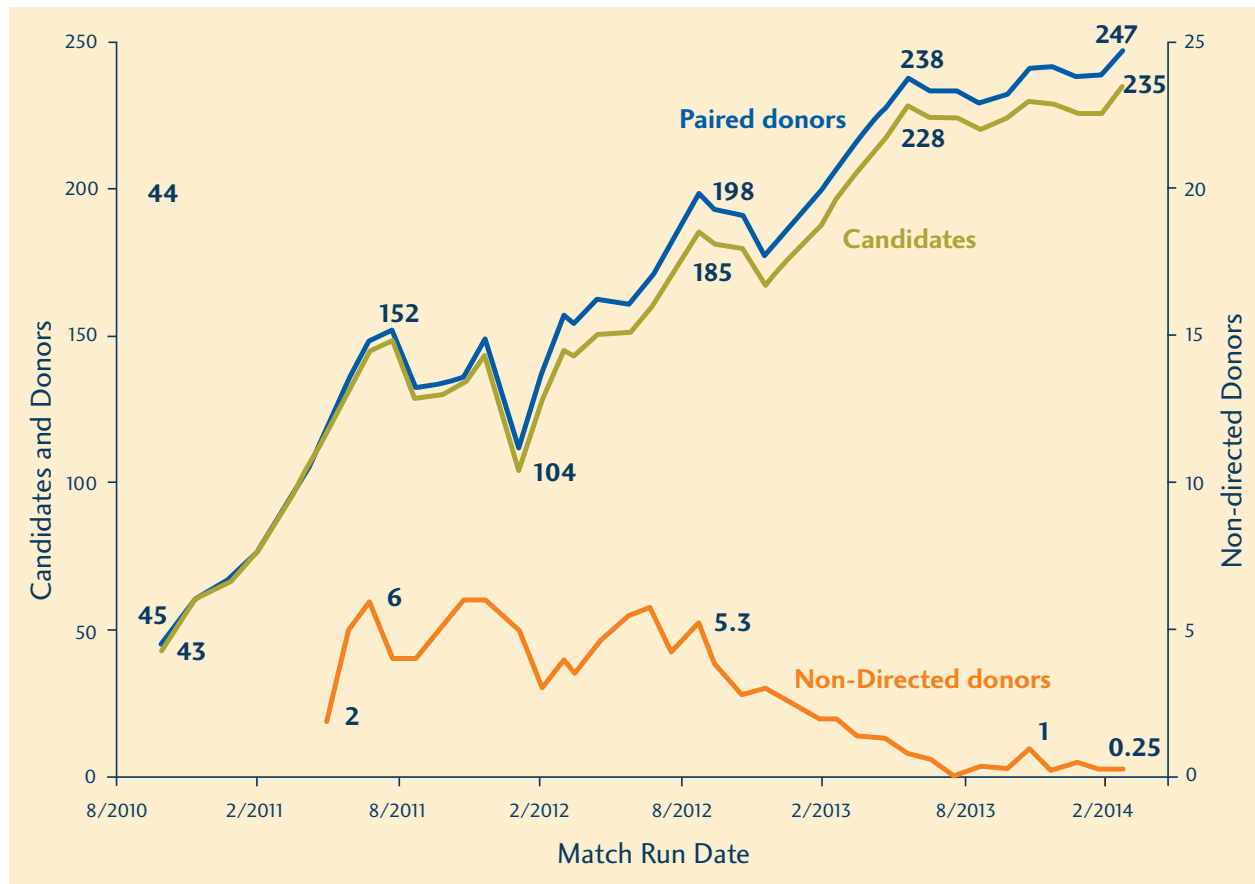
## Match Run Participation

Coinciding with the steady growth in participating programs, the number of candidate-donor pairs eligible<sup>4</sup> for each match run has increased dramatically since KPDPP initiation (**Figure 4**). In late 2010, the candidate-donor pool consisted of less than 50 pairs available for matching. By 2013, more than 200 candidates and donors were consistently entered into each weekly match run. In the first quarter of 2014, the numbers had grown to average 247 donors and 235 candidates per match run, and a record 270 donors and 256 candidates were included in the match run on April 21, 2014.

Despite the overall increasing trends, the number of non-directed donors (NDDs) eligible for match runs has declined in recent months. NDD chains are an especially powerful way to uncover matching opportunities for a large number of patients because chains operate in one direction, without requiring a match to “close the loop,” as in two-way and three-way exchanges. The KPD Work Group continues to explore ways to encourage centers to enter NDDs into the system, including providing the option of bridge donation. In bridge donation, a paired donor at the end of a chain can opt to become a non-directed donor in a future match run, turning a short chain into a potentially much longer chain that will result in more patients receiving transplants (**Figure 4**).

**Figure 4: Average Number of Eligible Candidates and Donors per Match Run**

— through March 31, 2014



<sup>4</sup> To be match run eligible, a candidate must have all required data elements entered and be set to “active” status in the KPD system.

## Trends in Matching Opportunities

A growing pool of candidates and donors eligible for match runs (Figure 4), the introduction of non-directed donor (NDD) chains, and the switch in 2012 from monthly to weekly match runs have led to substantial increases in the number of donor-candidate matches found over time (Figure 5A). In March 2014, 47 matches were identified. Through the first quarter of 2014, an average of 44 match offers have been sent per month, a 22% increase over 2013. In response to member feedback, on June 2, 2014 the program started running the match twice per week on a trial basis. Since 2010, over 1,000 match offers have been sent to participating transplant programs.

