# A Guide to Calculating and Interpreting the Estimated Post-Transplant Survival (EPTS) Score Used in the Kidney Allocation System (KAS)

*Updated: April 23, 2018*

## What is the EPTS score?

The Estimated Post Transplant Survival (EPTS) score is a numerical measure used to allocate some kidneys in the new kidney allocation system. Every adult patient on the kidney waitlist receives an EPTS score for use in the kidney allocation system.

EPTS scores range from 0% to 100%. Candidates with a lower EPTS score are expected to experience more years of graft function from high-longevity kidneys compared to candidates with higher EPTS scores.

Per OPTN policy, the EPTS score is derived from the following formula:

$$
\begin{aligned}
\text{Raw EPTS } = & \ 0.047 * max(\text{Age} - 25, 0) - 0.015 * \text{Diabetes} * max(\text{Age} - 25, 0) \\
& + 0.398 * \text{Prior Solid Organ Transplant} - 0.237 * \text{Diabetes} * \text{Prior Organ Transplant} \\
& + 0.315 * log(\text{Years on Dialysis} + 1) - 0.099 * \text{Diabetes} * log(\text{Years on Dialysis} + 1) \\
& + 0.130 * (\text{Years on Dialysis} = 0) - 0.348 * \text{Diabetes} * (\text{Years on Dialysis} = 0) + 1.262 * \text{Diabetes}
\end{aligned}
$$

The factors included in the formula are the candidate's age in years, duration on dialysis in years, current diagnosis of diabetes, and whether the candidate has had a prior solid organ transplant.

The raw EPTS is converted to an EPTS score by using the EPTS mapping table, which is updated annually.



Figure 1. Kaplan–Meier Patient Survival Curves by EPTS Score for Deceased Donor, Adult, Kidney–Alone Transplants Performed During 2006–2016

*Based on OPTN data as of April 20, 2018.*
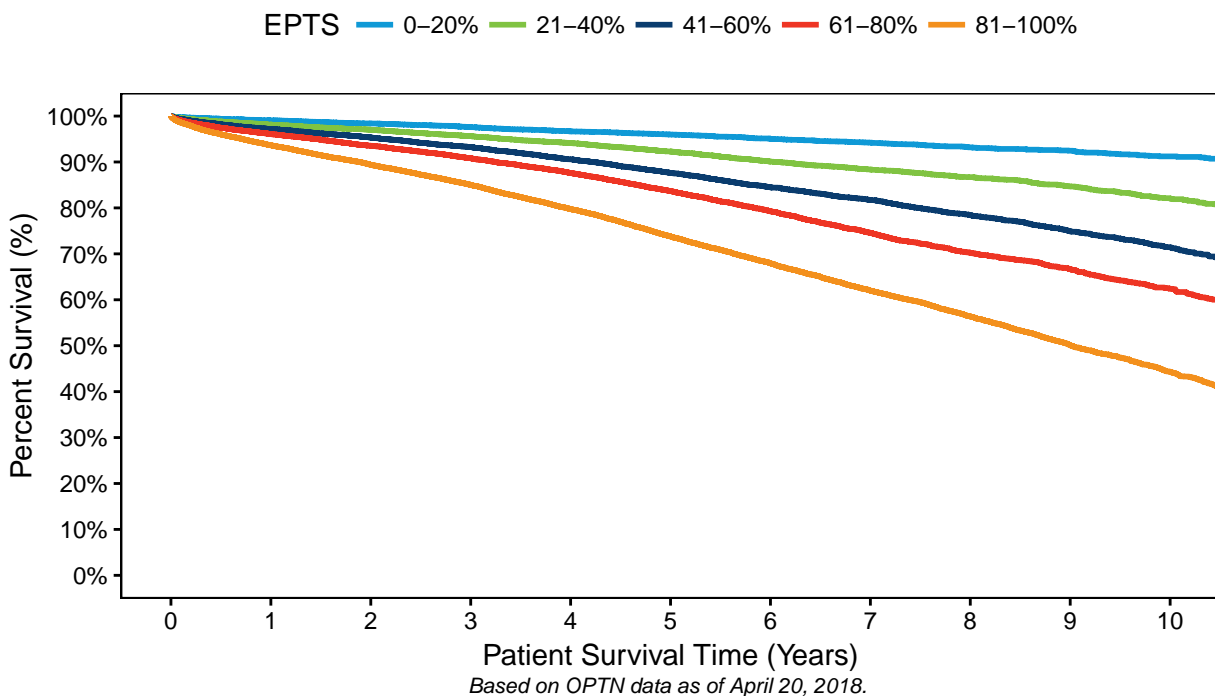
# Where did the EPTS score come from?

