United States Organ Transplantation

OPTN/SRTR Annual Data Report 2021

US Department of Health and Human Services
Health Resources and Services Administration

SCIENTIFIC REGISTRY OF TRANSPLANT RECIPIENTS

U.S. Department of Health and Human Services
HRSA
Health Resources and Services Administration

OPTN/SRTR 2021 Annual Data Report: Preface

This Annual Data Report of the US Organ Procurement and Transplantation Network (OPTN) and the Scientific Registry of Transplant Recipients (SRTR) is the 31st annual report and is based on data pertaining to the period 2010-2021. The title *OPTN/SRTR 2021 Annual Data Report* reflects the fact that the report covers the most recent complete year of transplants, those performed in 2021.

This publication was developed for the US Department of Health and Human Services, Health Resources and Services Administration, Healthcare Systems Bureau, Division of Transplantation, by the SRTR contractor, Hennepin Healthcare Research Institute (HHRI), and the OPTN contractor, United Network for Organ Sharing (UNOS), under SRTR contract HHSH75R60220C00011 and OPTN contract HHSH250201900001C.

As the SRTR contractor, HHRI, through its Chronic Disease Research Group (CDRG), determined which data to present, conducted the required analyses, created the figures and tables, and drafted the text. As the OPTN contractor, UNOS reviewed the draft report and contributed to the content. This report is available at https://srtr.transplant.hrsa.gov. Individual chapters may be downloaded.

1 OVERVIEW AND HIGHLIGHTS

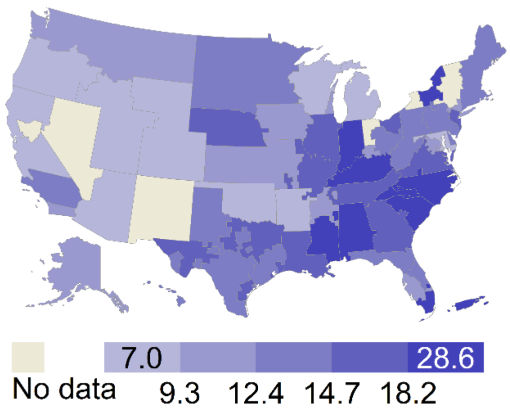
This Annual Data Report includes chapters on kidney, pancreas, liver, intestine, heart, and lung transplants, as well as chapters on deceased organ donation, vascularized composite allograft transplant, and COVID-19. The organ-specific chapters include information on such topics as the waiting list, deceased donor organ donation, living donor organ donation, transplant, outcomes, and pediatric transplant. When possible, similar data and formats are used for each chapter. However, this is not always possible because some data are not pertinent to all organs.

Graphical presentation of the data is emphasized: more than 600 figures (including any maps) and tables are included in the chapters. They may be copied and pasted from the HTML files into slides.

Maps in this report present data divided into quintiles. Figure 1 is a sample map.

Maps by donation service area (DSA) use DSA boundaries in effect at the beginning of 2021, after the merger of LifeChoice Donor Services and New England Organ Bank. Some

Pretransplant mortality rates among adults waitlisted for liver transplant in 2021 by DSA



OPTN/SRTR 2021 Annual Data Report

Figure 1: Example map. In this example, about one-fifth of all data points have a value above 18.2. Ranges include the number at the lower end of the range and exclude that at the upper end (eg, the second range here is 9.3 to <12.4). Numbers in the first and last boxes are the minimum and maximum of observed data.

DSAs include noncontiguous areas. If a DSA has no transplant program for a given organ or no listings during the map's timeframe, it is labeled "No data" on the map and shaded accordingly.

2 MILESTONE DATES IN THE PRODUCTION OF THIS REPORT

Data were cut: July 2022.

Data were analyzed: July 2022.

3 METHODS

cPRA

For recipients of kidney and pancreas transplants performed on January 1, 2010, or later, panel-reactive antibody (PRA) at the time of transplant is the calculated PRA (cPRA) value.

For recipients of heart transplants performed from January 1, 2010, through March 30, 2015, PRA at the time of transplant is the minimum value between the most recently recorded PRA and the peak PRA. For recipients of heart transplants performed on March 31, 2015, or later, the cPRA value was used at the time of transplant. If that value is missing, we use the peak cPRA value known at the time of transplant.

Heart status groups
Starting on October 18, 2018, adult candidates were allocated hearts based on status groups 1-6. Status 1 candidates have the highest waitlist mortality risk and status 6 the lowest. Before that date, candidates were allocated hearts based on status groups 1A (highest priority), 1B, and 2.

Incidence
Cumulative incidence of posttransplant outcomes (diabetes, posttransplant lymphoproliferative disorder, and acute rejection) are computed using survival methods.

Graft failure
Unless otherwise specified, "graft failure" refers to graft failure from any cause, including death and retransplant. For kidney failure, this also includes return to maintenance dialysis. "Graft survival" similarly refers to the absence of all-cause graft failure.

Patient survival
Posttransplant patient survival is not censored at graft failure. Thus, patient survival includes follow-up after graft failure, retransplant, and return to maintenance dialysis in the case of kidney recipients.

Transplant rates
Transplant rates include all waiting time (ie, active and inactive) in the interval described.

Pretransplant mortality
Pretransplant mortality rates include all waiting time, and patients are followed until the earliest date of transplant, death, transfer to another program, removal from the waiting list due to improved condition, or cohort censor date. Because we continue to follow candidates for death outcomes beyond removal (except removal due to improved condition), we do not include removal due to deteriorated condition as part of a combined outcome.

Rates by subgroup
When rates are shown by subgroup (ie, sex, race, or primary cause of disease), the numerator and denominator are computed exclusively within those groups. For example, for pretransplant mortality by race, the numerator for each race is the number of deaths

in that group during the interval described. The denominator is the total waiting time within each race group in that same time interval. When a characteristic is subject to change over time (eg, model for end-stage liver disease [MELD], PRA), it is assessed at the earliest of transplant, death, removal, or December 31 of the year, and a candidate contributes waiting time and outcome only at that level. For example, age is assessed only once a year; therefore, a candidate contributes all of his or her waiting time to a single age category in a given yearly rate calculation but may change age categories over time. For example, a waitlisted candidate who was 34 years old on December 31, 2012, would be included in the 18- to 34-year age group in 2012, but if that candidate were still listed in 2014, he or she would be included in the 35- to 49-year age group.

Donor risk index

The kidney donor risk index (KDRI) and pancreas donor risk index (PDRI) are measures of donor quality based on donor factors.

$$
\begin{aligned}
\text{KDRI}^1 = \exp(&-0.0194 \times [\text{if age} < 18\text{yrs}] \times [\text{age} - 18\text{yrs}] + \\
&0.0128 \times [\text{age} - 40\text{yrs}] + \\
&0.0107 \times [\text{if age} > 50\text{yrs}] \times [\text{age} - 50\text{yrs}] + \\
&0.179 \times [\text{if African-American race}] + \\
&0.126 \times [\text{if hypertensive}] + \\
&0.130 \times [\text{if diabetic}] + \\
&0.220 \times [\text{serum creatitine} - 1\text{mg/dL}] - \\
&0.209 \times [\text{if serum creatinine} > 1.5\text{mg/dL}] \times [\text{serum creatinine} - 1.5\text{mg/dL}] + \\
&0.0881 \times [\text{if cause of death = cerebrovascular accident}] - \\
&0.0464 \times [(\text{height} - 170\text{cm})/10] - \\
&0.0199 \times [\text{if weight} < 80\text{kg}] \times [(\text{weight} - 80\text{kg})/5] + \\
&0.133 \times [\text{if DCD}] + \\
&0.240 \times [\text{if HCV+}])
\end{aligned}
$$

$$
\begin{aligned}
\text{PDRI}^2 = \exp(&-0.1379 \times [\text{if female}] - \\
&0.03446 \times [\text{if age} < 20\text{yrs}] \times [\text{age} - 20\text{yrs}] + \\
&0.02615 \times [\text{age} - 28\text{yrs}] + \\
&0.1949 \times [\text{if creatinine} > 2.5\text{mg/dL}] + \\
&0.2395 \times [\text{if African-American}] + \\
&0.1571 \times [\text{if Asian}] - \\
&0.0009863 \times [\text{BMI} - 24] + \\
&0.03327 \times [\text{if BMI} > 25] \times [\text{BMI} - 25] - \\
&0.006074 \times [\text{height} - 173\text{cm}] + \\
&0.2102 \times [\text{if cause of death = cerebrovascular accident}] + \\
&0.3317 \times [\text{if DCD}])
\end{aligned}
$$

[1] Rao PS, Schaubel DE, Guidinger MK, Andreoni KA, Wolfe RA, Merion RM, Port FK, Sung RS. A comprehensive risk quantification score for deceased donor kidneys: the kidney donor risk index. *Transplantation*. 2009;88(2):231-236. doi:10.1097/TP.0b013e3181ac620b

[2] Axelrod DA, Sung RS, Meyer KH, Wolfe RA, Kaufman DB. Systematic evalua-

tion of pancreas allograft quality, outcomes and geographic variation in utilization. *Am J Transplant*. 2010;10:837-845. doi:10.1111/j.1600-6143.2009.02996.x

Complete versions of these indices also include transplant factors, but the donor-specific indices in this report are limited to donor-specific factors. Conversion of KDRI to a cumulative percentage scale (ie, KDPI) is done using the OPTN KDPI Mapping Tables. For donors with organs recovered January through May, the cohort 2 years prior was used to assign KDPI; for donors with organs recovered June through December, the cohort 1 year prior was used to assign KDPI. Kidneys recovered en bloc were counted once.

4 NOTES

Population reported

Figure titles indicate adult or pediatric populations; if not specified, data include patients of all ages. In the past, lung data included patients aged 12 years or older with adults, and figure titles specified the age ranges. Since the 2019 report, we have classified all lung patients aged 18 years or older as adults and younger patients as pediatrics.

Unless otherwise specified, data in each organ-specific chapter include both isolated transplants and multiorgan transplants of the given type. For example, patients on the kidney transplant waiting list include those listed for an isolated kidney, kidney-pancreas, or any other organ combination that includes kidney.

Waitlist populations are no longer reported at the person level. If a patient is listed at more than one center, that patient is counted once per listing.

Age

Adult patients are defined as those aged 18 years or older for all organs. For waitlist figures, age is defined at the time of first listing, unless otherwise specified.

Race and ethnicity

Multiracial patients are defined as other/unknown. When a given race is not shown, it is included with other/unknown.

Pancreas data

Pancreas data encompass the three types of pancreas waiting lists or transplants: simultaneous kidney-pancreas, pancreas after kidney, and pancreas transplant alone (ie, without kidney). Pancreata used for islet transplant are excluded.

MELD score
MELD scores shown in figures and tables are calculated MELD scores, not allocation MELD scores, unless otherwise specified.

Metropolitan and non-metropolitan designation
Many data are displayed by the designation of a candidate's or recipient's permanent zip code as metropolitan or non-metropolitan. We used rural-urban commuting area (RUCA) codes and defined metropolitan, micropolitan, small town, and rural areas. These were then collapsed into metropolitan areas, which include suburbs adjacent to major cities, and non-metropolitan, which include cities, towns, and rural areas of fewer than 50,000 people.

5 DATA REQUESTS

Requests for data can be made to SRTR at http://www.srtr.org or to OPTN at http://optn.transplant.hrsa.gov.

6 WEBSITES

http://www.srtr.org is a public website containing transplant program-specific reports, organ procurement organization (OPO)–specific reports, summary tables, archives of past reports, timelines for future reports, risk-adjustment models, methods, basic references for researchers who use SRTR data files, links to current and past Annual Data Reports and their supporting documentation and data tables, answers to frequently asked questions, and other information.

https://securesrtr.transplant.hrsa.gov is a secure website that provides access to the prerelease program- and OPO-specific reports, survival spreadsheets, and other useful information. All individual authorized users from transplant programs and OPOs have their own unique logins.

http://unos.org is a public website containing information on donation and transplant, data collection instruments, data reports, education materials for patients and transplant professionals, policy development, and other information. This website also links to the OPTN website.

http://optn.transplant.hrsa.gov is a public website containing news, information, and resources about transplant and donation, including transplant data reports, policy development, and related boards and committees. It also contains allocation calculators, a calendar of events, answers to frequently asked questions, and other information.

7 CONTACT INFORMATION

Research Inquiries
SRTR data requests: 877-970-7787 (toll free); srtr@srtr.org (email)

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Rockville, MD 20857
301-443-7577

8 COMMONLY USED ABBREVIATIONS IN THIS REPORT

BMI	body mass index
CAKUT	congenital anomalies of the kidney and urinary tract
CAS	composite allocation score
CDC	Centers for Disease Control and Prevention
CDRG	Chronic Disease Research Group
CKD	cystic kidney disease
CMV	cytomegalovirus
COPD	chronic obstructive pulmonary disease
COVID-19	coronavirus disease 2019
cPRA	calculated panel-reactive antibody
DBD	donation after brain death
DCD	donation after circulatory death
DD	deceased donor
DM	diabetes mellitus
DOD	deceased organ donation
DoT	Division of Transplantation
DSA	donation service area
EBV	Epstein-Barr virus
ECD	expanded criteria donor

ECMO	extracorporeal membrane oxygenation
ESRD	end-stage renal disease
eGFR	estimated glomerular filtration rate
FSGS	focal segmental glomerulosclerosis
GN	glomerulonephritis
HHS	US Department of Health and Human Services
HIV	human immunodeficiency virus
HLA	human leukocyte antigen
HMO	health maintenance organization
HRSA	Health Resources and Services Administration
HSB	Healthcare Systems Bureau
HTN	hypertension
ICU	intensive care unit
KAS	kidney allocation system
KDPI	kidney donor profile index
KDRI	kidney donor risk index
LAS	lung allocation score
LD	living donor
LVAD	left ventricular assist device
MELD	model for end-stage liver disease
mTOR	mammalian target of rapamycin
OPO	organ procurement organization
OPTN	Organ Procurement and Transplantation Network
ORPD	organs recovered per donor
OTPD	organs transplanted per donor
PAK	pancreas-after-kidney transplant
PELD	pediatric end-stage liver disease
PDRI	pancreas donor risk index
PRA	panel-reactive antibody
PTA	pancreas transplant alone
PTLD	posttransplant lymphoproliferative disorder
SCD	standard criteria donor
SGS	short-gut syndrome
SPK	simultaneous pancreas-kidney transplant
SRTR	Scientific Registry of Transplant Recipients
TAH	total artificial heart

UNOS	United Network for Organ Sharing
VAD	ventricular assist device
VCA	vascularized composite allograft

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OPTN/SRTR 2021 Annual Data Report: Introduction

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Abstract

The *OPTN/SRTR 2021 Annual Data Report* presents the status of the solid organ transplantation system in the United States from 2010 through 2021. Organ-specific chapters are presented for kidney, pancreas, liver, intestine, heart, and lung transplant. Each organ-specific chapter is organized to present waitlist information, donor information (both deceased and living, as appropriate), transplant information, and patient outcomes. Data pertaining to pediatric patients are generally presented separately from the adult data. In addition to the organ-specific chapters, you will find chapters dedicated to deceased organ donation, vascularized composite allograft, and the COVID-19 pandemic. The data presented in the Annual Data Report are descriptive in nature. In other words, most tables and figures present raw data without statistical adjustment for possible confounding or changes over time. Therefore, the reader should keep in mind the observational nature of the data when attempting to draw inferences before trying to ascribe a cause to any observed patterns or trends. This introduction provides a brief overview of trends in waitlist and transplant activity. More detailed descriptions can be found in the respective organ-specific chapters.

Keywords: allocation, transplant, waiting list

1 TRENDS IN KIDNEY TRANSPLANT

In 2021, 141,807 adult and pediatric candidates were on the kidney waiting list at some point (Figure INT 1), an increase of 0.3% from 2020. Notably, however, the size of the kidney waiting list in 2021 was similar to the size in 2020, both down from a high of 146,639 in 2019. The number of new candidates added to the kidney waiting list in 2021 increased to 42,852. This is an 11.4% increase from 38,482 in 2020 (Figure INT 3). The number of kidney transplants also increased in 2021 to 25,487, a 7.8% increase from 2020 (Figure INT 5). Despite these advances, the proportion of kidneys from deceased donors recovered for the purpose of transplant but ultimately not transplanted increased to about 25%, 15.5% higher than in 2020 (Figure INT 7). Among transplant recipients from 2014 through 2016, 1-year patient survival was 97.2% and 5-year patient survival was 88.2% (Figure INT 8).

2 TRENDS IN PANCREAS TRANSPLANT

The demand for pancreas transplant has continued to decline, likely due to improvements in the medical treatment of diabetes. Since 2010, the number of candidates on the waiting list for pancreas-alone or pancreas-after-kidney transplant has generally declined, from 1,950 in 2010 to 1,026 in 2021. The only increase occurred in 2021 after a low of 999 in 2020, likely due to the COVID-19 pandemic (Figure INT 2). The number of candidates waiting for a combined kidney-pancreas transplant declined from 3,794 in 2010 to 3,211 in 2021, with declines in all but 2 years: 2019 and 2021. Trends were similar in the number of new additions to the pancreas transplant waiting list, with declines to 317 for pancreas-alone and pancreas-after-kidney in 2021 and 1,488 for simultaneous kidney-pancreas (Figure INT 4). The total number of pancreas transplants performed in the United States was 963 in 2021, almost the same as the 962 in 2020; this represents a 5.1% decline from 2019 (Figure INT 6). Patient survival after pancreas transplant is similar to that after kidney transplant and higher than that for all other organs. In the cohort of recipients from 2014 through 2016, 1-year patient survival was 95.8% and 5-year patient survival was 88.8% (Figure INT 8).

3 TRENDS IN LIVER TRANSPLANT

The number of adult and pediatric candidates on the liver waiting list has remained fairly consistent since 2010, ranging from a high of 28,622 in 2011 to a low of 26,004 in 2021 (Figure INT 1). The year 2021 marked the fifth consecutive year of declines in the liver waiting list. Although the total number of candidates on the liver waiting list has been slowly declining in recent years, the number of additions to it has been generally increasing since 2014 (Figure INT 3). In 2021, 13,831 candidates were added to the waiting list, a 6.2% increase over the previous year. The number of transplants increased to 9,234 in 2021, a 3.7% increase from 2020 (Figure INT 5). The proportion of livers recovered for transplant but not transplanted was 10.0% in 2021 (Figure INT 7). Recipient survival from 2014 through 2016 was 91.7% at 1 year and 81.7% at 5 years (Figure INT 8).

4 TRENDS IN INTESTINE TRANSPLANT

In 2021, 364 candidates were on the waiting list for an intestine transplant for at least 1 day (Figure INT 2) and 143 new candidates were added to the intestine waiting list (Figure INT 4). The number of intestine transplants remained small, with 96 performed in 2021 (Figure INT 6). This represents a 36% decline in yearly intestine transplants since 2010. Among intestine transplant recipients from 2014 through 2016, 1-year survival was 81.0% and 5-year survival was 59.7% (Figure INT 8).

5 TRENDS IN HEART TRANSPLANT

The first full year of the new heart allocation system, which incorporates six medical urgency statuses rather than the previous three-tier system, was 2019. In 2021, there were 8,665 candidates on the heart waiting list for at least 1 day, which is similar to the count in 2019 (8,650 candidates) (Figure INT 2). Of these patients, 5,076 were newly added to the list in 2021 (Figure INT 2). The number of heart transplants performed in 2021 reached a record high of 3,862, a 4.0% increase over 2020 (Figure INT 6). Among the cohort of recipients from 2014 through 2016, 1-year patient survival was 91.1% and 5-year survival was 81.0% (Figure INT 8).

6 TRENDS IN LUNG TRANSPLANT

The year 2021 saw 2,569 lung transplants performed (Figure INT 6) among 4,186 patients who were on the waiting list at some point (Figure INT 2). New listings in 2021 accounted for 3,158 of the 4,186 candidates on the list (Figure INT 4). The 2,569 lung transplants performed in 2021 was a 6.8% decrease from the record high of 2,759 in 2019. Among recipients from 2014 through 2016, 1-year survival was 87.8% and 5-year survival was 60.5% (Figure INT 8).

7 SUMMARY

The year 2021 set another record for the number of solid organ transplants performed in the United States. Since 2010, the number of kidney transplants has increased by 44%; liver transplants, by 47%; heart transplants, by 63%; and lung transplants, by 42%.

During the same period, there was a decline for pancreas and intestine transplants of 18% and 36%, respectively. The number of newly listed candidates increased in 2021 compared with 2020 for kidney, pancreas, liver, lung, and heart transplants. This is a sign of recovery from the COVID-19 pandemic. The waitlist additions outpace the number of transplants performed for all organs, which exemplifies the supply-demand imbalance in solid organ transplantation. Each organ-specific chapter of this Annual Data Report presents a more detailed look at the status of organ donation and transplantation in the United States.

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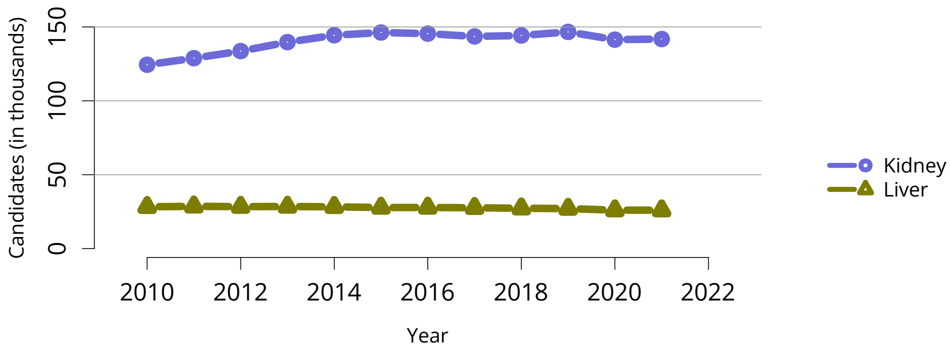

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Figure INT 1: All candidates on the kidney or liver waiting list. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time during the year.

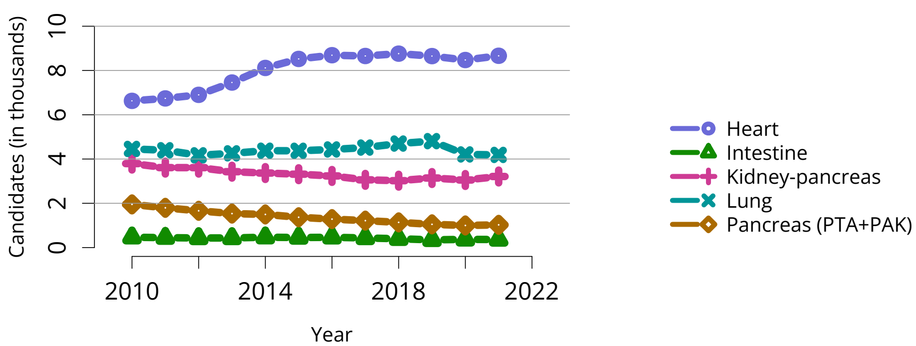

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Figure INT 2: All candidates on the waiting list for organs other than isolated kidney or liver. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time during the year. PAK, pancreas after kidney; PTA, pancreas transplant alone.

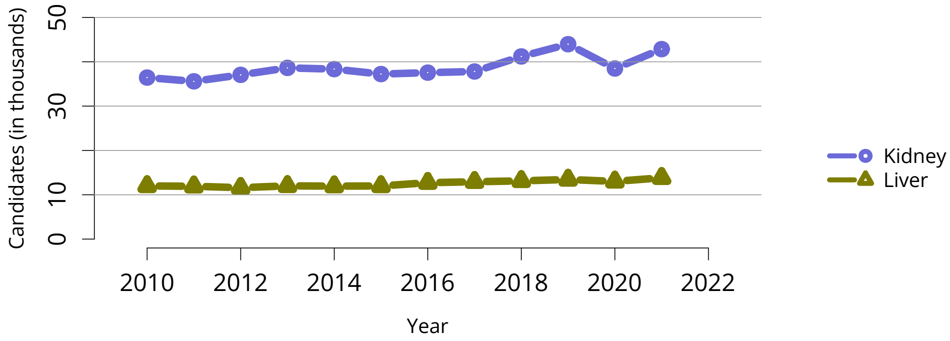

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Figure INT 3: New candidates added to the kidney or liver waiting list during the year. A new candidate is one who first joined the list during the given year, without having been listed in a previous year. Previously listed candidates who underwent transplant and subsequently relisted are considered new. Active and inactive patients are included.

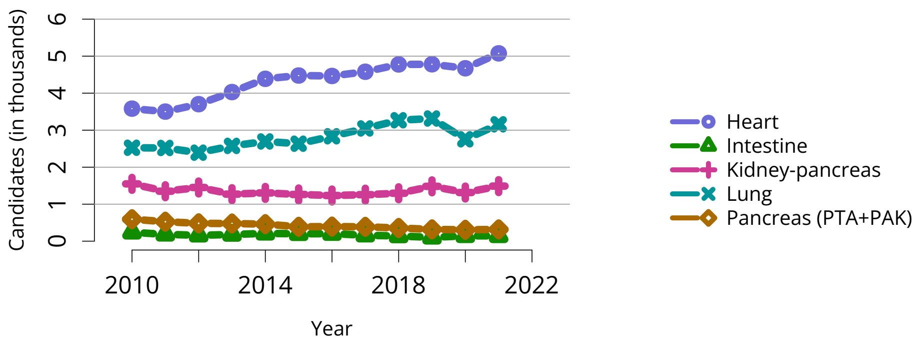

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Figure INT 4: New candidates added to the waiting list during the year for organs other than isolated kidney or liver. A new candidate is one who first joined the list during the given year, without having been listed in a previous year. Previously listed candidates who underwent transplant and subsequently relisted are considered new. Active and inactive patients are included.

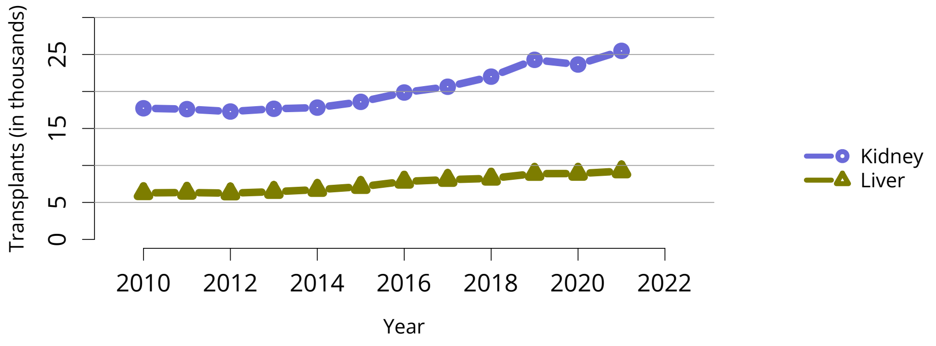

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Figure INT 5: Total counts of kidney or liver transplants. Kidney: patients undergoing kidney or SPK transplant. Retransplants and multiorgan transplants are included. SPK, simultaneous pancreas-kidney.

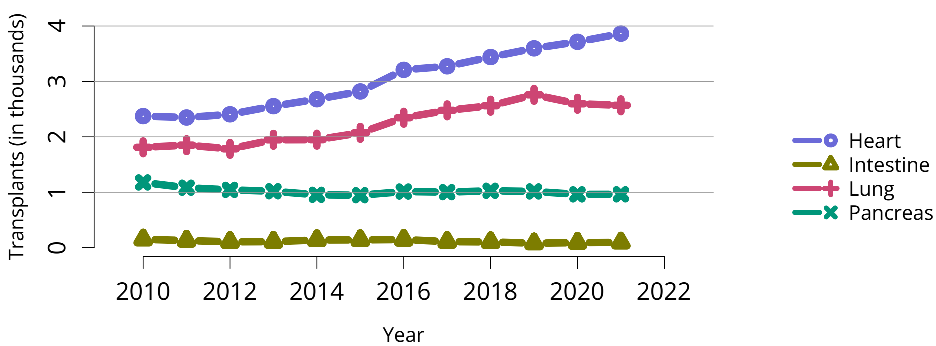

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Figure INT 6: Total counts of transplants for organs other than isolated kidney or liver. Pancreas: patients undergoing pancreas or SPK transplant. Heart: patients undergoing heart or heart-lung transplant. Lung: patients undergoing lung or heart-lung transplant. Retransplants and multiorgan transplants are included. SPK, simultaneous pancreas-kidney.

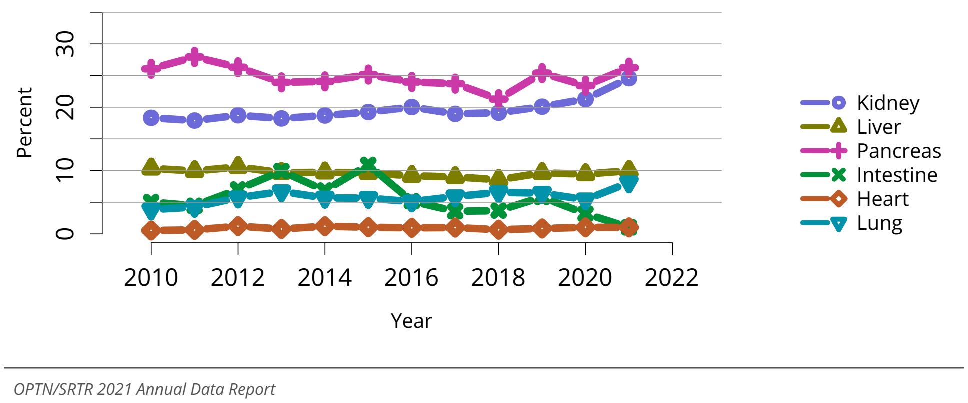

Figure INT 7: Rates of organs recovered for transplant and not transplanted. Percentage of organs not transplanted out of all organs recovered for transplant. Kidneys and lungs recovered en bloc are counted once, and those recovered separately are counted twice.

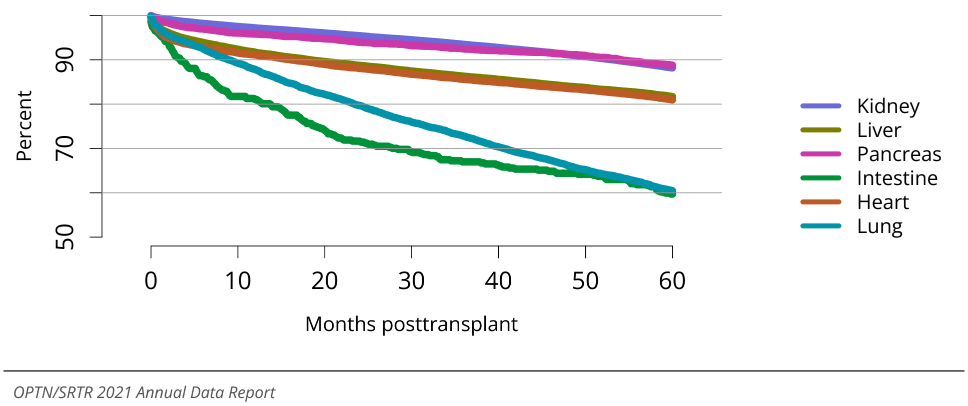

Figure INT 8: Patient survival among all transplant recipients, 2014-2016, by organ. Patient survival estimated using unadjusted Kaplan-Meier methods. Similar overall survival rates for kidney and pancreas recipients may obscure one organ's line on the graph.

OPTN/SRTR 2021 Annual Data Report: Kidney

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Abstract

The year 2021 marked both successes and challenges for the field of kidney transplantation, in the context of the ongoing COVID-19 pandemic and broader geographic organ distribution. The total number of kidney transplants in the United States reached a record count of 25,487, driven by growth in deceased donor kidney transplants. The total number of candidates listed for deceased donor kidney transplant rose slightly in 2021 but remained below 2019 listing levels, with nearly 10% of candidates having been waiting 5 years or longer. Pretransplant mortality declined slightly among candidates of Black, Hispanic, and other races, in parallel with increasing numbers of Black and Hispanic transplant recipients. In the context of broader organ sharing, there is growing disparity in pretransplant mortality among non-metropolitan compared with metropolitan residents. The proportion of deceased donor kidneys recovered but not used for transplant (nonuse rate) rose to a high of 24.6% overall, with greater nonuse among biopsied kidneys (35.9%), kidneys from donors aged 55 years or older (51.1%), and kidneys with kidney donor profile index (KDPI) of 85% or greater

(66.6%). Nonuse of kidneys from donors who are hepatitis C virus (HCV) antibody positive only slightly exceeded that of HCV antibody–negative donors. Disparities in access to living donor kidney transplant persists, especially for non-White and publicly insured patients. Delayed graft function continues an upward trend and occurred in 24% of adult kidney transplants in 2021. Five-year graft survival after living compared with deceased donor transplant was 88.6% versus 80.7% for recipients aged 18-34 years, and 82.1% versus 68.0% for recipients aged 65 years or older. The total number of pediatric kidney transplants performed increased to 820 in 2021, the highest number since 2010. Despite numerous efforts, living donor kidney transplant remains low among pediatric recipients, with continued racial disparities. The rate of deceased donor transplants among pediatric candidates recovered in 2021 from a low in 2020. Congenital anomalies of the kidney and urinary tract remain the leading primary kidney disease diagnosis among pediatric candidates. Most pediatric deceased donor recipients receive a kidney from a donor with KDPI less than 35%. Graft survival continues to improve, with superior outcomes for living donor transplant recipients.

Keywords: Kidney transplant, transplant outcomes, waiting list outcomes

1 INTRODUCTION

Kidney transplant provides eligible patients with end-stage kidney disease the best opportunity for long-term, dialysis-free survival at lowest cost to the health care system, but maximizing transplant access, reducing access disparities, and optimizing long-term allograft survival are ongoing challenges. A national urgency to increase access to kidney transplant received unprecedented attention from the federal government in the July 2019 Executive Order "Advancing American Kidney Health"[1] and is an ongoing focus area in regulatory and legislative actions and proposals. The COVID-19 pandemic profoundly affected kidney transplant practices since the declaration of a public health emergency in March 2020, including living donor transplant rates, organ use rates from deceased donors, and waitlist and posttransplant mortality rates. Changes in kidney distribution from locally prioritized allocation to broader geographic sharing in March 2021 (KAS250) were followed by notable increases in cold ischemia times and delayed graft function. The Annual Data Report is an opportunity to assess the state of kidney transplantation and examine successes along with concerning trends that warrant further monitoring and evaluation. Data on adult and pediatric kidney transplant waiting lists, deceased and living donation, transplants, and outcomes are provided.

2 ADULT KIDNEY TRANSPLANT

2.1 Waiting List

The number of adult candidates added to the kidney waiting list during the year 2021 rose to 41,765, recovering from the pandemic-related decline to 37,399 in 2020, and returning to waitlist addition rates similar to those in 2018-2019 (Figure KI 1). The total number of adult candidates listed for kidney transplant (including those listed at more than one center) rose slightly to 139,025, compared with 138,761 in 2020, but remained below the 144,060 candidates listed in 2019, prior to the COVID-19 pandemic (Figure KI 2). Amidst the ongoing COVID-19 pandemic, in 2021, there were 5,011 waitlist removals due to death, reflecting a slight decline from 5,105 removals due to death in 2020; however, the 4,056 waitlist removals due to being too sick for transplant in 2021 reflects a slight increase from 3,908 in 2020 (Table KI 5). The trend of a gradual increase in the age of candidates on the waiting list over the past 10 years persisted (Figure KI 3). Candidates aged 50-64 years at listing remained the largest age group (42.5% of listed candidates), while the proportion of candidates aged 65 years or older rose slightly to a high of 25.7% (Figure KI 3). The sex distribution of the waiting list was largely unchanged, with men making up 62.0% of kidney candidates (Figure KI 4). Since 2010, the proportion of Asian and Hispanic candidates on the kidney waiting list has gradually increased, accompanied by a decline in the proportion of White candidates, but the distribution in 2021 was stable compared with 2020 (Figure KI 5). The distribution of primary kidney failure diagnoses was stable in 2021, with diabetes (38.3%) and hypertension (20.5%) as the most common identified causes (Figure KI 6).

The proportion of candidates prevalent on the waiting list with waiting time less than 1 year rose to 34.2% in 2021 from 31.4% in 2020 and 33.9% in 2019, while 13.6% on the waiting list at some point in 2021 have been waiting 5 years or longer, a proportion that has been decreasing in recent years (Figure KI 7). The proportion of waitlisted candidates with high body mass index (BMI) also continued to increase slightly in 2021, with 27.6% having a BMI of 30-<35 kg/m^2 and 18.4% having a BMI of 35 kg/m^2 or greater (Figure KI 8). Encouragingly, the proportion of candidates waitlisted before starting dialysis continued to increase, reaching 22.7% in 2021, although 16.7% of those waitlisted had been on dialysis for 6 or more years (Figure KI 9). More than half of waitlisted kidney candidates had blood type O (Figure KI 10). The proportion of candidates with a previous transplant was 11.3% in 2021, reflecting a gradual decline from 15.3% in 2010 (Figure KI 11).

The proportion of candidates willing to accept a kidney with a high kidney donor profile index (KDPI) declined in all age groups in 2021 compared with 2020, continuing a decline after implementation of the revised kidney allocation system (KAS) in December 2014 (Figure KI 12). Half of candidates aged 50-64 years and less than two-thirds of candidates aged 65 years or older were willing to accept these kidneys (Figure KI 12), even though patients aged 50 years and older are less likely than younger patients to undergo kidney transplant under the current KAS (Figure KI 15). Conversely, the proportion of candidates willing to accept a kidney from a donor who is hepatitis C virus (HCV) antibody positive continues to increase sharply, to 40.6% in 2021, correlating with availability of highly effective direct-acting antiviral (DAA) agents and experience using DAA regimens to manage anticipated donor-derived infections (Figure KI 13). To date, the information on willingness to accept HCV-positive kidneys does not differentiate between donor HCV antibody (exposed) and nucleic acid (viremic) status.

Deceased donor kidney transplant (DDKT) rates among adult waitlisted candidates continued to increase in 2021, after a nadir in 2014 (Figure KI 14). Increased rates were noted across all age groups (Figure KI 15) and primary kidney disease diagnosis groups (Figure KI 17). DDKT rates declined slightly among White candidates in 2021, but rose for all other racial and ethnic groups, especially among Black and Hispanic candidates, such that Black candidates had the highest DDKT rate among racial groups in 2021 (20.8 per 100 patient-years) (Figure KI 16). DDKT rates among patients with calculated panel-reactive antibody (cPRA) levels of 98%-100% rose slightly in 2021 compared with 2020, similar to the rate following the 2014 KAS revision (Figure KI 18). Following the March 2021 (KAS250) changes in organ distribution policy, the DDKT rate for patients with cPRA levels of 80%-<98% rose sharply in 2021 compared with 2020, to 31.0 transplants per 100 patient-years, compared with 16.1 to 19.8 DDKT per 100 patient-years in the other cPRA groups (Figure KI 18). While patients with type AB blood type continued to have the highest DDKT rate, the rate in this group declined slightly in 2021 while rising in other blood type groups (Figure KI 19); these patterns may in part reflect the 2014 revised KAS allowing allocation of A2 and A2B kidneys to B candidates. In 2021, DDKT rates increased across the range of waiting times, especially among those on the waiting list 5 years or longer (Figure KI 20). DDKT rates were similar between men and women in 2021 (Figure KI 21). After the March 2021 KAS250 changes in organ distribution policy and broader sharing, DDKT rates rose in residents of metropolitan areas but declined slightly among non-metropolitan residents, to reach similar rates of 19.4 and 20.4 per 100 patient-years, respectively (Figure KI 22).