Figure 5A: Matches Found per Month

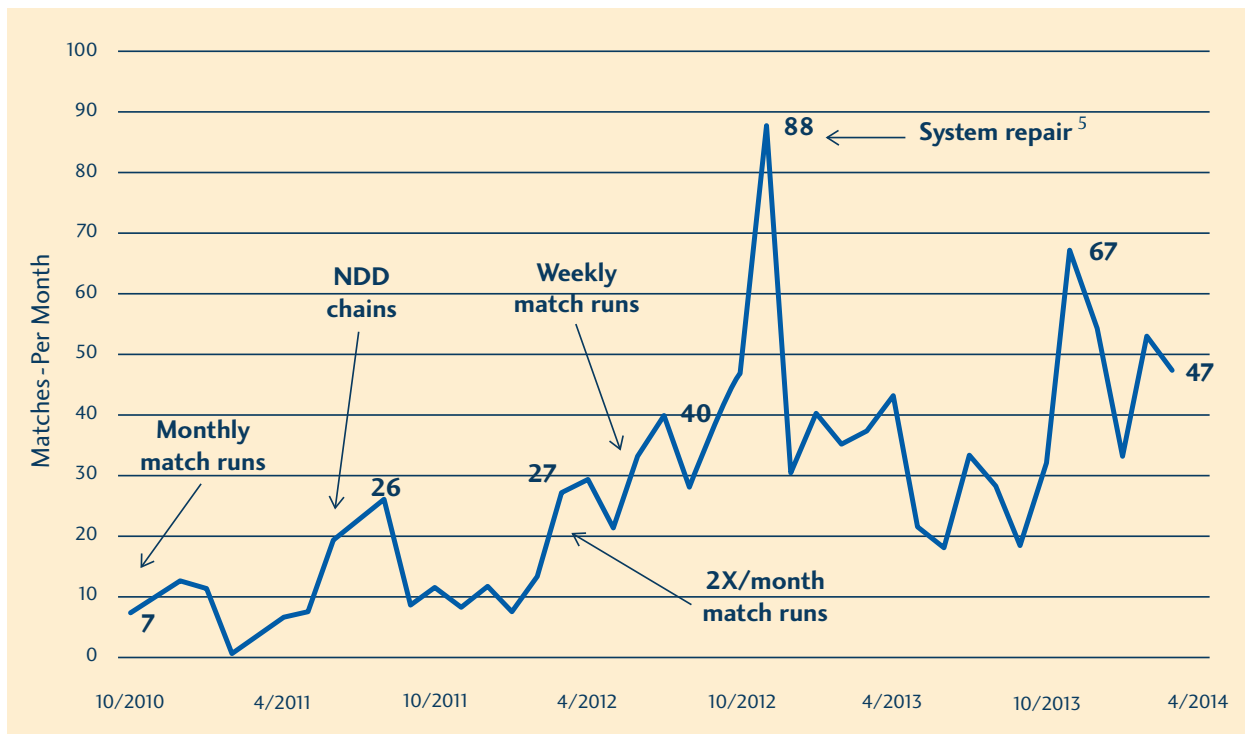
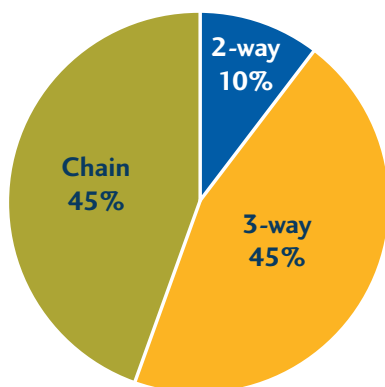


Figure 5B: Matches Found by Exchange Type



Relatively few (10%) of the matches found in the KPDPP have been from two-way exchanges, while three-way exchanges (45%) and NDD chains (45%) have together accounted for the majority of matches (Figure 5B).

<sup>5</sup> The generation of “input files” that are used by the algorithm that identifies all possible edges between compatible donors and candidates was implemented as part of UNet’s KPD application in early 2013. Previously, these input files were generated using a non-fully automated process (outside of UNet) that inadvertently led to fewer edges being drawn. Once this “manual” process was remedied, a bolus of matches that would likely have been identified previously was found all at once in November 2012.

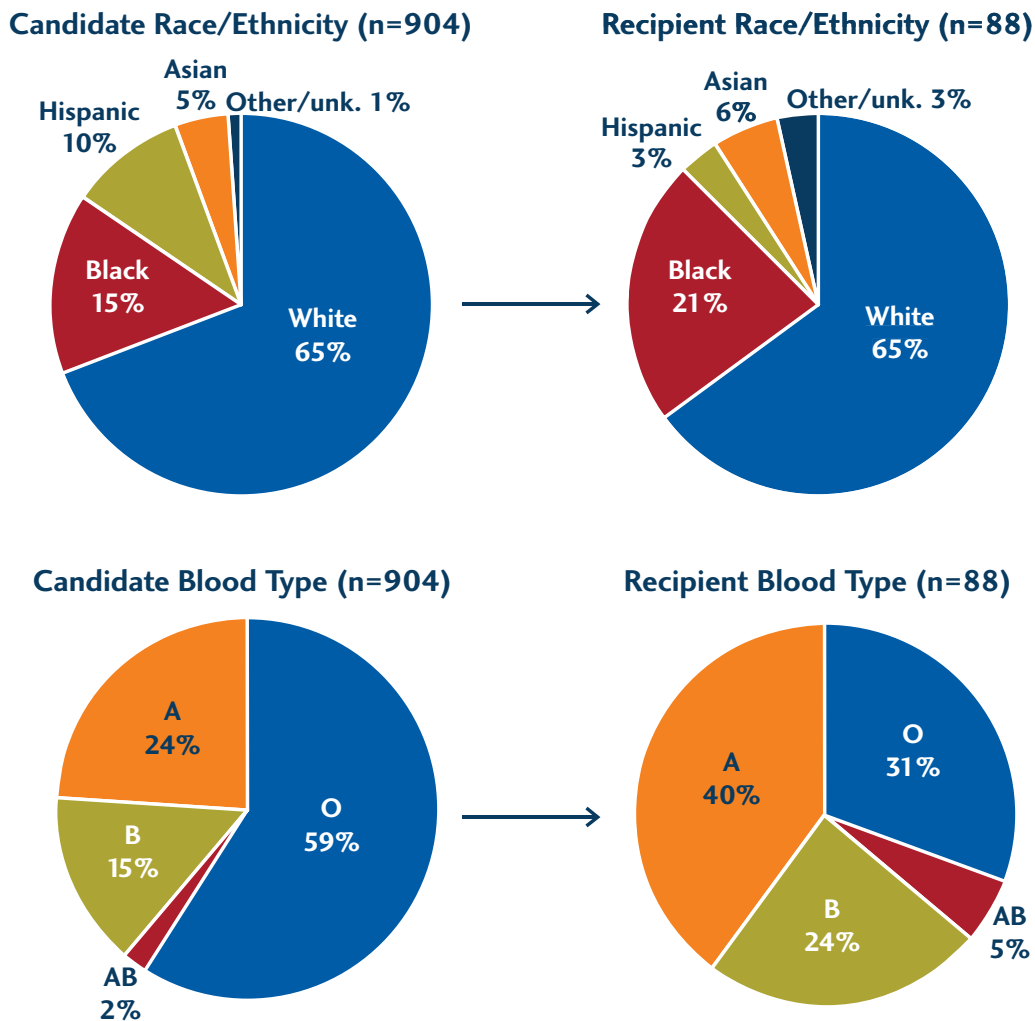


## Characteristics of Candidates and Transplant Recipients

Nearly 70% of the 904 total KPDPP candidates have been white, 15% black, 10% Hispanic and 5% Asian. The race/ethnicity distribution of the 88 KPDPP transplant recipients is fairly similar to that of candidates entered into the program, with 65% of recipients having been white (**Figure 6A**).

While nearly 60% of candidates have had blood type O, only 31% of recipients have had this most difficult to match blood type. Blood type O candidates tend to be more difficult to match since they are generally only compatible with other blood type O donors. Blood type B candidates are also often difficult to match. However, while blood type B candidates have represented only 15% of candidates, they have accounted for 24% of the transplants facilitated thus far through the KPDPP (**Figure 6A**).