The EPTS score was developed by the Scientific Registry of Transplant Recipients (SRTR) contractor upon request of the OPTN Kidney Transplantation Committee. They established the score by analyzing the relationship between characteristics of deceased donor kidney recipients and their survival times after transplant. For the sake of simplicity and transparency, the committee requested that the score only include the four factors described above.

The formula used for calculating the raw EPTS value was derived from a Cox proportional hazards model used to quantify the associations between the four candidate factors – age, diabetes status, prior solid organ transplant, and time on dialysis – and the time until patient death following transplant.

# How is the EPTS score used in the kidney allocation system?

The EPTS is used in tandem with the Kidney Donor Profile Index (KDPI) to introduce the concept of longevity matching into the new allocation system. Candidates with EPTS scores of 20% or less will receive increased priority for offers for kidneys with KDPI scores of 20% or less. Allocation still proceeds by geography, with local candidates – even those with an EPTS score exceeding 20% – appearing on the match list before candidates listed outside the donor service area[1].

The EPTS score is only used in kidney allocation when the donor has a KDPI of 20% or less. In other words, the EPTS is used to prioritize patients in only 20% of kidney allocations, while for 80% of allocations, EPTS is not used at all.

The intent of longevity matching is to ensure that those kidneys expected to function the longest are most often transplanted into those candidates expected to live the longest, in order to realize the most benefit from the highest quality kidneys. Transplanting high longevity kidneys into patients not expected to live long after transplant leads to unutilized graft years from these precious, donated gifts. Likewise, transplanting kidneys not expected to last as long into high longevity recipients can lead to high rates of graft failure and return to the waiting list, further increasing demand for kidneys. Achieving the "best use" of each donated organ through better longevity matching is a primary goal of the kidney allocation system.

## Are kidney candidates rank-ordered on the waitlist by their EPTS score in the same way as liver patients are rank-ordered by their MELD score?

No. The EPTS score is only used to identify two broad groups of patients: those with scores of 20% or less and those with scores exceeding 20%. Patients with EPTS scores $\leq 20\%$ are prioritized ahead of patients with lower scores, but only for the highest longevity (KDPI $\leq 20\%$) kidneys. Within these two EPTS groups, patients are rank-ordered by allocation points, which are determined by waiting time (defined by time on dialysis, or time after meeting eGFR or CrCl criteria), the CPRA sliding scale, HLA-DR matching, pediatric status, and other factors, per OPTN policy.

## What types of candidates tend to have EPTS scores of 20% or less?

In general, candidates with lower EPTS scores tend to be younger. However, an analysis produced by the OPTN contractor for the OPTN Kidney Transplantation Committee revealed that candidates in their early to mid-50s can still have EPTS scores in the Top 20%[2]. Though candidates with diabetes tend to have higher EPTS scores, the same analysis showed that some younger diabetics still managed to have EPTS scores of 20% or less. Patients who have had a prior solid organ transplant, as well as those having spent many years on dialysis, tend to have higher EPTS scores.

The EPTS calculator (available in the Waitlist℠ application and on the OPTN website) is intended to help transplant clinicians and patients become more familiar with the EPTS score. The tool is useful for experimenting with different combinations of the four candidate factors to evaluate their impact and generate profiles of patients with varying EPTS scores.

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[1] Non-local offers to candidates with CPRA of 99 or 100, as well as non-local zero-HLA mismatch offers, are exceptions; generally speaking, allocation will still proceed locally, regionally, and then nationally as in the current system.

