

THE KIDNEY TRANSPLANT PROCESS MODEL*

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ABSTRACT

The Kidney Transplant Process Model (KTPM) was created to demonstrate the kidney transplant process from initial placement on the waiting list to life post-transplant. The KTPM focuses on the effects of donor availability on the entire transplant process with a specific concentration on ethnicity. The model was designed as a tool for analyzing the transplant process and its outcomes, supplemented with data from the Organ Procurement and Transplantation Network (OPTN) database and reports. Experiments with this model have shown that changes to the process are necessary to keep the list from increasing. While increases in the availability of donors are not likely to entirely eliminate the waiting list in the near term, these solutions could help to decrease the size of the list. A specific increase in living donor transplants in minorities would also help to decrease the size of the waiting list for kidney transplants.

1 INTRODUCTION

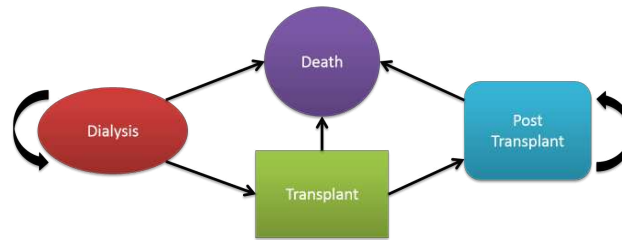
There are currently over 100,000 people on the waiting list for a kidney transplant in America (Organ Procurement and Transplantation Network). If the current transplant process remains as is, this number of waiting patients will only continue to grow. Even though the growth rate of active patients on the waiting list has slowed, it has been predicted that the waiting list will grow by over 4,000 people per year (Leichtman, Cohen, Keith, O'Connor, Goldstein, McBride, Gould, Christensen, and Ashby 2008).

While waiting for a kidney transplant, patients undergo dialysis treatments which take over the kidneys former job of filtering the bloodstream. Dialysis is generally completed by patients at a facility three times a week for three to four hours at a time. Patients on the waiting list only need to continue dialysis until they have been selected to receive a transplant. Having a transplant greatly increases the patients quality of life and patients can often resume a normal lifestyle following recovery from surgery. A general outline of the kidney transplant process can be seen in Figure 1.

Previous research and studies have realized that there are currently racial and ethnic disparities in the access to transplants for minority patients. Currently, the percentage of deceased donor transplants for African Americans, Asians, and Hispanic/Latinos in the U.S. lag behind the respective proportions of whites. In an ideal and fair kidney transplant system, there would be no disproportions (Fan, Ashby, Fuller, Boulware, Kao, Norman, Randall, Young, Kalbfleisch, and Leichtman 2010). This research also noted that the disparity in access to Deceased Donor transplants has been narrowing significantly for African American patients in recent years, but not for Asian and Hispanic patients (Fan, Ashby, Fuller, Boulware, Kao, Norman, Randall, Young, Kalbfleisch, and Leichtman 2010).

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Figure 1: Simple outline of the transplant process. Patients can transition between the stages of the process according to the directions on the chart.



2 METHODS

The Kidney Transplant Process Model (KTPM) was built using data from the Organ Procurement and Transplantation Network Database. This system was developed by UNOS and contains all OPTN data related to every organ donation and transplant event in America since 1987 (Organ Procurement and Transplantation Network). Statistics taken from this database as well as from OPTN reports were used to generate and then validate the model (U.S. Department of Health & Human Services 2014). The model was created using MASON, a Java library core designed for discrete-event multi-agent simulations (Luke, Cioffi-Revilla, Panait, Sullivan, and Balan 2005).

The KTPM is comprised of agents that are experiencing the transplant process. These agents can be divided into three collectives: patients on the waiting list, post-transplant patients, and deceased or otherwise removed patients. All patients have attributes that help determine their specific journey through the transplant process, including age and ethnicity. As well as these characteristics, each agent keeps track of how long they spend on the waiting list and how long they survive post-transplant.

Experiments developed for this research involved taking a close look at the effects of the Living and Deceased factors on the model. These trials involved varying the number of available living and deceased donors from the current range to a 100% or 200% increase. This set of experiments resulted in 231 trials.

3 RESULTS

Results from this experiment give a detailed look into how the size of the waiting list could be affected if there were to be an increase in the number of living and deceased donors. Increasing the number of living donors by 100% corresponds to a 2% decrease in the waiting list while a 100% increase in the number of deceased donors represents a 33% decrease in the waiting list after 15 years. Increasing the number of living donors by 200% and deceased donors by 100% could lead to a 52% decrease in the waiting list.

REFERENCES

- Fan, P. Y., V. B. Ashby, D. S. Fuller, L. E. Boulware, A. Kao, S. P. Norman, H. B. Randall, C. Young, J. D. Kalbfleisch, and a. B. Leichtman. 2010. "Access and outcomes among minority transplant patients, 1999-2008, with a focus on determinants of kidney graft survival". *American Journal of Transplantation* 10 (4 PART 2): 1090–1107.
- Leichtman, a. B. and Cohen, D. and Keith, D. and O'Connor, K. and Goldstein, M. and McBride, V. and Gould, C. J. and Christensen, L. L. and Ashby, V. B. 2008. "Kidney and pancreas transplantation in the United States, 1997-2006: The HRSA breakthrough collaboratives and the 58 DSA challenge".
- Luke, S., C. Cioffi-Revilla, L. Panait, K. Sullivan, and G. Balan. 2005. "MASON: A Multiagent Simulation Environment". *Simulation* 81 (7): 517–527.
- Organ Procurement and Transplantation Network. "OPTN Website". Accessed March 1, 2015. <http://optn.transplant.hrsa.gov/>.
- U.S. Department of Health & Human Services 2014. "OPTN/SRTR 2012 Annual Data Report". Technical Report June.