**Figure 6A: Characteristics of Match Run-Eligible Candidates and Recipients (Blood Type, Race/Ethnicity)**— through March 31, 2014



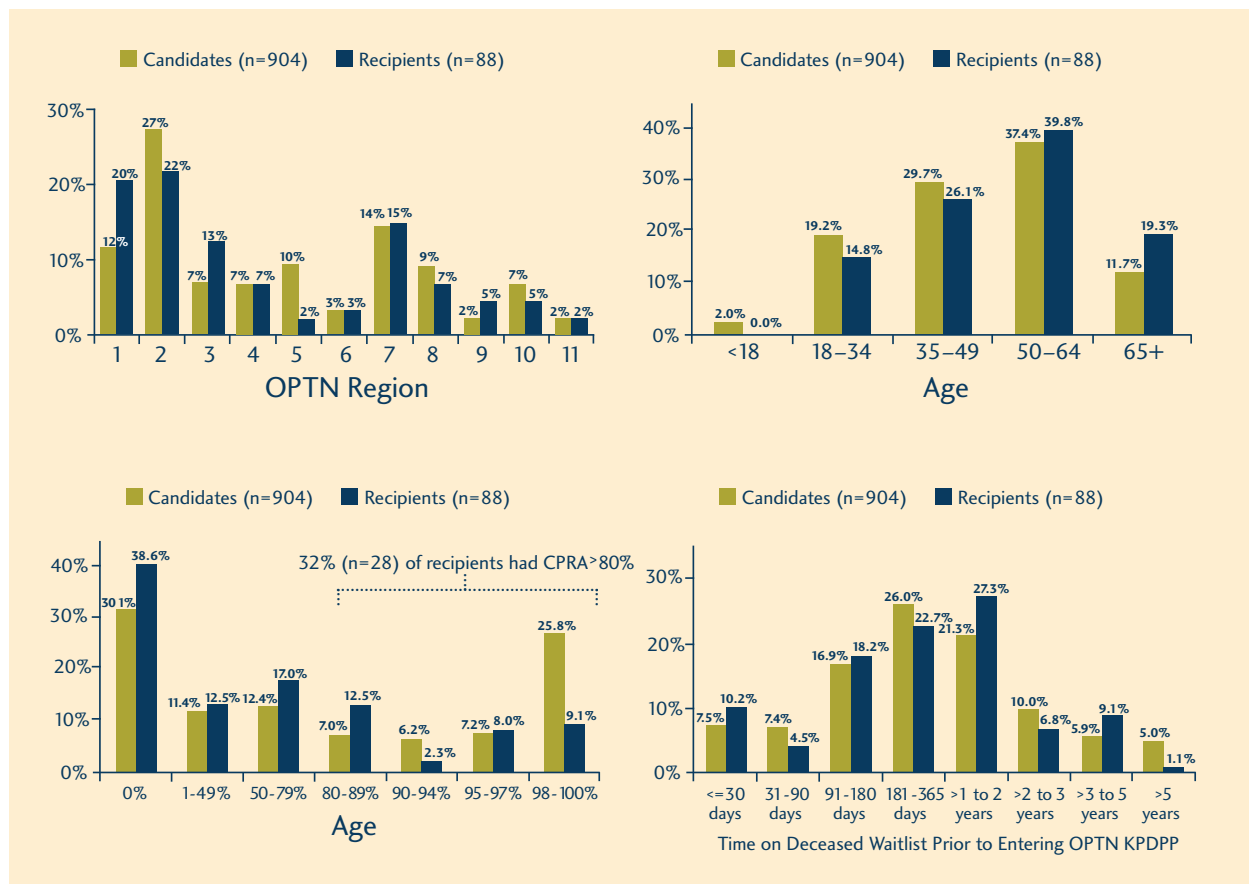
Transplant centers representing all 11 OPTN/UNOS regions have had candidates participate in OPTN/UNOS KPDPP match runs. Centers in Region 2 have contributed the most candidates (27%), followed by Region 7 (14%) and Region 1 (12%). At least one of the 88 transplants performed thus far through the KPDPP have occurred in each region. (**Figure 6B**).

The average age<sup>6</sup> of the 904 participating candidates has been 47.3 years, with 37.4% in the 50-64 age group. Only 2% of the candidates have been pediatric. The age distribution of patients transplanted through the program is fairly similar to the age distribution of participating candidates, although a moderately higher percentage of the recipients (19.3%) compared to candidates (11.7%) have been age 65 or older.

Only 30% of KPDP candidates have had a CPRA<sup>7</sup> of zero, whereas 46.2% have had CPRA of 80% or greater. Over a quarter of candidates have been extremely sensitized, having a CPRA of at least 98%. Though these patients are more difficult to match, 32% (n=28) of the transplants facilitated thus far have been for CPRA>80% patients and 17.1% (n=15) of recipients have had a CPRA of 95% or higher. Finding transplants for difficult-to-match patients is one of the goals of the KPDP, and we are encouraged by these successes.

On average, candidates have waited 507 days (about 1 year and 4 months) on the deceased donor waitlist<sup>8</sup> before entering the KPDP. The distribution of time on the deceased donor waitlist is fairly similar for candidates and recipients.

**Figure 6B: Characteristics of Match Run-Eligible Candidates and Recipients (Region, Age, CPRA, Time on Deceased Donor Waitlist)— through March 31, 2014**



<sup>6</sup> Candidate age as of first KPDP match run; recipient age as of transplant date.

<sup>7</sup> Candidate CPRA as of first KPDP match run; recipient CPRA as of the match run that led to transplant or at time of WL removal for chain-closing WL recipients.

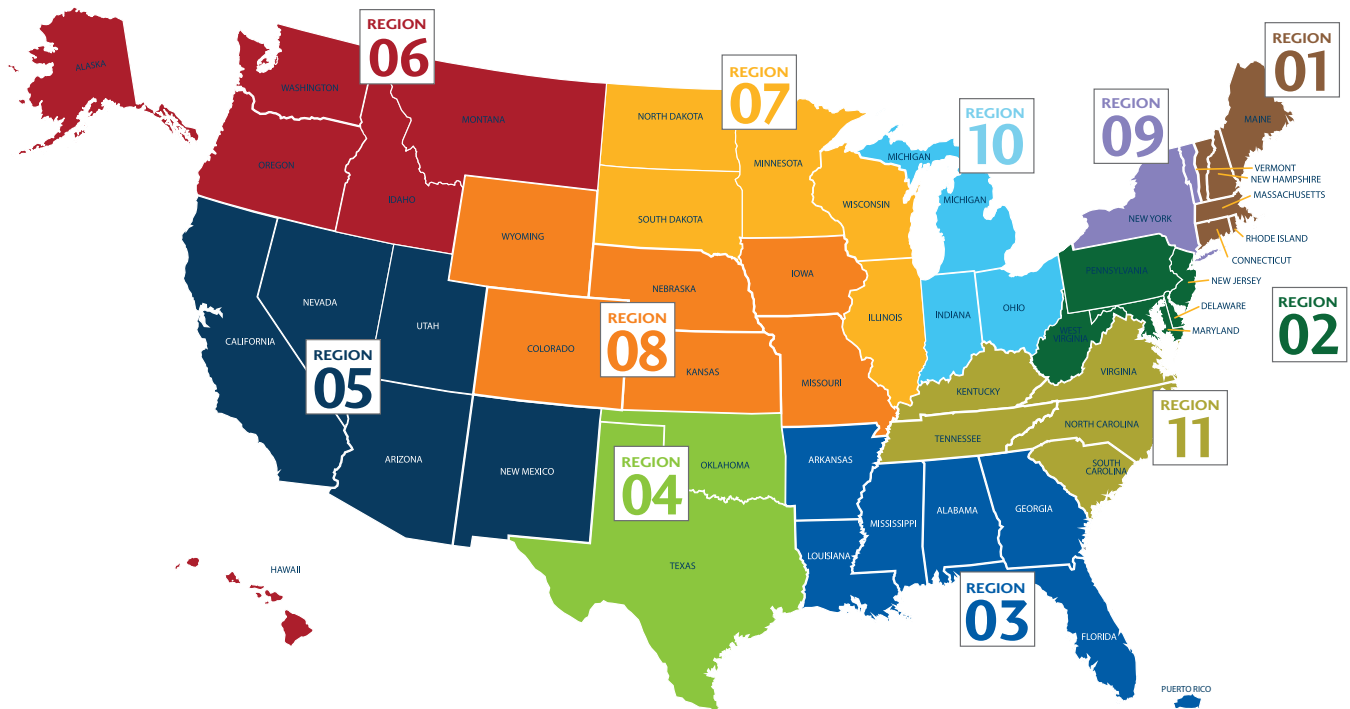
<sup>8</sup> Candidate and recipient time on WL = date candidate added to KPDP minus date candidate added to WL; chain-closing recipient time on WL = transplant date minus date candidate added to WL