For patients waitlisted in 2016-2018, 33.0% were still waiting in 2021 (3 years after listing); 27.1% had undergone DDKT, 14.3% had undergone living donor kidney transplant (LDKT), 6.2% had died, and 19.4% were removed from the waiting list (Figure KI 23). The proportion of patients who underwent DDKT within 3 months rose to a high of 10.6% among those listed in 2020, while the percentage who underwent DDKT within 3 years also continued to rise (Figure KI 24).

Pretransplant mortality rose slightly in 2021 to 6.0 deaths per 100 patient-years, the highest value since 2010 (Figure KI 25), with similar increases across diagnosis groups (Figure KI 29). Pretransplant mortality rose among men but declined slightly among women (Figure KI 28). Considered by candidate age, pretransplant mortality increased among candidates aged 18-34 years, but remained relatively stable in adults aged 35-64 years and older (Figure KI 26). While pretransplant mortality rates rose among White and Asian candidates in 2021, pretransplant mortality rates declined slightly among candidates of Black, Hispanic, and other races (Figure KI 27). Considered by blood type, pretransplant mortality was lowest for those with type AB, the group with the highest DDKT rate (Figure KI 30). Pretransplant mortality continued to vary greatly by donation service area, from 3.0 to 8.5 deaths per 100 patient-years (Figure KI 32), and there was a growing disparity in pretransplant mortality among non-metropolitan compared with metropolitan residents (Figure KI 31).

Death within 6 months of removal from the waiting list (for waitlist removal reasons other than transplant) was stable in 2021 compared with 2020 (Figure KI 33). Considered by diagnosis group, mortality after waitlist removal increased for those with hypertension and other/unknown causes, was stable in those with diabetes, and declined in those with cystic kidney disease or glomerulonephritis (Figure KI 34). By age, death within 6 months of waitlist removal rose for candidates aged 35-64 years, while remaining stable in younger candidates and declining in older candidates (Figure KI 35).

2.2 Deceased Donation

The counts of deceased donors from whom at least one kidney was recovered continued to increase in 2021 (Figure KI 36), particularly among donors aged 30 years and older (Figure KI 37). The counts of HCV-positive deceased donors from whom kidneys were recovered also rose in 2021 (Figure KI 38), although the proportion was slightly lower compared to in 2020 at 10.2% (Figure KI 42). The racial and ethnic distribution of deceased kidney donors remained largely unchanged over the past decade (Figure KI 41), while the proportion of male deceased donors trended slightly higher over the past 2 years (Figure KI 40). In 2021, the proportion of deceased kidney donors aged 18-39 years declined slightly and those younger than 18 years remained stable, while deceased kidney donation rose for donors aged 40 years and older (Figure KI 39). The proportion of kidneys recovered from patients who died of anoxia continued to rise slightly in 2021 (Figure KI 43), amid the opioid epidemic.

The proportion of deceased donor kidneys recovered but not transplanted (nonuse rate) rose to a high of 24.6% in 2021 compared with 17.9% in 2011, in the context of the COVID-19 pandemic and broader geographic organ distribution (Figure KI 44). Nonuse rates were highest for kidneys recovered from donors aged 55 years or older, reaching 51.1% in 2021 (Figure KI 45). The nonuse rate was also higher in kidneys recovered from donors with diabetes, hypertension, or elevated BMI (Figures KI 46, 49, and 50). Racial disparity in kidney nonuse has diminished since 2016, although this is a result of increased nonuse of kidneys from White donors in 2021, rather than lower nonuse of kidneys from non-White donors (Figure KI 48). Recovered kidneys from which biopsies were obtained continued to have rising nonuse rates, up to 35.9% in 2021 (Figure KI 52). The proportion of nonused kidneys recovered from HCV antibody–positive donors declined sharply from 2016 to 2020, but increased to 28.3% in 2021 (Figure KI 54). A lower proportion of kidneys from donors with increased infection risk as defined by the US Public Health Service guidelines were recovered for transplant but not transplanted than those from donors with standard infection risk in 2021 (18.9% vs 25.9%) (Figure KI 55), perhaps because kidneys with increased infection risk are often from younger donors,[2] and otherwise of high quality with low KDPI. In 2021, the nonuse rate of kidneys with KDPI of 85% or greater reached a high of 66.6% (Figure KI 57), while the nonuse rate of kidneys from donation after circulatory death (DCD) donors rose to 29.8% (Figure KI 56).

2.3 Living Donation

Following a rise in the number of LDKTs from 2017 up to 6,855 in 2019, LKDTs decreased to 5,226 in 2020 during the COVID-19 pandemic, followed by partial recovery to 5,949 in 2021 with more widespread access to testing and use of vaccination (Figure KI 58). The largest increases in LDKT in 2021 compared with 2020 occurred among related and paired donors, while spousal donations declined (Figure KI 58). Of note, only a small proportion of the waiting list receives LDKTs each year, despite Health Resources and Services Administration initiatives to reduce financial barriers to living donation and Centers for Medicare & Medicaid Services initiatives to encourage early LDKT.[1,3,4]

In 2021, the proportion of living donors aged 55 years or older declined slightly and the proportion aged 30-39 years rose slightly, while living donors aged 40-54 years continued to make up the most common age group (Figure KI 59). In 2021, the proportion of living kidney donors who were women remained stably high, at 64.6% (Figure KI 60). The racial and ethnic composition of living donors in 2021 was relatively stable compared with 2020, with 70.1% White, 15.3% Hispanic, and 8.0% Black (Figure KI 61). Notably, this reflects a general decline in the proportion of Black living donors, from 12.0% in 2010 (Figure KI 61). The proportion of living donors who were obese, based on BMI > 30 kg/m^2, increased slightly to 23.8% (Figure KI 63). Most donation surgeries began as laparoscopic hand assisted (62.1%) or pure laparoscopy (36.8%) (Figure KI 62).

2.4 Transplants

The upward trajectory in total kidney transplants was modestly slowed by the COVID-19 pandemic in 2020, then continued to rise in 2021, reaching a high of 25,487 (Figure KI 64). This trend was driven by growth in DDKT, which rose to 19,517 (Figure KI 65), predominantly from donors with KDPI < 85%. In 2021, the proportion of DDKTs classified as KDPI <20% increased slightly to 23.8%, while proportions in other KDPI levels showed slight declines, with less than 7.0% of DDKTs from donors with KDPI of 85% or greater (Figure KI 70). Distributions of total kidney transplants in 2021 were similar to 2020 distributions across recipient age, sex, and cause of kidney disease groups (Figures KI 66, 67, and 69), while kidney transplant counts increased more among Black and Hispanic recipients compared with other racial and ethnic groups (Figure KI 68). In 2021, 89.3% of DDKTs and 91.7% of LDKTs were performed in first-time recipients (Table KI 8).

Disparities in access to LDKT persist. While 32.0% of waitlisted candidates as of December 31, 2021, were Black (Table KI 1), Black patients constituted only 13.5% of LDKT recipients, versus 34.1% of DDKT recipients in 2021 (Table KI 6). White patients made up 35.8% of the waiting list (Table KI 1), while 61.8% of LDKT recipients and 36.0% of DDKT recipients were White (Table KI 6). Most LDKT recipients (55.4%) had private insurance at the time of transplant, compared with 24.9% of DDKT recipients (Table KI 6); 64.7% of DDKT recipients were Medicare beneficiaries (Table KI 6). LDKT recipients tended to have less dialysis time and lower cPRA levels than DDKT recipients (Table KI 7). Proportions of metropolitan and non-metropolitan place of residence and distance from transplant centers were similar among DDKT and LDKT recipients (Table KI 6) and similar to the proportions of these characteristics among waitlisted patients on December 31, 2021 (Table KI 1).

Induction immunosuppression was used in 91.3% of kidney transplants in 2021, a stable proportion compared with 2020 (Figure KI 71). Most patients received tacrolimus and mycophenolate mofetil (MMF)–based maintenance regimens at discharge, with triple therapy including steroids showing a slight increase to 67.5% in 2021, while use of tacrolimus-MMF (without reported steroid use) declined slightly to 25.6% (Figure KI 72). As noted previously, the proportion of DDKTs in recipients with peak cPRA levels of 98%-100% increased sharply after the 2014 KAS revision and then gradually declined, from 12.5% in 2015 to 6.3% in 2020, and remained stable at 6.4% in 2021 (Figure KI 73). Following the March 2021 KAS250 revision, there was an increase in the proportion of DDKTs in recipients with cPRA of 80%-98%, from 7.0% in 2020 to 10.4% in 2021 (Figure KI 73). By comparison, only 0.8% of LDKT recipients in 2021 had peak cPRA levels of 98%-100%, while most (72.5%) LDKT recipients had peak cPRA levels <1% (Figure KI 74).

2.5 Outcomes

Delayed graft function, defined as dialysis within the first 7 days posttransplant, has trended up over the past decade, occurring in 24% of kidney recipients in 2021 (Figure KI 76). Estimated glomerular filtration rate (eGFR) at 12 months, calculated using the 2021 race-free Chronic Kidney Disease–Epidemiology Collaboration creatinine-based equation, an early surrogate allograft outcome, was 45 mL/min/1.73 m^2 or higher for 64.1% of DDKT recipients in 2020, reflecting a downtrend from 67.8% in 2016 (Figure KI 88). Among LDKT recipients, 80.3% had 12-month eGFR of 45 mL/min/1.73 m^2 or higher in 2020, a slight decline from 82.6% in 2016 (Figure KI 89). For transplants performed in 2020, acute rejection by 1 year was highest in recipients aged 18-34 years at 9.3% and lowest in recipients aged 65 years or older at 5.3% (Figure KI 90). Acute rejection at 1 year occurred in 10.6% of those who received combined interleukin 2 (IL-2) receptor antibody with T-cell–depleting induction, compared with 7.3% who received only IL-2 receptor antibody, 6.4% who received only T-cell–depleting induction, and 6.2% of the small subgroup whose transplants were managed without induction (Figure KI 91).

Among DDKTs, 5-year graft survival was lowest among older (vs younger) recipients, with 68.0% graft survival at 5 years among recipients aged 65 years and older compared with 80.7% graft survival at 5 years among recipients aged 18-34 years (Figure KI 77). Graft survival was also lower among recipients with diabetes as the cause of kidney failure (vs other causes; Figure KI 78), and recipients with BMI of 35 kg/m^2 or higher (vs BMI 18.5 to <25 kg/m^2; Figure KI 82). Five-year DDKT graft survival was 64.0% for allografts with KDPI of 85% or greater, compared with 84.2%, 81.8%, and 76.1% for those with KDPI <20%, KDPI 20%-35%, and KDPI 35%-<85%, respectively (Figure KI 79). Five-year graft survival did not differ for DCD transplants compared with donation after brain death transplants (Figure KI 80). Graft survival was lower after transplant of kidneys that underwent a procurement biopsy (Figure KI 81), although the utility of procurement biopsy in informing appropriate organ use warrants further consideration.[5]

Among LDKTs, 5-year graft survival was 82.1% in recipients aged 65 years or older, compared with 88.6% in recipients aged 18-34 years (Figure KI 84), and was lower in recipients with diabetic kidney failure compared with those with other disease causes (Figure KI 86). Five-year LDKT survival was highest among Asian recipients and lowest among Black recipients and recipients of other races (Figure KI 85). Graft survival was slightly lower in recipients who resided in non-metropolitan compared with metropolitan zip codes (Figures KI 83 and 87).

Trends in adult posttransplant patient survival generally paralleled patterns of graft survival (Figures KI 93, 94, 95, 96, 97, 98, 99, 100, and 101). Five years posttransplant, 72.5% of DDKT recipients and 84.4% of LDKT recipients aged 65 years or older were alive, compared with 95.7% and 97.6% of those aged 18-34 years, respectively (Figures KI 93 and 98). Five-year patient survival was lowest among recipients with diabetes as the cause of kidney disease, at 79.5% for DDKT recipients with diabetes and 87.8% for LDKT recipients with diabetes (Figures KI 94 and 99). Patient survival was also lower among DDKT recipients who received kidneys with KPDI of 85% or greater and grafts that had undergone a procurement biopsy (Figures KI 96 and 97). Patient survival was slightly lower in recipients who resided in non-metropolitan compared with metropolitan zip codes (Figures KI 95 and 101).

3 PEDIATRIC KIDNEY TRANSPLANT

3.1 Waiting List

In 2021, 1,087 pediatric candidates were added to the kidney transplant waiting list (Figure KI 102). The number of prevalent pediatric candidates (listed before age 18 years) continues to increase, reaching 2,782 in 2021 (Figure KI 103). By age, candidates aged 12 years and older accounted for the largest proportion of those waiting, at 67.3%, compared with those aged 6-11 years at 17.7%, 1-5 years at 14.9%, and younger than 1 year at 0.07% (Figure KI 104). In terms of race and ethnicity, White candidates accounted for the largest group (43.0%) on the kidney transplant waiting list followed by Hispanic (28.2%), Black (19.4%), and Asian candidates (5.9%) (Figure KI 105). Over the past decade, the age, sex, and geographic location of transplant candidates have remained largely unchanged (Table KI 11). The proportion of Black candidates decreased since 2011 (Table KI 11). The proportion of candidates with congenital anomalies of the kidney and urinary tract as primary cause of disease continues to increase, from 27.9% in 2011 to 35.9% in 2021, and the proportions with glomerulonephritis and focal segmental glomerulosclerosis decreased (Table KI 12). Most pediatric candidates (69.1%) waiting as of December 31, 2021, had a cPRA level less than 1% (Table KI 12). The proportion of pediatric candidates waiting for retransplant decreased over the past decade from 32.5% in 2011 to 18.1% in 2021 (Table KI 13).

The distribution of waiting time among pediatric candidates on the waiting list has remained similar over the past decade, with almost 50% of pediatric candidates waiting for less than 1 year (Figure KI 108). Of the 1,084 candidates removed from the waiting list in 2021, 692 (63.8%) received a deceased donor kidney, 257 (23.7%) received a living donor kidney, 20 (1.8%) died, 4 (0.3%) were removed from the list because their condition improved, and 9 (0.8%) were considered too sick to undergo transplant (Tables KI 14 and 15). Among patients newly listed from 2016-2018, 50.5% underwent DDKT within 3 years, 25.6% underwent LDKT, 15.9% were still waiting, 7.1% were removed from the list for other reasons, and 0.9% died (Figure KI 110). After declining to its lowest point in 2020, the rate of DDKT among pediatric waitlisted candidates increased to 41.0 transplants per 100 patient-years in 2021 (Figure KI 111). In 2021, transplant rates were highest for candidates aged 12-17 years (56.1 per 100 patient-years), followed by candidates aged 1-5 years (49.9 per 100 patient-years), 6-11 years (43.9 per 100 patient-years), and younger than 1 year (19.1 per 100 patient-years) (Figure KI 112). Transplant rates vary by cPRA, with the highest rates among candidates 20%-<80% (46.7 transplants per 100 patient-years in 2021). The priority for highly sensitized candidates continued to result in higher transplant rates than pre-KAS, remaining steady at approximately 14 transplants per 100 patient-years since 2015 (Figure KI 114). Compared with pretransplant mortality of 6.0 deaths per 100 patient-years among adult kidney transplant candidates (Figure KI 25), pretransplant mortality among pediatric candidates was 1.2 deaths per 100 patient-years in 2021, with little variation by age or race (Figures KI 116, 117, and 118).

3.2 Transplant

The total number of pediatric kidney transplants performed increased to its highest point in the past decade, at 820 transplants in 2021 (Figure KI 120). This increase was driven by an increase in the number of DDKTs as the number of LDKTs remains disappointingly low (Figure KI 121). In 2021, LDKTs accounted for only 28.5% of total transplants among pediatric recipients (Figure KI 121). Children aged 12-17 years made up the largest group of LDKT recipients (45.3%) (Figure KI 123).

In 2021, 36 programs were performing only pediatric kidney transplants, compared with 136 performing only adult transplants and 54 performing transplants in both adults and children (Figure KI 124). Looking at transplant center volume, 14.5% of transplants in candidates aged younger than 18 years were performed at programs with volume of five or fewer pediatric transplants in 2021 (Figure KI 125). Most pediatric recipients who underwent transplant in 2021 were aged 12-17 years, 59.2% among DDKT recipients and, again, 45.3% among LDKT recipients (Table KI 16). The racial and ethnic distribution was notably different for DDKT and LDKT recipients. For LDKT recipients, 69.7% were White, 4.7% were Black, 19.7% were Hispanic, and 3.4% were Asian. In contrast, 36.3% of DDKT recipients were White, 20.8% were Black, 32.9% were Hispanic, and 6.5% were Asian (Table KI 16). Private insurance was more common among LDKT recipients (57.3%) and Medicare/Medicaid among DDKT recipients (60.9%) (Table KI 16). Most DDKT recipients (96.4%) underwent transplant with a kidney from a donor with KDPI less than 35% (Table KI 18). Most pediatric DDKT recipients (82.9%) had four or more HLA mismatches compared with only 29.6% of LDKT recipients (Figure KI 128). Multiorgan transplant remained uncommon; only 2.3% of pediatric candidates received multiorgan transplant in 2021 (Table KI 18).

The combination of a donor who was positive for cytomegalovirus and a pediatric recipient who was negative occurred in 36.7% of DDKTs (Table KI 19) and in 29.1% of LDKTs (Table KI 20). The combination of a donor who was positive for Epstein-Barr virus (EBV) and a pediatric recipient who was negative occurred in 37.6% (Table KI 19) of DDKTs and in 55.5% of LDKTs (Table KI 20).

3.3 Immunosuppressive Medication Use

Almost all (94.0%) pediatric kidney transplant recipients reported some induction use in 2021 (Figure KI 126). The most common maintenance immunosuppression regimens at hospital discharge were tacrolimus, MMF, and steroids in 52.7% of recipients, followed by tacrolimus and MMF in 38.8% (Figure KI 127).

3.4 Outcomes

Graft failure after kidney-alone DDKT in pediatric recipients was 1.8% at 6 months and 2.4% at 1 year for transplants in 2020, 5.4% at 3 years for transplants in 2018, 13.9% at 5 years for transplants in 2016, and 31.9% at 10 years for transplants in 2011 (Figure KI 132). Corresponding graft failure after LDKT was 2.3% at 6 months and 2.7% at 1 year for transplants in 2020, 4.7% at 3 years for transplants in 2018, 4.8% at 5 years for transplants in 2016, and 20.5% at 10 years for transplants in 2011 (Figure KI 133). For the cohort of recipients who underwent transplant in 2014-2016, 1- and 5-year graft survival were 96.9% and 85.2% for DDKT recipients and 97.6% and 93.1% for LDKT recipients, respectively (Figure KI 135). In the 2020 cohort, the overall incidence of acute rejection within the first year ranged from 7.7% among patients aged 6-11 years to 11.3% among patients aged 12-17 years (Figure KI 136). Short-term renal function, measured by eGFR, has remained stable over the past decade. Proportions of LDKT and DDKT recipients from 2020 with eGFR of 60 mL/min/1.73 m^2 or higher at 12 months posttransplant were 69.8% and 72.0%, respectively (Figures KI 131 and 130). Incidence of posttransplant lymphoproliferative disorder among EBV-negative recipients from 2010-2016 was 3.5% at 5 years posttransplant, compared with 0.9% among EBV-positive recipients (Figure KI 137). Overall, 5-year patient survival among pediatric DDKT recipients in 2014-2016 was very high, at 97.0% (Figure KI 139), with little variability by age (Figure KI 140).

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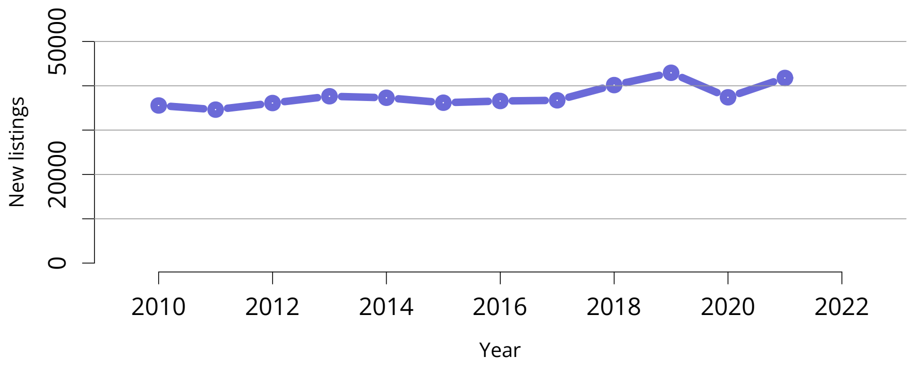
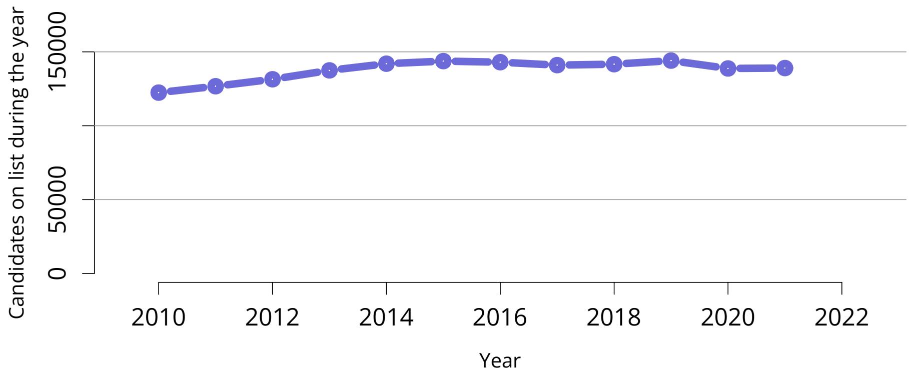


OPTN/SRTR 2021 Annual Data Report

Figure KI 1: New adult candidates added to the kidney transplant waiting list. A new candidate is one who first joined the list during the given year, without having been listed in a previous year. Previously listed candidates who underwent transplant and subsequently relisted are considered new. Active and inactive patients are included. Candidates listed at more than one center are counted once per listing. Includes kidney and kidney-pancreas listings.



OPTN/SRTR 2021 Annual Data Report

Figure KI 2: All adult candidates on the kidney transplant waiting list. Adult candidates on the list at any time during the year. Candidates listed at more than one center are counted once per listing. Includes kidney and kidney-pancreas candidates.

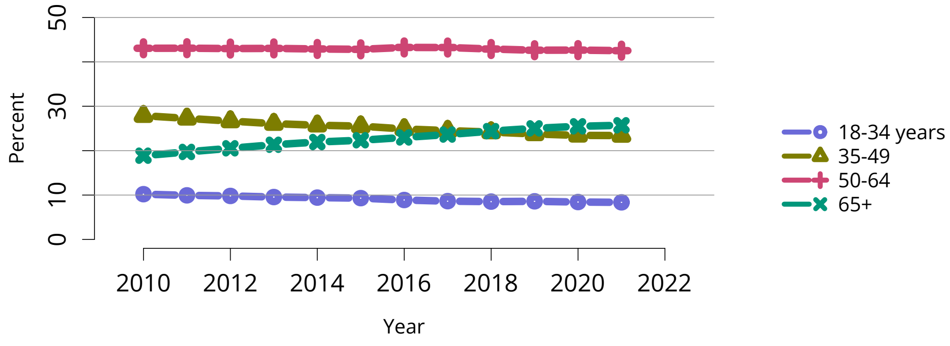


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Figure KI 3: Distribution of adults waiting for kidney transplant by age. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive candidates are included. Age is determined at the earliest of transplant, death, removal, or December 31 of the year.

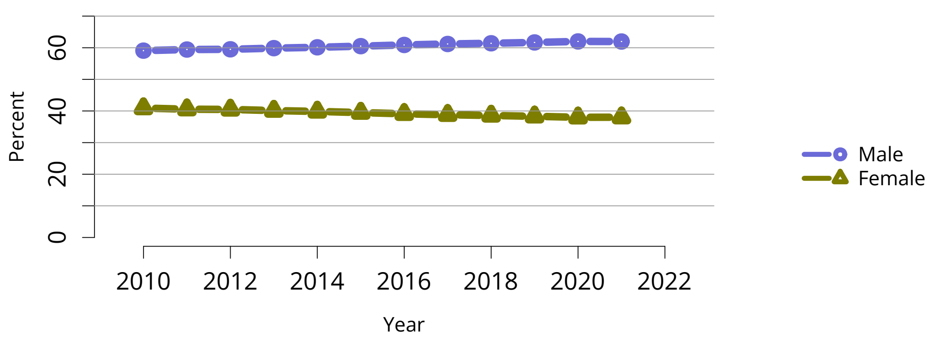

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Figure KI 4: Distribution of adults waiting for kidney transplant by sex. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

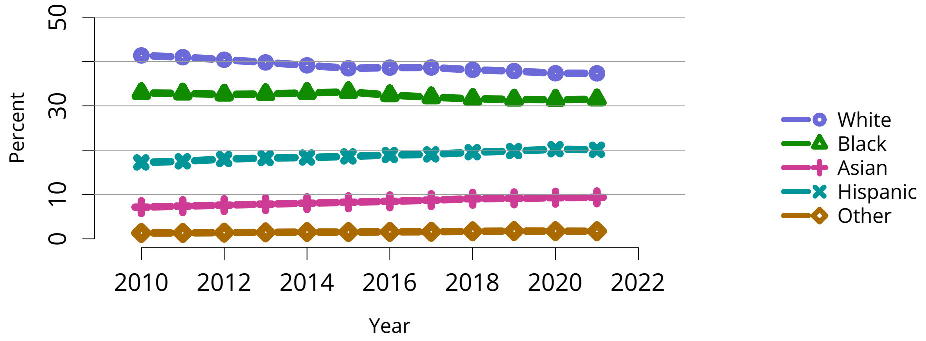

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Figure KI 5: Distribution of adults waiting for kidney transplant by race. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

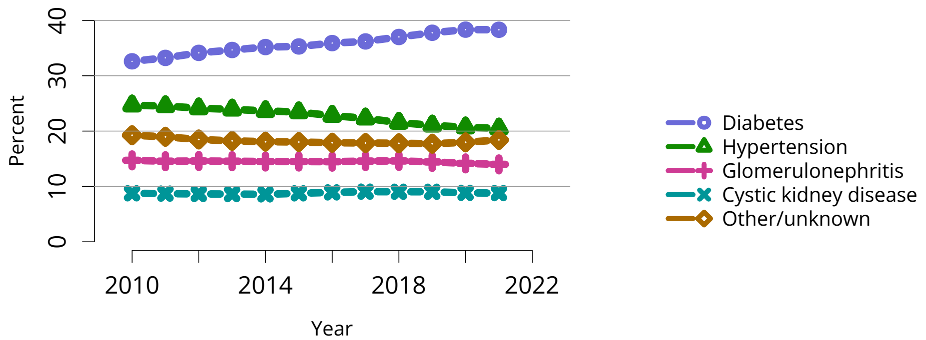

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Figure KI 6: Distribution of adults waiting for kidney transplant by diagnosis. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

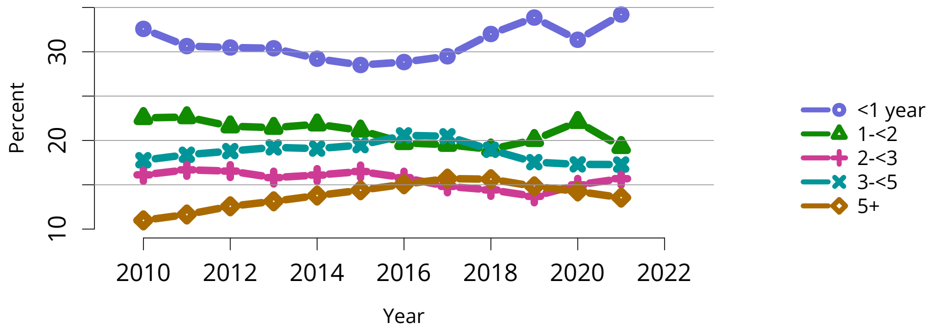

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Figure KI 7: Distribution of adults waiting for kidney transplant by waiting time (years). Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Time on the waiting list is determined at the earliest of transplant, death, removal, or December 31 of the year. Candidates listed in the given year are considered to have been listed less than 1 year. Active and inactive candidates are included.

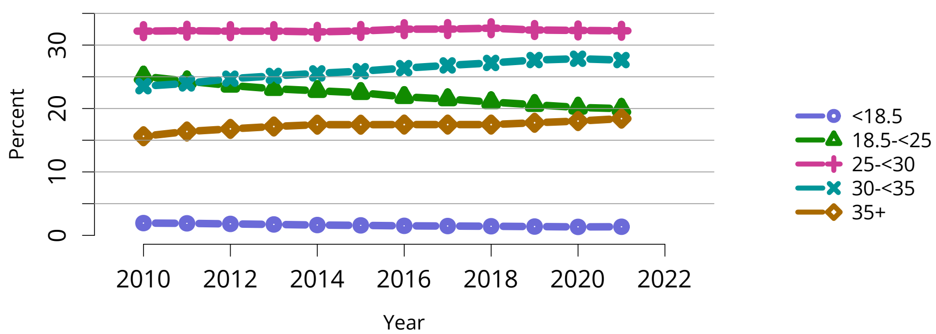

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Figure KI 8: Distribution of adults waiting for kidney transplant by BMI. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

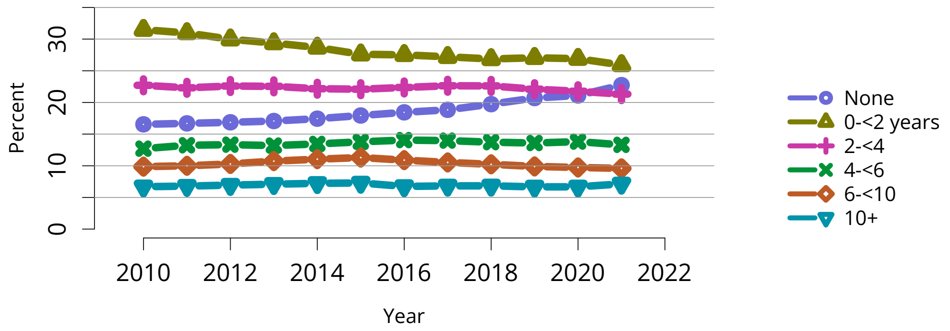

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Figure KI 9: Distribution of adults waiting for kidney transplant by years on dialysis. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Time on dialysis is computed as time from minimum of first ESRD service date or most recent graft failure to listing date or January 1 of the given year. Active and inactive candidates are included.

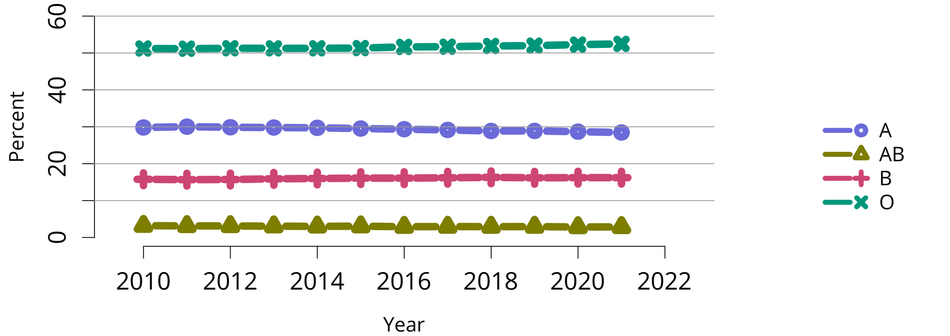

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Figure KI 10: Distribution of adults waiting for kidney transplant by blood type. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

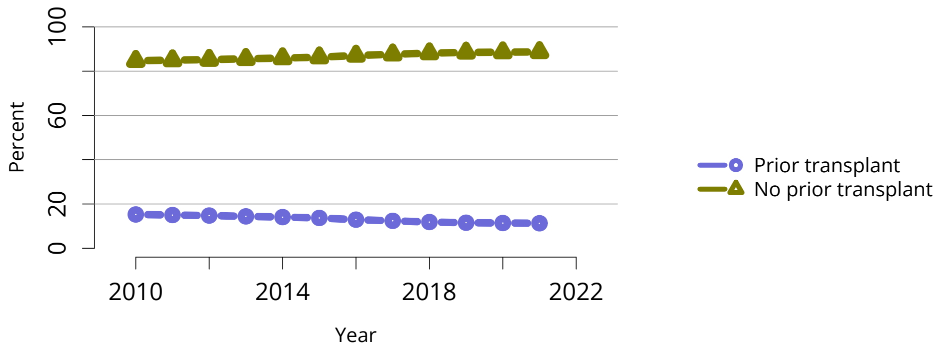

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Figure KI 11: Distribution of adults waiting for kidney transplant by prior transplant status. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

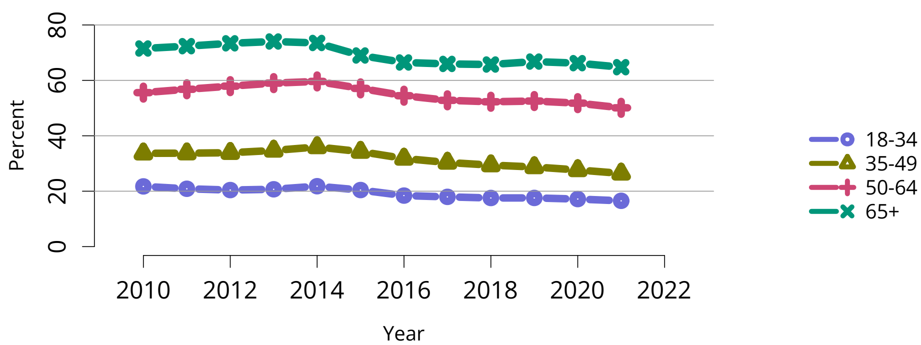

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Figure KI 12: Adults willing to accept a kidney designated ECD or KDPI >= 85% by age. Adults waiting for kidney transplant on December 31 of the given year. Candidates listed at more than one center are counted once per listing. Willingness to accept ECD at time of listing or willingness to accept a local non-zero HLA mismatch KDPI >=85% kidney at the later of listing date or January 1 of the given year, beginning in 2014. ECD, expanded criteria donor.

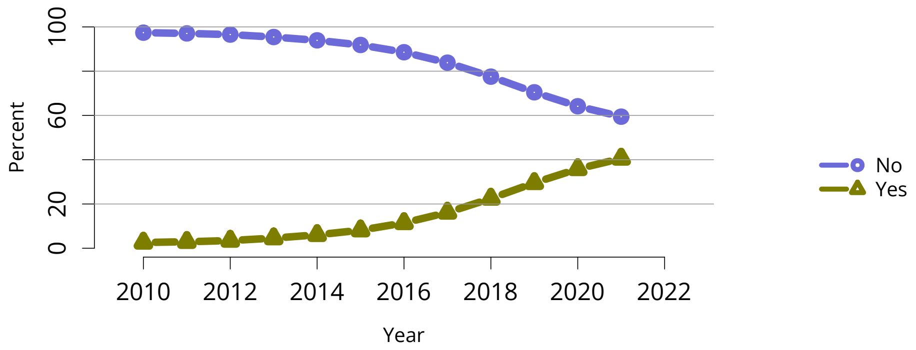

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Figure KI 13: Adults willing to accept kidney from HCV+ donor. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Willingness to accept HCV+ organ at time of listing. HCV, hepatitus C virus.

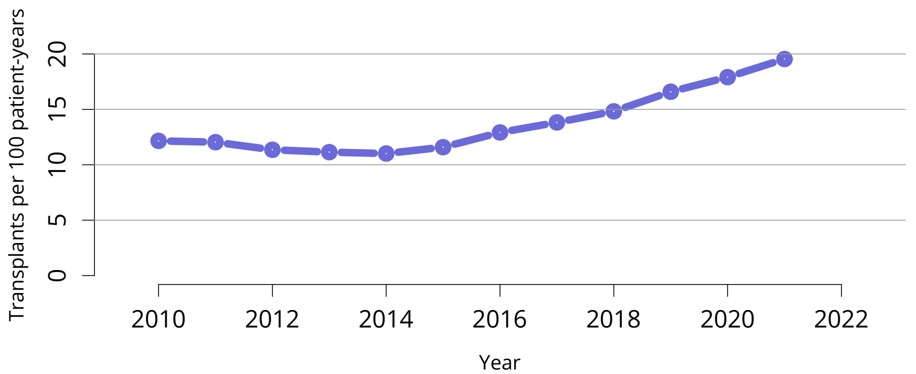

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Figure KI 14: Overall deceased donor kidney transplant rates among adult waitlist candidates. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

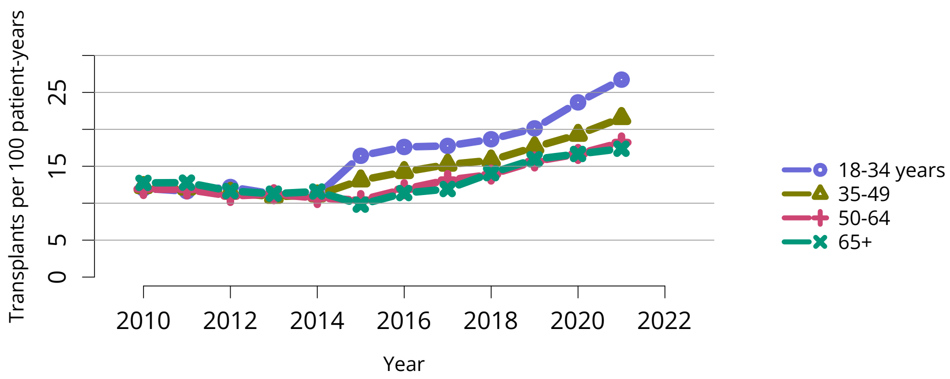

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Figure KI 15: Deceased donor kidney transplant rates among adult waitlist candidates by age. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.