[2] "An Analysis of the Distribution of Estimated Post-Transplant Survival (EPTS) Scores for Kidney Candidates," presented to the OPTN Kidney Transplantation Committee, October 15, 2012.

## What do transplant centers need to do?

Programs are responsible for keeping the current diabetes status and number of prior solid organ transplants data fields updated for candidates. For example, if a patient develops diabetes while on the waitlist, the program must update the current diabetes status on the candidate's waitlist record. Likewise, if a patient has a liver transplant while waiting for a kidney, the program must update the number of prior transplants field.

## What if some of the four factors used to calculate the EPTS score are not provided for a kidney candidate?

Transplant programs are expected to update and/or verify the factors used for calculating EPTS for all kidney patients. Patients with missing or unverified EPTS factors will have a missing EPTS score in the kidney allocation system. These candidates will appear on the match list, but will be assumed to have an EPTS score outside the top 20%.

Since dialysis start date is also used to determine waiting time points, candidates without a verified dialysis start date will not receive points for time spent on dialysis prior to being registered on the waitlist.

## Does the type of diabetes matter in the EPTS score?

No. While the candidate's current diagnosis status goes into calculating the EPTS score, the type of diabetes does not affect the score.

## Does the number of prior transplants matter in the EPTS score?

No. While the EPTS score takes into consideration whether the candidate has had a prior transplant, the score is not affected by the particular number of transplants.

## Does the EPTS score apply to pediatric patients?

No. Even after they turn 18, candidates who were registered while pediatric (age < 18) maintain priority over adults at the local, regional, and national levels of distribution, irrespective of EPTS. Once a candidate turns 18, the EPTS score will be calculated, displayed in the Waitlist application, and used for prioritizing the top 20% of EPTS candidates ahead of the bottom 80% of candidates for zero-antigen mismatch offers.

Even though the EPTS score does not apply to pediatric patients, centers must still verify the dialysis start date for these candidates in order to receive full waiting time points. Centers should update all EPTS fields for pediatric patients, so that these patients do not have missing scores when they turn 18 and potentially miss out on priority for zero-HLA mismatch offers.

## Can a candidate's EPTS score change after the candidate is registered on the waitlist?

Yes. When any of the four fields used to calculate the EPTS – age (date of birth), time on dialysis (dialysis start date), diabetes status, or number of prior transplants – is updated or corrected, the EPTS score will automatically be recalculated. In addition, EPTS will be recalculated on a nightly basis to take into account each candidate's one day increase in age and time on dialysis (if on dialysis).

## How predictive is the EPTS score of recipients' post-transplant survival?

The index of concordance, or c-statistic, measures the ability of a predictive model, or score, to distinguish among patients based on an outcome of interest, such as patient survival. The c-statistic ranges from 0.5 (no predictive ability) to 1.0 (perfect predictive power). For the EPTS score, the c-statistic is estimated to be 0.69. In a "full" model including all measured and available factors predictive of kidney transplant outcomes, the c-statistic for distinguishing kidney recipient longevity tops out at around 0.7218[3]. This suggests that the simplified, 4-factor EPTS model has not lost significant predictive power compared to the maximum predictive capability possible given the data currently available.

Though a c-statistic around 0.70 is considered good, the EPTS model is better able to distinguish patients at opposite ends of the spectrum, as opposed to being able to accurately predict which of two clinically similar recipients will survive longer. The EPTS score is not being used to rank-order patients, but rather to categorize patients into two broad groups: $0 - 20\%$ and $21 - 80\%$.

**Figure 1** shows that the EPTS score is able to distinguish between expected outcomes among broad groups of kidney transplant recipients.

## Calculating the Raw EPTS Value

A candidate's EPTS score is derived by first calculating a raw EPTS value.