## KPDPP Participation by OPTN/UNOS Region

More than one kidney transplant program from each of the 11 OPTN/UNOS regions have signed the agreement to participate in the KPDPP. All 14 programs in region 1, in fact, have signed up. Region 2 has entered 245 match run-eligible candidates into the system, more than any other region and over a quarter of the total number of candidates entered.

KPDPP transplants have occurred in all 11 regions. Centers in Region 2 have performed the most transplants (N=19, 22% of KPDPP transplants) followed by Region 1 (N=18, 20%). More than 75% of the 88 total transplants have resulted from interregional exchanges.

**Figure 7: Participating Centers, Match Run-Eligible Candidates and Transplants by OPTN/UNOS Region — through March 31, 2014**



### Region 1

14 (of 14) programs participating  
N=105 KPDPP candidates (12%)  
N=18 KPDPP transplants (20%)

### Region 2

21 (of 30) programs participating  
N=245 KPDPP candidates (27%)  
N=19 KPDPP transplants (22%)

### Region 3

7 (of 22) programs participating  
N=63 KPDPP candidates (7%)  
N=11 KPDPP transplants (13%)

### Region 4

19 (of 28) programs participating  
N=62 KPDPP candidates (7%)  
N=6 KPDPP transplants (7%)

### Region 5

15 (of 30) programs participating  
N=86 KPDPP candidates (10%)  
N=2 KPDPP transplants (2%)

### Region 6

3 (of 9) programs participating  
N=27 KPDPP candidates (3%)  
N=3 KPDPP transplants (3%)

### Region 7

17 (of 22) programs participating  
N=131 KPDPP candidates (14%)  
N=13 KPDPP transplants (15%)

### Region 8

11 (of 18) programs participating  
N=83 KPDPP candidates (9%)  
N=6 KPDPP transplants (7%)

### Region 9

9 (of 13) programs participating  
N=22 KPDPP candidates (2%)  
N=4 KPDPP transplants (5%)

### Region 10

12 (of 19) programs participating  
N=62 KPDPP candidates (7%)  
N=4 KPDPP transplants (5%)

### Region 11

10 (of 22) programs participating  
N=18 KPDPP candidates (2%)  
N=2 KPDPP transplants (2%)

### Figure 7 Key

# programs participating in KPDPP (of 228 total active living kidney donor programs)  
# KPDPP candidates (% of total 904 KPDPP candidates)  
# KPDPP transplants (% of total 88 KPDPP transplants)

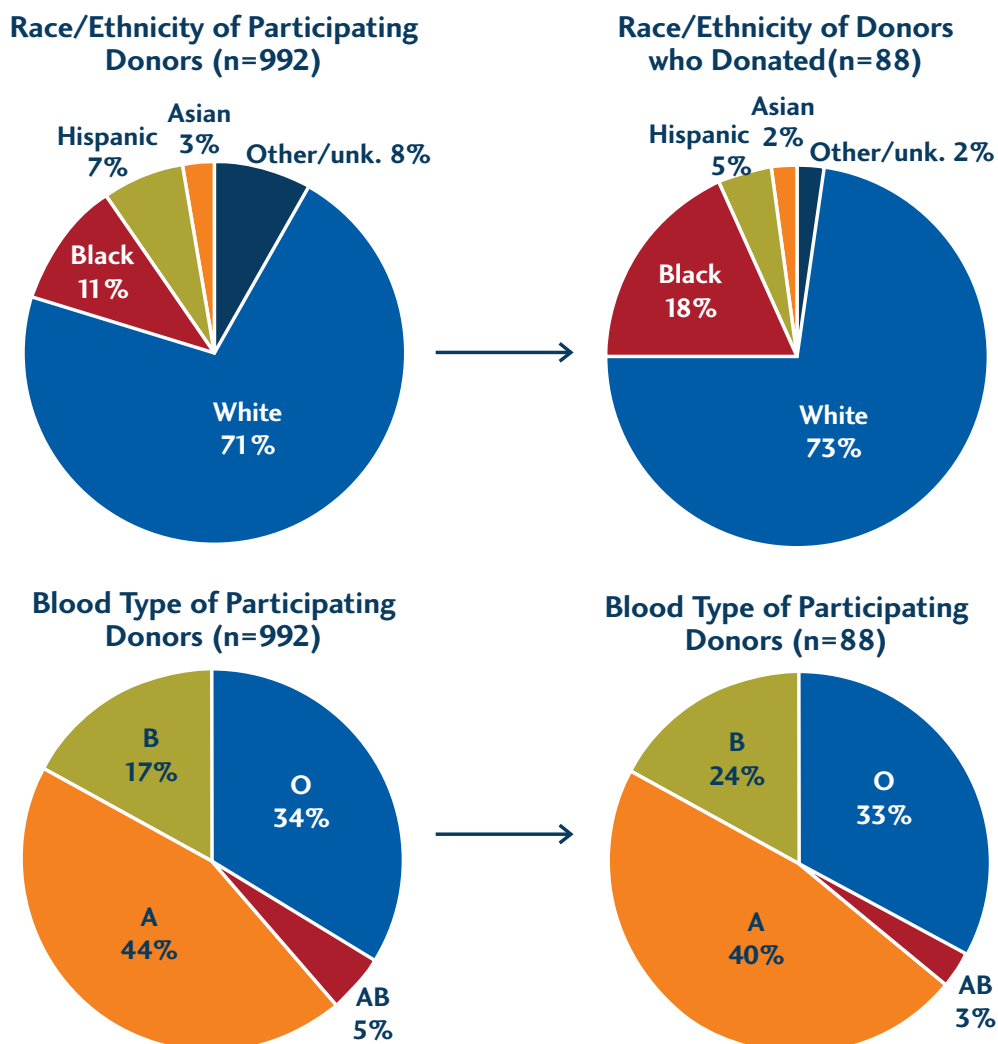
## Characteristics of Participating vs. Actual Donors

The race/ethnicity distribution of match run-eligible donors participating in the KPDP (Figure 8) is very similar to the distribution of candidates (shown previously in Figure 6A). About 70% of participating donors have been white and about 30% have been minorities. While 11% of the participating donors have been black, 18% of the donors that actually donated through the KPDP have been black.