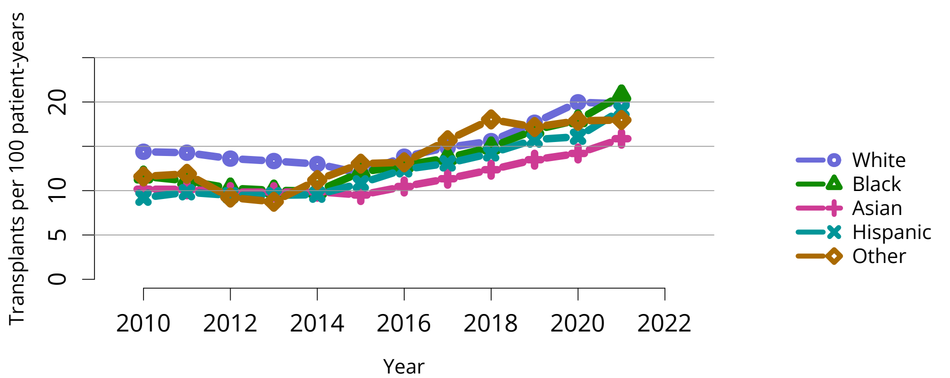

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Figure KI 16: Deceased donor kidney transplant rates among adult waitlist candidates by race. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

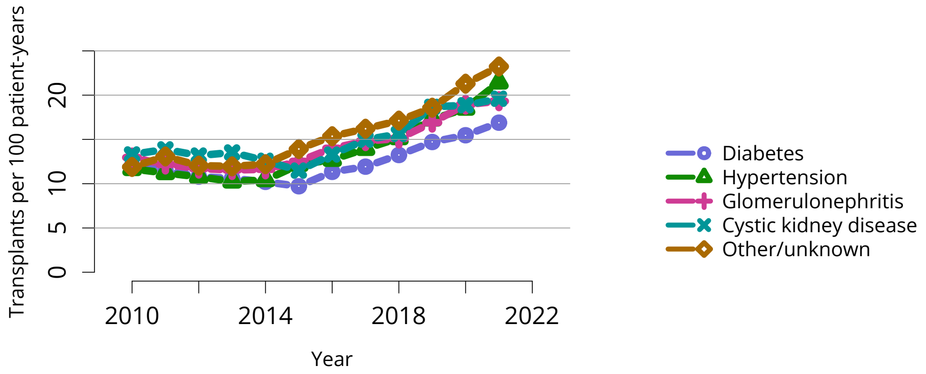

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Figure KI 17: Deceased donor kidney transplant rates among adult waitlist candidates by diagnosis. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

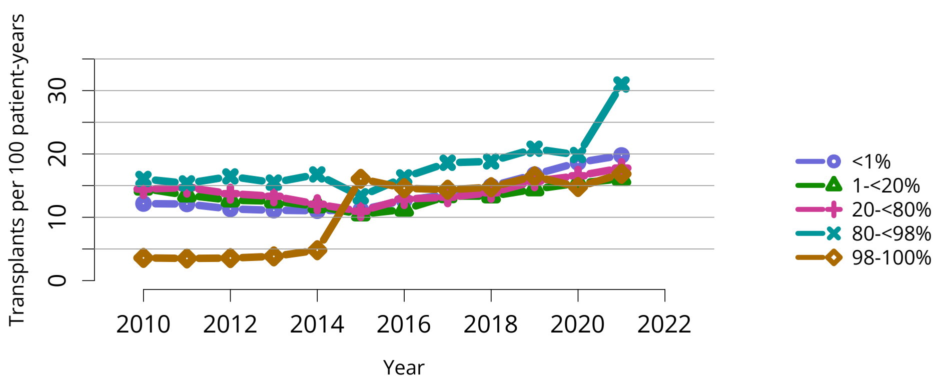

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Figure KI 18: Deceased donor kidney transplant rates among adult waitlist candidates by cPRA. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately. cPRA is determined at the later of listing date or January 1 of the given year.

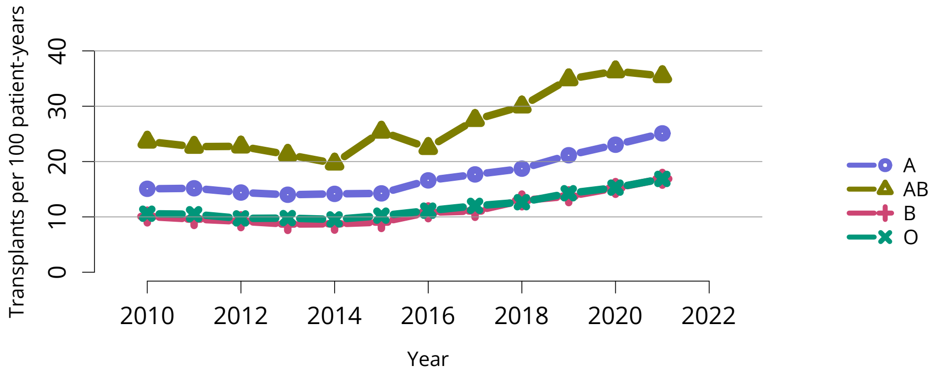

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Figure KI 19: Deceased donor kidney transplant rates among adult waitlist candidates by blood type. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

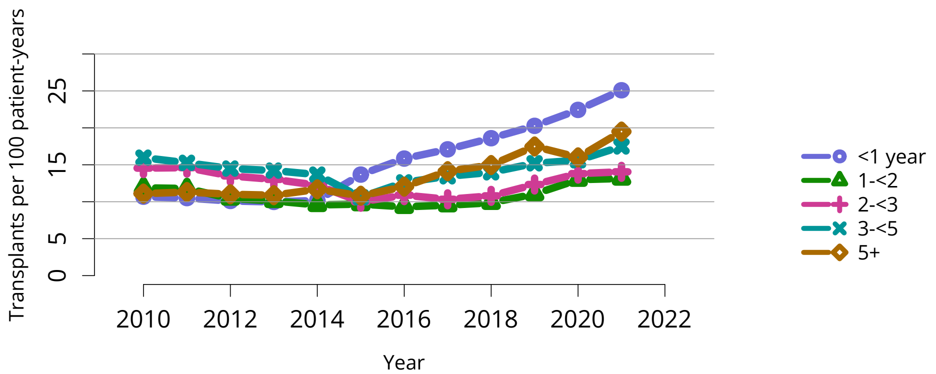

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Figure KI 20: Deceased donor kidney transplant rates among adult waitlist candidates by time on the waitlist. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

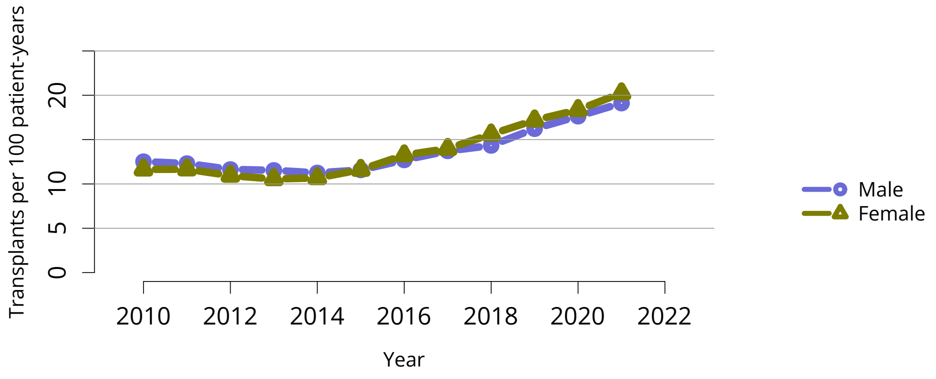

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Figure KI 21: Deceased donor kidney transplant rates among adult waitlist candidates by sex. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

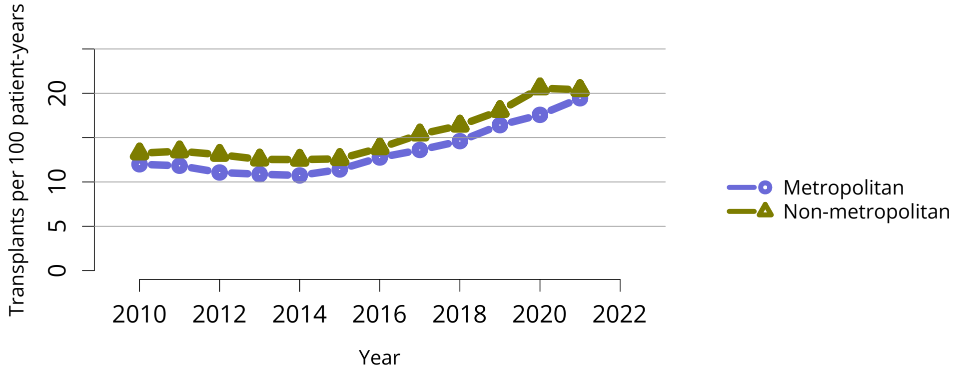

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Figure KI 22: Deceased donor kidney transplant rates among adult waitlist candidates by metropolitan vs. non-metropolitan residence. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately. Metropolitan/non-metropolitan determination is made using the RUCA (rural-urban commuting area) designation of the candidate's permanent zip code.

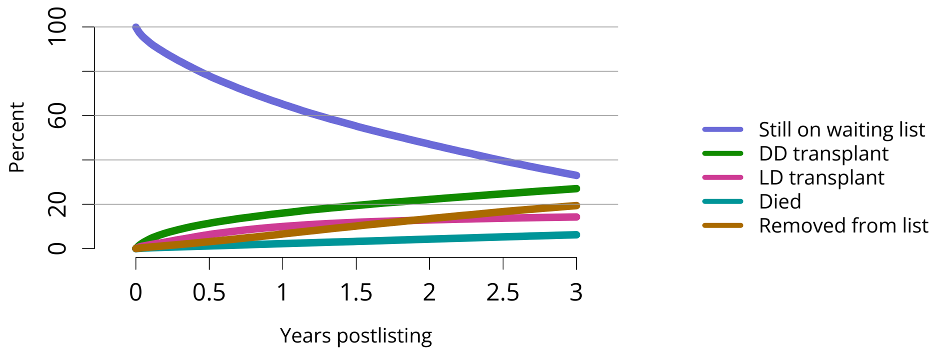

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Figure KI 23: Three-year outcomes for adults waiting for kidney transplant, new listings in 2016-2018. Candidates listed at more than one center are counted once per listing. Removed from list includes all reasons except transplant and death. DD, deceased donor; LD, living donor.

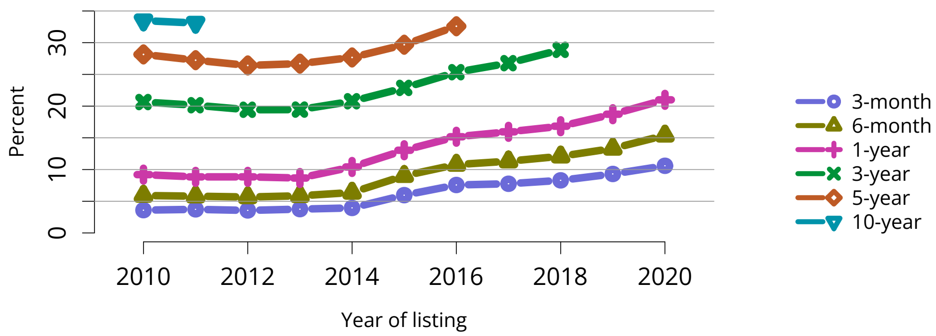

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Figure KI 24: Percentage of adults who underwent deceased donor kidney transplant within a given time period of listing. Candidates listed at more than one center are counted once per listing.

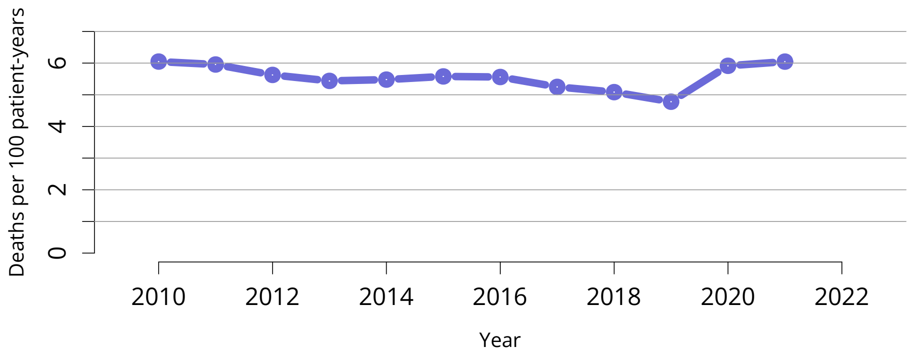

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Figure KI 25: Overall pretransplant mortality rates among adults waitlisted for kidney transplant. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

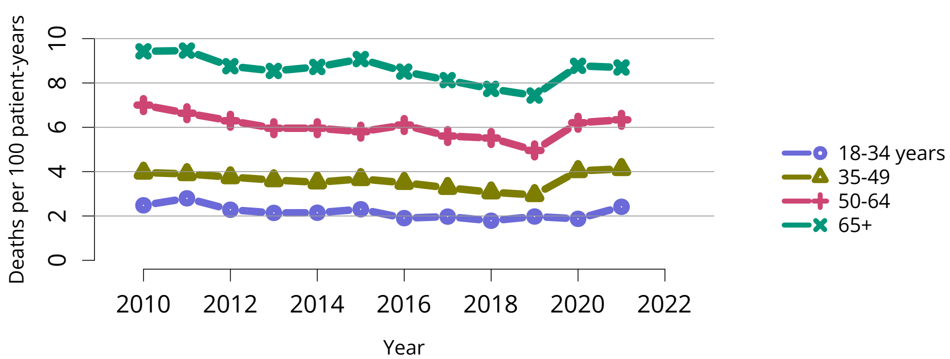

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Figure KI 26: Pretransplant mortality rates among adults waitlisted for kidney transplant by age. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.

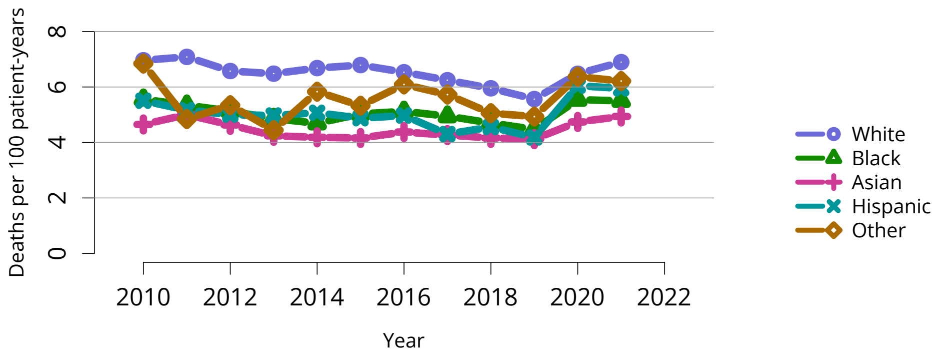

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Figure KI 27: Pretransplant mortality rates among adults waitlisted for kidney transplant by race. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

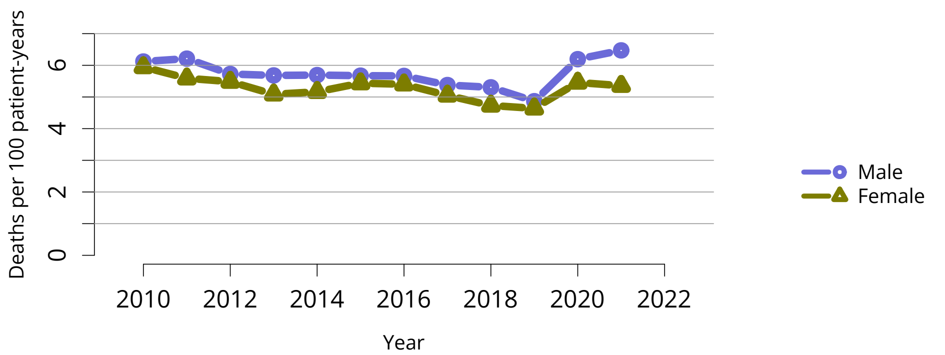

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Figure KI 28: Pretransplant mortality rates among adults waitlisted for kidney transplant by sex. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

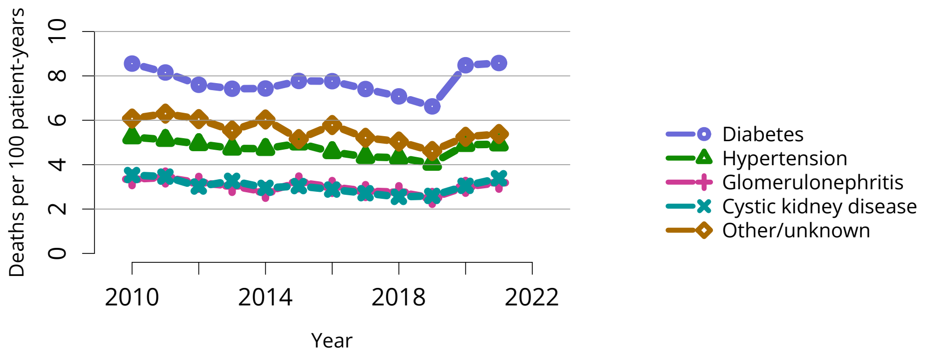

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Figure KI 29: Pretransplant mortality rates among adults waitlisted for kidney transplant by diagnosis. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

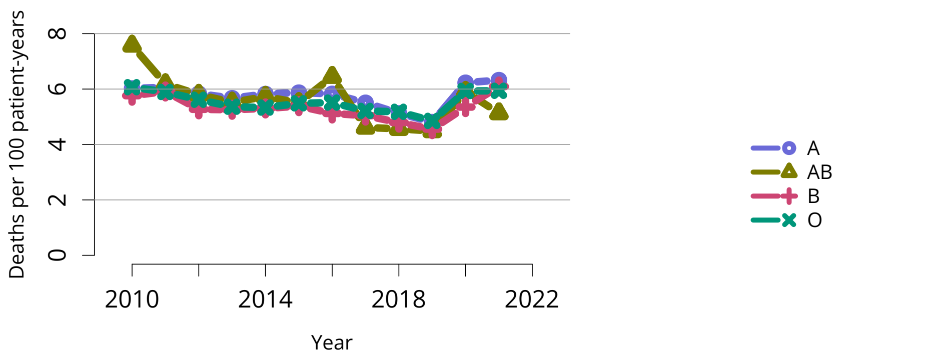

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Figure KI 30: Pretransplant mortality rates among adults waitlisted for kidney transplant by blood type. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

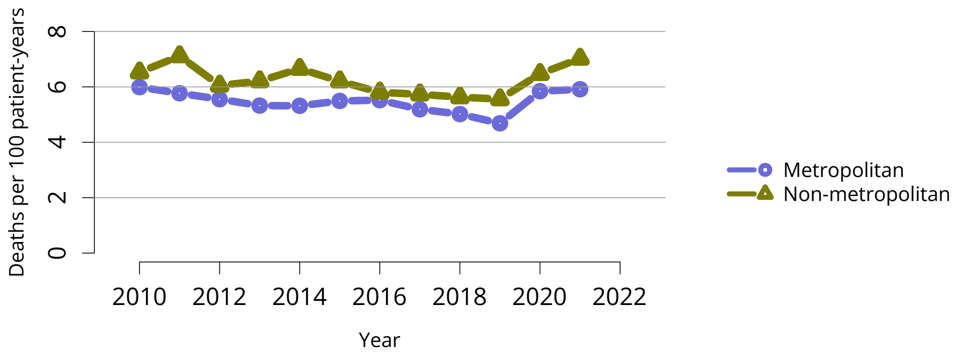

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Figure KI 31: Pretransplant mortality rates among adults waitlisted for kidney transplant by metropolitan vs. non-metropolitan residence. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Urban/rural determination is made using the RUCA (rural-urban commuting area) designation of the candidate's permanent zip code.

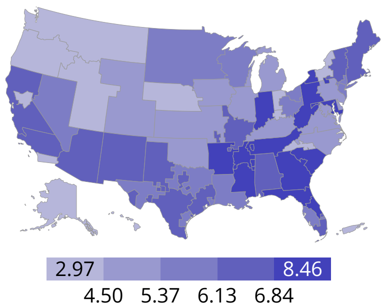

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Figure KI 32: Pretransplant mortality rates among adults waitlisted for kidney transplant in 2021 by DSA. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

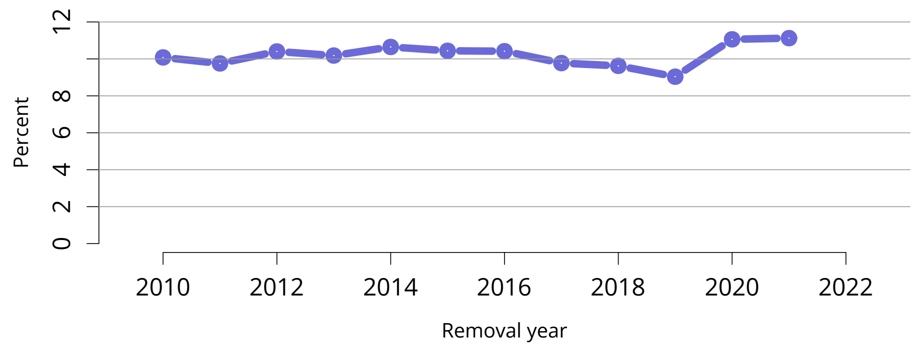

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Figure KI 33: Deaths within six months after removal among adult kidney waitlist candidates, overall. Denominator includes only candidates removed from the waiting list for reasons other than transplant or death while on the list.

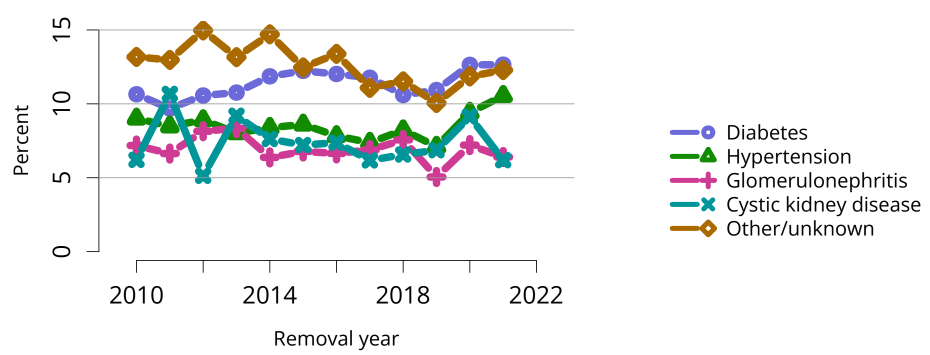

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Figure KI 34: Deaths within six months after removal among adult kidney waitlist candidates, by diagnosis group at removal. Denominator includes only candidates removed from the waiting list for reasons other than transplant or death while on the list.

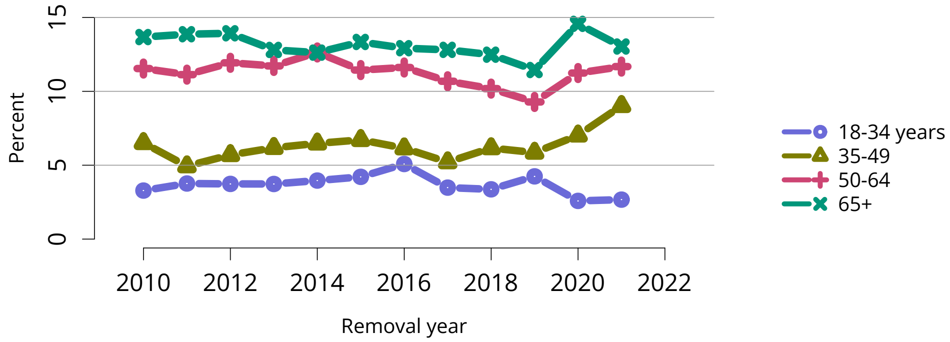

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Figure KI 35: Deaths within six months after removal among adult kidney waitlist candidates, by age. Denominator includes only candidates removed from the waiting list for reasons other than transplant or death while on the list. Age is determined at the later of listing date or January 1 of the given year.

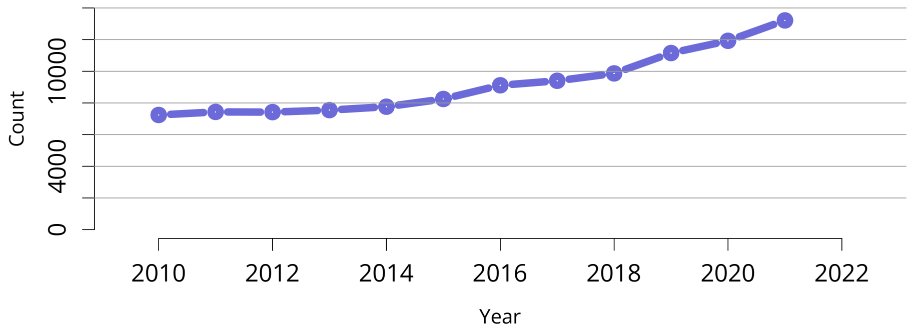

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Figure KI 36: Overall deceased kidney donor count. Count of deceased donors from whom at least one kidney was recovered for transplant.

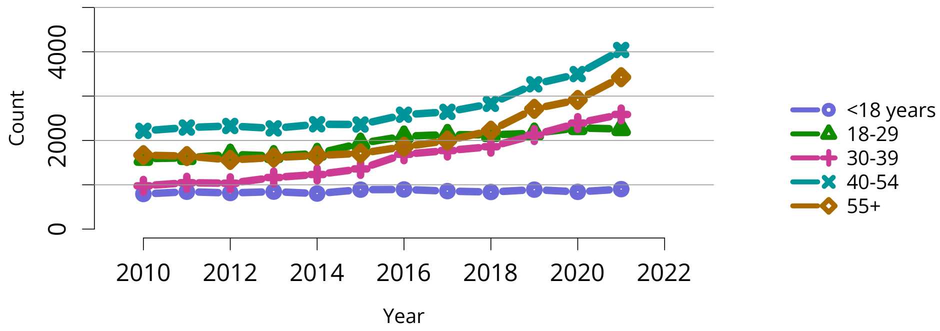

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Figure KI 37: Deceased kidney donor count by age. Count of deceased donors from whom at least one kidney was recovered for transplant.

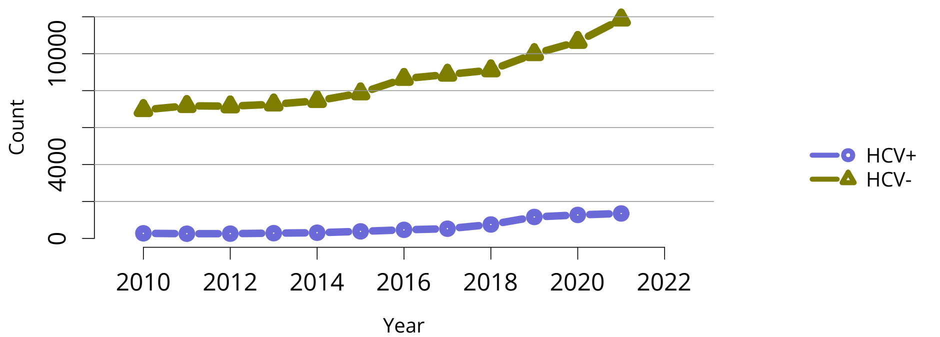

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Figure KI 38: Deceased kidney donor count by HCV status. Count of deceased donors from whom at least one kidney was recovered for transplant. Donor HCV status was based on an antibody test.

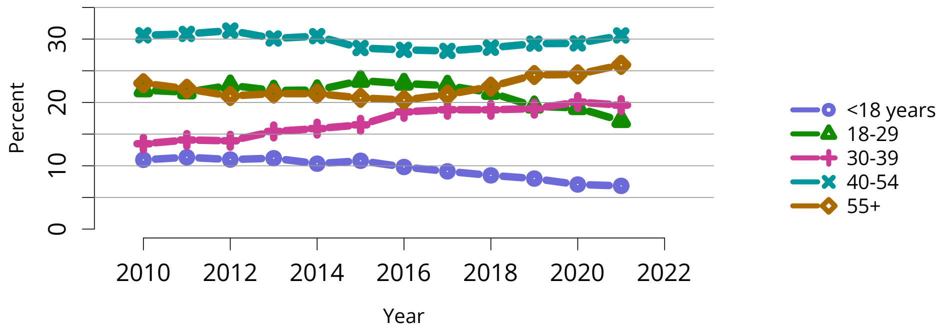

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Figure KI 39: Distribution of deceased kidney donors by age. Deceased donors from whom at least one kidney was recovered for transplant.

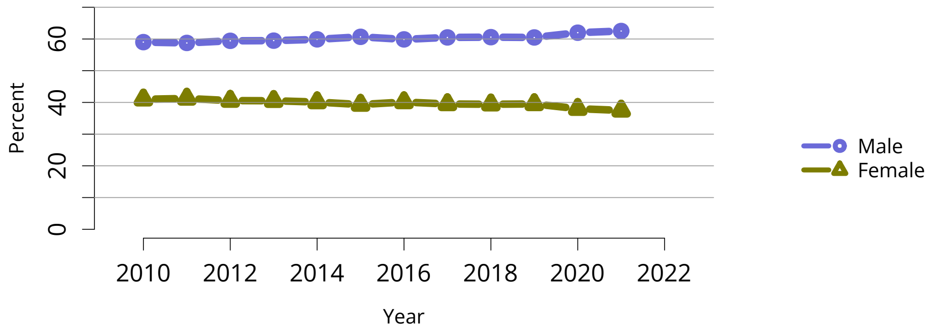

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Figure KI 40: Distribution of deceased kidney donors by sex. Deceased donors from whom at least one kidney was recovered for transplant.

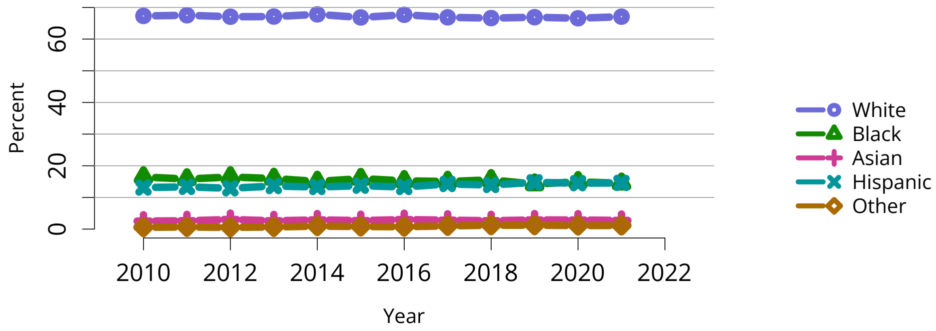

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Figure KI 41: Distribution of deceased kidney donors by race. Deceased donors from whom at least one kidney was recovered for transplant.

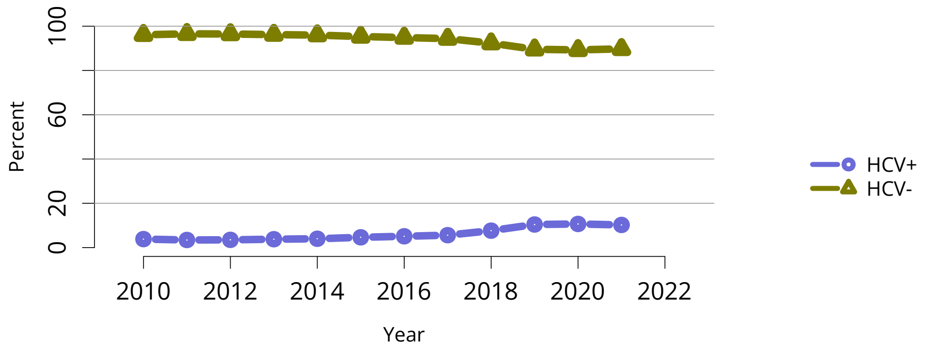

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Figure KI 42: Distribution of deceased kidney donors by donor HCV status. Deceased donors from whom at least one kidney was recovered for transplant. Donor HCV status was based on an antibody test.

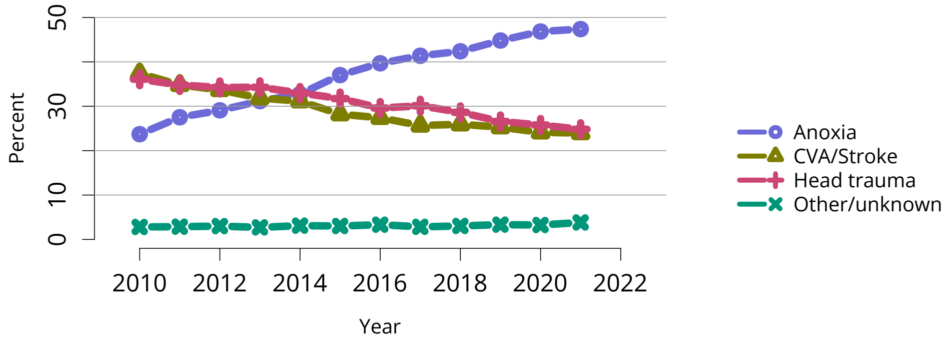

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Figure KI 43: Cause of death among deceased kidney donors. Deceased donors with at least one kidney recovered for transplant. Each donor is counted once. CVA, cerebrovascular accident.

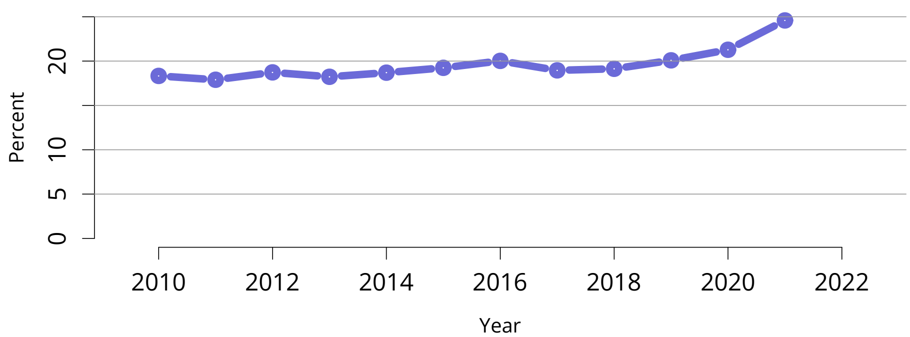

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Figure KI 44: Overall percent of kidneys recovered for transplant and not transplanted. Percentages of kidneys not transplanted out of all kidneys recovered for transplant.

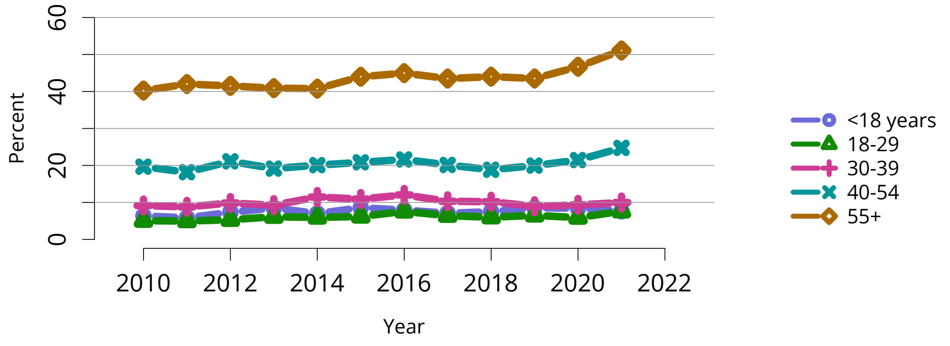

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Figure KI 45: Percent of kidneys recovered for transplant and not transplanted by donor age. Percentages of kidneys not transplanted out of all kidneys recovered for transplant.

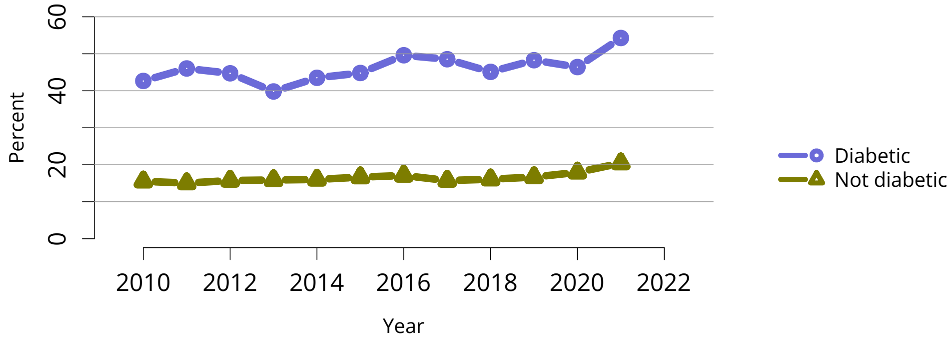

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Figure KI 46: Percent of kidneys recovered for transplant and not transplanted by donor diabetes status. Percentages of kidneys not transplanted out of all kidneys recovered for transplant.

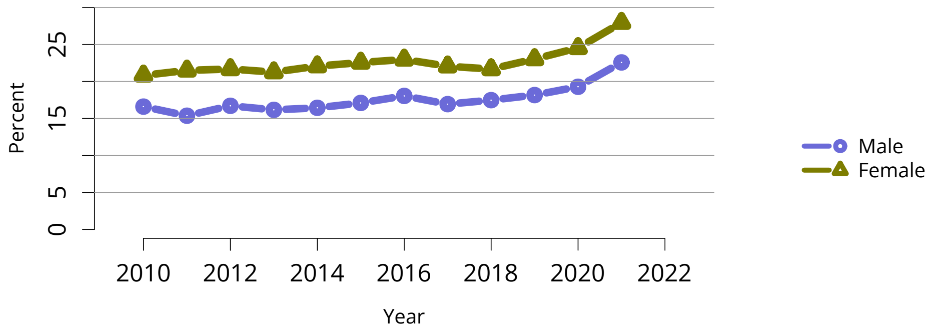

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Figure KI 47: Percent of kidneys recovered for transplant and not transplanted by donor sex. Percentages of kidneys not transplanted out of all kidneys recovered for transplant.

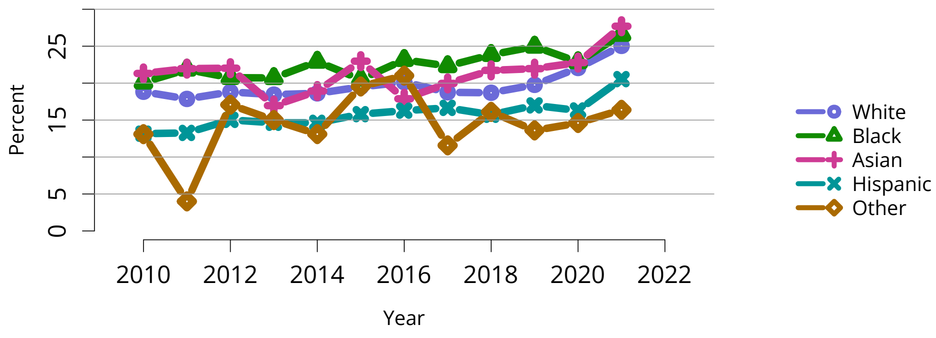

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Figure KI 48: Percent of kidneys recovered for transplant and not transplanted by donor race. Percentages of kidneys not transplanted out of all kidneys recovered for transplant.

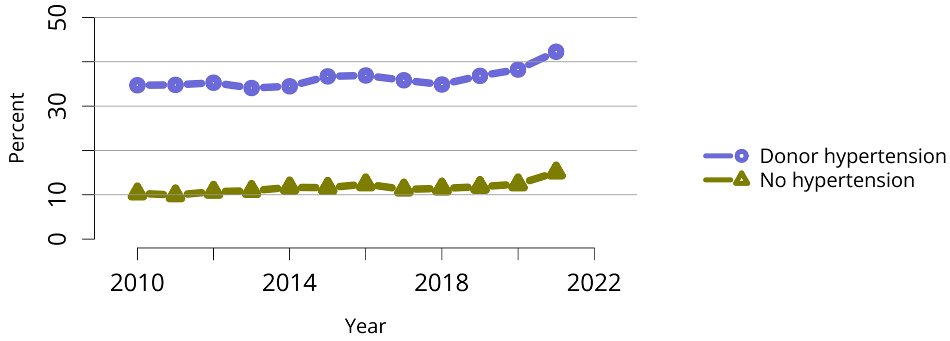

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Figure KI 49: Percent of kidneys recovered for transplant and not transplanted by donor hypertension status. Percentages of kidneys not transplanted out of all kidneys recovered for transplant.