The following candidate characteristics are used to calculate the EPTS:

- Age
- Current diabetes status
- Duration on dialysis
- Prior solid organ transplant

The association between these factors and recipients' post-transplant survival time was determined by estimating a multivariable Cox proportional hazards regression model, resulting in the following EPTS formula:

$$
\begin{aligned}
\text{Raw EPTS } &= 0.047 * max(\text{Age} - 25, 0) - 0.015 * \text{Diabetes} * max(\text{Age} - 25, 0) \\
&+ 0.398 * \text{Prior Solid Organ Transplant} - 0.237 * \text{Diabetes} * \text{Prior Organ Transplant} \\
&+ 0.315 * log(\text{Years on Dialysis} + 1) - 0.099 * \text{Diabetes} * log(\text{Years on Dialysis} + 1) \\
&+ 0.130 * (\text{Years on Dialysis} = 0) - 0.348 * \text{Diabetes} * (\text{Years on Dialysis} = 0) + 1.262 * \text{Diabetes}
\end{aligned}
$$

The factors shown in the formula are candidate age in years, duration on dialysis in years, current diagnosis of diabetes, and whether the candidate has had a prior solid organ transplant.

The diabetes variable is binary: it is 0 if the candidate does not have a current diagnosis of diabetes or 1 if the candidate has a current diagnosis of any type of diabetes.

The prior organ transplant variable is binary: it is 0 if the candidate has not had any prior solid organ transplants or 1 if the candidate has had one or more solid organ transplants.

Candidate age is measured in fractional years, and is calculated as the number of full days between the candidate's date of birth and the current date, divided by 365.25.

Years on dialysis is also measured in fractional years, and is calculated as the number of full days between the candidate's dialysis start date and the current date, divided by 365.25. If years on dialysis is zero, then "(Years on Dialysis $= 0$)" is treated as 1.0 in the formula.

The log function represents the natural (base $e$) logarithm.

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[3]C-statistic is from the 3-year, adult deceased donor kidney patient survival model Program Specific Report (PSR) produced by the SRTR and released in July 2017 using transplants between 1/1/2012 and 6/30/2014.

## Converting the Raw EPTS Value to an EPTS Score

To determine a candidate's EPTS score, the raw EPTS value is calculated and converted to a cumulative percentage using the EPTS mapping table.

The EPTS mapping table is derived based on a recent snapshot, or reference population, of all adult patients on the (national) kidney waitlist. For example, the mapping table updated in 2016 is based on all adult kidney candidates on the waitlist on December 31, 2016, including both those in active and inactive status. The mapping table is derived by calculating the raw EPTS score for the candidates in the snapshot, and then estimating the $1^{st}, 2^{nd}, 3^{rd}, \ldots, 99^{th}$, and $100^{th}$ percentiles from this distribution of raw EPTS values. The raw EPTS is converted to the cumulative percentage associated with the percentile range in which the raw EPTS value lies. This cumulative percentage is the EPTS score.

An EPTS score of 0% means that the candidate's raw EPTS value was lower than the minimum observed value in the reference population. A candidate with a raw EPTS value higher than all those in the reference population will receive an EPTS score of 100%.

The mapping table is updated annually each spring to reflect changes in the population of adult kidney candidates on the waitlist.

## Interpreting the EPTS Score

The EPTS score, which ranges from 0% to 100%, represents the percentage of kidney candidates in the reference population with a higher expected post-transplant survival. Lower EPTS scores are associated with higher expected post-transplant longevity, and vice-versa (Figure 1).

Candidates with EPTS scores less than or equal to 20% will be prioritized by the kidney allocation system to receive kidney offers from donors with the highest estimated quality (KDPI $\leq$ 20%). Candidates with EPTS scores exceeding 20% will be eligible to receive these offers. They will be prioritized after candidates in the EPTS top 20%.