Blood types of participating donors (Figure 8) are notably different from those of participating candidates (Figure 6A). While nearly 60% of candidates have had blood type O, only 34% of donors have had blood type O. In general, blood type O candidates are the most difficult to match, since they are only compatible with type O donors. Type O donors are the easiest to match, since they are compatible with all blood types. However, despite the disproportion in blood type O donors and candidates, as well as the high percentage of candidates having a CPRA of 98% or above (Figure 6B), the KPDP still finds more than 40 matches per month (Figure 5A) due to a steadily growing participant pool (Figure 4).

Though only 17% of participating donors are blood type B donors, they have accounted for nearly a quarter of the donations. Of the 435 participating blood type A donors, 25 (5.7%) have been reported as having a non-A1 (e.g., “A2”) subtype. Though non-A1 donors are compatible with blood group B and O candidates, so far only nine candidates have been reported as both willing and medically eligible to receive non-A1 subtype-compatible match offers.

**Figure 8: Characteristics of Participating vs. Actual Donors — through March 31, 2014**



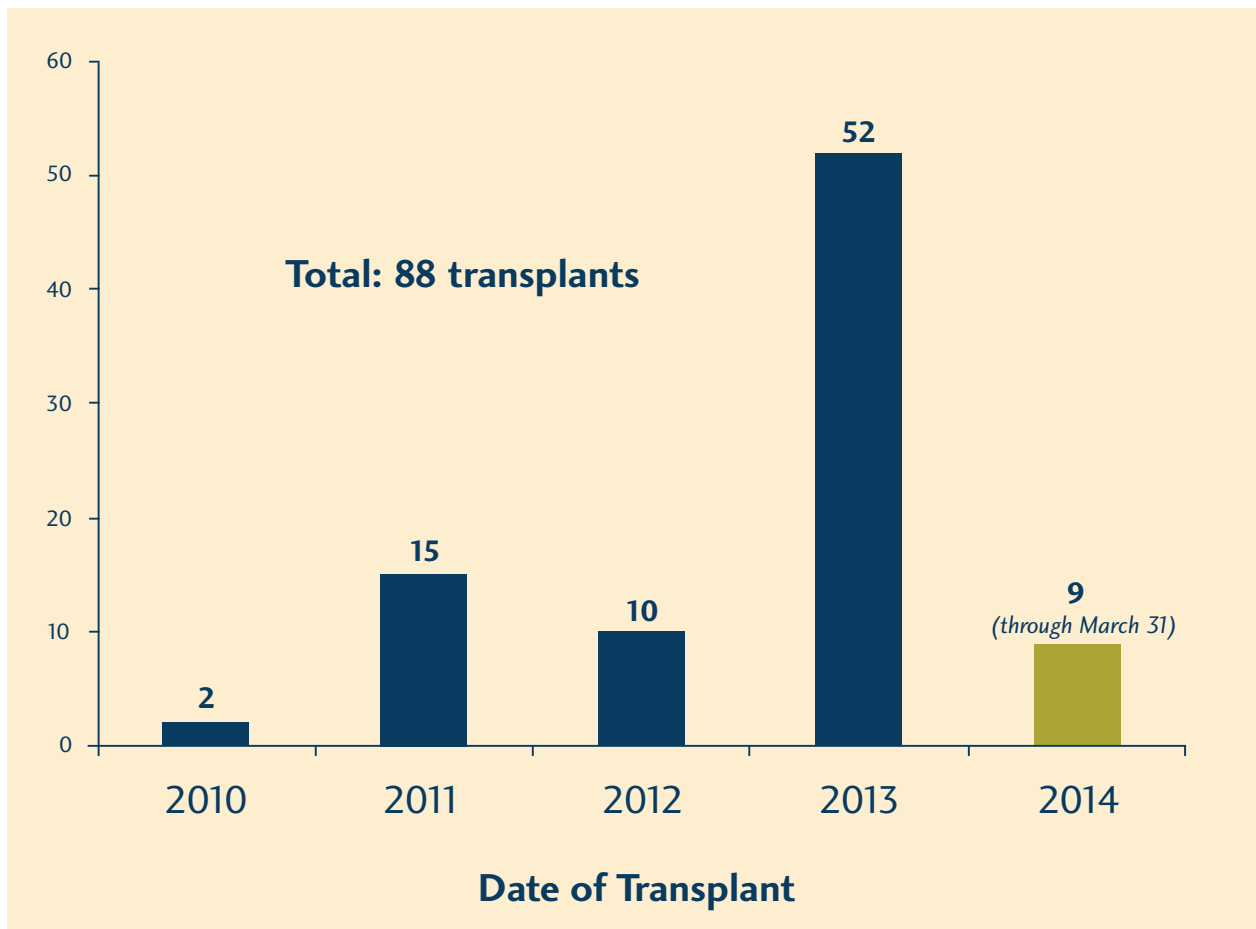
## Trends in Matching Opportunities

The annual number of transplants facilitated by the KPDPP surged to 52 in 2013 from 10 the prior year and a previous high of 15 in 2011 (**Figure 9**). Through the first three months of 2014, an additional 9 transplants have occurred, bringing the total since inception to 88.

Several factors contributed to the dramatic increase in 2013, including more matches found (**Figure 5A**), coupled with an improved match success rate. The match success rate—the percentage of match offers resulting in a transplant—was less than 3% for much of 2012 but jumped to 12% in 2013<sup>9</sup>. To increase match success rates, an online tool that allows participating programs to “pre-accept” or “pre-refuse” donors that could potentially match to their candidates was implemented in early 2013.

Common reasons for matches not resulting in a transplant include unacceptable donor antigens, unexpected positive cross-matches and the candidate being involved in an exchange through another KPD program. The KPD Work Group and its Histocompatibility Advisory Subcommittee continue to evaluate interventions that can increase the likelihood of matches becoming transplants.

**Figure 9: Transplants in the KPDPP — through March 31, 2014**



<sup>9</sup> Based on KPDPP match runs from January 1, 2013 - December 2, 2013.