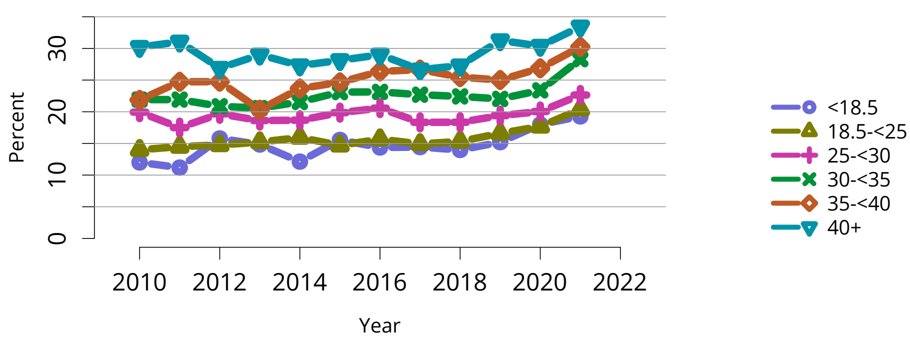

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Figure KI 50: Percent of kidneys recovered for transplant and not transplanted by donor BMI. Percentages of kidneys not transplanted out of all kidneys recovered for transplant.

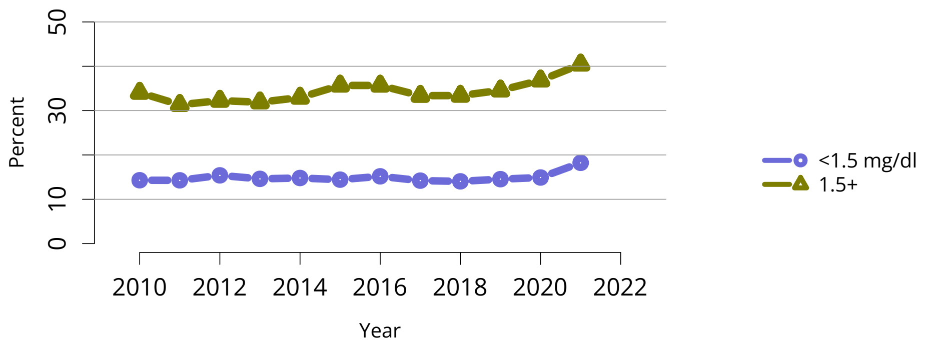

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Figure KI 51: Percent of kidneys recovered for transplant and not transplanted by donor terminal creatinine. Percentages of kidneys not transplanted out of all kidneys recovered for transplant.

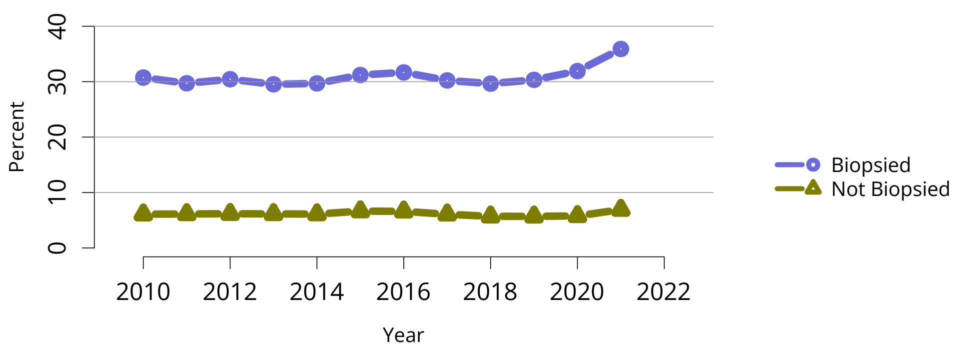

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Figure KI 52: Percent of kidneys recovered for transplant and not transplanted by donor biopsy status. Percentages of kidneys not transplanted out of all kidneys recovered for transplant. Kidneys are classified as biopsied if either of the donor's kidneys was biopsied.

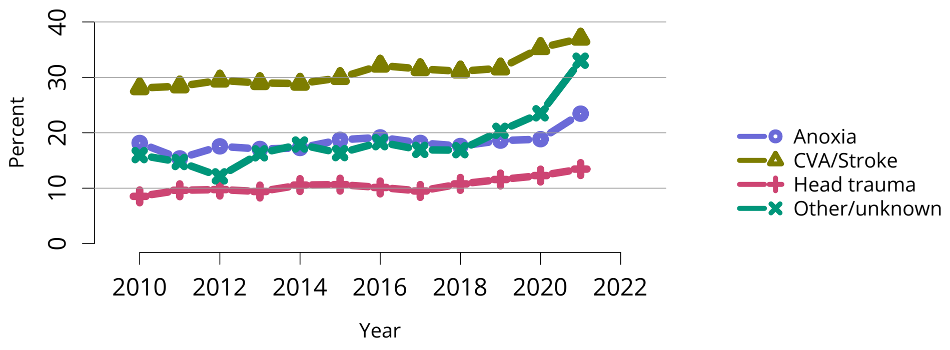

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Figure KI 53: Percent of kidneys recovered for transplant and not transplanted by donor cause of death. Percentages of kidneys not transplanted out of all kidneys recovered for transplant. CVA, cerebrovascular accident.

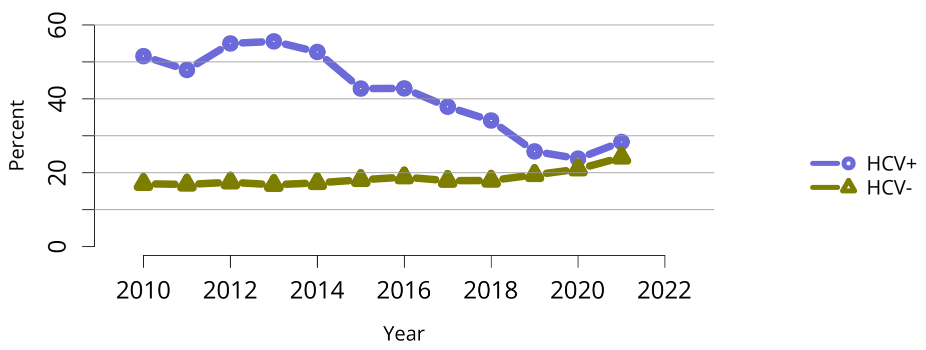

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Figure KI 54: Percent of kidneys recovered for transplant and not transplanted by donor HCV status. Percentages of kidneys not transplanted out of all kidneys recovered for transplant. Donor HCV status was based on an antibody test.

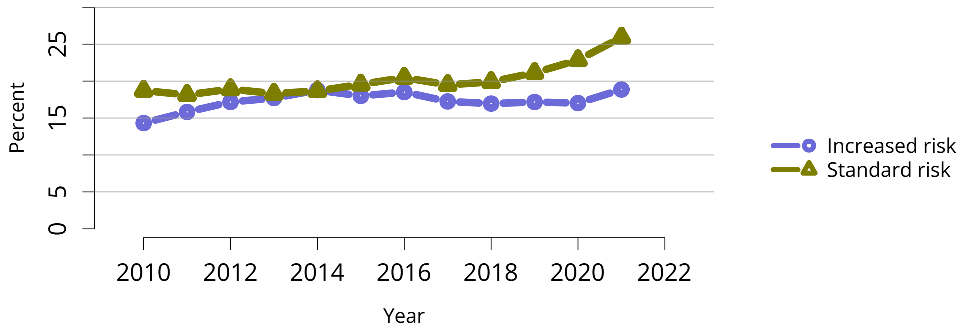

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Figure KI 55: Percent of kidneys recovered for transplant and not transplanted, by donor risk of disease transmission. Percentages of kidneys not transplanted out of all kidneys recovered for transplant. "Increased risk" is defined by criteria from the US Public Health Service Guidelines for increased risk for HIV, hepatitis B, and hepatitis C transmission.

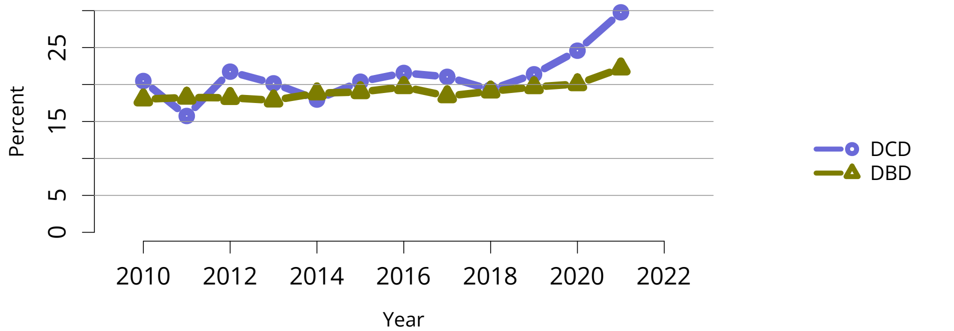

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Figure KI 56: Percent of kidneys recovered for transplant and not transplanted by DCD status. Percentages of kidneys not transplanted out of all kidneys recovered for transplant. DBD, donation after brain death; DCD, donation after circulatory death.

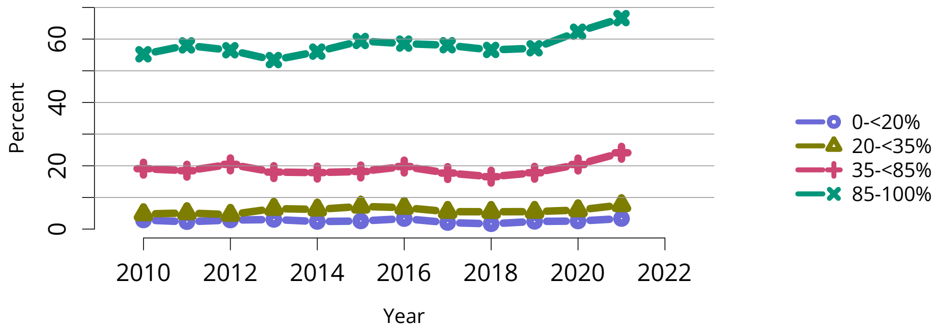

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Figure KI 57: Percent of kidneys recovered for transplant and not transplanted by KDPI. Percentages of kidneys not transplanted out of all kidneys recovered for transplant, by KDPI classification. Conversion of KDRI to KDPI is done using the OPTN KDPI Mapping Tables. For donors recovered January through May, the cohort 2 years prior was used to assign KDPI; for donors recovered June through December, the cohort 1 year prior was used to assign KDPI. KDPI, kidney donor profile index; KDRI, kidney donor risk index.

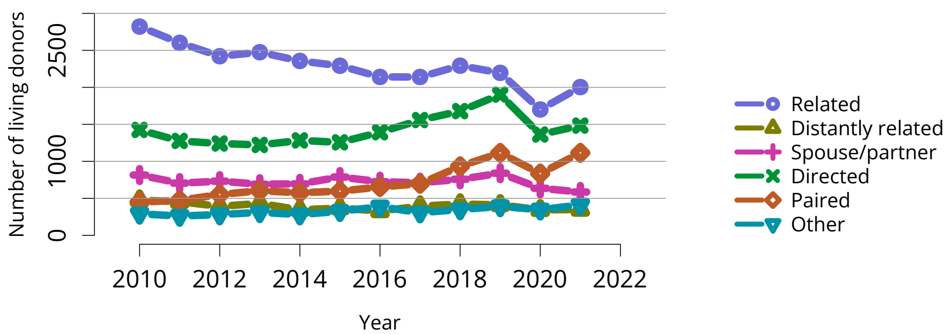

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Figure KI 58: Number of living kidney transplants by donor relation. As reported on the OPTN Living Donor Registration Form.

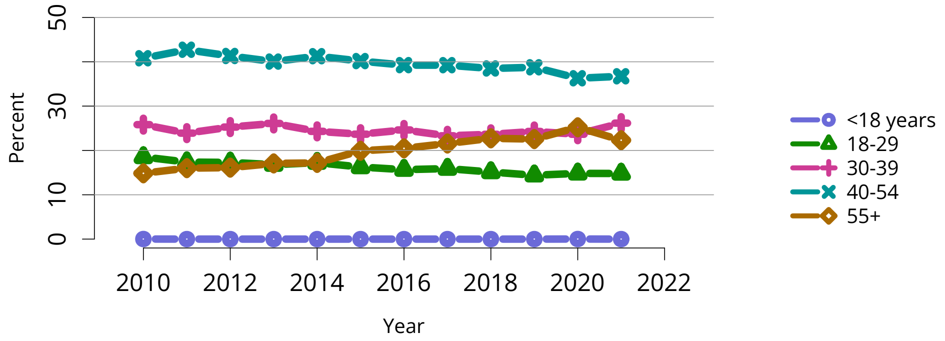

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Figure KI 59: Living kidney donors by age. As reported on the OPTN Living Donor Registration Form.

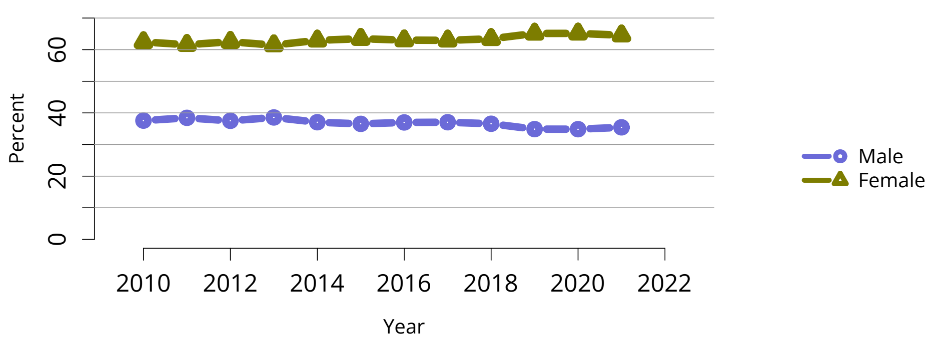

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Figure KI 60: Living kidney donors by sex. As reported on the OPTN Living Donor Registration Form.

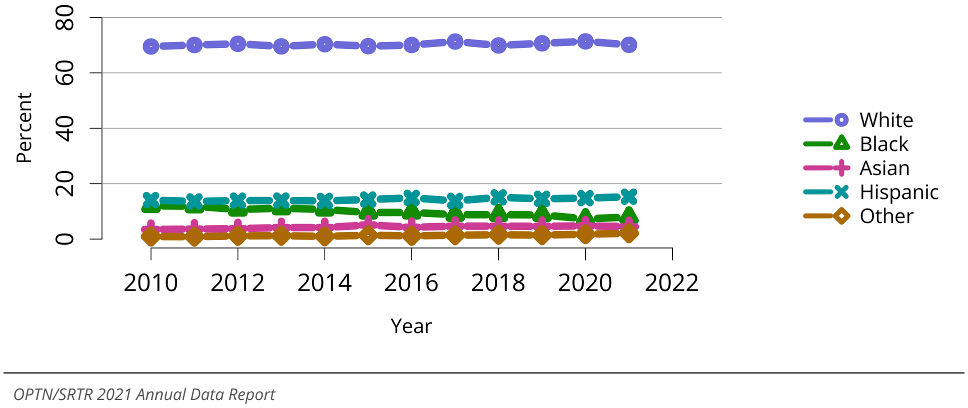

Figure KI 61: Living kidney donors by race. As reported on the OPTN Living Donor Registration Form.

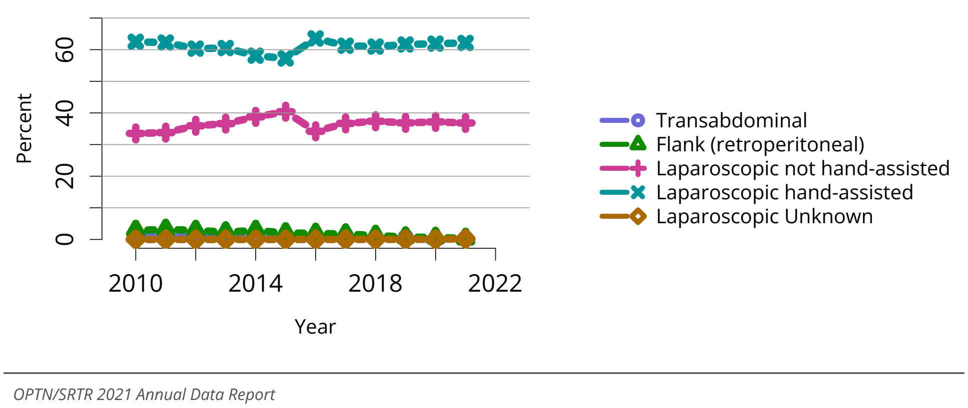

Figure KI 62: Intended living kidney donor procedure type. As reported on the OPTN Living Donor Registration Form.

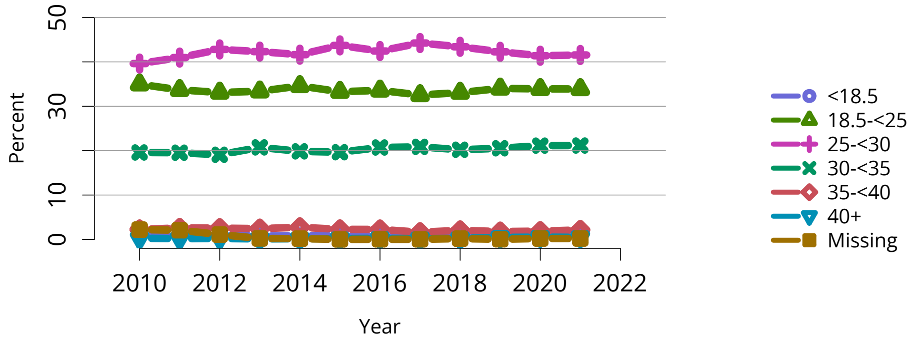

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Figure KI 63: BMI among living kidney donors. Donor height and weight reported on the OPTN Living Donor Registration Form.

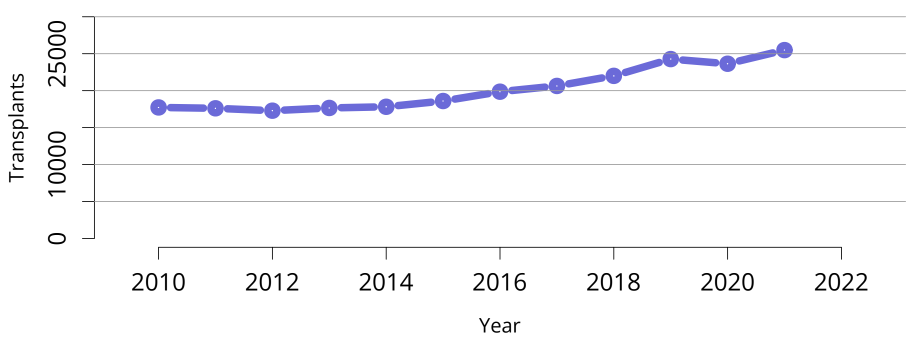

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Figure KI 64: Overall kidney transplants. All kidney transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

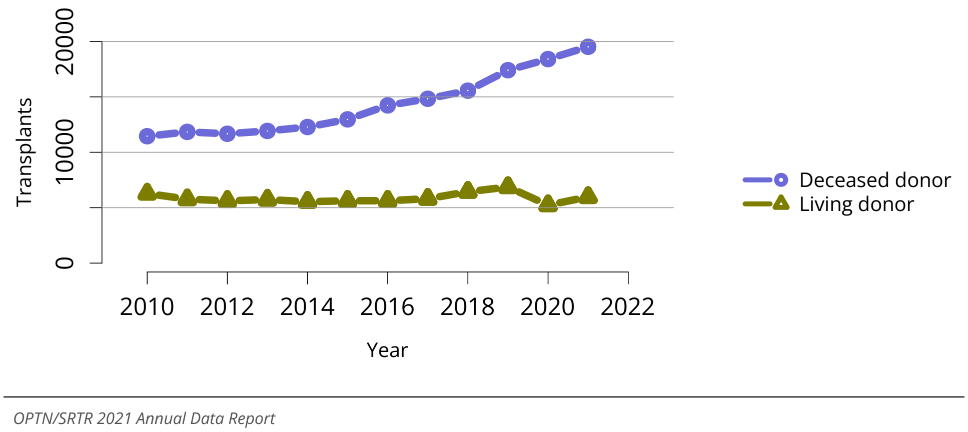

Figure KI 65: Total kidney transplants by donor type. All kidney transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

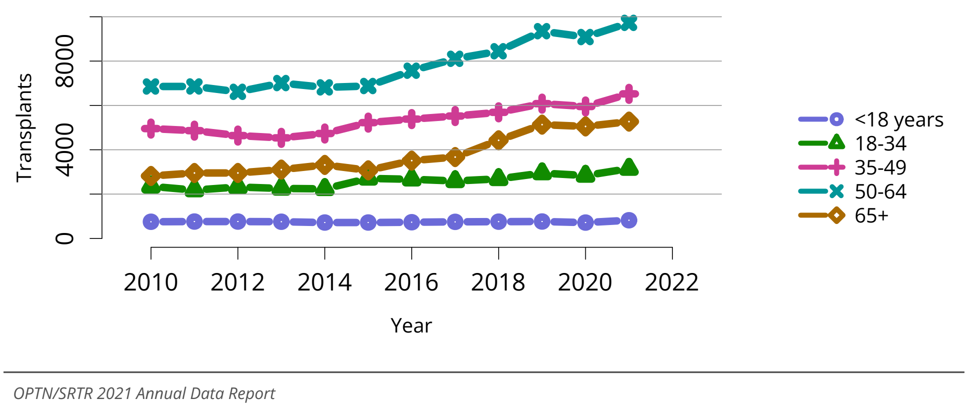

Figure KI 66: Total kidney transplants by age. All kidney transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

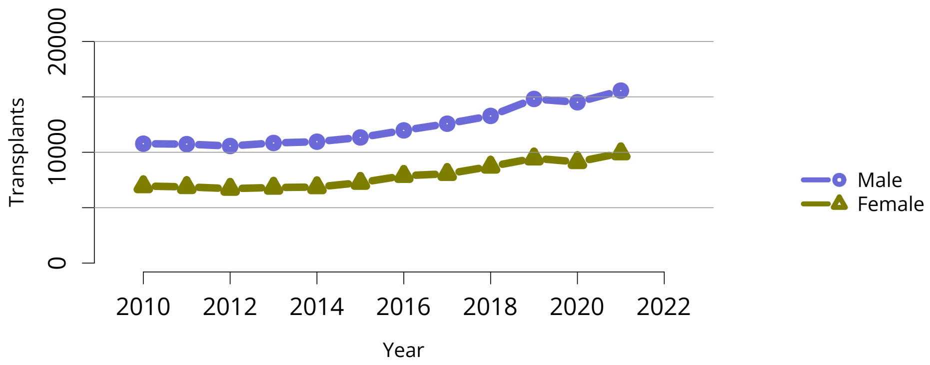

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Figure KI 67: Total kidney transplants by sex. All kidney transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

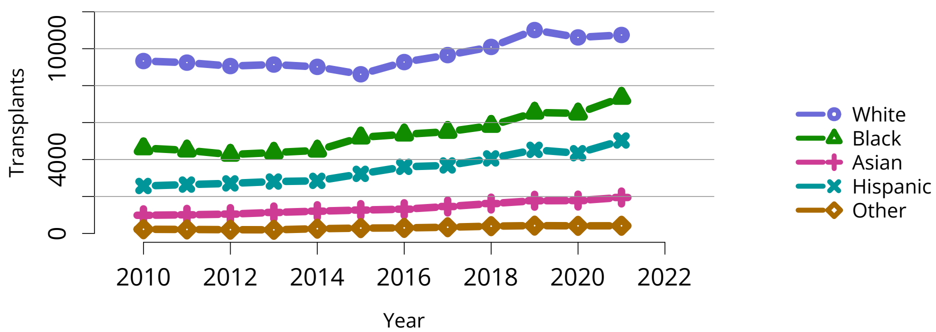

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Figure KI 68: Total kidney transplants by race. All kidney transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

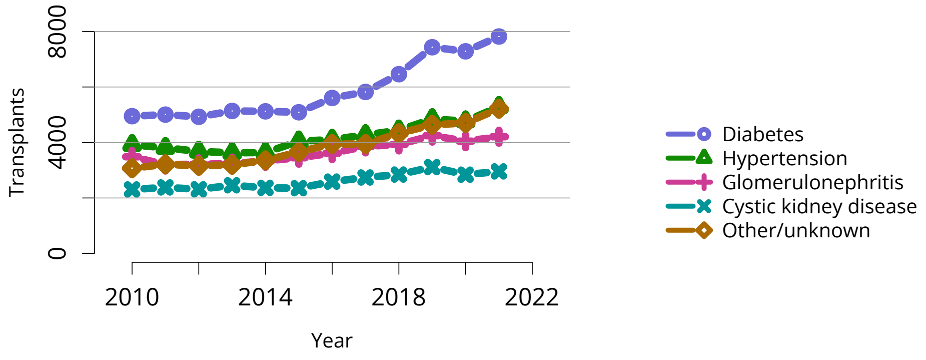

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Figure KI 69: Total kidney transplants by diagnosis. All kidney transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

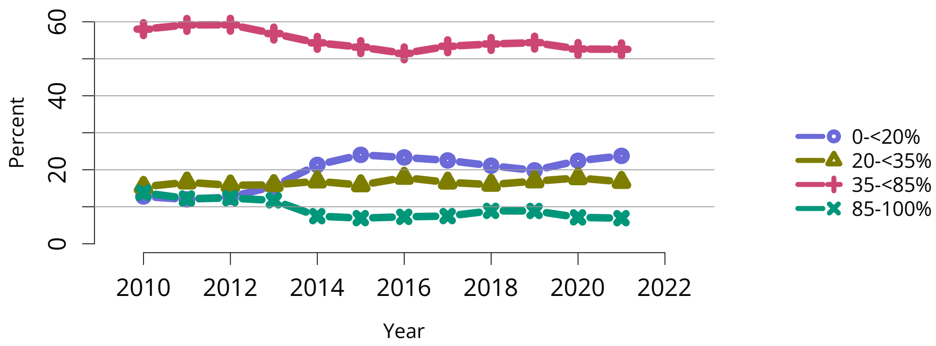

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Figure KI 70: Kidney transplants by kidney donor profile index (KDPI). All adult recipients of deceased donor kidneys, including multiorgan transplants. Conversion of KDRI to KDPI is done using the OPTN KDPI Mapping Tables. For donors recovered January through May, the cohort 2 years prior was used to assign KDPI; for donors recovered June through December, the cohort 1 year prior was used to assign KDPI. Kidneys recovered en bloc are counted once. KDPI, kidney donor profile index; KDRI, kidney donor risk index.

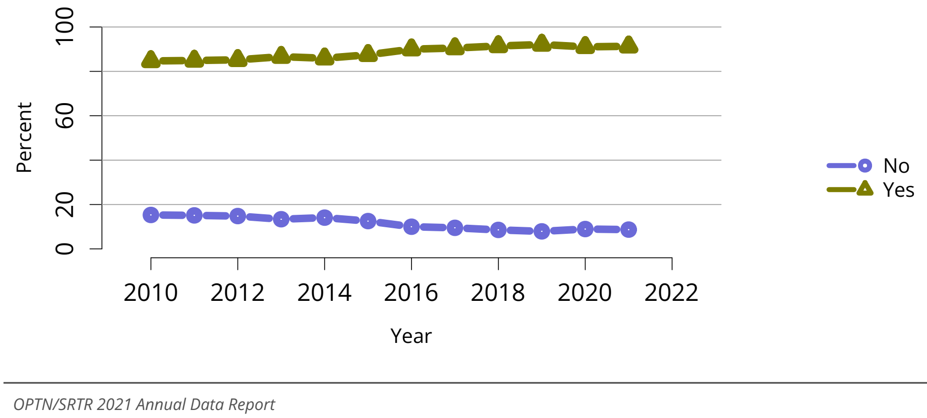

Figure KI 71: Induction agent use in adult kidney transplant recipients. Immunosuppression at transplant reported to the OPTN.

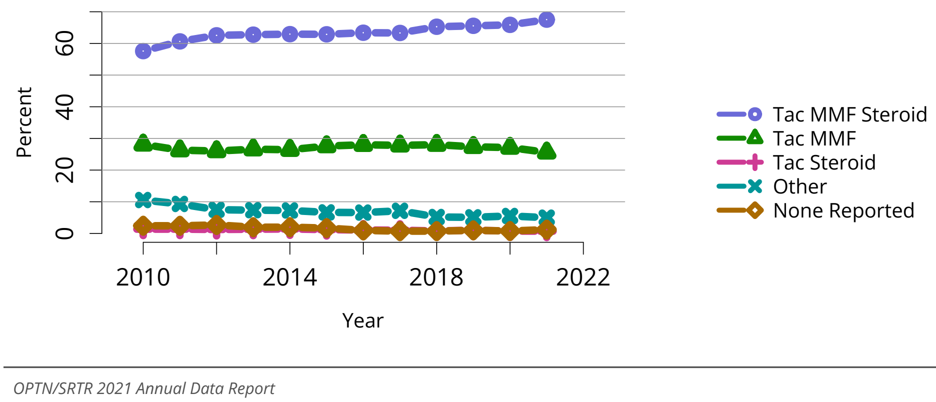

Figure KI 72: Immunosuppression regimen use in adult kidney transplant recipients. Immunosuppression regimen at transplant reported to the OPTN. Tac, tacrolimus. MMF, all mycophenolate agents.

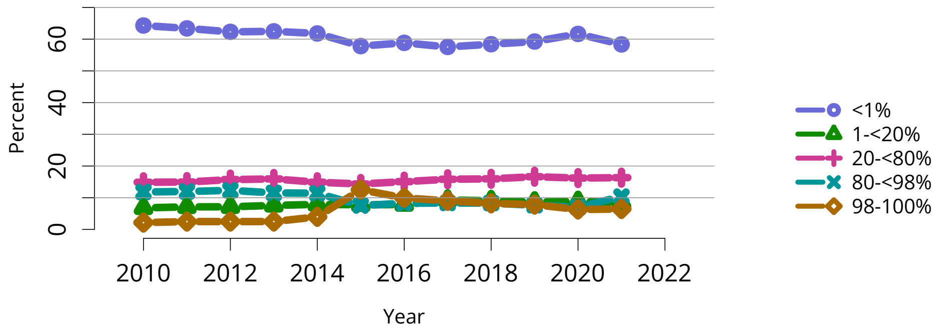

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Figure KI 73: Peak cPRA at time of kidney transplant in adult deceased donor recipients. Peak cPRA is used.

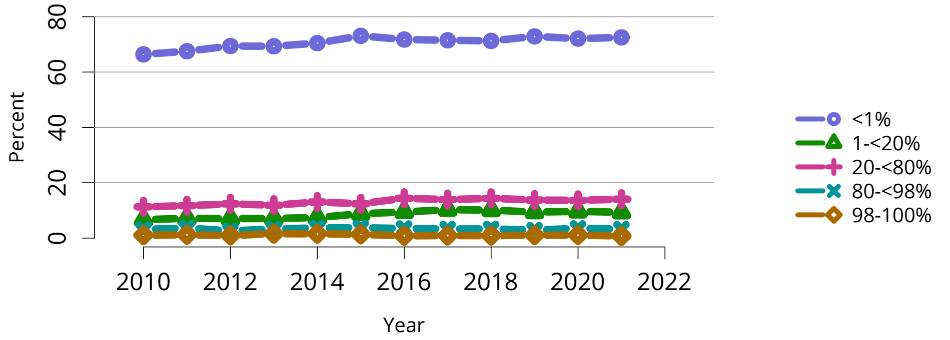

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Figure KI 74: Peak cPRA at time of kidney transplant in adult living donor recipients. Peak cPRA is used.

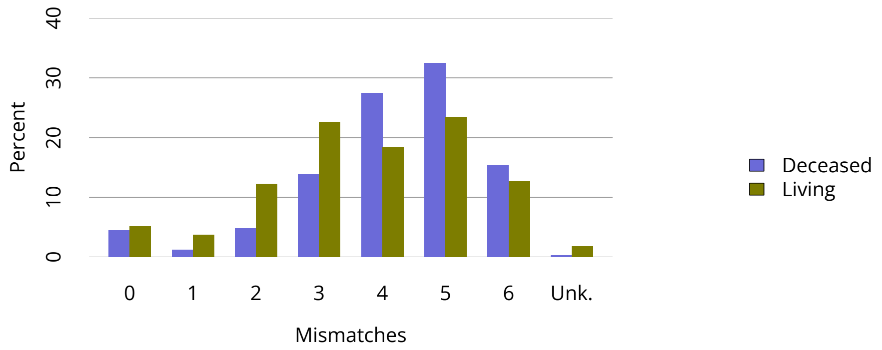

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Figure KI 75: Total HLA A, B, and DR mismatches among adult kidney transplant recipients, 2017-2021. Donor and recipient antigen matching is based on OPTN antigen values and split equivalences policy as of 2019.

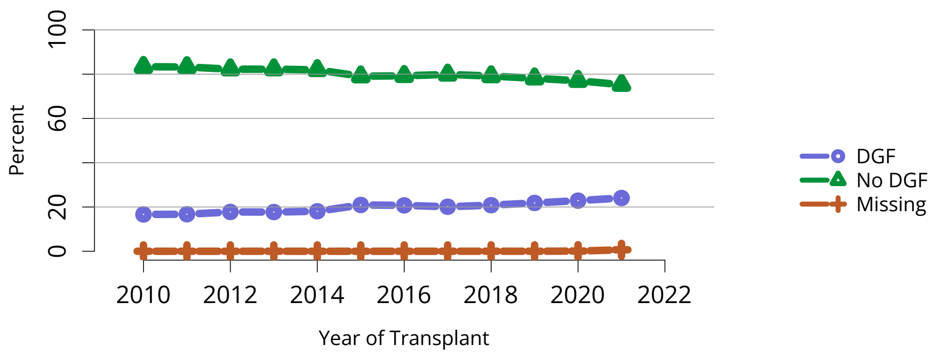

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Figure KI 76: Delayed graft function among adult kidney transplant recipients. All adult recipients of kidneys. Delayed graft function is defined as dialysis administered within the first seven days posttransplant.

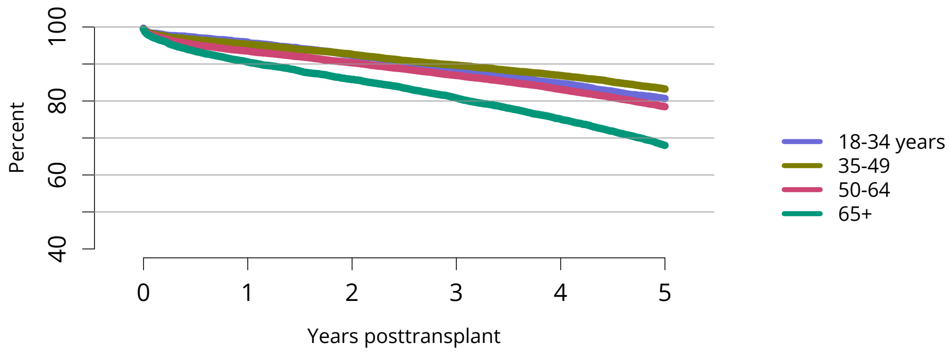

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Figure KI 77: Graft survival among adult deceased donor kidney transplant recipients, 2014-2016, by age. Graft survival estimated using unadjusted Kaplan-Meier methods.

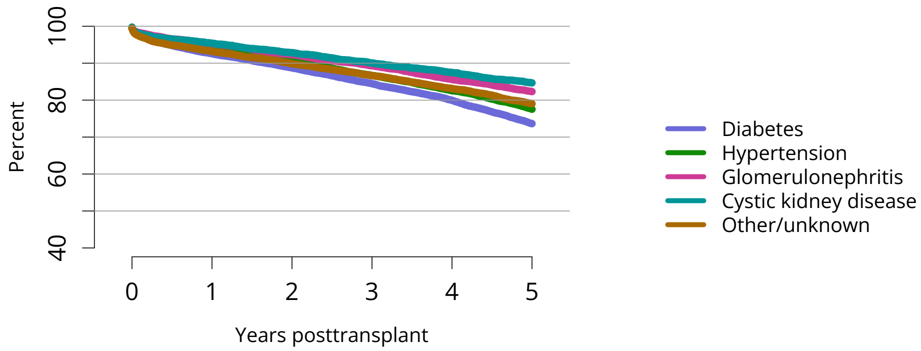

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Figure KI 78: Graft survival among adult deceased donor kidney transplant recipients, 2014-2016, by diagnosis. Graft survival estimated using unadjusted Kaplan-Meier methods.

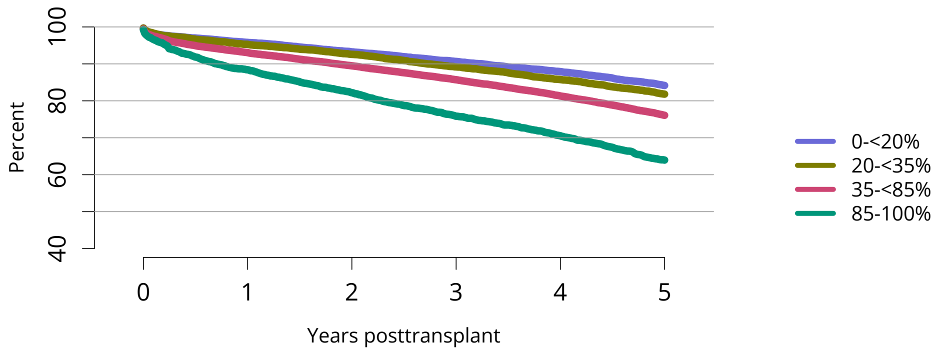

Figure KI 79: Graft survival among adult deceased donor kidney transplant recipients, 2014-2016, by KDPI. Graft survival estimated using unadjusted Kaplan-Meier methods. Conversion of KDRI to KDPI is done using the OPTN KDPI Mapping Tables. For donors recovered January through May, the cohort 2 years prior was used to assign KDPI; for donors recovered June through December, the cohort 1 year prior was used to assign KDPI. KDPI, kidney donor profile index.

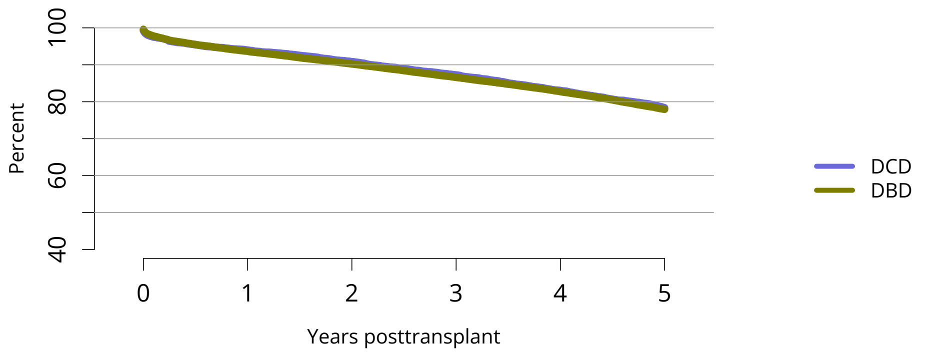

Figure KI 80: Graft survival among adult deceased donor kidney transplant recipients, 2014-2016, by DCD status. Graft survival estimated using unadjusted Kaplan-Meier methods. DCD, donation after circulatory death; DBD, donation after brain death.