## Example EPTS Calculation #1

To calculate the EPTS as of 01/01/2017 for a candidate waiting with the following characteristics:

- Date of birth: 06/02/1993
- Dialysis start date: 12/02/2011
- Diabetes status: No
- Previous transplants: Kidney (2007)

Fractional age in years $= \frac{\text{Days between 01-01-2017 and 06-02-1993}}{365.25} = \frac{8614}{365.25} = 23.5838466803559$

Fractional years on dialysis $= \frac{\text{Days between 01-01-2017 and 12-02-2011}}{365.25} = \frac{1856}{365.25} = 5.08145106091718$

Diabetes $= 0$

Prior organ transplant $= 1$

$$
\begin{aligned}
\text{Raw EPTS (Example 1)} &= 0.047 * max(23.5838466803559 - 25, 0) - 0.015 * 0 * max(23.5838466803559 - 25, 0) \\
&\quad + 0.398 * 1 - 0.237 * 0 * 1 + 0.315 * ln(5.08145106091718 + 1) \\
&\quad - 0.099 * 0 * ln(5.08145106091718 + 1) + 0.130 * 0 - 0.348 * 0 * 0 + 1.262 * 0 \\
\\
&= 0.398 + 0.315 * ln(6.08145106091718) \\
&= \mathbf{0.966651648583986}
\end{aligned}
$$

Using the EPTS mapping table (reference population: December 31, 2016): EPTS Score = **9%**

Will the candidate receive priority for KDPI $\leq$ 20% kidneys due to EPTS $\leq$ 20%? **Yes**

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## Example EPTS Calculation #2

To calculate the EPTS as of 01/01/2017 for a candidate waiting with the following characteristics:

- Date of birth: 02/14/1964
- Dialysis start date: Not on dialysis (preemptive listing)
- Diabetes status: No
- Previous transplants: No

Fractional age in years $= \frac{\text{Days between 01-01-2017 and 02-14-1964}}{365.25} = \frac{19314}{365.25} = 52.8788501026694$

Fractional years on dialysis $= 0$

Diabetes $= 0$

Prior organ transplant $= 0$

$$
\begin{aligned}
\text{Raw EPTS (Example 2)} &= 0.047 * max(52.8788501026694 - 25, 0) - 0.015 * 0 * max(52.8788501026694 - 25, 0) \\
&\quad + 0.398 * 0 - 0.237 * 0 * 0 + 0.315 * ln(0 + 1) - 0.099 * 0 * ln(0 + 1) \\
&\quad + 0.130 * 1 - 0.348 * 0 * 1 + 1.262 * 0 \\
\\
&= 0.047 * 27.8788501026694 + 0.315 * ln(1) + 0.315 * ln(1) + 0.130 \\
&= \mathbf{1.44030595482546}
\end{aligned}
$$

Using the EPTS mapping table (reference population: December 31, 2016): EPTS Score = **19%**

Will the candidate receive priority for KDPI $\leq$ 20% kidneys due to EPTS $\leq$ 20%? **Yes**

## Example EPTS Calculation #3

To calculate the EPTS as of 01/01/2017 for a candidate waiting with the following characteristics:

- Date of birth: 06/24/1994
- Dialysis start date: 02/16/2010
- Diabetes status: Type I
- Previous transplants: Pancreas (1997), Kidney (2008)

Fractional age in years $= \frac{\text{Days between 01-01-2017 and 06-24-1994}}{365.25} = \frac{8226}{365.25} = 22.5215605749487$

Fractional years on dialysis $= \frac{\text{Days between 01-01-2017 and 02-16-2010}}{365.25} = \frac{2511}{365.25} = 6.87474332648871$

Diabetes $= 1$

Prior organ transplant $= 1$

$$
\begin{aligned}
\text{Raw EPTS (Example 3)} &= 0.047 * max(22.5215605749487 - 25, 0) - 0.015 * 1 * max(22.5215605749487 - 25, 0) \\
&\quad + 0.398 * 1 - 0.237 * 1 * 1 + 0.315 * ln(6.87474332648871 + 1) \\
&\quad - 0.099 * 1 * ln(6.87474332648871 + 1) + 1.262 \\
\\
&= 0.398 - 0.237 + 0.315 * ln(7.87474332648871) - 0.099 * ln(7.87474332648871) + 1.262 \\
&= \mathbf{1.86875068759525}
\end{aligned}
$$

Using the EPTS mapping table (reference population: December 31, 2016): EPTS Score = **33%**

Will the candidate receive priority for KDPI $\leq$ 20% kidneys due to EPTS $\leq$ 20%? **No**

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