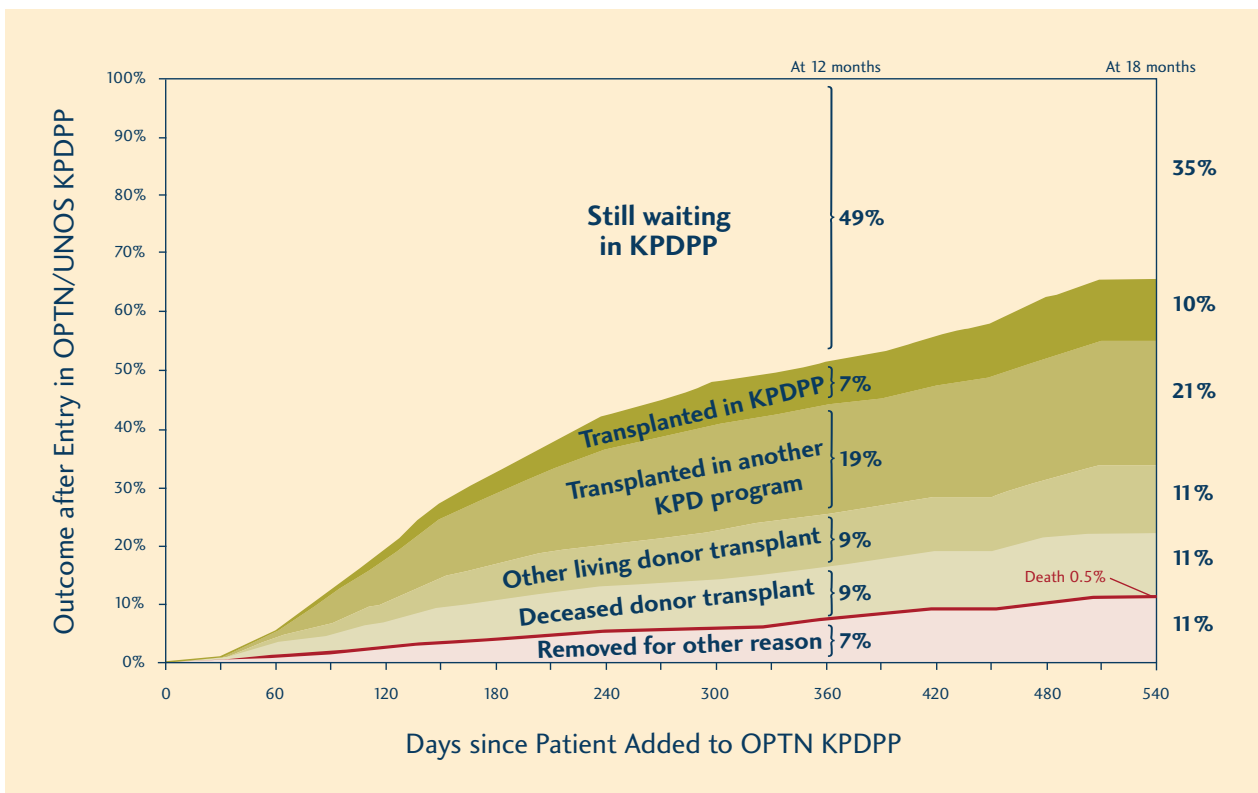
## Time to Transplant after Entering KPDPP

Figure 10A shows outcomes for match run-eligible candidates from 0 to 540 days after being added to the KPDPP. The cumulative percentage of candidates reaching each possible outcome by 12 and 18 months is highlighted.

By 18 months, 53% had received a transplant in one of four different ways: through the KPDPP (10%); through another KPD program (21%); from a non-KPD living donor transplant (11%); or from a deceased donor transplant (11%).

Less than 1% of patients were removed due to death, 11% were removed from the KPDPP for another reason, and 35% of candidates were still waiting for a transplant after 18 months.

**Figure 10A: Time to Transplant (or Other Outcome<sup>10</sup>) for Candidates Added to the KPDPP**  
Includes Match Run-Eligible Patients Added to the KPDPP<sup>11</sup> from Jan 1, 2012 – Nov 22, 2013



<sup>10</sup> Cumulative incidence curves shown in Figure 10A were derived using competing risks methodology for time-to-event data.

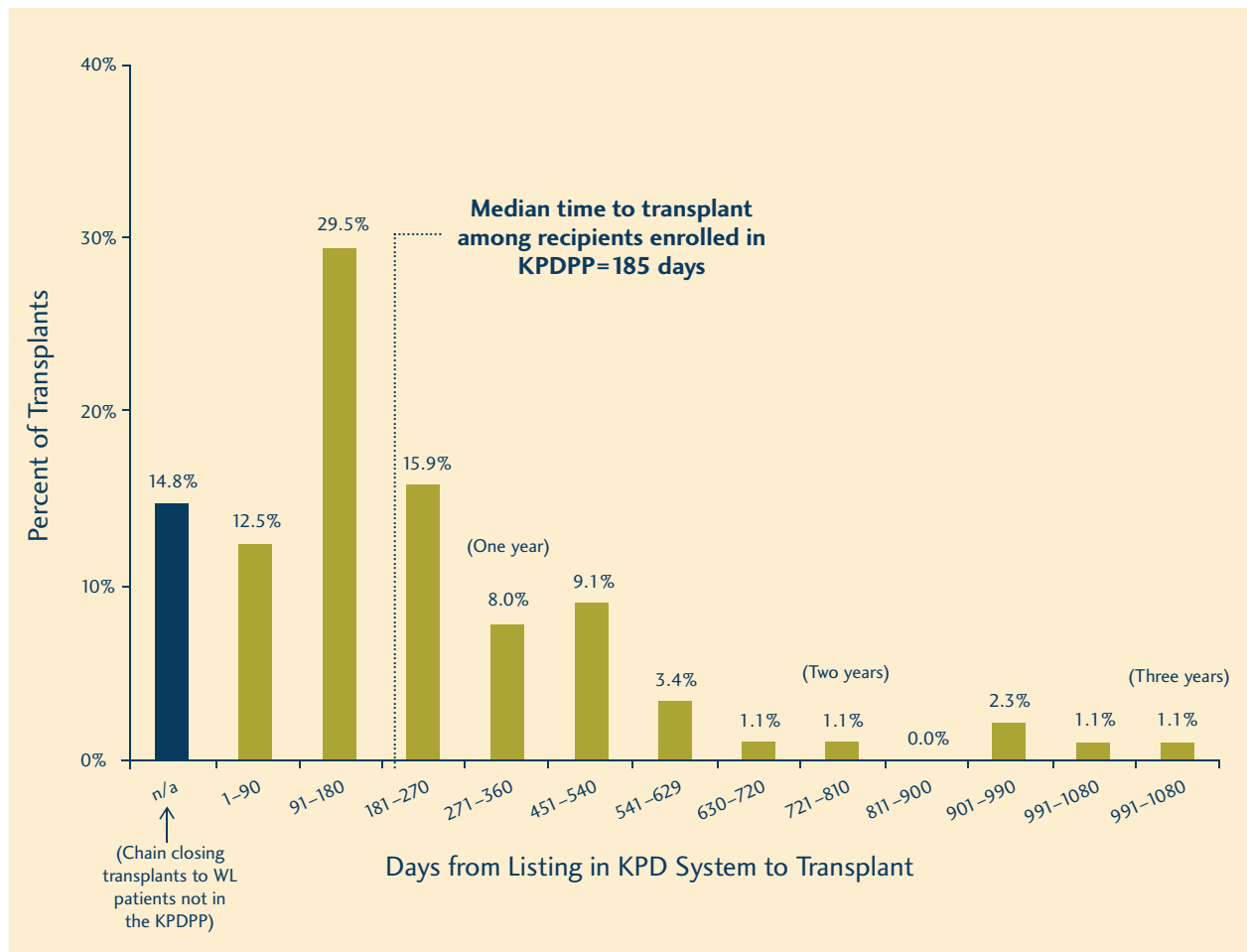
<sup>11</sup> Based on OPTN KPDPP data as of November 30, 2013.