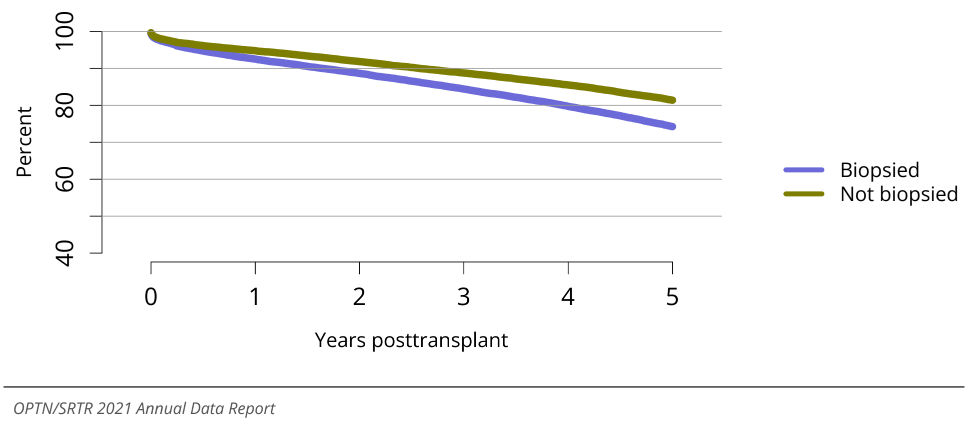

Figure KI 81: Graft survival among adult deceased donor kidney transplant recipients, 2014-2016, by biopsy status. Graft survival estimated using unadjusted Kaplan-Meier methods. Kidneys are classified as biopsied if either of the donor's kidneys was biopsied.

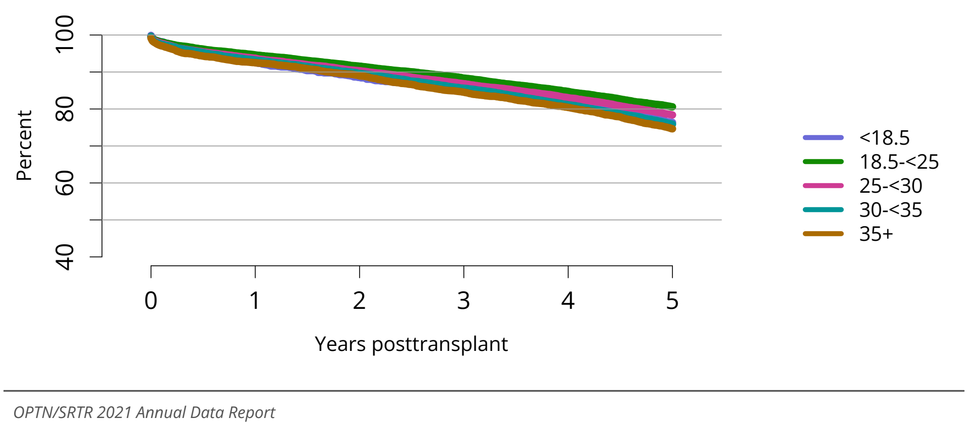

Figure KI 82: Graft survival among adult deceased donor kidney transplant recipients, 2014-2016, by BMI. Graft survival estimated using unadjusted Kaplan-Meier methods.

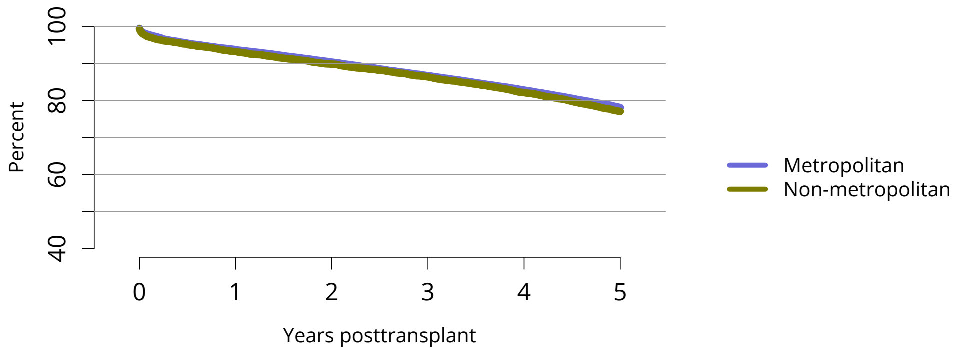

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Figure KI 83: Graft survival among adult deceased donor kidney transplant recipients, 2014-2016, by metropolitan vs. non-metropolitan recipient residence. Graft survival estimated using unadjusted Kaplan-Meier methods.

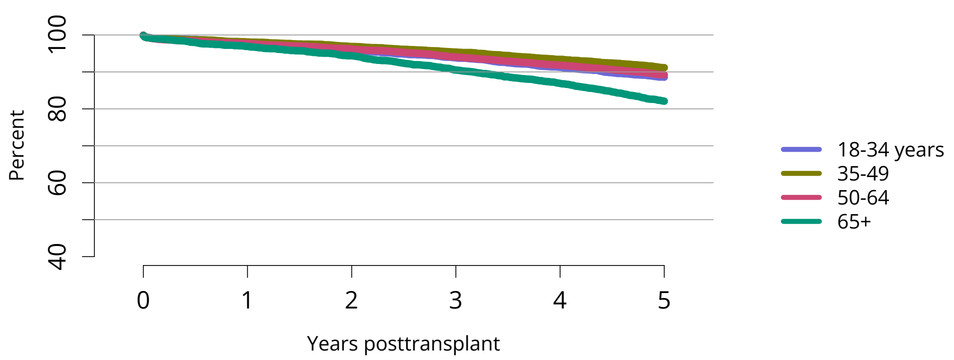

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Figure KI 84: Graft survival among adult living donor kidney transplant recipients, 2014-2016, by age. Graft survival estimated using unadjusted Kaplan-Meier methods.

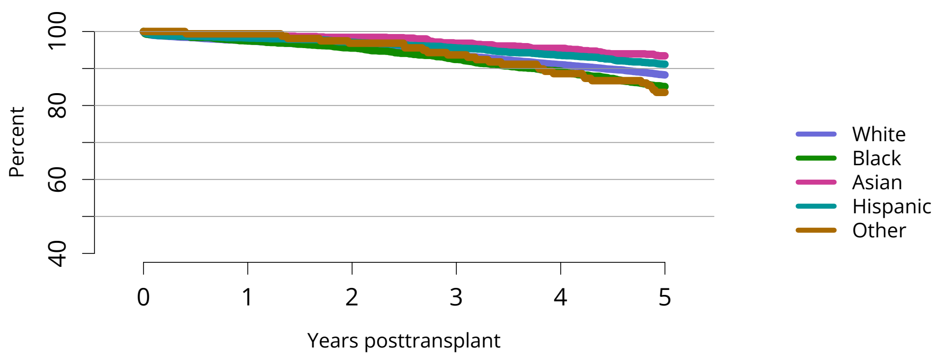

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Figure KI 85: Graft survival among adult living donor kidney transplant recipients, 2014-2016, by race. Graft survival estimated using unadjusted Kaplan-Meier methods.

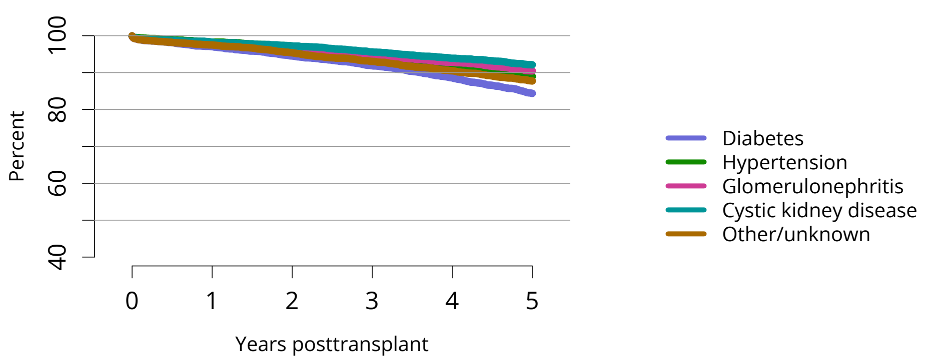

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Figure KI 86: Graft survival among adult living donor kidney transplant recipients, 2014-2016, by diagnosis. Graft survival estimated using unadjusted Kaplan-Meier methods.

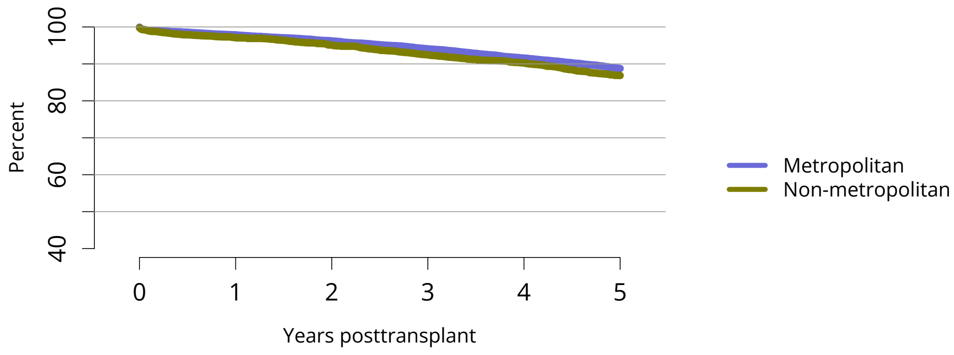

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Figure KI 87: Graft survival among adult living donor kidney transplant recipients, 2014-2016, by metropolitan vs. non-metropolitan recipient residence. Graft survival estimated using unadjusted Kaplan-Meier methods.

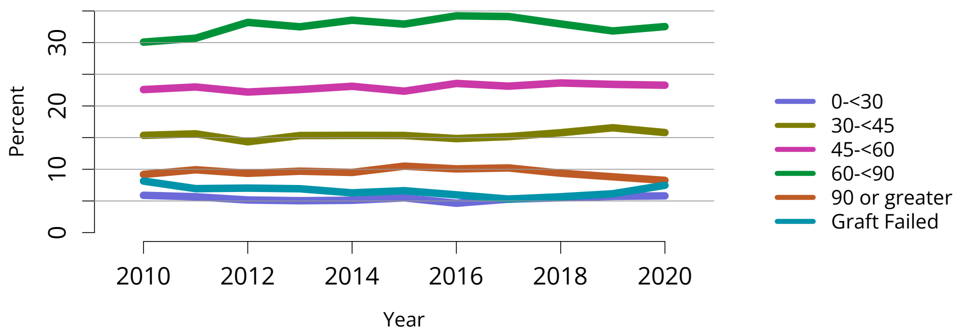

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Figure KI 88: Distribution of eGFR at 12 months posttransplant among adult deceased donor kidney transplant recipients. GFR (mL/min/1.73 m^2) estimated using the Chronic Kidney Disease Epidemiology Collaboration equation, and computed by SRTR for patients alive with graft function at 12 months post-transplant.

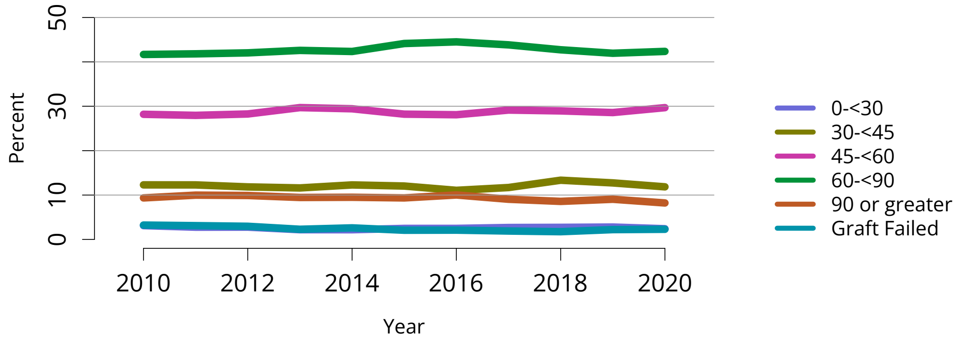

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Figure KI 89: Distribution of eGFR at 12 months posttransplant among adult living donor kidney transplant recipients. GFR (mL/min/1.73 m^2) estimated using the Chronic Kidney Disease Epidemiology Collaboration equation, and computed by SRTR for patients alive with graft function at 12 months post-transplant.

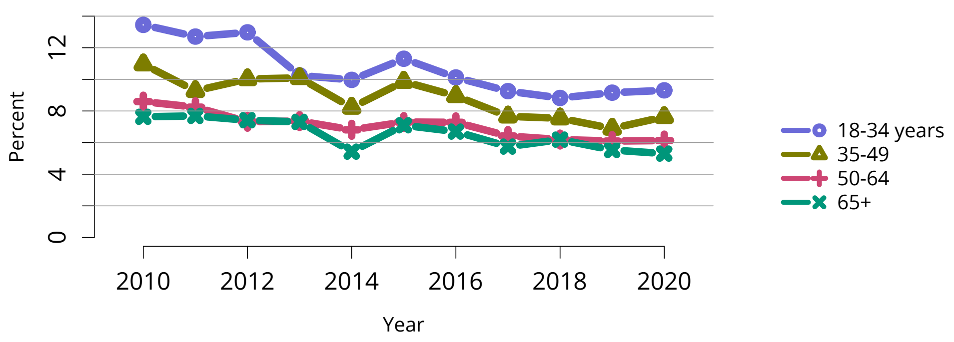

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Figure KI 90: Incidence of acute rejection by 1 year posttransplant among adult kidney transplant recipients by age. Only the first reported rejection event is counted. Cumulative incidence is estimated using the Kaplan-Meier method.

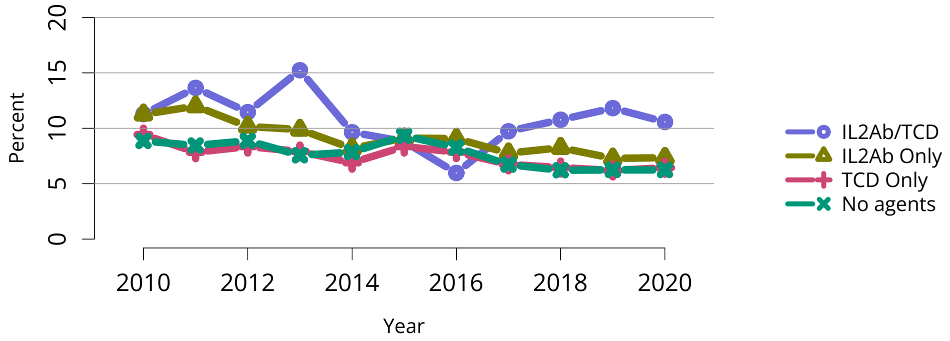

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Figure KI 91: Incidence of acute rejection by 1 year posttransplant among adult kidney transplant recipients by induction agent. Only the first reported rejection event is counted. Cumulative incidence is estimated using the Kaplan-Meier method. IL2Ab, interleukin 2 receptor antibody; TCD, T-cell depleting.

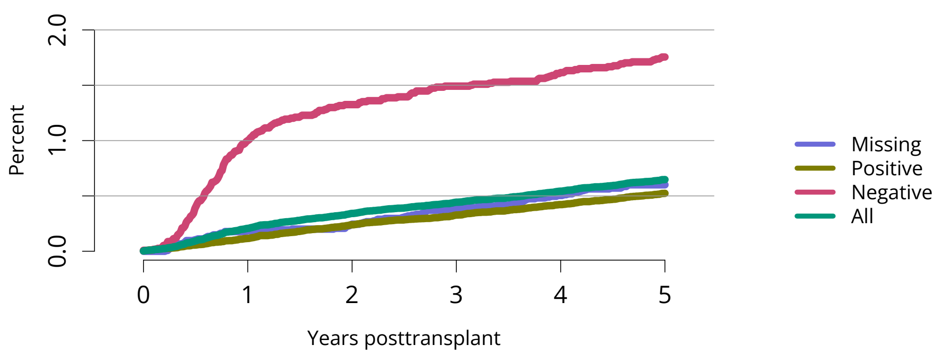

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Figure KI 92: Incidence of PTLD among adult kidney transplant recipients by recipient EBV status at transplant, 2010-2016. Cumulative incidence is estimated using the Kaplan-Meier method. PTLD is identified as a reported complication or cause of death on the OPTN Transplant Recipient Follow-up Form or the Posttransplant Malignancy Form as polymorphic PTLD, monomorphic PTLD, or Hodgkin's disease. Only the earliest date of PTLD diagnosis is considered. EBV, Epstein-Barr virus; PTLD, posttransplant lymphoproliferative disorder.

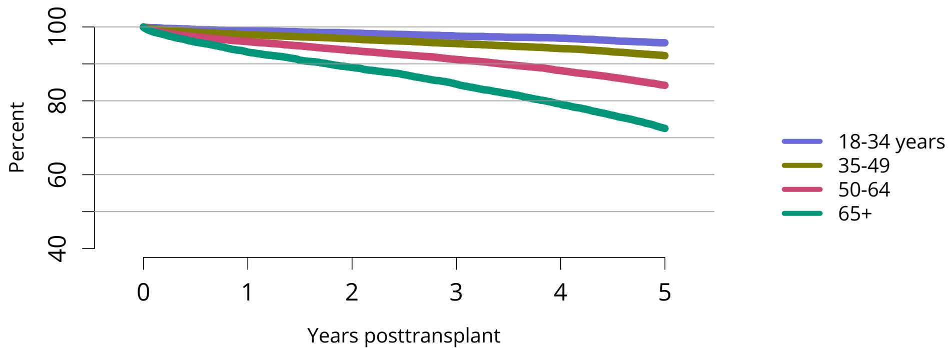

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Figure KI 93: Patient survival among adult deceased donor kidney transplant recipients, 2014-2016, by age. Patient survival estimated using unadjusted Kaplan-Meier methods.

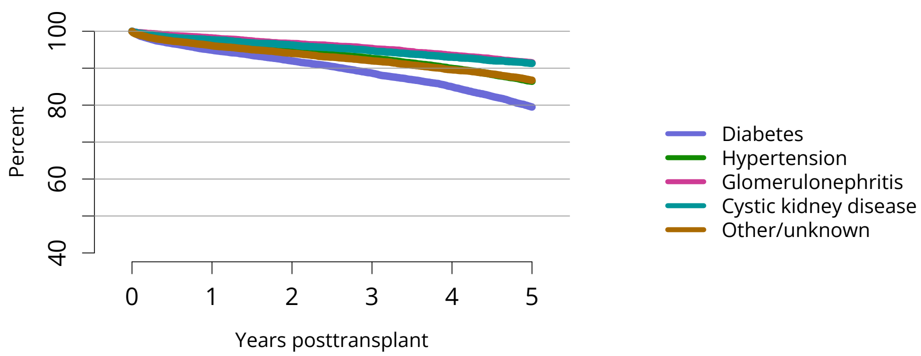

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Figure KI 94: Patient survival among adult deceased donor kidney transplant recipients, 2014-2016, by diagnosis. Patient survival estimated using unadjusted Kaplan-Meier methods.

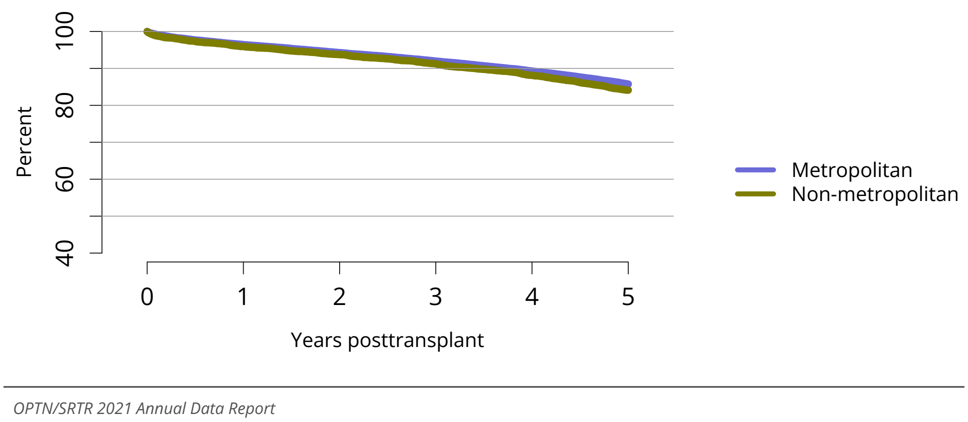

Figure KI 95: Patient survival among adult deceased donor kidney transplant recipients, 2014-2016, by metropolitan vs. non-metropolitan recipient residence. Patient survival estimated using unadjusted Kaplan-Meier methods.

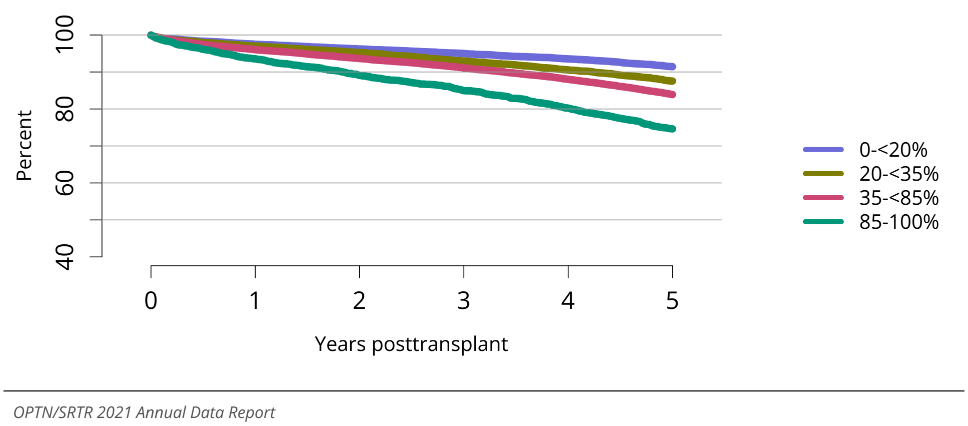

Figure KI 96: Patient survival among adult deceased donor kidney transplant recipients, 2014-2016, by KDPI. Patient survival estimated using unadjusted Kaplan-Meier methods. Conversion of KDRI to KDPI is done using the OPTN KDPI Mapping Tables. For donors recovered January through May, the cohort 2 years prior was used to assign KDPI; for donors recovered June through December, the cohort 1 year prior was used to assign KDPI. KDPI, kidney donor profile index.

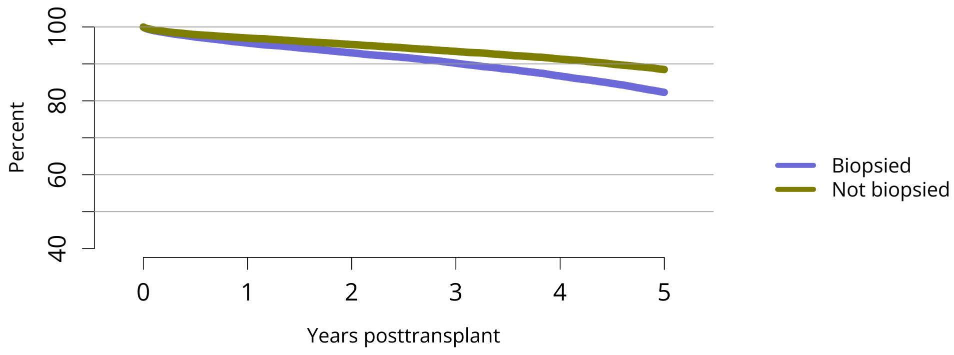

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Figure KI 97: Patient survival among adult deceased donor kidney transplant recipients, 2014-2016, by biopsy status. Patient survival estimated using unadjusted Kaplan-Meier methods. Kidneys are classified as biopsied if either of the donor's kidneys was biopsied.

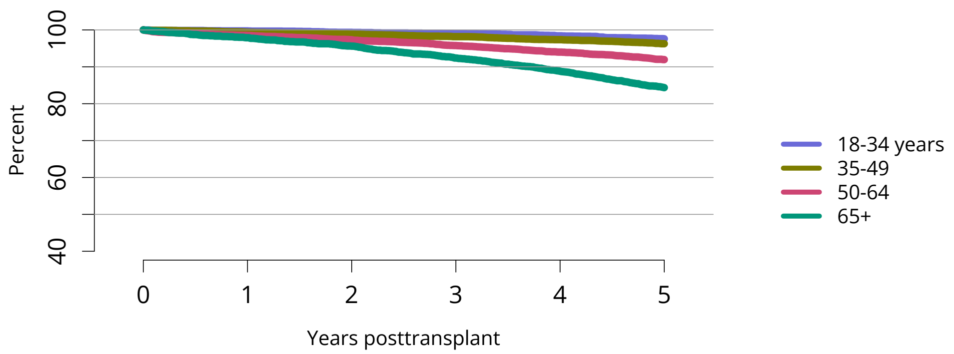

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Figure KI 98: Patient survival among adult living donor kidney transplant recipients, 2014-2016, by age. Patient survival estimated using unadjusted Kaplan-Meier methods.

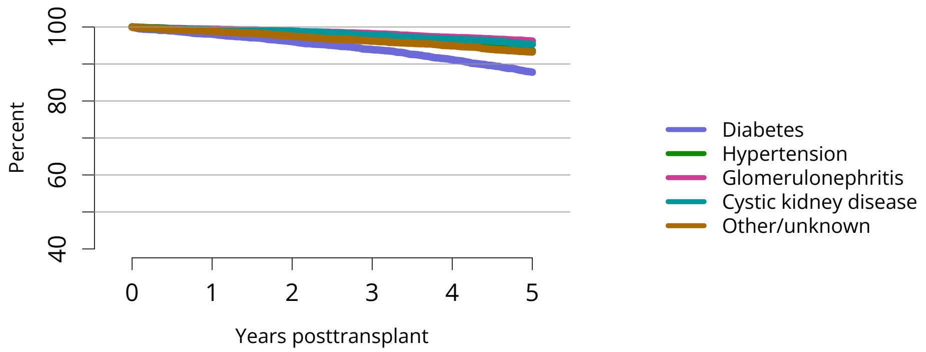

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Figure KI 99: Patient survival among adult living donor kidney transplant recipients, 2014-2016, by diagnosis. Patient survival estimated using unadjusted Kaplan-Meier methods.

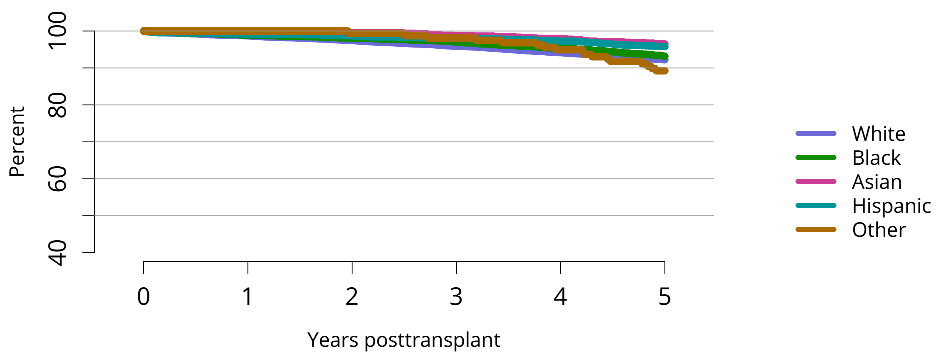

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Figure KI 100: Patient survival among adult living donor kidney transplant recipients, 2014-2016, by race. Patient survival estimated using unadjusted Kaplan-Meier methods.

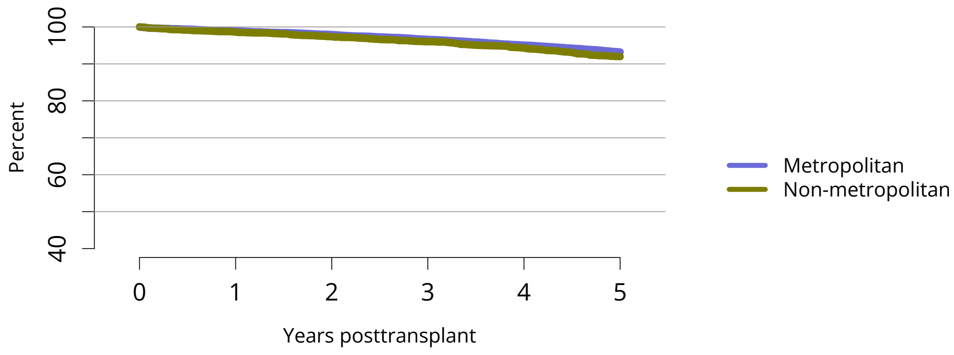

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Figure KI 101: Patient survival among adult living donor kidney transplant recipients, 2014-2016, by metropolitan vs. non-metropolitan recipient residence. Patient survival estimated using unadjusted Kaplan-Meier methods.

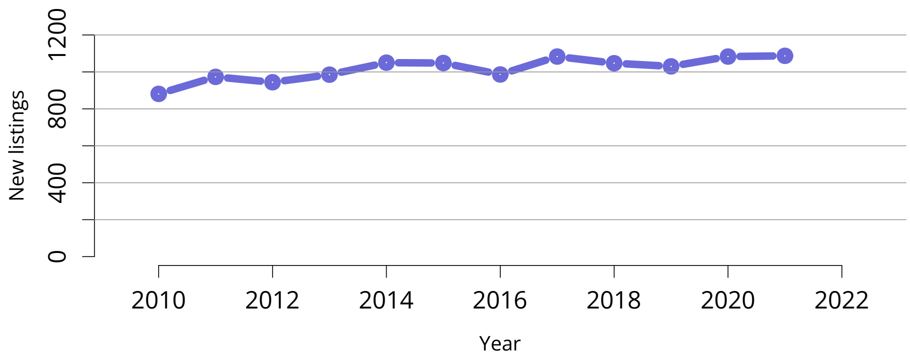

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Figure KI 102: New pediatric candidates added to the kidney transplant waiting list. A new candidate is one who first joined the list during the given year, without having been listed in a previous year. Previously listed candidates who underwent transplant and subsequently relisted are considered new. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

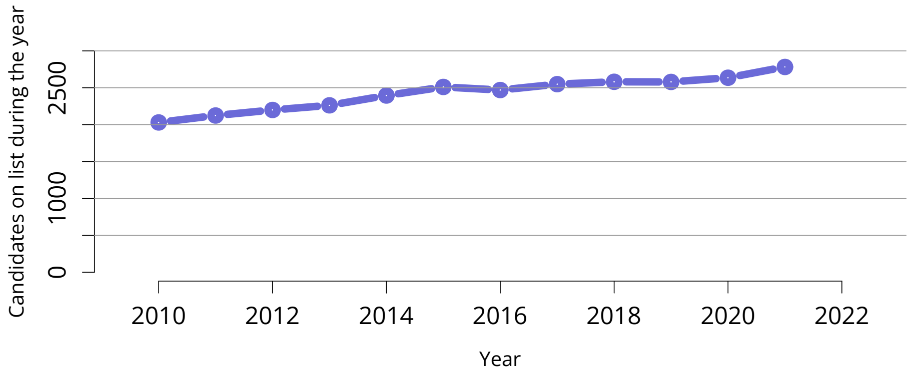

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Figure KI 103: All pediatric candidates on the kidney transplant waiting list. Candidates listed at more than one center are counted once per listing; age determined at first listing.

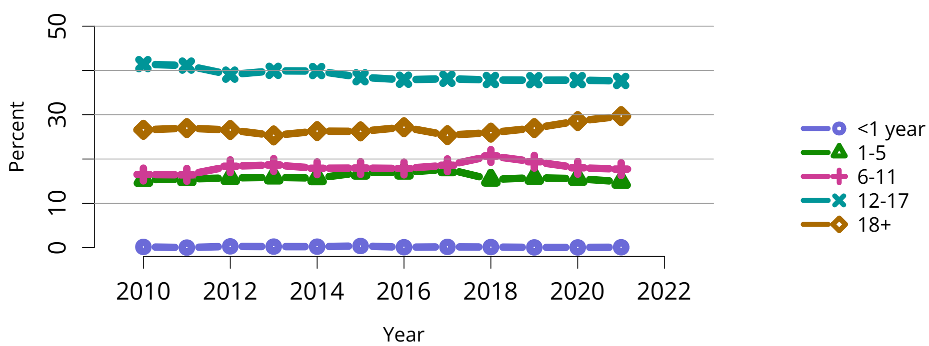

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Figure KI 104: Distribution of pediatric candidates waiting for kidney transplant by age. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive candidates are included. Age is determined at the earliest of transplant, death, removal, or December 31 of the year.

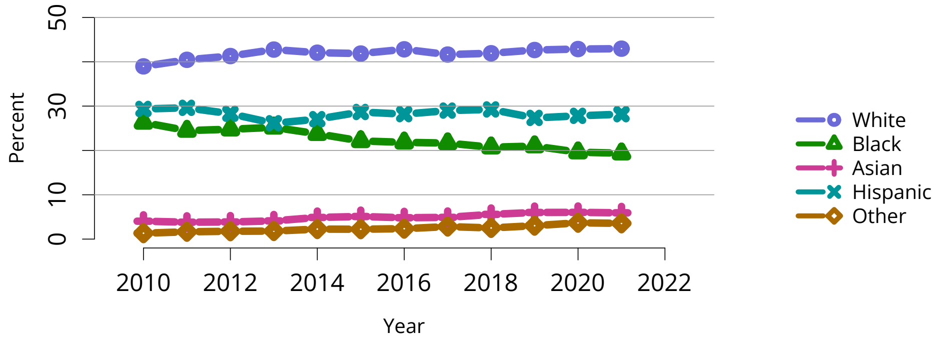

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Figure KI 105: Distribution of pediatric candidates waiting for kidney transplant by race. Candidates waiting for transplant any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive candidates are included.

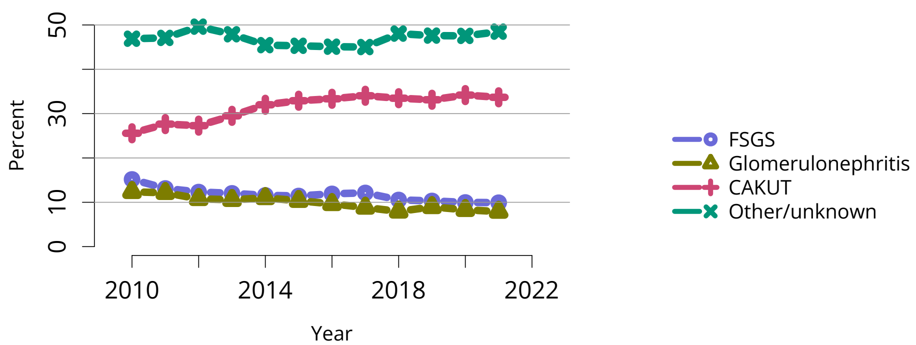

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Figure KI 106: Distribution of pediatric candidates waiting for kidney transplant by diagnosis. Candidates waiting for transplant any time in the given year. Candidates listed at more than one center are counted once per listing. Diagnosis categories follow North American Pediatric Renal Trials and Collaborative Studies recommendations. Active and inactive candidates are included. FSGS, focal segmental glomerulosclerosis; CAKUT, congenital anomalies of the kidney and urinary tract.

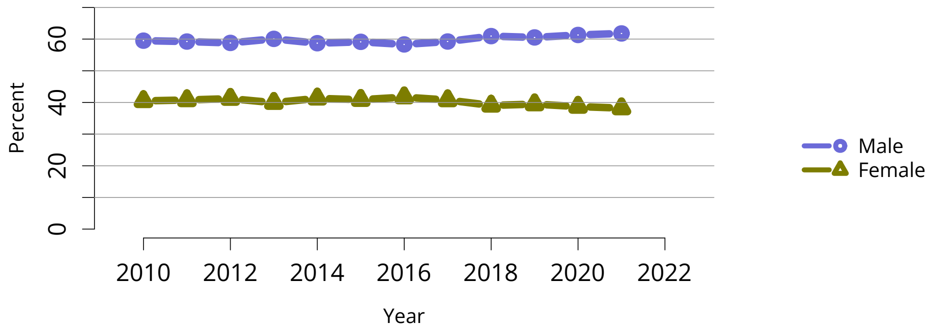

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Figure KI 107: Distribution of pediatric candidates waiting for kidney transplant by sex. Candidates waiting for transplant any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

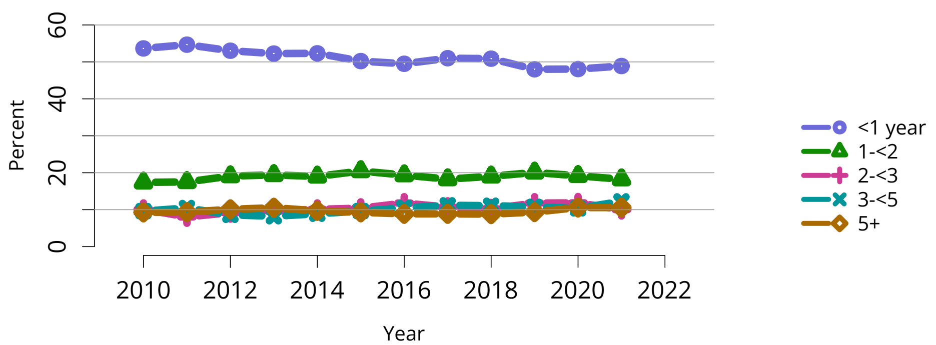

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Figure KI 108: Distribution of pediatric candidates waiting for kidney transplant by waiting time. Candidates waiting for transplant any time in the given year. Candidates listed at more than one center are counted once per listing. Time on the waiting list is determined at the earliest of transplant, death, removal, or December 31 of the year. Candidates listed in the given year are considered to have been listed less than 1 year. Active and inactive candidates are included.

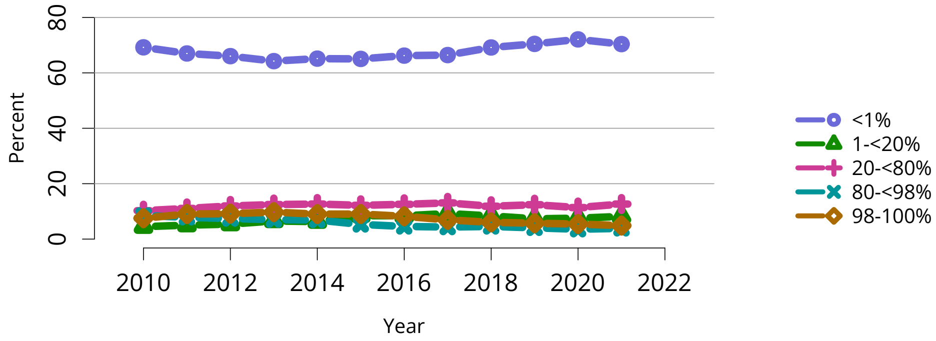

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Figure KI 109: Distribution of pediatric candidates waiting for kidney transplant by cPRA. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. cPRA is determined at the earliest of transplant, death, removal, or December 31 of the year. Active and inactive candidates are included.