## Time to Transplant for Recipients

The 88 recipients of a kidney transplant through the KPDPP waited a median of 185 days<sup>12</sup> in the system before the transplant. **Figure 10B** illustrates that the waiting times among recipients have varied greatly from patient to patient. Although a few recipients waited nearly three years before their KPDPP transplant, 42% were transplanted after waiting for less than six months.

Thirteen recipients (14.8%) benefited from the KPDPP by receiving a transplant without having been entered into the program. These transplants, which are shown in blue in Figure 10B, happened as a result of chains that began with a non-directed donor (NDD) and ended with a patient on the deceased donor waitlist at the transplant hospital that entered the NDD.

**Figure 10B: Time Waiting in the KPDPP System for Transplant Recipients**  
— through March 31, 2014



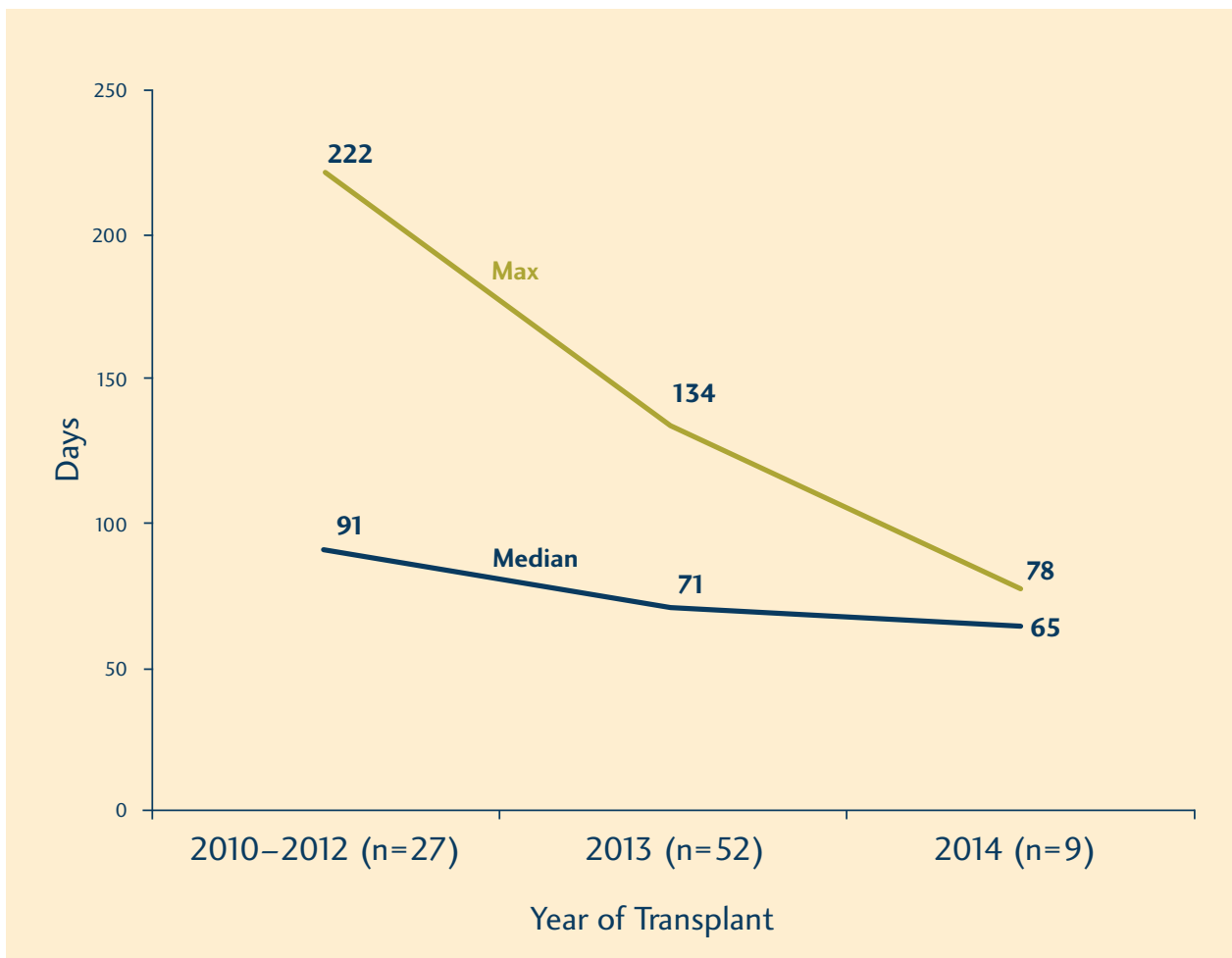
<sup>12</sup> This “median waiting time” estimate must be interpreted carefully since it only includes those KPDPP candidates that actually received a transplant through the program. Figure 10B is intended to be interpreted together with the results shown in Figure 10A.

## Time between Match Run and Transplant Surgery

For the 88 recipients transplanted through the KPDPP, the median time between finding the match and performing the transplant was 71 days. This time lag was primarily due to logistics, such as sending samples for testing, performing cross-matches, financial complexities and scheduling OR dates, but it was also affected by acute changes in a candidate's or a donor's health. The lag time has decreased from 91 days in the first few years of the KPDPP to just 65 days in 2014 (Figure 12). The maximum number of days between finding a match and proceeding to transplant has also sharply declined.

The KPD Work Group continues to pursue ways to further reduce the time lag from match offer to transplant. The KPDPP operational guidelines were recently updated to include required timelines for responding to match offers, providing matched donor information, sending test kits and running crossmatches.

**Figure 12: Time from Match Run to Transplant — through March 31, 2014**



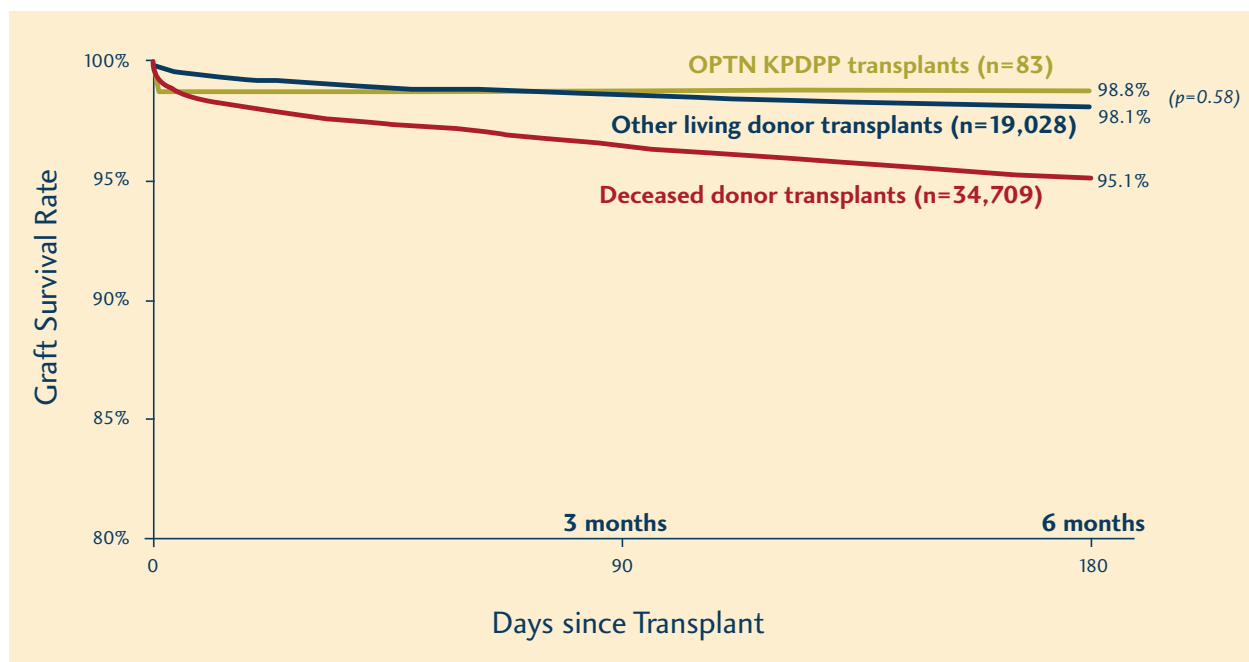


## Kidney Function after Transplant

Of the 83 KPDPP transplants with available data, only two recipients (2.4%) have experienced delayed graft function (DGF), defined as requiring dialysis within a week of the transplant. By comparison, 3.1%<sup>15</sup> of other living donor transplant recipients and nearly 25% of deceased donor recipients experienced DGF during this same time period (October 2010 through February 2014).

So far, only one graft failure within six months of the transplant has been reported. **Figure 13** shows that the estimated six-month graft survival rate for KPDPP transplants is 98.8%, compared to 98.1% for all other living donor kidney transplants and 95.1% for deceased donor kidney transplants. The graft survival curve for KPDPP transplants is statistically no different from other living donor transplants ( $p=0.58$ ), despite a median cold ischemic time of eight hours in the KPDPP (primarily due to shipping donor kidneys to the recipient center) compared to just one hour for all other living donor transplants.<sup>14</sup>

**Figure 13: Six-Month Kidney Graft Survival Rate<sup>15</sup> Comparison**  
*Includes Kidney Transplants Performed October 2010 – February 2014*



<sup>15</sup> Difference in DGF rates for KPDPP vs. other living donor transplants is not statistically significant ( $p$ -value=0.69, per likelihood ratio chi-squared test).

<sup>14</sup> P-value for difference in graft survival curves is based on the log-rank test.

<sup>15</sup> Kaplan-Meier graft survival curves estimated using kidney transplants with a validated Transplant Recipient Registration (TRR) form. Thus, some transplant recipients in this cohort had less than six months of follow-up, yet this graft survival time can still contribute to the Kaplan-Meier survival estimates. Patient death, as well as graft failure without patient death, were both considered to be a graft failure. Multi-organ transplants were excluded from deceased donor transplant analysis.

## KPD Resources

### For professionals

<http://transplantpro.org/kidney-paired-donation/>

### For patients

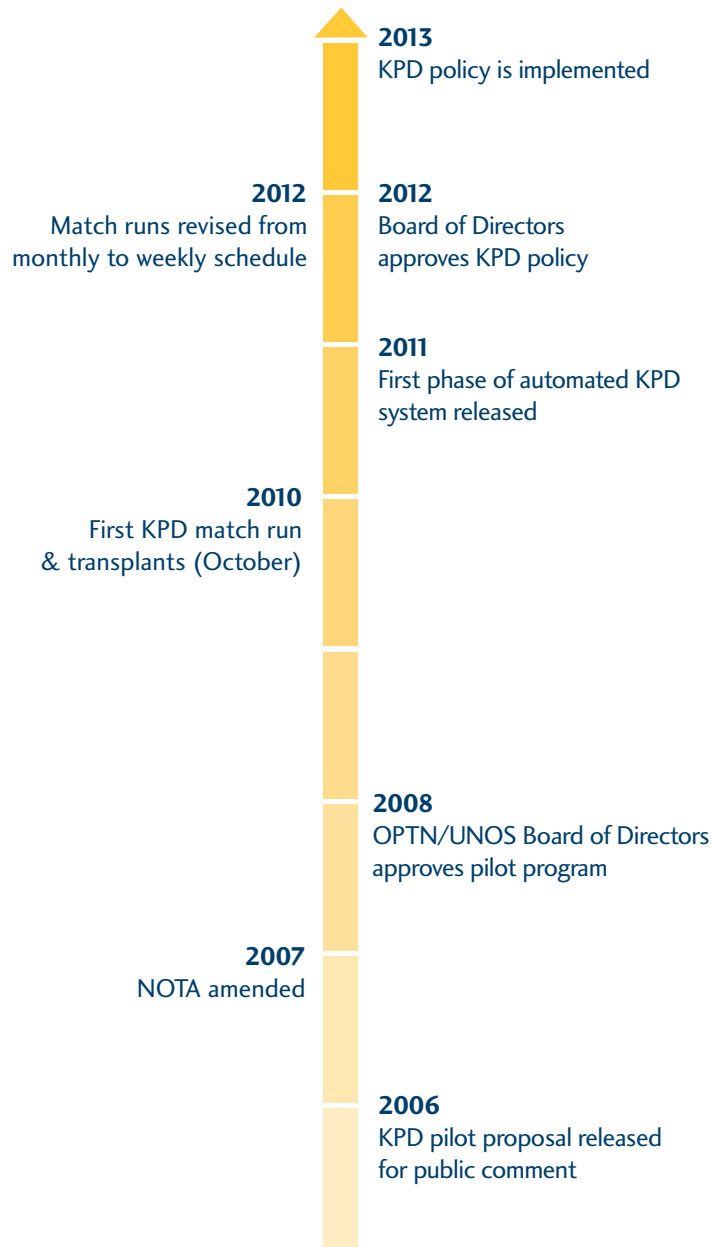
<http://www.transplantliving.org/living-donation/types/paired-donation/http://unos.org/donation/index.php?topic=kpd>

<http://optn.transplant.hrsa.gov/resources/KPDPP.asp>

### Questions?

Contact KPD Program Manager Ruthanne Leishman at [ruthanne.leishman@unos.org](mailto:ruthanne.leishman@unos.org) or (804) 782-4770, or email [kidneypaireddonation@unos.org](mailto:kidneypaireddonation@unos.org).

## OPTN/UNOS KPD Pilot Program Progress Timeline



## **OPTN/UNOS KPD Work Group 2013/2014**

Mark Aeder, M.D. (Chair)

John Friedewald, M.D.

Richard Formica Jr., M.D.

Adam Bingaman, M.D., Ph.D.

Mary Amanda Dew, Ph.D.

Matthew Cooper, M.D.

Lloyd Ratner, M.D.

Mariza Turner, RN

Mary Leffell, Ph.D.

Gene Ridolfi, RN, M.H.A.

Nancy Reinsmoen, Ph.D., D(ABHI)

Pat McDonough, RN, CPTC, CCTC

Michael Rees, M.D., Ph.D.

Mike Gallichio, M.D.

Eric Gibney, M.D.

Alvin Roth, Ph.D.

Daniel Ranch, M.D.

### **Technical Advisors**

Sommer Gentry, Ph.D.

Tuomas Sandholm, Ph.D.

Itai Ashlagi, Ph.D.