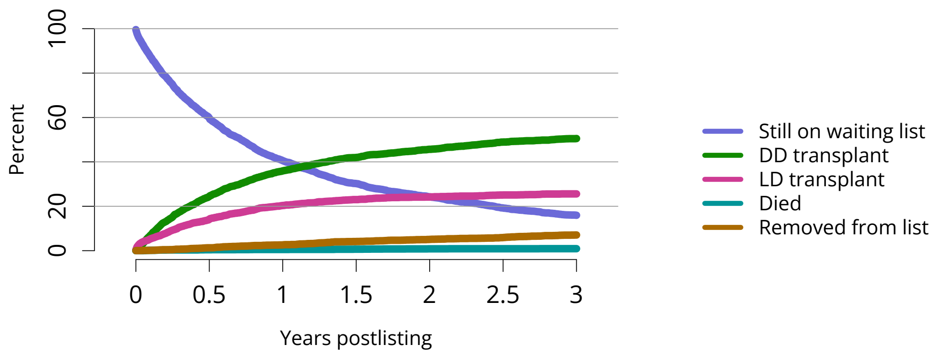

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Figure KI 110: Three-year outcomes for newly listed pediatric candidates waiting for kidney transplant, 2016-2018. Pediatric candidates who joined the waitlist in 2016-2018. Candidates listed at more than one center are counted once per listing. DD, deceased donor; LD, living donor.

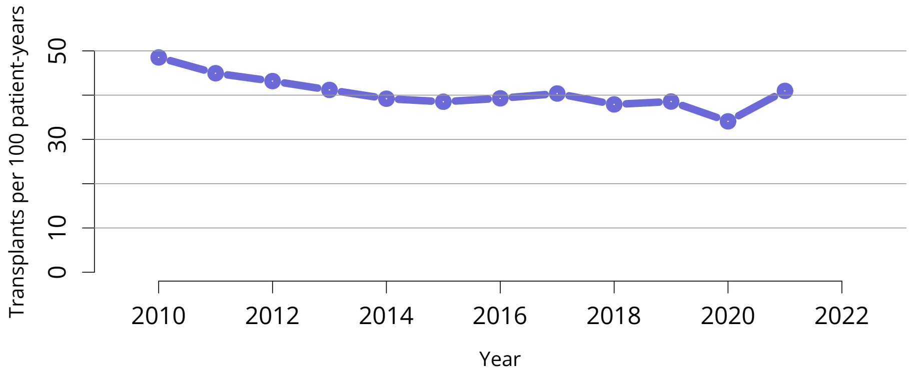

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Figure KI 111: Overall deceased donor kidney transplant rates among pediatric waitlist candidates. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given year. Individual listings are counted separately.

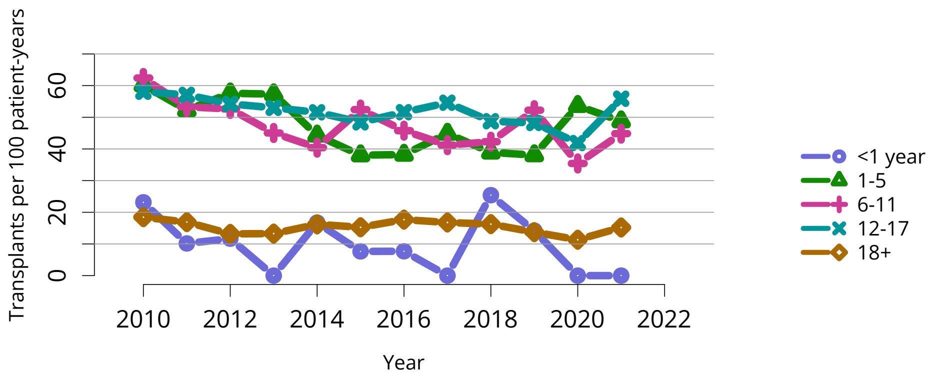

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Figure KI 112: Deceased donor kidney transplant rates among pediatric waitlist candidates by age. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given year. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.

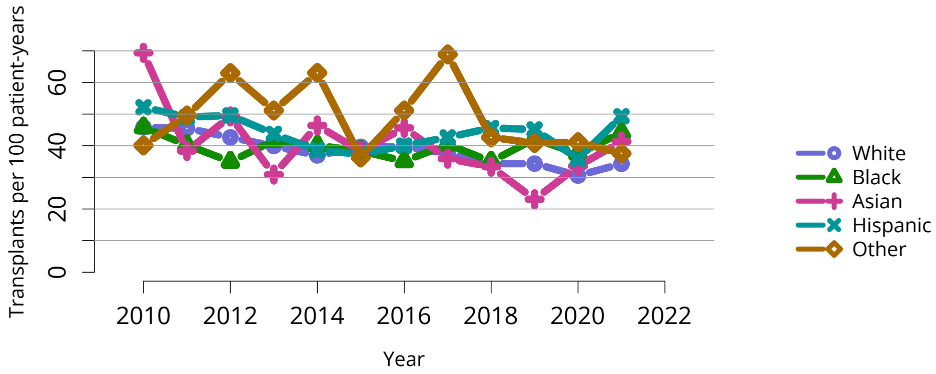

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Figure KI 113: Deceased donor kidney transplant rates among pediatric waitlist candidates by race. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given year. Individual listings are counted separately.

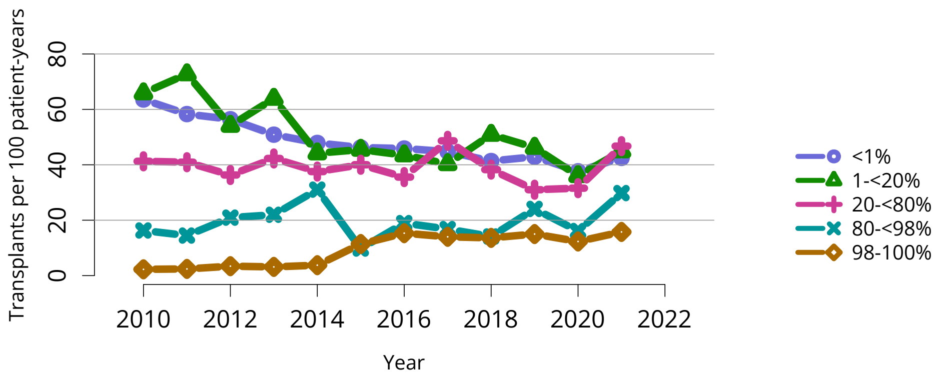

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Figure KI 114: Deceased donor kidney transplant rates among pediatric waitlist candidates by cPRA. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given year. Individual listings are counted separately. cPRA is determined at the earliest of transplant, death, removal, or December 31 of the year.

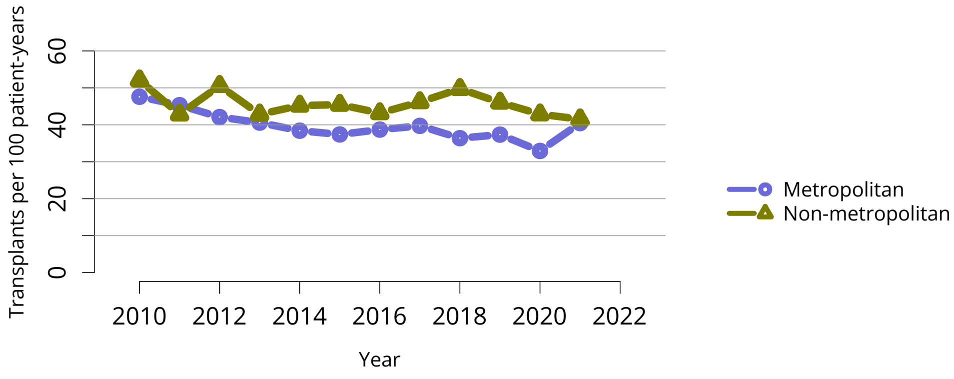

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Figure KI 115: Deceased donor kidney transplant rates among pediatric waitlist candidates by metropolitan vs. non-metropolitan residence. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given year. Individual listings are counted separately.

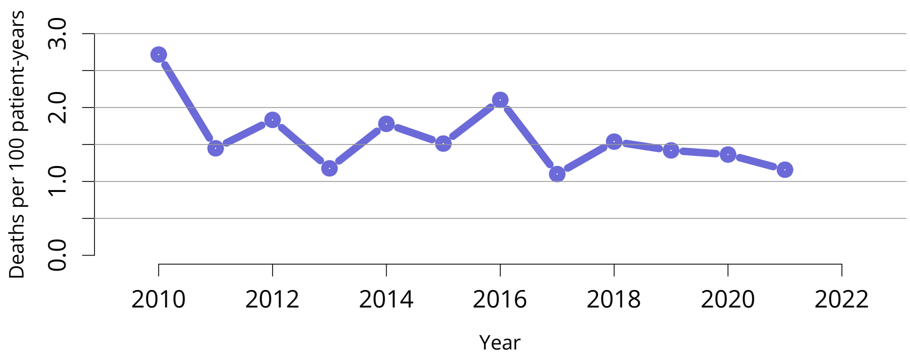

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Figure KI 116: Overall pretransplant mortality rates among pediatric candidates waitlisted for kidney. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

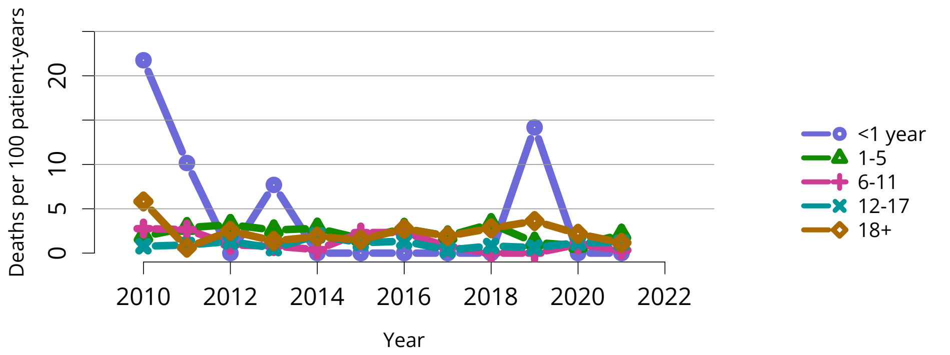

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Figure KI 117: Pretransplant mortality rates among pediatric candidates waitlisted for kidney transplant by age. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.

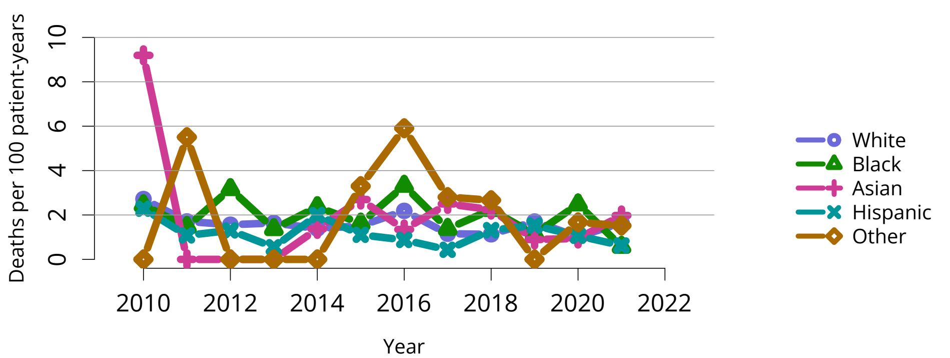

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Figure KI 118: Pretransplant mortality rates among pediatric candidates waitlisted for kidney transplant by race. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

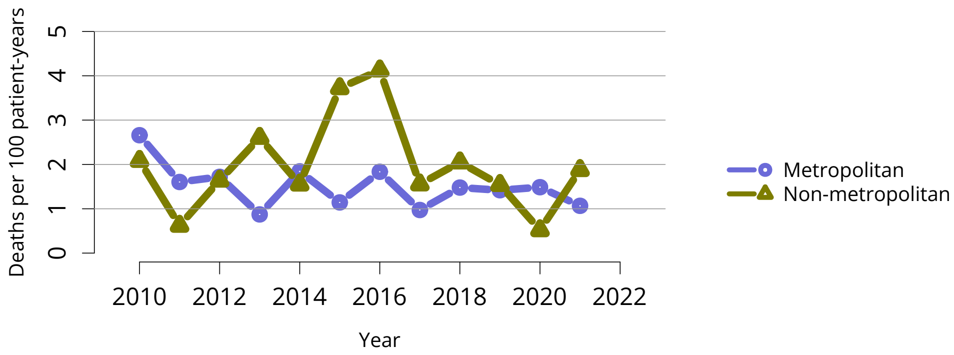

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Figure KI 119: Pretransplant mortality rates among pediatric candidates waitlisted for kidney transplant by metropolitan vs. non-metropolitan residence. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Urban/rural determination is made using the RUCA (rural-urban commuting area) designation of the candidate's permanent zip code.

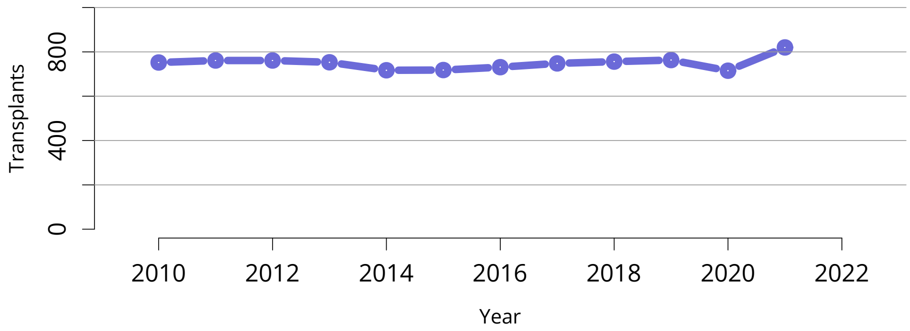

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Figure KI 120: Overall pediatric kidney transplants. All pediatric kidney transplant recipients, including retransplant, and multiorgan recipients.

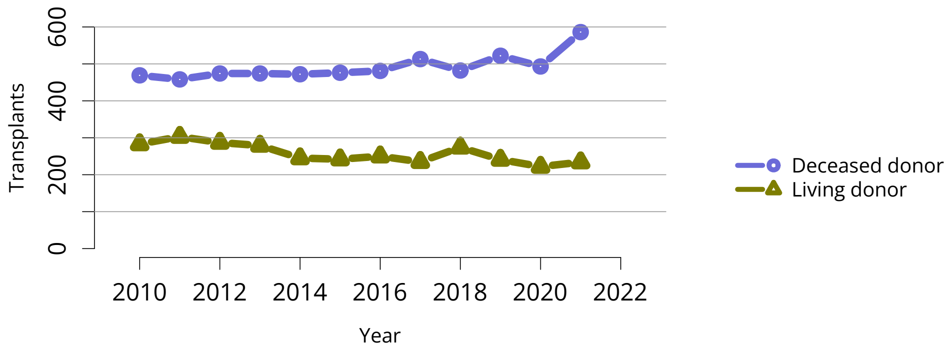

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Figure KI 121: Pediatric kidney transplants by donor type. All pediatric kidney transplant recipients, including retransplant, and multiorgan recipients.

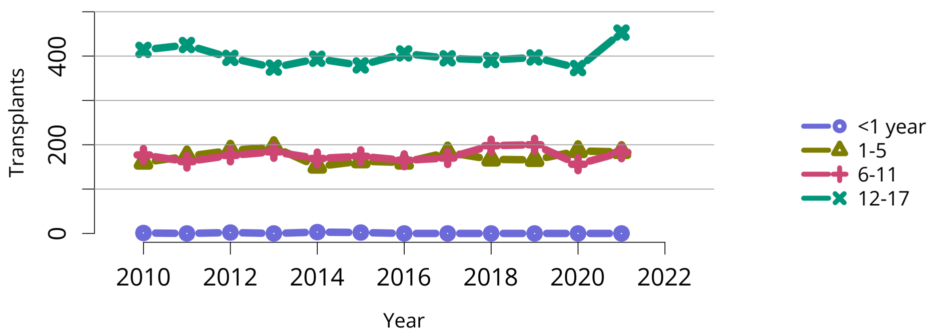

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Figure KI 122: Pediatric kidney transplants by recipient age. All pediatric kidney transplant recipients, including retransplant, and multiorgan recipients.

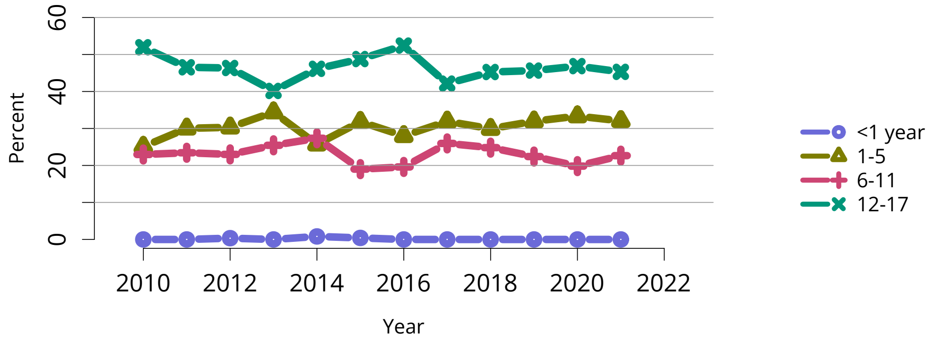

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Figure KI 123: Percent of pediatric kidney transplants from living donors by recipient age. All pediatric living kidney transplant recipients, including retransplant, and multiorgan recipients.

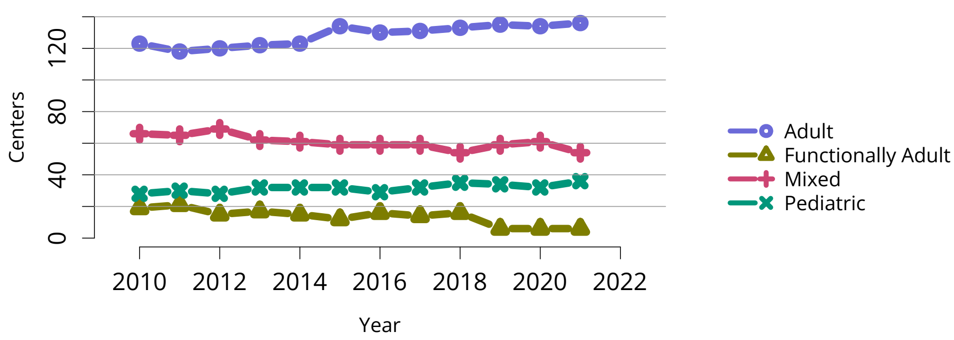

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Figure KI 124: Number of centers performing pediatric and adult kidney transplants by center age mix. Adult centers performed transplants only for recipients aged 18 years or older. Functionally adult centers performed transplants for 80% adults or more, and the remainder were children aged 15-17 years. Mixed included adults and children of any age groups. Pediatric centers performed transplants for recipients aged 0-17 years, and a small number of adults up to age 21 years.

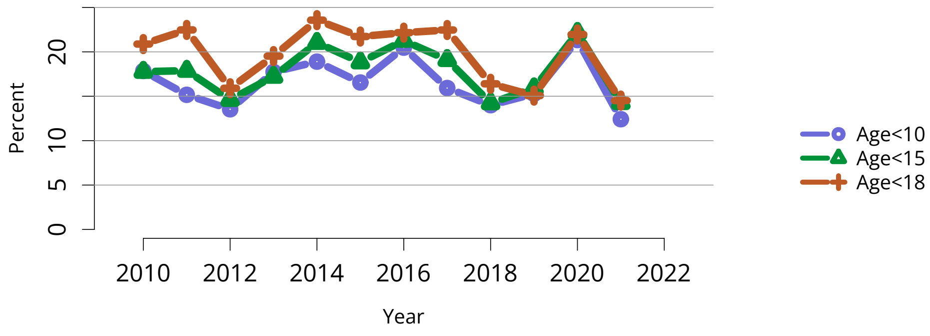

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Figure KI 125: Pediatric kidney recipients at programs that perform 5 or fewer pediatric transplants annually. Age groups are cumulative.

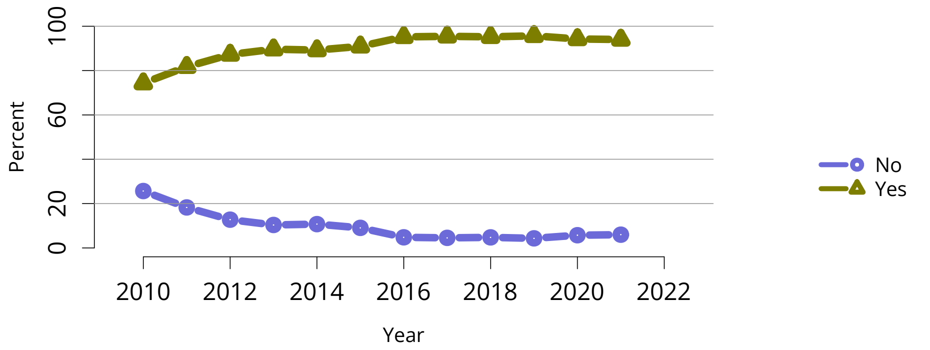

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Figure KI 126: Induction agent use in pediatric kidney transplant recipients. Immunosuppression at transplant reported to the OPTN.

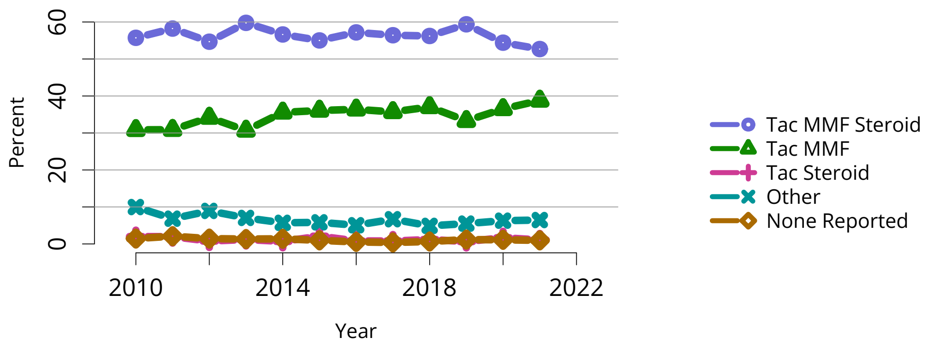

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Figure KI 127: Immunosuppression regimen use in pediatric kidney transplant recipients. Immunosuppression regimen at transplant reported to the OPTN. Tac, tacrolimus. MMF, all mycophenolate agents.

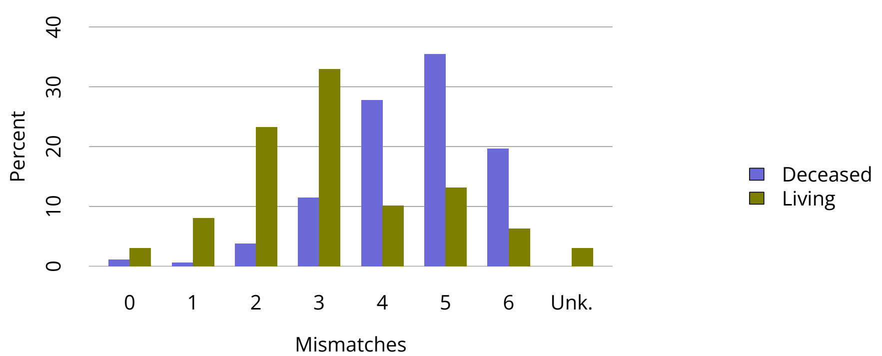

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Figure KI 128: Total HLA A, B, and DR mismatches among pediatric kidney transplant recipients, 2017-2021. Donor and recipient antigen matching is based on OPTN antigen values and split equivalences policy as of 2019.

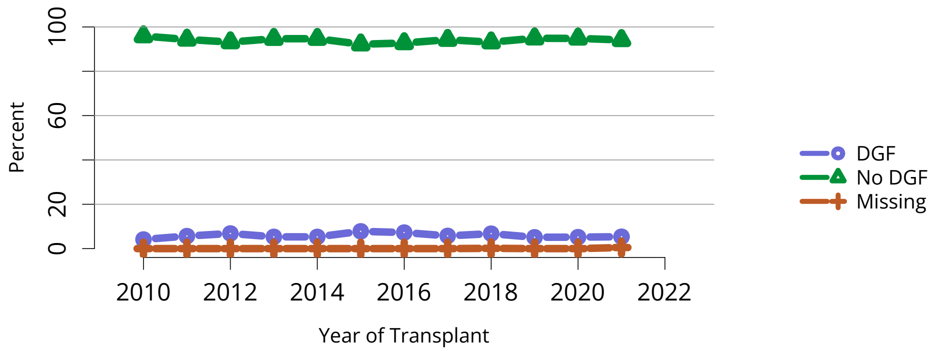

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Figure KI 129: Delayed graft function among pediatric kidney transplant recipients. All pediatric recipients of kidneys. Delayed graft function is defined as dialysis administered within the first seven days posttransplant.

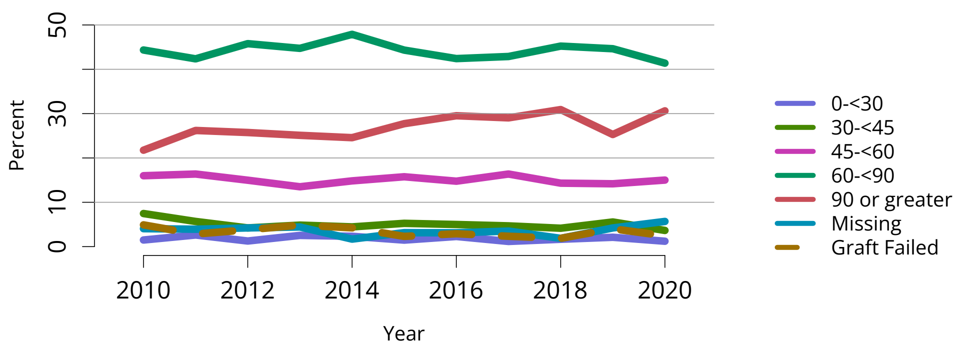

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Figure KI 130: Distribution of eGFR at 12 months posttransplant among pediatric deceased donor kidney-alone transplant recipients. GFR (mL/min/1.73 m^2) estimated using the bedside Schwartz equation, and computed by SRTR for patients alive with graft function at 12 months posttransplant. Equation: eGFR = 0.413*Height(cm)/Creatinine (mg/dL).

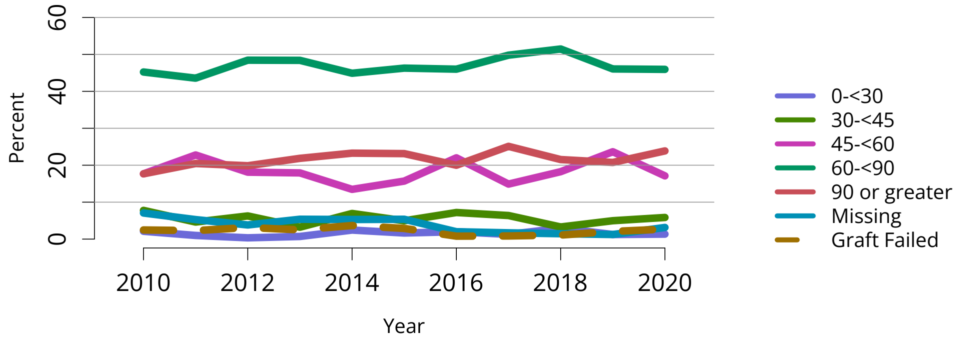

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Figure KI 131: Distribution of eGFR at 12 months posttransplant among pediatric living donor kidney-alone transplant recipients. GFR (mL/min/1.73 m^2) estimated using the bedside Schwartz equation, and computed by SRTR for patients alive with graft function at 12 months posttransplant. Equation: eGFR = 0.413*Height(cm)/Creatinine (mg/dL).

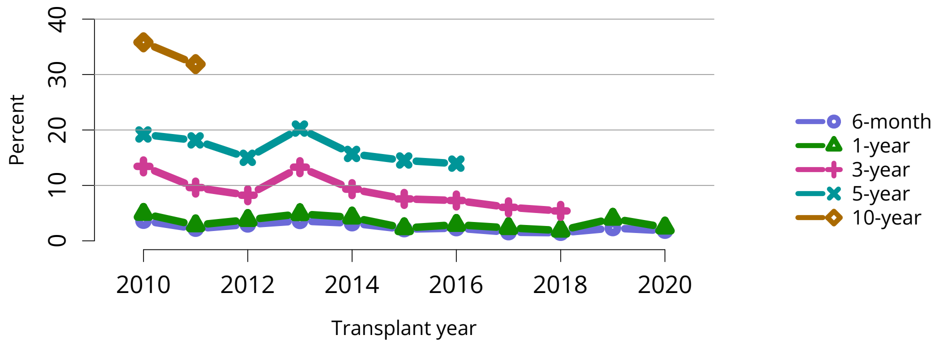

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Figure KI 132: Graft failure among pediatric deceased donor kidney transplant recipients. All pediatric recipients of deceased donor kidneys, including multiorgan transplants. Estimates are unadjusted, computed using Kaplan-Meier methods. Recipients are followed to the earliest of kidney graft failure; kidney retransplant; return to dialysis; death; or 6 months, 1, 3, 5, or 10 years posttransplant. All-cause graft failure is defined as any of the prior outcomes prior to 6 months, 1, 3, 5, or 10 years, respectively.

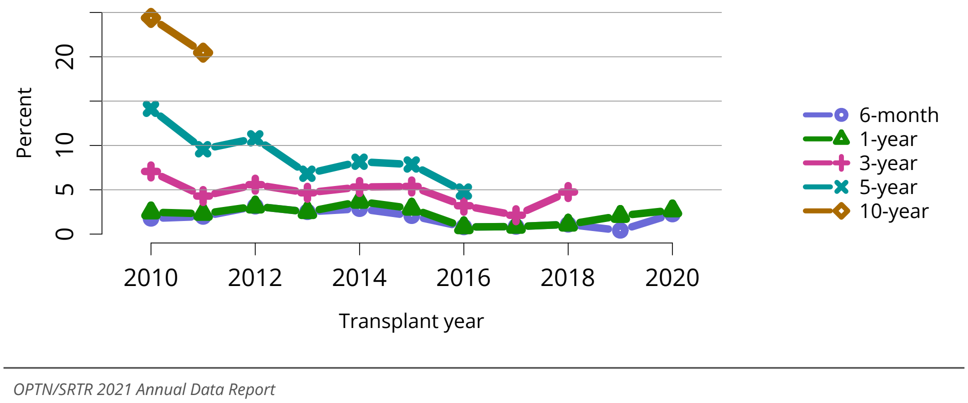

Figure KI 133: Graft failure among pediatric living donor kidney transplant recipients. All pediatric recipients of living donor kidneys, including multiorgan transplants. Estimates are unadjusted, computed using Kaplan-Meier methods. Recipients are followed to the earliest of kidney graft failure; kidney retransplant; return to dialysis; death; or 6 months, 1, 3, 5, or 10 years posttransplant. All-cause graft failure is defined as any of the prior outcomes prior to 6 months, 1, 3, 5, or 10 years, respectively.

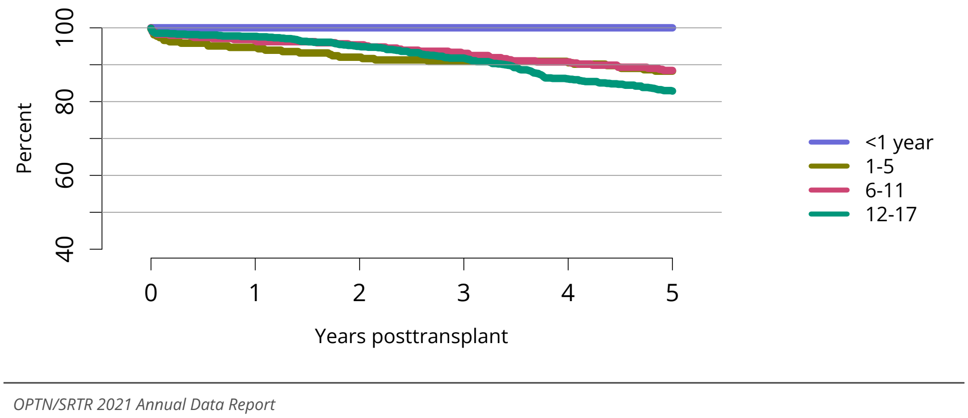

Figure KI 134: Graft survival among pediatric deceased donor kidney transplant recipients, 2014-2016, by age. Recipient survival estimated using unadjusted Kaplan-Meier methods.

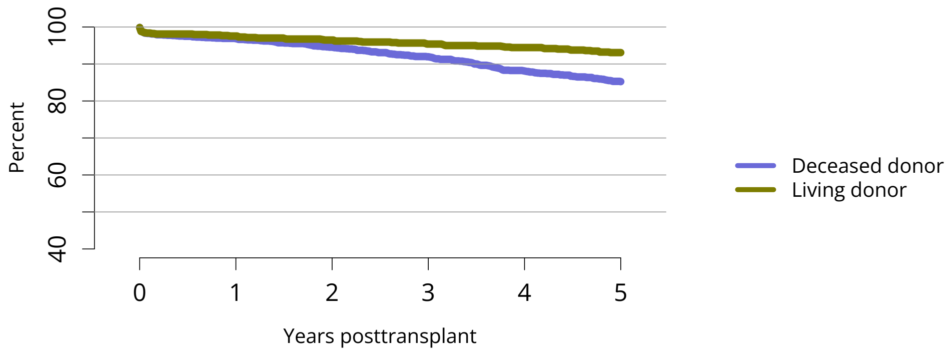

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Figure KI 135: Graft survival among pediatric kidney transplant recipients, 2014-2016, by donor type. Recipient survival estimated using unadjusted Kaplan-Meier methods.

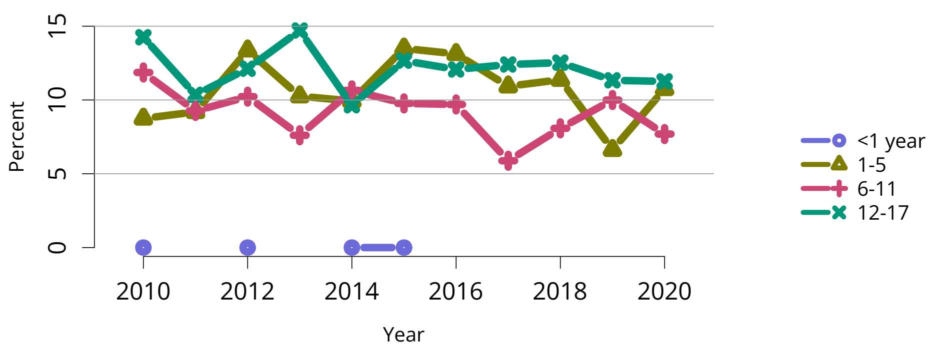

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Figure KI 136: Incidence of acute rejection by 1 year posttransplant among pediatric kidney transplant recipients by age. Only the first reported rejection event is counted. Cumulative incidence is estimated using the Kaplan-Meier method.

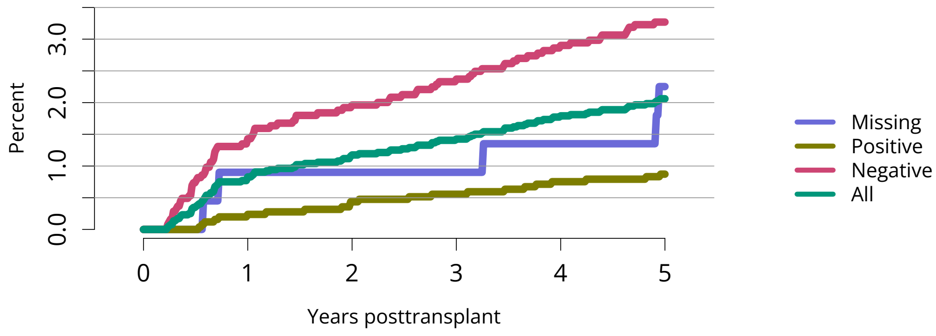

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Figure KI 137: Incidence of PTLD among pediatric kidney transplant recipients by recipient EBV status at transplant, 2010-2016. Cumulative incidence is estimated using the Kaplan-Meier method. PTLD is identified as a reported complication or cause of death on the OPTN Transplant Recipient Follow-up Form or on the Posttransplant Malignancy Form as polymorphic PTLD, monomorphic PTLD, or Hodgkin's disease. Only the earliest date of PTLD diagnosis is considered. EBV, Epstein-Barr virus. PTLD, posttransplant lymphoproliferative disorder.

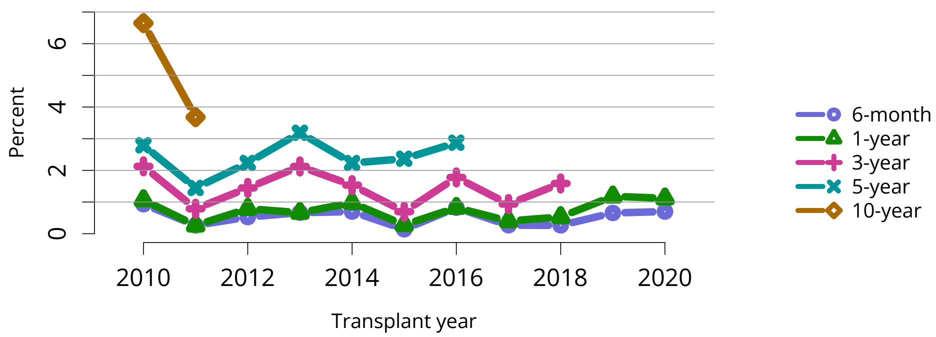

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Figure KI 138: Patient death among pediatric kidney transplant recipients. All pediatric recipients of deceased donor kidneys, including multiorgan transplants. Estimates are unadjusted, computed using unadjusted Kaplan-Meier methods.

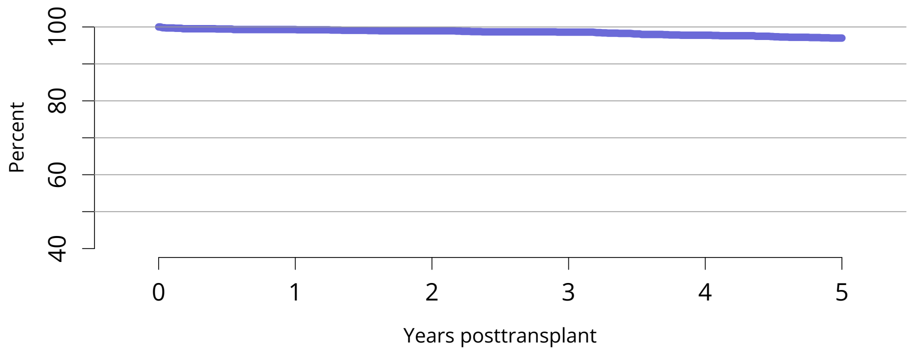

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Figure KI 139: Overall patient survival among pediatric deceased donor kidney transplant recipients, 2014-2016. Recipient survival estimated using unadjusted Kaplan-Meier methods.

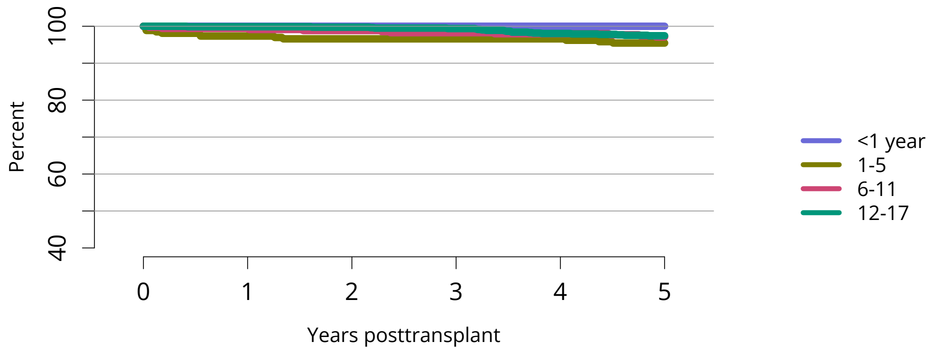

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Figure KI 140: Patient survival among pediatric deceased donor kidney transplant recipients, 2014-2016, by recipient age. Recipient survival estimated using unadjusted Kaplan-Meier methods.

Table KI 1: Demographic characteristics of adults on the kidney transplant waiting list on December 31, 2011, December 31, 2016 and December 31, 2021. Candidates waiting for transplant on December 31 of the given year, regardless of first listing date. Distance is computed from candidate's home zip code to the transplant center. Age is determined on December 31 of the year.

	2011		2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Age (years)						
18-34 years	9464	9.9	8841	8.5	7501	7.8
35-49	26429	27.7	26079	25	22415	23.3
50-64	41372	43.4	46099	44.2	41759	43.4
65+	18107	19	23310	22.3	24455	25.4
Sex						
Male	56361	59.1	63583	60.9	59527	61.9
Female	39011	40.9	40746	39.1	36603	38.1
Race						
White	36684	38.5	38273	36.7	34399	35.8
Black	32538	34.1	34772	33.3	30746	32
Asian	7400	7.8	9404	9	9566	10
Hispanic	17424	18.3	20246	19.4	19757	20.6
Other	1326	1.4	1634	1.6	1662	1.7
Geography						
Metropolitan	81820	85.8	90668	86.9	83598	87
Non-metropolitan	12141	12.7	12494	12	11619	12.1
Missing	1411	1.5	1167	1.1	913	0.9
Miles between candidate to center						
<50 miles	63494	66.6	68850	66	63318	65.9
50-<100	14226	14.9	15880	15.2	15250	15.9
100-<150	6822	7.2	7565	7.3	6565	6.8
150-<250	6234	6.5	6933	6.6	5785	6
250+	3784	4	4561	4.4	4766	5
Missing	812	0.9	540	0.5	446	0.5
All candidates						
All candidates	95372	100	104329	100	96130	100

Table KI 2: Clinical characteristics of adults on the kidney transplant waiting list on December 31, 2011, December 31, 2016 and December 31, 2021. Candidates waiting for transplant on December 31 of the given year, regardless of first listing date. *Diabetes status based on diagnosis and comorbid conditions.

	2011		2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Diagnosis						
Diabetes	31796	33.3	37714	36.1	37162	38.7
Hypertension	23873	25	24272	23.3	19734	20.5
Glomerulonephritis	13946	14.6	15028	14.4	13513	14.1
Cystic kidney disease	8081	8.5	9202	8.8	8424	8.8
Other/unknown	17675	18.5	18112	17.4	17297	18
NA	1	0	1	0	0	0
Blood Type						
A	27425	28.8	29011	27.8	25749	26.8
AB	2709	2.8	2735	2.6	2407	2.5
B	15369	16.1	17353	16.6	15985	16.6
O	49869	52.3	55230	52.9	51989	54.1
CPRA						
<1%	60276	63.2	65371	62.7	59609	62
1-<20%	6380	6.7	9160	8.8	9125	9.5
20-<80%	13357	14	15835	15.2	16493	17.2
80-<98%	6626	6.9	6231	6	5003	5.2
98-100%	8733	9.2	7732	7.4	5900	6.1
All candidates						
All candidates	95372	100	104329	100	96130	100

Table KI 3: Listing characteristics of adults on the kidney transplant waiting list on December 31, 2011, December 31, 2016 and December 31, 2021. Candidates waiting for transplant on December 31 of the given year, regardless of first listing date.

	2011		2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Waiting time (years)						
<1 year	29311	30.7	29244	28	31622	32.9
1-<2	22336	23.4	21418	20.5	19210	20
2-<3	15806	16.6	16972	16.3	15925	16.6
3-<5	17034	17.9	21416	20.5	16979	17.7
5+	10885	11.4	15279	14.6	12394	12.9
Previous transplant						
No prior transplant	80501	84.4	90844	87.1	85012	88.4
Prior transplant	14871	15.6	13485	12.9	11118	11.6
All candidates						
All candidates	95372	100	104329	100	96130	100

Table KI 4: Kidney transplant waitlist activity among adults. Candidates listed at more than one center are counted once per listing. Candidates who are listed, undergo transplant, and are relisted are counted more than once. Candidates are not considered to be on the list on the day they are removed; counts on January 1 may differ from counts on December 31 of the prior year. Candidates listed for multiorgan transplants are included.

Waiting list state	**2019**	**2020**	**2021**
Waiting list state			
Patients at start of year	101127	101362	97260
Patients added during year	42933	37399	41765
Patients removed during year	42643	41470	42895
Patients at end of year	101417	97291	96130

Table KI 5: Removal reason among adult kidney transplant candidates. Removal reason as reported to the OPTN. Candidates with death dates that precede removal dates are assumed to have died waiting.

Removal reason	2019	2020	2021
Removal reason			
Deceased donor transplant	16796	17848	18827
Living donor transplant	6605	4986	5714
Transplant outside US	64	47	39
Patient died	4060	5105	5011
Patient refused transplant	398	304	282
Improved, transplant not needed	205	180	217
Too sick for transplant	4302	3908	4056
Other	9933	8820	8269
Changed to kidney-pancreas list	242	198	242
Still on waiting list	38	74	238

Table KI 6: Demographic characteristics of adult kidney transplant recipients, 2021. Kidney transplant recipients, including retransplants. Distance is computed from recipient's home zip code to the transplant center.

	Deceased		Living		All	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Recipient age (years)						
18-34 years	2185	11.5	965	16.8	3150	12.8
35-49	4942	26.1	1580	27.5	6522	26.4
50-64	7664	40.5	2061	35.9	9725	39.4
65+	4140	21.9	1130	19.7	5270	21.4
Sex						
Male	11459	60.5	3598	62.7	15057	61
Female	7472	39.5	2138	37.3	9610	39
Race						
White	6821	36	3546	61.8	10367	42
Black	6449	34.1	772	13.5	7221	29.3
Asian	1523	8	377	6.6	1900	7.7
Hispanic	3830	20.2	961	16.8	4791	19.4
Other	308	1.6	80	1.4	388	1.6
Insurance						
Private	4718	24.9	3180	55.4	7898	32
Medicare	12243	64.7	2150	37.5	14393	58.3
Medicaid	1438	7.6	266	4.6	1704	6.9
Other/unknown	532	2.8	140	2.4	672	2.7
Geography						
Metropolitan	16293	86.1	4900	85.4	21193	85.9
Non-metropolitan	2330	12.3	742	12.9	3072	12.5
Missing	308	1.6	94	1.6	402	1.6
Miles between recipient to center						
<50 miles	12318	65.1	3721	64.9	16039	65
50-<100	2969	15.7	879	15.3	3848	15.6
100-<150	1448	7.6	407	7.1	1855	7.5
150-<250	1075	5.7	282	4.9	1357	5.5
250+	906	4.8	364	6.3	1270	5.1
Missing	215	1.1	83	1.4	298	1.2
All recipients						
All recipients	18931	100	5736	100	24667	100

Table KI 7: Clinical characteristics of adult kidney transplant recipients, 2021. Kidney transplant recipients, including retransplants.

	Deceased		Living		All	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Diagnosis						
Diabetes	6376	33.7	1442	25.1	7818	31.7
Hypertension	4338	22.9	945	16.5	5283	21.4
Glomerulonephritis	2757	14.6	1327	23.1	4084	16.6
Cystic kidney disease	1732	9.1	886	15.4	2618	10.6
Other/unknown	3728	19.7	1136	19.8	4864	19.7
Blood Type						
A	6521	34.4	2144	37.4	8665	35.1
AB	856	4.5	248	4.3	1104	4.5
B	2717	14.4	821	14.3	3538	14.3
O	8837	46.7	2523	44	11360	46.1
Years of dialysis						
None	4148	21.9	2930	51.1	7078	28.7
<1 year	371	2	327	5.7	698	2.8
1-<3	3446	18.2	1416	24.7	4862	19.7
3-<5	3559	18.8	425	7.4	3984	16.2
5+	7407	39.1	638	11.1	8045	32.6
CPRA						
<1%	11046	58.3	4161	72.5	15207	61.6
1-<20%	1608	8.5	535	9.3	2143	8.7
20-<80%	3092	16.3	806	14.1	3898	15.8
80-<98%	1964	10.4	186	3.2	2150	8.7
98-100%	1221	6.4	44	0.8	1265	5.1
Missing	0	0	4	0.1	4	0
All recipients						
All recipients	18931	100	5736	100	24667	100

Table KI 8: Transplant characteristics of adult kidney transplant recipients, 2021. Kidney transplant recipients, including retransplants. DBD, donation after brain death; DCD, donation after circulatory death; KDPI, kidney donor profile index. DCD status and KDPI scores apply to deceased donor transplants only.

	Deceased		Living		All	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Waiting time (years)						
None	188	1	85	1.5	273	1.1
<1 year	8584	45.3	3449	60.1	12033	48.8
1-<3	4911	25.9	1767	30.8	6678	27.1
3-<5	2693	14.2	333	5.8	3026	12.3
5+	2555	13.5	102	1.8	2657	10.8
KDPI						
0-<20%	4499	23.8	0	0	4499	18.2
20-<35%	3175	16.8	0	0	3175	12.9
35-<85%	9948	52.5	0	0	9948	40.3
85-100%	1309	6.9	0	0	1309	5.3
Missing	0	0	5736	100	5736	23.3
Donation after circulatory death						
DBD	13227	69.9	0	0	13227	53.6
DCD	5704	30.1	0	0	5704	23.1
Living donor	0	0	5736	100	5736	23.3
Previous transplant for recipients						
Prior transplant	2033	10.7	477	8.3	2510	10.2
No Prior transplant	16898	89.3	5259	91.7	22157	89.8
Organs Transplanted						
Kidney only	16988	89.7	5736	100	22724	92.1
Kidney-pancreas	818	4.3	0	0	818	3.3
Kidney-liver	756	4	0	0	756	3.1
Heart-kidney	344	1.8	0	0	344	1.4
Kidney-lung	15	0.1	0	0	15	0.1
Intestine-pancreas-liver-kidney	1	0	0	0	1	0
Other	9	0	0	0	9	0
All recipients						
All recipients	18931	100	5736	100	24667	100

Table KI 9: Adult deceased donor kidney donor-recipient serology matching, 2018-2020. Donor serology is reported on the OPTN Donor Registration Form and recipient serology on the OPTN Transplant Recipient Registration Form. There may be multiple fields per serology. Any evidence for a positive serology is treated as positive for that serology. Donor HCV NAT data are shown by recipient HCV antibody status. CMV, cytomegalovirus; EBV, Epstein-Barr virus; HBsAg, hepatitis B surface antigen; HCV, hepatitis C virus; HIV, human immunodeficiency virus; NAT, nucleic acid test.

Donor	Recipient	CMV	EBV	HBsAg	HCV antibody	HCV NAT
Donor						
D-	R-	13.43	0.63	97.33	84.98	88.57
D-	R+	24.9	7.71	1.24	3.13	3.35
D-	R unk	0.46	0.23	1.21	1.56	1.63
D+	R-	18.55	4.96	0.17	9.18	5.57
D+	R+	41.55	83.33	0.01	0.96	0.74
D+	R unk	0.63	2.89	0	0.19	0.11
D unk	R-	0.15	0.01	0.04	0.01	0.02
D unk	R+	0.32	0.22	0	0	0
D unk	R unk	0.01	0.01	0	0	0

Table KI 10: Adult living donor kidney donor-recipient serology matching, 2019-2021. Donor serology is reported on the OPTN Donor Registration Form and recipient serology on the OPTN Transplant Recipient Registration Form. There may be multiple fields per serology. Any evidence for a positive serology is treated as positive for that serology. Donor HCV NAT data are shown by recipient HCV antibody status. CMV, cytomegalovirus; EBV, Epstein-Barr virus; HBsAg, hepatitis B surface antigen; HCV, hepatitis C virus; HIV, human immunodeficiency virus; NAT, nucleic acid test.

Donor	Recipient	CMV	EBV	HBsAg	HCV antibody	HCV NAT
Donor						
D-	R-	24.95	1.24	95.67	93.82	85.62
D-	R+	20.76	6.99	0.85	1.81	1.67
D-	R unk	0.55	0.17	1.4	2.1	1.96
D+	R-	17.46	6.01	0.31	0.76	0.07
D+	R+	32.03	82.08	0	0.03	0.01
D+	R unk	0.67	1.77	0	0.01	0
D unk	R-	1.67	0.14	1.69	1.39	10.28
D unk	R+	1.87	1.46	0.02	0.02	0.19
D unk	R unk	0.05	0.13	0.06	0.05	0.2

Table KI 11: Demographic characteristics of pediatric candidates on the kidney transplant waiting list on December 31, 2011, December 31, 2016, and December 31, 2021. Candidates aged younger than 18 years at listing waiting for transplant on December 31 of the given year, regardless of first listing date. Age is determined on December 31 of the year. Distance is computed from candidate's home zip code to the transplant center.

	2011		2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Age (years)						
1-5	182	14.5	246	16.8	216	12.7
6-11	194	15.5	253	17.3	291	17.1
12-17	470	37.5	494	33.7	575	33.9
18+	409	32.6	472	32.2	614	36.2
<1 year	0	0	1	0.1	2	0.1
Sex						
Male	741	59	880	60	1054	62.1
Female	514	41	586	40	644	37.9
Race						
White	487	38.8	571	38.9	709	41.8
Black	329	26.2	350	23.9	353	20.8
Asian	45	3.6	72	4.9	108	6.4
Hispanic	375	29.9	438	29.9	467	27.5
Other	19	1.5	35	2.4	61	3.6
Geography						
Metropolitan	1054	84	1259	85.9	1482	87.3
Non-metropolitan	181	14.4	191	13	204	12
Missing	20	1.6	16	1.1	12	0.7
Miles between candidate to center						
<50 miles	786	62.6	935	63.8	1105	65.1
50-<100	217	17.3	227	15.5	278	16.4
100-<150	101	8	114	7.8	108	6.4
150-<250	86	6.9	109	7.4	114	6.7
250+	47	3.7	69	4.7	85	5
Missing	18	1.4	12	0.8	8	0.5
All candidates						
All candidates	1255	100	1466	100	1698	100

Table KI 12: Clinical characteristics of pediatric candidates on the kidney transplant waiting list on December 31, 2011, December 31, 2016, and December 31, 2021. Candidates aged younger than 18 years at listing waiting for transplant on December 31 of the given year, regardless of first listing date. FSGS, focal segmental glomerulosclerosis; GN, glomerulonephritis; CAKUT, congenital anomalies of the kidney and urinary tract.

	2011		2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Pediatric diagnosis						
FSGS	165	13.1	182	12.4	162	9.5
Glomerulonephritis	144	11.5	131	8.9	127	7.5
CAKUT	350	27.9	512	34.9	610	35.9
Other/unknown	596	47.5	640	43.7	799	47.1
Blood Type						
A	384	30.6	421	28.7	572	33.7
AB	45	3.6	35	2.4	53	3.1
B	211	16.8	241	16.4	240	14.1
O	615	49	769	52.5	833	49.1
CPRA						
<1%	784	62.5	926	63.2	1174	69.1
1-<20%	44	3.5	126	8.6	133	7.8
20-<80%	140	11.2	186	12.7	206	12.1
80-<98%	123	9.8	79	5.4	80	4.7
98-100%	164	13.1	149	10.2	105	6.2
All candidates						
All candidates	1255	100	1466	100	1698	100

Table KI 13: Listing characteristics of pediatric candidates on the kidney transplant waiting list on December 31, 2011, December 31, 2016, and December 31, 2021. Candidates aged younger than 18 years at listing waiting for transplant on December 31 of the given year, regardless of first listing date.

	2011		2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Waiting time (years)						
<1 year	577	46	607	41.4	679	40
1-<2	239	19	307	20.9	323	19
2-<3	117	9.3	192	13.1	195	11.5
3-<5	164	13.1	197	13.4	260	15.3
5+	158	12.6	163	11.1	241	14.2
Previous transplant						
No prior transplant	847	67.5	1132	77.2	1390	81.9
Prior transplant	408	32.5	334	22.8	308	18.1
All candidates						
All candidates	1255	100	1466	100	1698	100

Table KI 14: Kidney transplant waitlist activity among pediatric candidates. Candidates who are listed, undergo transplant, and are relisted are counted more than once. Candidates are not considered to be on the list on the day they are removed; counts on January 1 may differ from counts on December 31 of the prior year. Candidates listed for multiorgan transplants are included.

Waiting list state	2019	2020	2021
Waiting list state			
Patients at start of year	1549	1553	1695
Patients added during year	1030	1083	1087
Patients removed during year	1025	941	1084
Patients at end of year	1554	1695	1698

Table KI 15: Removal reason among pediatric kidney transplant candidates. Removal reason as reported to the OPTN. Candidates with death dates that precede removal dates are assumed to have died waiting.

Removal reason	2019	2020	2021
Removal reason			
Deceased donor transplant	611	563	692
Living donor transplant	262	248	257
Transplant outside US	0	1	0
Patient died	18	20	20
Patient refused transplant	3	2	6
Improved, transplant not needed	6	5	4
Too sick for transplant	11	8	9
Other	114	92	96
Changed to kidney-pancreas list	0	1	0
Still on waiting list	0	1	0

Table KI 16: Demographic characteristics of pediatric kidney transplant recipients, 2021. Pediatric kidney transplant recipients, including retransplants. Distance is computed from recipient's home zip code to the transplant center.

	Deceased		Living		All	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Recipient age (years)						
1-5	109	18.6	75	32.1	184	22.4
6-11	130	22.2	53	22.6	183	22.3
12-17	347	59.2	106	45.3	453	55.2
Sex						
Male	359	61.3	147	62.8	506	61.7
Female	227	38.7	87	37.2	314	38.3
Race						
White	213	36.3	163	69.7	376	45.9
Black	122	20.8	11	4.7	133	16.2
Asian	38	6.5	8	3.4	46	5.6
Hispanic	193	32.9	46	19.7	239	29.1
Other	20	3.4	6	2.6	26	3.2
Insurance						
Private	165	28.2	134	57.3	299	36.5
Medicare	132	22.5	34	14.5	166	20.2
Medicaid	225	38.4	54	23.1	279	34
Other/unknown	64	10.9	12	5.1	76	9.3
Geography						
Metropolitan	499	85.2	184	78.6	683	83.3
Non-metropolitan	80	13.7	45	19.2	125	15.2
Missing	7	1.2	5	2.1	12	1.5
Miles between recipient to center						
<50 miles	367	62.6	132	56.4	499	60.9
50-<100	94	16	42	17.9	136	16.6
100-<150	53	9	21	9	74	9
150-<250	42	7.2	20	8.5	62	7.6
250+	25	4.3	14	6	39	4.8
Missing	5	0.9	5	2.1	10	1.2
All recipients						
All recipients	586	100	234	100	820	100

Table KI 17: Clinical characteristics of pediatric kidney transplant recipients, 2021. Pediatric kidney transplant recipients, including retransplants. Diagnosis categories follow North American Pediatric Renal Trials and Collaborative Studies recommendations. FSGS, focal segmental glomerulosclerosis; GN, glomerulonephritis; CAKUT, congenital anomalies of the kidney and urinary tract.

	Deceased		Living		All	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Diagnosis						
FSGS	61	10.4	21	9	82	10
Glomerulonephritis	57	9.7	12	5.1	69	8.4
CAKUT	192	32.8	87	37.2	279	34
Other/unknown	276	47.1	114	48.7	390	47.6
Blood Type						
A	180	30.7	99	42.3	279	34
AB	19	3.2	9	3.8	28	3.4
B	71	12.1	31	13.2	102	12.4
O	316	53.9	95	40.6	411	50.1
Years of dialysis						
None	297	50.7	162	69.2	459	56
<1 year	28	4.8	16	6.8	44	5.4
1-<3	148	25.3	38	16.2	186	22.7
3-<5	56	9.6	9	3.8	65	7.9
5+	57	9.7	9	3.8	66	8
CPRA						
<1%	417	71.2	185	79.1	602	73.4
1-<20%	55	9.4	25	10.7	80	9.8
20-<80%	83	14.2	23	9.8	106	12.9
80-<98%	18	3.1	0	0	18	2.2
98-100%	13	2.2	0	0	13	1.6
Missing	0	0	1	0.4	1	0.1
All recipients						
All recipients	586	100	234	100	820	100

Table KI 18: Transplant characteristics of pediatric kidney transplant recipients, 2021. Pediatric kidney transplant recipients, including retransplants. DBD, donation after brain death; DCD, donation after circulatory death; DGF, delayed graft function; KDPI, kidney donor profile index. DCD status and KDPI scores apply to deceased donor transplants only.

	Deceased		Living		All	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Waiting time (years)						
None	1	0.2	6	2.6	7	0.9
<1 year	401	68.4	189	80.8	590	72
1-<3	136	23.2	32	13.7	168	20.5
3-<5	32	5.5	5	2.1	37	4.5
5+	16	2.7	2	0.9	18	2.2
KDPI						
0-<20%	451	77	0	0	451	55
20-<35%	114	19.5	0	0	114	13.9
35-<85%	20	3.4	0	0	20	2.4
85-100%	1	0.2	0	0	1	0.1
Missing	0	0	234	100	234	28.5
Donation after circulatory death						
DBD	568	96.9	0	0	568	69.3
DCD	18	3.1	0	0	18	2.2
Living donor	0	0	234	100	234	28.5
Previous transplant for recipients						
Prior transplant	45	7.7	7	3	52	6.3
No Prior transplant	541	92.3	227	97	768	93.7
Organs Transplanted						
Kidney only	567	96.8	234	100	801	97.7
Kidney-liver	13	2.2	0	0	13	1.6
Heart-kidney	5	0.9	0	0	5	0.6
Intestine-pancreas-liver-kidney	1	0.2	0	0	1	0.1
All recipients						
All recipients	586	100	234	100	820	100

Table KI 19: Pediatric deceased donor kidney donor-recipient serology matching, 2019-2021. Donor serology is reported on the OPTN Donor Registration Form and recipient serology on the OPTN Transplant Recipient Registration Form. There may be multiple fields per serology. Any evidence for a positive serology is treated as positive for that serology. CMV, cytomegalovirus; EBV, Epstein-Barr virus.

Donor	Recipient	CMV	EBV
Donor			
D-	R-	27.73	5.81
D-	R+	12.87	7.56
D-	R unk	0.94	0.25
D+	R-	36.66	37.6
D+	R+	20.55	47.16
D+	R unk	0.31	1.31
D unk	R-	0.56	0.19
D unk	R+	0.37	0.12
D unk	R unk	0	0

Table KI 20: Pediatric living donor kidney donor-recipient serology matching, 2019-2021. Donor serology is reported on the OPTN Donor Registration Form and recipient serology on the OPTN Transplant Recipient Registration Form. There may be multiple fields per serology. Any evidence for a positive serology is treated as positive for that serology. CMV, cytomegalovirus; EBV, Epstein-Barr virus.

Donor	Recipient	CMV	EBV
Donor			
D-	R-	38.59	6.74
D-	R+	10.47	3.44
D-	R unk	0.57	0
D+	R-	29.12	55.52
D+	R+	15.21	30.7
D+	R unk	0.43	2.3
D unk	R-	4.02	0.43
D unk	R+	1.43	0.86
D unk	R unk	0.14	0

OPTN/SRTR 2021 Annual Data Report: Pancreas

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Abstract

The number of pancreas transplants in the United States was largely unchanged in 2021 at 963 transplants compared with 962 in 2020, showing that recovery from the COVID-19 pandemic was not as pronounced in pancreas transplantation as in other organs. The number of simultaneous pancreas-kidney transplants (SPKs) decreased from 827 to 820, whereas the number of pancreas-after-kidney transplants and pancreas transplants alone increased marginally to compensate. The proportion of patients with type 2 diabetes on the waiting list increased to 22.9% in 2021, compared with 20.1% in 2020. Consequently, the proportion of transplants in patients with type 2 diabetes increased from 21.3% in 2020 to 25.9% in 2021. The proportion of transplants in older recipients (aged 55 years or older) also increased to 13.5% in 2021 from 11.7% in 2020. Outcomes after SPK continue to be the best of the three categories of pancreas transplants: 1-year graft failure for kidney at 5.7% and pancreas at 10.5% for transplants performed in 2020. The proportion of pancreas transplants performed by medium-volume centers (11-24 transplants per year) increased sharply to 48.3% in 2021 from 35.1% in 2020, with a corresponding decrease in transplants in large-volume centers (25 or more transplants per year) to 15.9% in 2021 from 25.7% in 2020.

Keywords: Pancreas transplant, transplant outcomes, waitlist outcomes

1 INTRODUCTION

The effect of the COVID-19 pandemic loomed large in 2020 and continued through 2021 in all areas of organ transplantation. The effect on pancreas transplantation, especially solitary pancreas transplants, was significant, with fewer transplants being performed and a sharp decrease in transplant rates in 2020. While most organs recovered their numbers to prepandemic levels in 2021, pancreas transplant numbers, including transplant rates, have not recovered to 2019 levels. In fact, the transplant rates for patients with type 1 diabetes decreased sharply in 2021. The overall numbers remained steady in 2021 due to an increase in transplants in patients with type 2 diabetes, with 26% of all transplants in 2021 in these patients. The goals of transplant and outcomes in patients with type 2 diabetes may not be identical to those in patients with type 1 diabetes, and these need to be better defined going forward as the proportion of patients with type 2 diabetes on the pancreas waiting list continues to increase.

One-year pancreas graft outcomes continue to be reported, as a result of a uniform definition of graft failure having been adopted in 2018. However, the rate of missingness for insulin dose and weight of recipient is a major issue, because one of the criteria for graft failure is a return to an insulin dose of 0.5 units/kg/day or greater. This will need to be addressed for more comprehensive reporting of graft failure in future iterations of this report.

A major accomplishment of the Scientific Registry of Transplant Recipients (SRTR) in 2021-2022 was the development of the new organ allocation simulator (OASIM). The simulated allocation modeling (SAM) software dated back about 20 years and was facing maintenance and operational challenges; therefore, the Health Resources and Services Administration (HRSA) tasked SRTR with creating an updated organ allocation simulator. OASIM was designed with the goals of supporting the same functionality as the SAM software: an event-based microsimulation that can run on a desktop computer, supporting a wider range of policy types and modeling approaches, and, most important, unifying the codebase for simulating all organ allocation policies.

The Organ Procurement and Transplantation Network (OPTN) Kidney and Pancreas Continuous Distribution Workgroup submitted a simulation request to SRTR in April 2022 to model four continuous allocation scenarios with varying priorities and compare them to existing policy. The Workgroup identified attributes under the following goals for each of these scenarios for pancreas/kidney-pancreas/pancreas islet allocation: candidate biology, patient access, and placement efficiency. Each goal contained specific attributes that were differentially weighted based on the scenario. The simulation results were presented at the fall 2022 meeting of the OPTN Pancreas Transplantation Committee.

Additionally, the OPTN Kidney Transplantation Committee and Pancreas Committee are in collaboration with the Massachusetts Institute of Technology (MIT) to perform a mathematical optimization analysis to help the Committees determine a range of acceptable policy options. MIT is augmenting SRTR's SAM with machine learning to quickly and accurately predict outcomes by identifying policies (attribute weights) that achieve any set of prespecified outcomes in near real-time. MIT did similar work for the lung continuous distribution project and helped inform the OPTN Lung Transplantation Committee's selection of weights for various attributes. The Workgroup is expected to submit a second modeling request with further refinements in the near future.

The American Society of Transplantation's Kidney Pancreas Community of Practice (KP COP) performed a recent national survey showing that the number of pancreas transplants performed at the local and national levels are not keeping pace with the needs of patients with diabetes who could benefit from these procedures. The KP COP went on to organize a national workshop with the following objectives: improving the candidate referral process before pancreas transplant and candidate selection, identifying best practice guidelines for maximizing donor utilization/organ procurement organization awareness, expanding excellence in patient outcomes and program performance, and identifying educational and research improvements in pancreas transplant, and competing therapies. The formal recommendations of this workshop, if implemented over time, would likely spur growth in pancreas transplantation. In addition, the International Pancreas and Islet Transplant Association is in the process of constituting a pancreas interest group with similar objectives of optimizing growth in pancreas transplantation.

2 WAITING LIST

The number of adult candidates added to the waiting list increased sharply for simultaneous pancreas-kidney transplant (SPK) in 2021 to 1,487 from 1,307 the previous year (Figure PA 1). This is the highest number since 2010. Prevalent adult listings also increased in SPK (3,207 in 2021 vs 3,044 in 2020) and pancreas transplant alone (PTA; 544 in 2021 vs 508 in 2020) (Figure PA 2), whereas pancreas-after-kidney transplant (PAK) was largely unchanged.

The age distribution of candidates on the waiting list shows an increase in two older age groups (35-44 and 55 years or older) and a corresponding decrease in the younger age group (18-34 years) (Figure PA 3). This is likely due to higher proportion of patients with type 2 diabetes being listed over the past few years.

Male to female ratio on the waiting list has remained fairly consistent over the past decade at 55:45 (Figure PA 4). The proportion of White candidates continues to decline, with a corresponding increase in candidates from racial and ethnic minority groups. White candidates constituted 52.3% of the list in 2021, a decrease of 23.8% from 2010 (68.6%). Listing of Black candidates increased by 54.3% (from 17.2% in 2010 to 26.5% in 2021); Hispanic candidates, by 38.3% (from 11% in 2010 to 15.3% in 2021); and Asian candidates, by 150.2% (1.7% in 2010 to 4.2% in 2021) (Figure PA 5).

Most of the waitlist demographic changes can be largely attributed to an increase in candidates with type 2 diabetes on the waiting list (22.9% in 2021 vs 7.8% in 2010) (Figure PA 6). The proportion of candidates with type 1 diabetes decreased to 70.5% in 2021 versus 83.2% in 2010. As would be expected, the proportion of candidates with higher body mass index (BMI) increased. Candidates with BMI of 30-<35 kg/m^2 showed the highest increase (14.5% in 2010 to 20.1% in 2021), whereas those with BMI 18.5-<25 kg/m^2 showed the largest decrease (41.7% in 2010 to 33.8% in 2021) (Figure PA 8). Of note, 3.8% of the candidates have a BMI of 35 kg/m^2 or greater, and this number has remained steady over the years.

The distribution of candidates by waiting time shows that 50.5% of candidates were within 1 year of listing (a slight increase) and 28.4% of candidates have been on the waiting list for 2 years or longer (a slight decrease) (Figure PA 7). The distribution of candidates by blood type was largely unchanged in 2021: O, 48.1%; A, 33.1%; B, 15.4%; and AB, 3.5% (Figure PA 9).

With regard to transplant type, SPK candidates continued to predominate (77.3% in 2021 vs 67.5% in 2010) (Figure PA 10), whereas PAK (9.6% in 2021 vs 18.5% in 2010) and PTA (13.1% in 2021 vs 14% in 2010) have seen a significant decrease. Retransplant candidates as a proportion of the waiting list continued to decrease to 7.9% in 2021 from 16.1% in 2010 (Figure PA 11).

Pancreas transplant rates, which decreased sharply in 2020 to 40.2 per 100 patient-years, did not increase in 2021 (40.2 again) (Figure PA 12). Looking at the distribution by diagnosis, transplant rates decreased for candidates with type 1 diabetes (36.9 per 100 patient-years in 2021 vs 38.2 per 100 patient-years in 2020) but increased in candidates with type 2 diabetes (52.1 per 100 patient-years in 2021 vs 49.8 per 100 patient-years in 2020) (Figure PA 13). Transplant rates by blood type showed no change from 2020 to 2021 in blood types O and A; there was a slight decrease in type B and a larger decrease in type AB, but this is presumably due to a small number of AB transplants performed (Figure PA 14). Transplant rates by type of transplant (SPK, PAK, and PTA) also did not change significantly from 2020 to 2021 (48.3, 11.9, and 23.7 per 100 patient-years, respectively) (Figure PA 15).

Three-year outcomes for patients added to the waiting list during 2016-2018 showed 61.7% of SPK candidates, 38.1% of PAK candidates, and 49.2% of PTA candidates underwent transplant (Figures PA 16, 17, and 18). Patients who died or were removed from the list accounted for 22% of SPK candidates, 36.1% of PAK candidates, and 32.5% of PTA candidates. Patients still waiting at the end of 3 years accounted for 11% of SPKs, 25.9% of PAKs, and 18.3% of PTAs. Overall mortality on the waiting list amounted to 5.2 per 100 patient-years in 2021, a decrease from 2020, but has held steady at 4-6 per 100 patient-years over the past decade (Figure PA 19). However, when broken down by age groups, there was a decrease in mortality on the waiting list in two of the older age groups (35-44 and 45-54 years) in 2021 and a simultaneous increase in the younger age group (18-34 years) compared with 2020 (Figure PA 20). When broken down by race and ethnicity, there were no major differences in the change in mortality rate on the waiting list year over year from 2020 to 2021 (Figure PA 21).

Mortality on the waiting list decreased slightly for both men and women in 2021 versus 2020, with men having a lower mortality than women (Figure PA 22). By transplant type, SPKs had the highest mortality rate on the waiting list in 2021 at 6.2 per 100 patient-years (vs 2.1 for PAKs and 2.7 for PTAs) (Figure PA 23).

Table 1 lists characteristics of waitlisted candidates by transplant type. Of note, most SPK (61.7%) and PAK (61.9%) candidates lived within 50 miles of the transplant center. PTA candidates tended to come from farther away, with 48.9% from within 50 miles and 15.2% from 250 miles away or farther from the transplant center. Metropolitan areas account for most candidates across all groups (83.2%). There are geographical variations by donation service area in the pretransplant mortality rates, but the significance of this is unclear (Figure PA 24).

Deaths within 6 months of removal from the waiting list increased for the second straight year, to 8.4% in 2021 from 6.6% in 2020 and 5.7% in 2019 (Figure PA 25). Reasons for this increase are not absolutely clear. The increase was most pronounced for those aged 45-54 years, and values actually decreased slightly for those aged 35-44 years and 55 years or older (Figure PA 26). The increase in death after removal was pronounced in SPKs, with PAKs and PTAs seeing a decrease in deaths (Figure PA 27).

3 DONATIONS

The number of deceased pancreas donors increased to 1,307 in 2021 compared with 1,256 in 2020 (Figure PA 28). The increase was across all age groups (Figure PA 29). The distribution of donors across age groups remained largely unchanged, with the younger age group (18-29 years) accounting for most donors (51%) (Figure PA 30). Also notable is that 19% of donors were younger than 18 years and 6.1% were aged 40 years or older. Sex distribution has been relatively unchanged over the past decade, with a male to female ratio of 69.5:30.5 in 2021 (Figure PA 31). Race distribution of donors reveals that most donors are still White (60.7% in 2021), although this proportion has been gradually decreasing over the past decade (64.9% in 2010). The proportion of Black donors decreased slightly (18.6% in 2021 vs 20.4% in 2020), while that of Asian donors increased (2.2% in 2021 vs 1.5% in 2020) (Figure PA 32). With regard to BMI, there has been a trend towards an increasing proportion of donors in the 18.5-25 kg/m^2 category (55.7% in 2021 compared with 51.6% in 2018) (Figure PA 33). Donors with BMI >30 kg/m^2 is at the lowest level in a decade (7% in 2021). Cause of death among deceased pancreas donors was largely unchanged year over year from 2020 to 2021; however, there has been a trend of decreasing proportion of head trauma compared with anoxia over the past decade, presumably from the opioid epidemic, but this curve seems to be flattening out since 2020 (onset of COVID-19 pandemic) (Figure PA 34).

Because the number of donors in 2021 increased and the number of transplants remained unchanged, the nonuse rate for pancreas (pancreata recovered for transplant but not transplanted) expectedly increased (26.2% in 2021 vs 23.4% in 2020) (Figure PA 35). Compared with other organs, pancreas has a high nonuse rate, and this is due to a combination of factors including demand versus supply, adequate expertise of surgical teams, and cold ischemia time. Nonuse rates across age groups up to 39 years were between 23.4% and 29.8%, then increase in the 40- to 54-year age group to 42.9% (Figure PA 36). By sex, nonuse rates are virtually identical between male and female donors (Figure PA 37). Nonuse rates by race and ethnicity reveal a sharp decrease in rates of nonuse for Asian donors; however, this is an exaggerated effect due to small numbers (Figure PA 38). Nonuse rates by BMI show no major differences between BMI groups, except in groups with BMI of 35 kg/m^2 or greater where there were sharp changes, due to low numbers in those groups (Figure PA 39). Nonuse rates by US Public Health Service donor risk factors for blood-borne disease transmission showed little difference between groups (Figure PA 40).

4 TRANSPLANTS

The number of overall pancreas transplants has remained stable in 2021 compared with 2020 but has not recovered from prepandemic numbers—and approximates the nadir seen in 2015 (Figure PA 41). The recovery for pancreas transplants is lagging behind that of other organs, which may in part be related to the large numbers of programs that put pancreas transplants on hold related to the increased resources required. Of note, the number of SPKs is higher than prepandemic values, particularly from the low in 2014, but PAK and PTA numbers have continued to decrease over the past decade (Figure PA 42).

It will be important to see whether the numbers of PAK and PTA rebound with reduction in the incidence of COVID-19.

There have been some notable changes in the age distribution of pancreas transplant recipients, with a substantial decrease in the number of pancreas transplants performed in recipients aged 18-34 years and a substantial increase in those aged 55 years or older from 11.7% of recipients in 2020 to 13.5% of recipients in 2021 (Figure PA 43). The shift to older age groups correlates with the notable increases in the number of pancreas transplants being performed for patients with type 2 diabetes (Figure PA 46). Similarly, the relative decrease in the number of pancreas transplants performed in the White population compared with the relative increase in the number of pancreas transplants performed in Black, Hispanic, and Asian recipients (Figure PA 45 and Table PA 10) correlates with the increased numbers of pancreas transplants performed for type 2 diabetes. The percentage of pancreas transplants performed for type 2 diabetes increased from 21.3% to 25.9% from 2020 to 2021 (Figure PA 46). Clearly, the demographic data of pancreas transplantation are being affected by the increasing numbers of transplants performed in people with type 2 diabetes.

Immunosuppressive regimens for pancreas transplants have remained stable for the past decade, reflecting the recognition that aggressive induction and maintenance regimens have been required for all categories of pancreas transplant to block the alloimmune and autoimmune responses that are necessary for successful transplant in people with type 1 diabetes. Induction with lymphodepleting regimens (Figure PA 47) and maintenance with tacrolimus and mycophenolate mofetil (Figure PA 48) are used in more than 90% of pancreas transplant recipients. Of note, steroids appear to be used in nearly 70% of regimens despite early hopes that steroids could be eliminated from the immunosuppressive regimens of people with diabetes. Indeed, nephrotoxic and beta-cell toxic calcineurin inhibitors and steroids continue to be used in the vast majority of pancreas transplant recipients.

The proportion of pancreas transplants performed at medium-volume centers (11-24 transplants per year) increased sharply to 48.3% in 2021 from 35.1% in 2020, with a corresponding decrease in transplants at large-volume centers (25 or more transplants per year) to 15.9% in 2021 from 25.7% in 2020 (Figure PA 53). Recovery from the COVID-19 pandemic will likely further affect shifts in the center volumes of the resource-intense pancreas transplants.

5 OUTCOMES

This 2021 Annual Data Report marks the second year that the new definition of pancreas graft failure has been in effect. Prior to 2020, SRTR did not report pancreas graft survival rates, because the accuracy of these data was compromised by the lack of consistent definitions of graft failure. Although patient survival and kidney allograft survival had precise definitions and consequently the reporting was accurate, there was considerable variation in each center's definition of pancreas graft success. Some programs considered insulin independence to be the criterion for defining pancreas allograft success, while others defined it by C-peptide production. Some programs considered any use of oral hypoglycemic agents or insulin as the definition of graft failure. The current uniform definition for pancreas graft failure includes any of the following: 1) a recipient's transplanted pancreas is removed; 2) a recipient reregisters for a pancreas transplant; 3) a recipient registers for an islet transplant after undergoing a pancreas transplant; 4) a recipient dies; or 5) a recipient's total insulin use is greater than or equal to 0.5 units/kg/day for 90 consecutive days (OPTN Policy 1.2: definitions). This last definition may be problematic if the recipient's starting insulin dose was less than 0.5 units/kg/day.

Using the new definition, the incidence of pancreas graft failure at 90 days posttransplant had remarkable increases for PAK and PTA, but not SPK, in 2021. The incidence of pancreas graft failure for PAK increased from 4.2% to 9.5% and that for PTA increased from 8.9% to 17.8% from 2020 to 2021 (Figure PA 54). Because these graft losses occurred early, they likely represent early technical losses.

There were notable increases in pancreas graft failure for all three categories of pancreas transplants within the first year of transplant. First-year pancreas graft failures increased between 2019 and 2020 from 6.8% to 14.6% for PAK, 10.3% to 15.6% for PTA, and from 7.2% to 10.5% for SPK (Figure PA 55). This is the first year this 1-year pancreas graft survival is available using the uniform definition of graft failure, and the higher rates of graft failure may reflect the stricter definition of graft failure.

Data for kidney allograft failure after SPK have been based on uniform definitions (ie, return to dialysis), unlike the previous variability in reporting pancreas allograft outcomes. Unadjusted outcomes for kidney allografts after SPK remained excellent, with 1-, 5-, and 10-year all-cause kidney failure at 5.7%, 16.4%, and 32.3%, respectively (Figure PA 56). The excellent long-term outcomes associated with SPK can be partly attributed to the lower kidney donor profile index (KDPI) for kidneys associated with SPK. However, the long-term kidney allograft success rates after PAK with a deceased donor kidney are also excellent, with 1-, 5-, and 10-year all-cause kidney graft failure rates of 6.3%, 14.7%, and 31.0%, respectively (Figure PA 58). The 10-year death-censored kidney graft failure among adult PAK transplant recipients with a decreased donor kidney had a marked decrease to 11.5% (Figure PA 59). The excellent long-term outcomes could be attributed to minimization of recurrent diabetic nephropathy in the presence of a functioning pancreas transplant. The 10-year death-censored kidney graft failure for SPK was 18.3% for the most recent cohort available for analysis (transplant in 2011-2012) (Figure PA 57), again reflecting the excellent KDPI of the kidneys used in SPK combined with the prevention of recurrent diabetic nephropathy with a normalized hemoglobin A1C. Finally, for PAK with a living donor kidney, the 10-year death-censored kidney graft failure was 14.3% (Figure PA 61). These low kidney graft failure rates highlight the high-quality kidneys of the deceased donors used in SPK and PAK and those of living donors in PAK.

Rejection rates after pancreas transplant have been consistently low for the past 5 years, with a rejection rate of 12.3% in the first year for recipients aged 18-34 years and 9.6% for recipients aged 35-64 years (Figure PA 63). The low rejection rates reflect a consistent and aggressive immunosuppressive approach used by more than 90% of transplant centers (Figures PA 47 and 48). Fortunately, there has not been an increase in the cumulative incidence of posttransplant lymphoproliferative disease (PTLD), which has remained consistent over the past 5 years. The highest cumulative incidence of PTLD was observed in Epstein-Barr virus (EBV)–negative PTA recipients (5.8%) compared with EBV-positive PTA recipients (1.6%) (Figure PA 66). The 5-year cumulative incidences of PTLD in EBV-negative PAK and SPK recipients were lower, at 2.2% (Figure PA 65) and 2.3% (Figure PA 67), respectively. The higher incidence of PTLD observed in EBV-negative PTA recipients may reflect the more aggressive immunosuppressive regimens that were historically used to manage PTA.

The safety of pancreas transplants is reflected in the ongoing low patient mortality rates for all categories of pancreas transplants at 1 year: 2.8%, 0%, and 3.6% for PAK, PTA, and SPK, respectively (Figure PA 68). Ten-year mortality rates in 2011-2012 transplant recipients were 20.1%, 18.5%, and 23.2%, for PAK, PTA, and SPK, respectively, likely reflecting the cardiovascular comorbidities in the population (Figure PA 70). Five-year survival rates for pancreas recipients were 92.2% and 89.1% for type 1 and type 2 diabetes, respectively (Figure PA 72). As more SPKs are performed for type 2 diabetes, seeing whether pancreas outcomes (using uniform definition of graft failure initiated in 2018) are comparable in both graft outcomes and survival will be of continued importance. Finally, the comparable 5-year patient survival among adult deceased donor pancreas transplant recipients in metropolitan versus non-metropolitan settings (92% in both settings) suggests that access to appropriate follow-up is not limited for recipients living in nonurban settings (Figure PA 73).

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This report is available at https://srtr.transplant.hrsa.gov. Individual chapters may be downloaded.

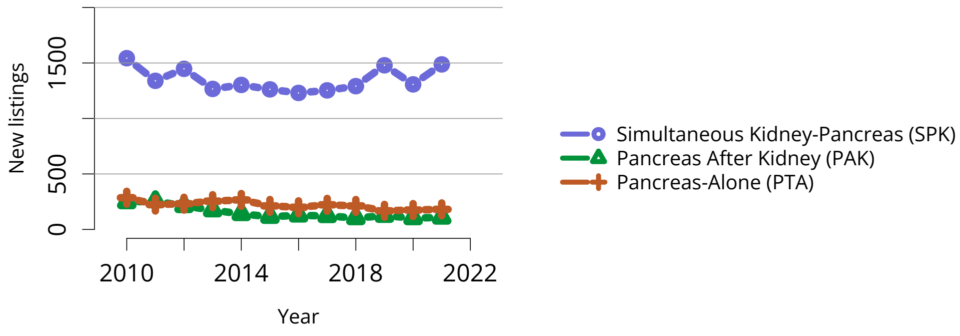

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Figure PA 1: New adult candidates added to the pancreas transplant waiting list. A new candidate is one who first joined the list during the given year, without having been listed in a previous year. Previously listed candidates who underwent transplant and subsequently relisted are considered new.

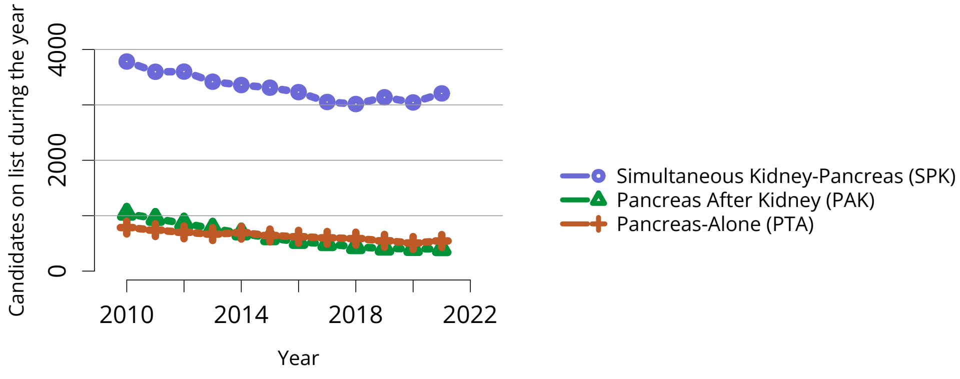

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Figure PA 2: All adult candidates on the pancreas transplant waiting list. Adult candidates on the list at any time during the year. Candidates listed at more than one center are counted once per listing.

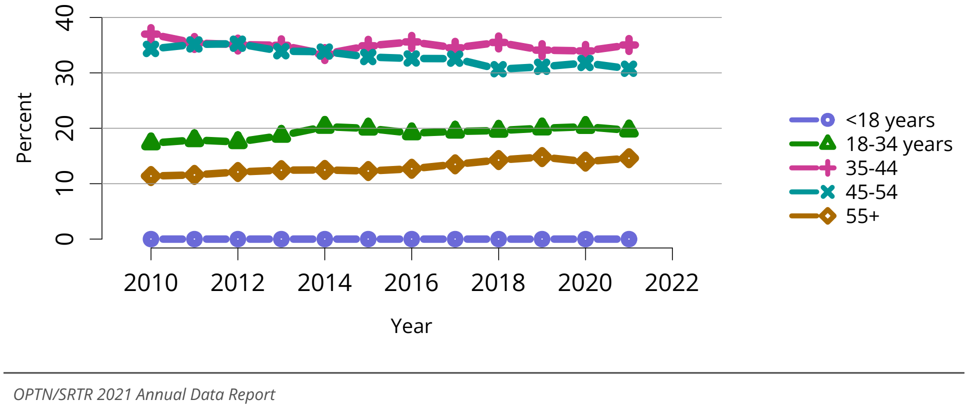


Figure PA 3: Distribution of adults waiting for pancreas transplant by age. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive candidates are included. Age is determined at the earliest of transplant, death, removal, or December 31 of the year.

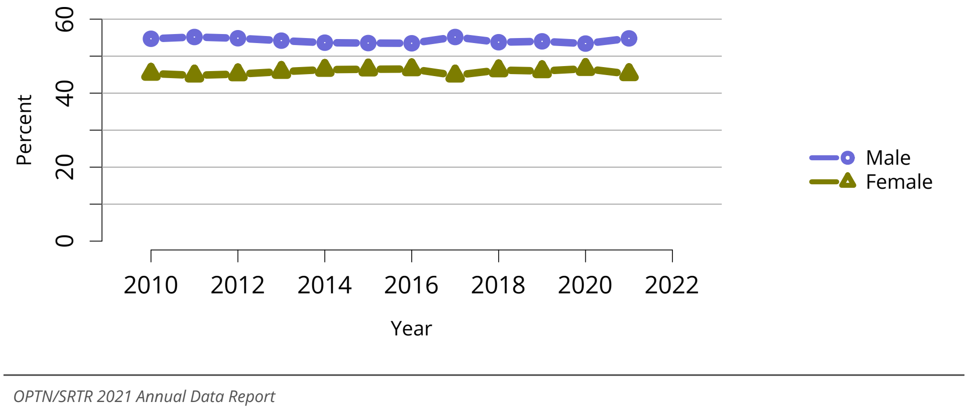
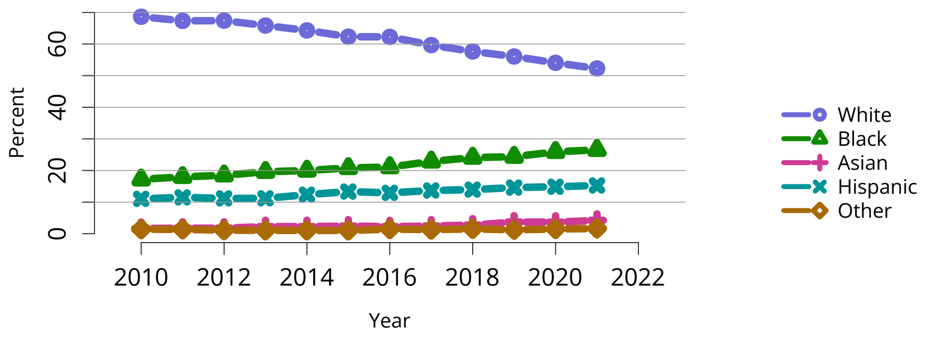
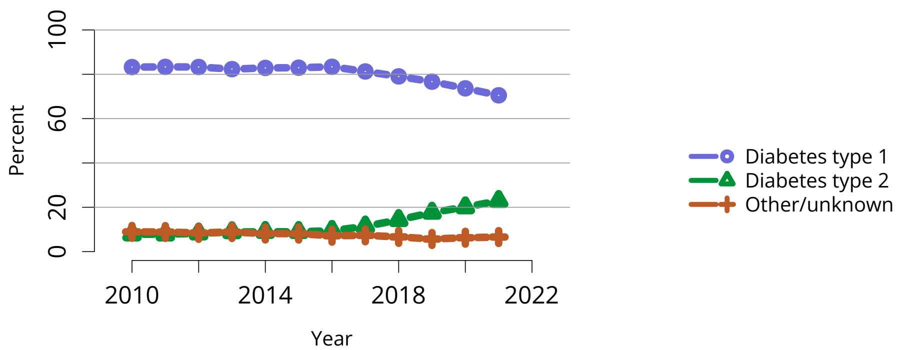


Figure PA 4: Distribution of adults waiting for pancreas transplant by sex. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.



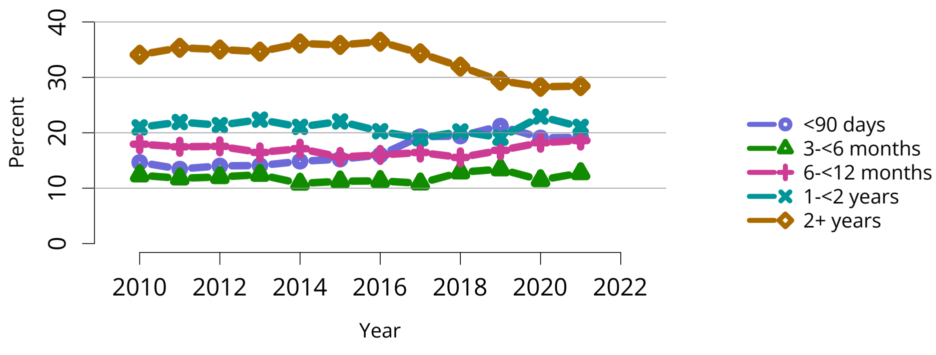
OPTN/SRTR 2021 Annual Data Report

Figure PA 5: Distribution of adults waiting for pancreas transplant by race. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.



OPTN/SRTR 2021 Annual Data Report

Figure PA 6: Distribution of adults waiting for pancreas transplant by diagnosis. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.



OPTN/SRTR 2021 Annual Data Report

Figure PA 7: Distribution of adults waiting for pancreas transplant by waiting time. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Time on the waiting list is determined at the earliest of transplant, death, removal, or December 31 of the year. Active and inactive candidates are included.

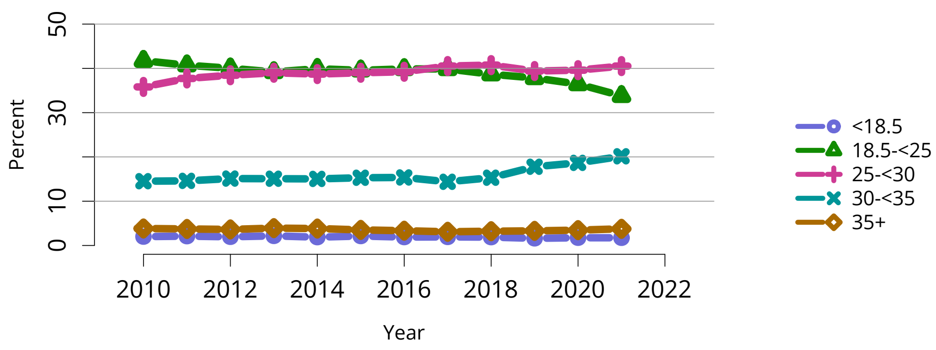


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Figure PA 8: Distribution of adults waiting for pancreas transplant by BMI. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

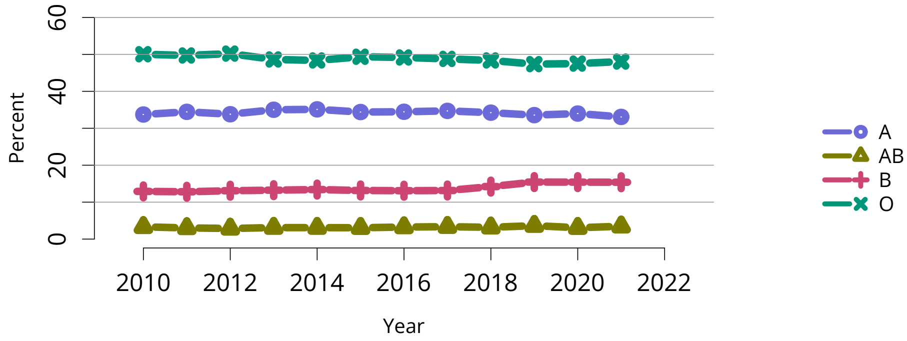

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Figure PA 9: Distribution of adults waiting for pancreas transplant by blood type. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

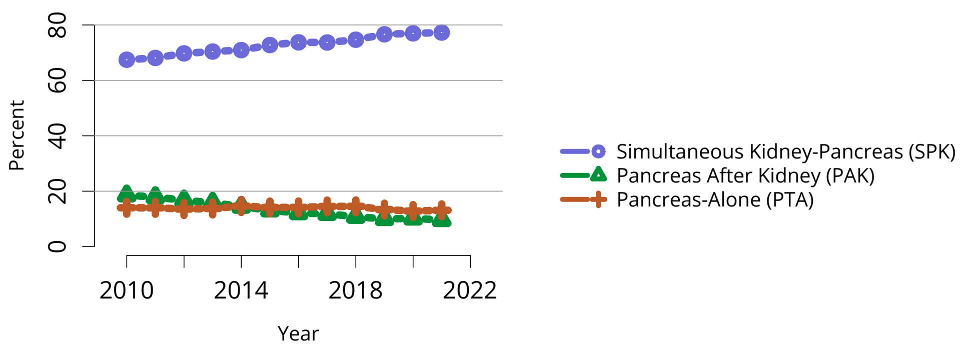

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Figure PA 10: Distribution of adults waiting for pancreas transplant by intended transplant type. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

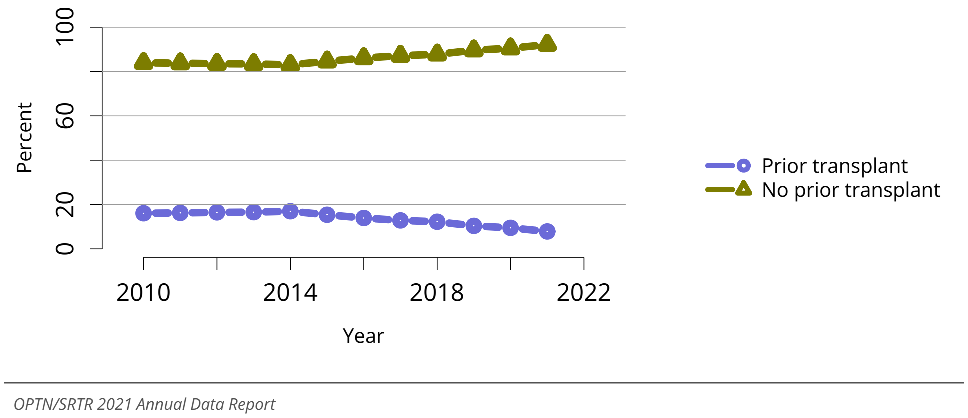

Figure PA 11: Distribution of adults waiting for pancreas transplant by prior transplant status. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

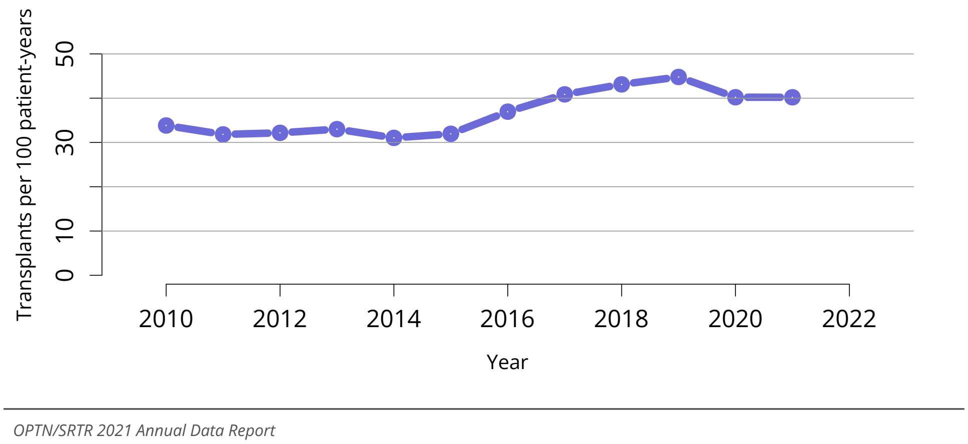

Figure PA 12: Overall deceased donor pancreas transplant rates among adult waitlist candidates. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

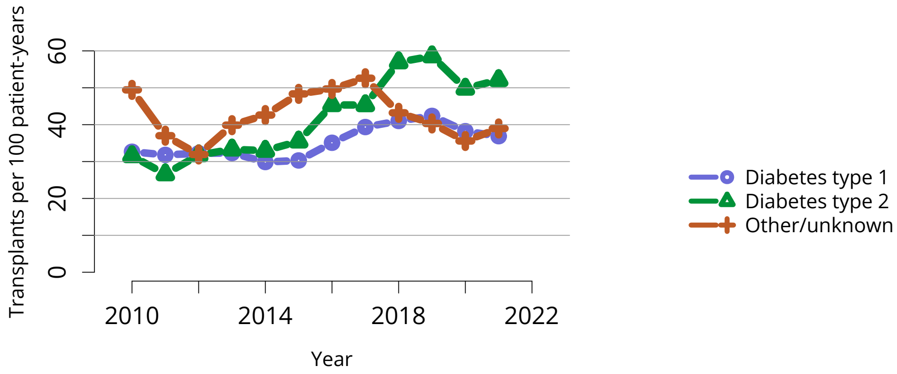

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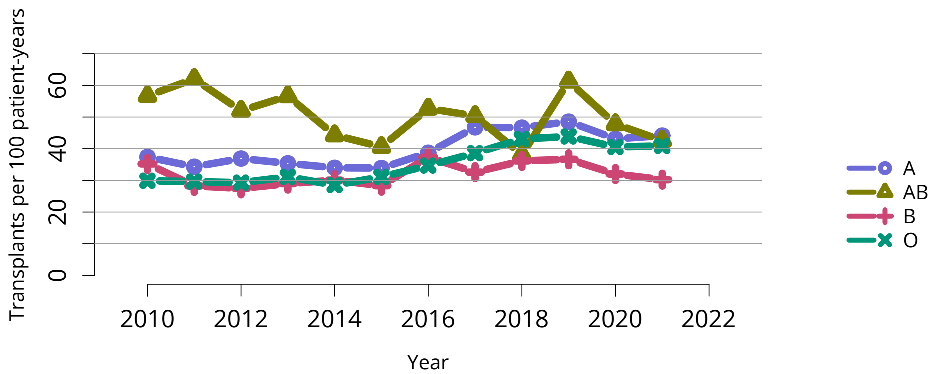
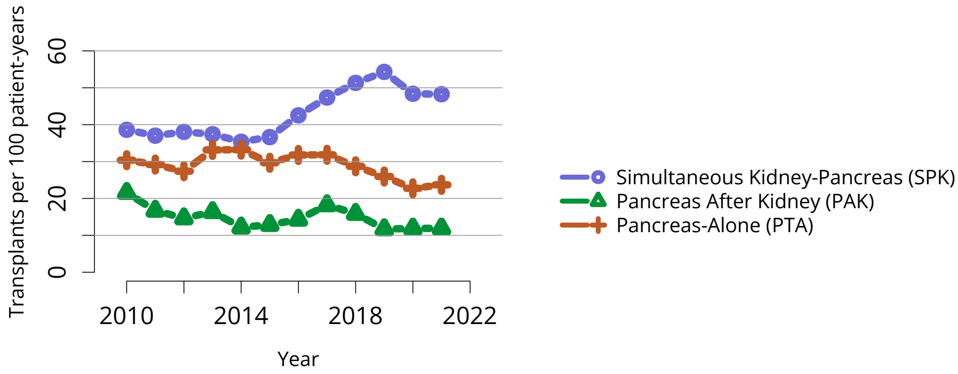
Figure PA 13: Deceased donor pancreas transplant rates among adult waitlist candidates by diagnosis. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.



OPTN/SRTR 2021 Annual Data Report

Figure PA 14: Deceased donor pancreas transplant rates among adult waitlist candidates by blood type. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.



OPTN/SRTR 2021 Annual Data Report

Figure PA 15: Deceased donor pancreas transplant rates among adult waitlist candidates by intended transplant type. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

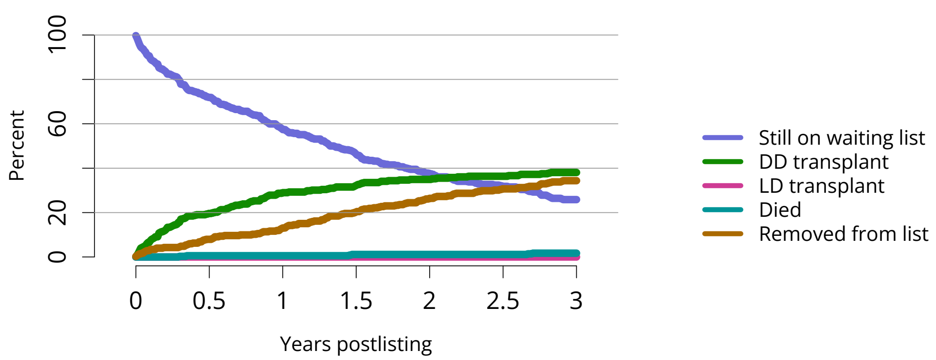


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Figure PA 16: Three-year outcomes for adults waiting for pancreas after kidney transplant, new listings in 2016-2018. Candidates listed at more than one center are counted once per listing. Removed from list includes all reasons except transplant and death. DD, deceased donor; LD, living donor.

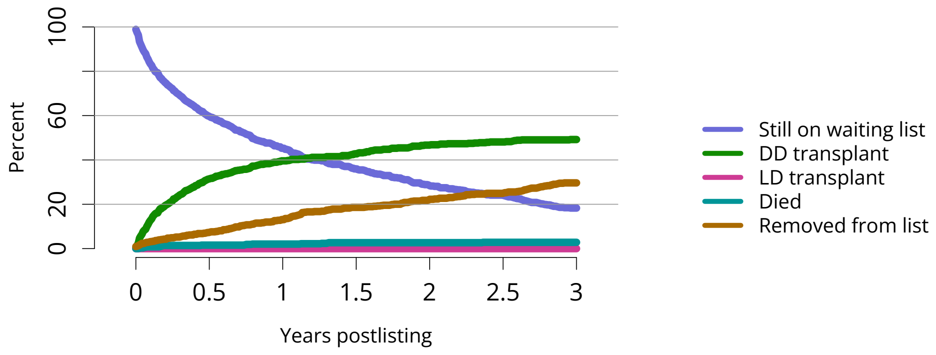

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Figure PA 17: Three-year outcomes for adults waiting for pancreas transplant alone, new listings in 2016-2018. Candidates listed at more than one center are counted once per listing. Removed from list includes all reasons except transplant and death. DD, deceased donor; LD, living donor.

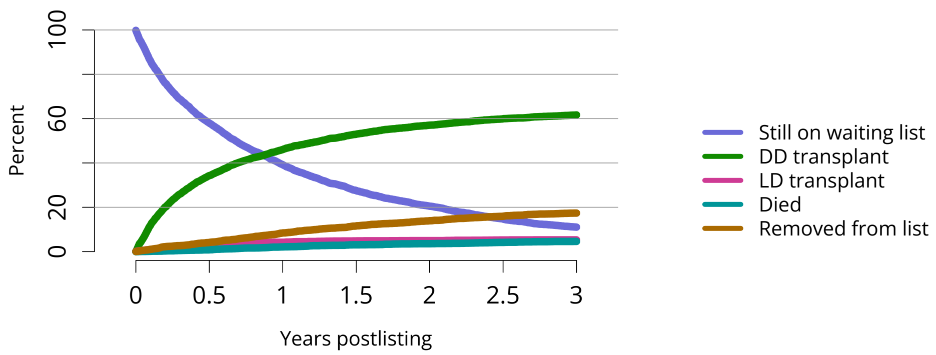

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Figure PA 18: Three-year outcomes for adults waiting for simultaneous pancreas-kidney transplant, new listings in 2016-2018. Candidates listed at more than one center are counted once per listing. Removed from list includes all reasons except transplant and death. DD, deceased donor; LD, living donor.

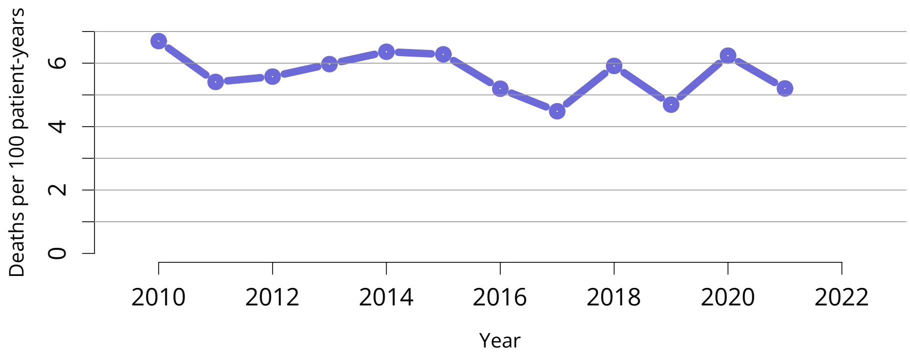

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Figure PA 19: Overall pretransplant mortality rates among adults waitlisted for pancreas transplant. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

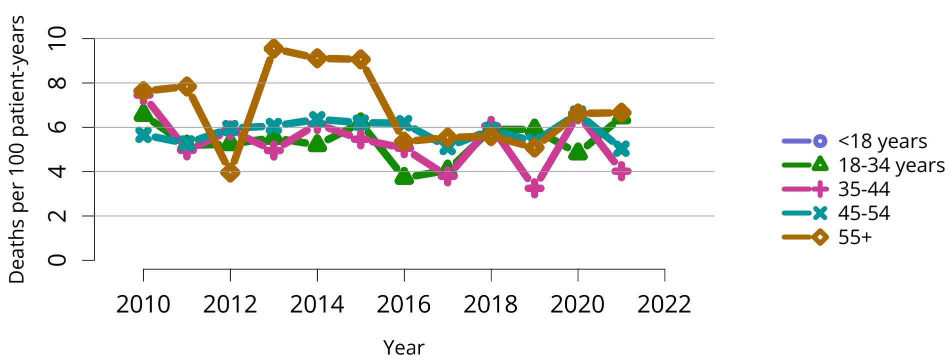

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Figure PA 20: Pretransplant mortality rates among adults waitlisted for pancreas transplant by age. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.

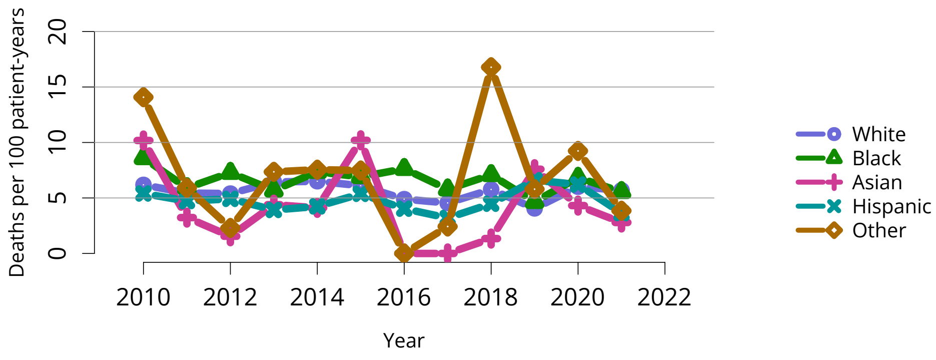

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Figure PA 21: Pretransplant mortality rates among adults waitlisted for pancreas transplant by race. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

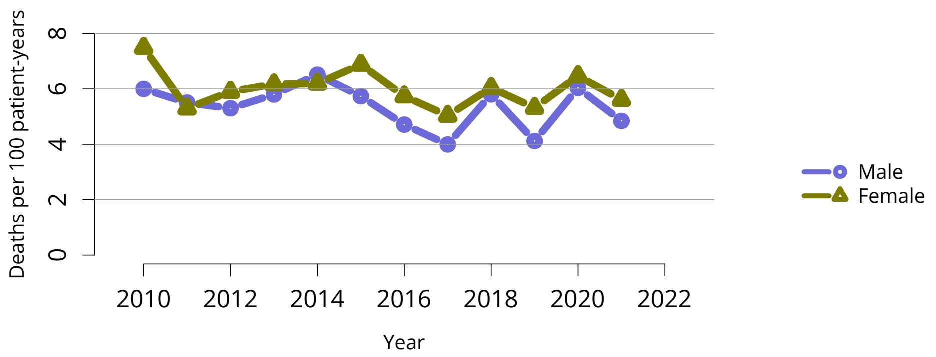

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Figure PA 22: Pretransplant mortality rates among adults waitlisted for pancreas transplant by sex. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

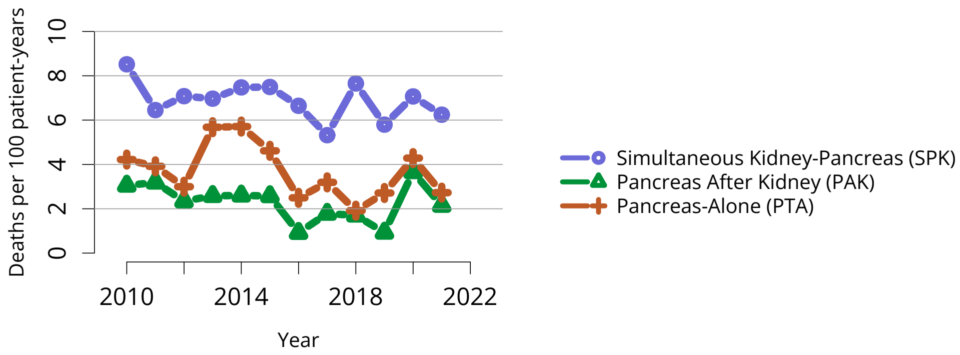

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Figure PA 23: Pretransplant mortality rates among adults waitlisted for pancreas transplant by intended transplant type. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

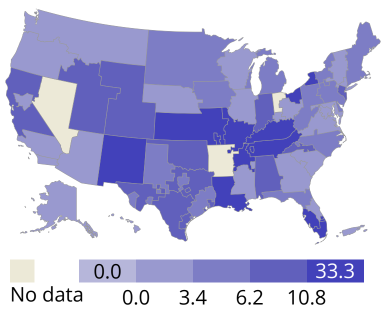

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Figure PA 24: Pretransplant mortality rates among adults waitlisted for pancreas transplant in 2021 by DSA. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

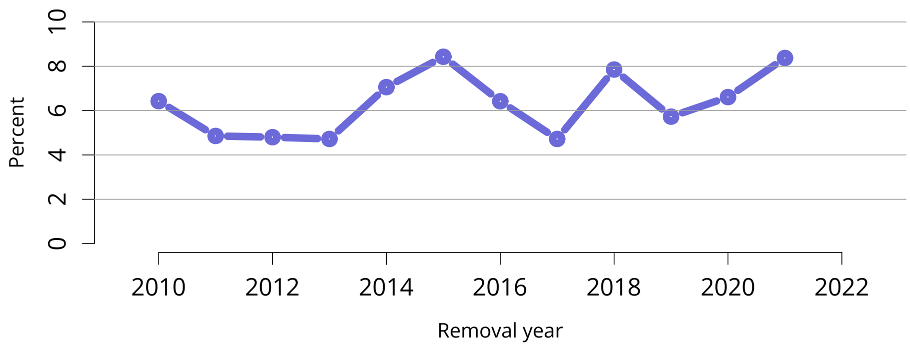

Figure PA 25: Deaths within six months after removal among adult pancreas waitlist candidates, overall. Denominator includes only candidates removed from the waiting list for reasons other than transplant or death while on the list.

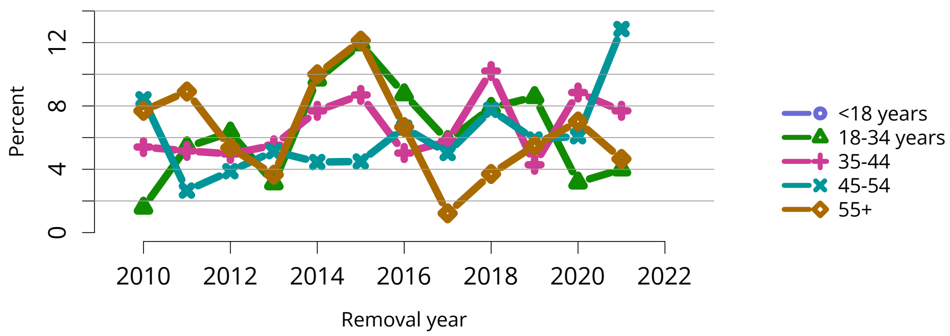

Figure PA 26: Deaths within six months after removal among adult pancreas waitlist candidates, by age. Denominator includes only candidates removed from the waiting list for reasons other than transplant or death while on the list. Age is determined at the later of listing date or January 1 of the given year.

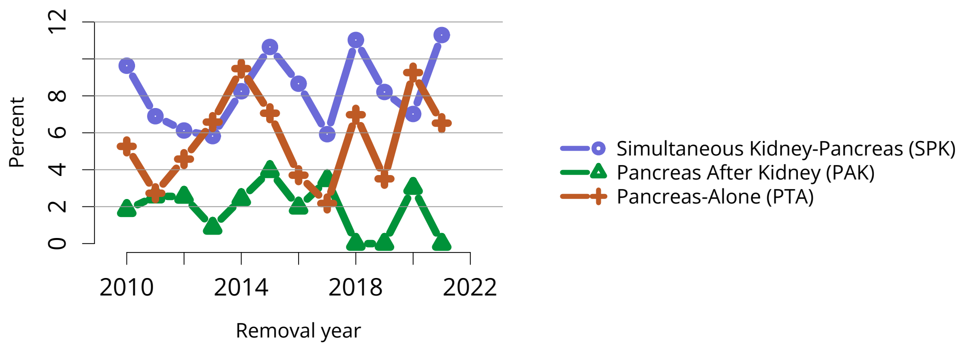

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Figure PA 27: Deaths within six months after removal among adult pancreas waitlist candidates, by intended transplant type. Denominator includes only candidates removed from the waiting list for reasons other than transplant or death while on the list.

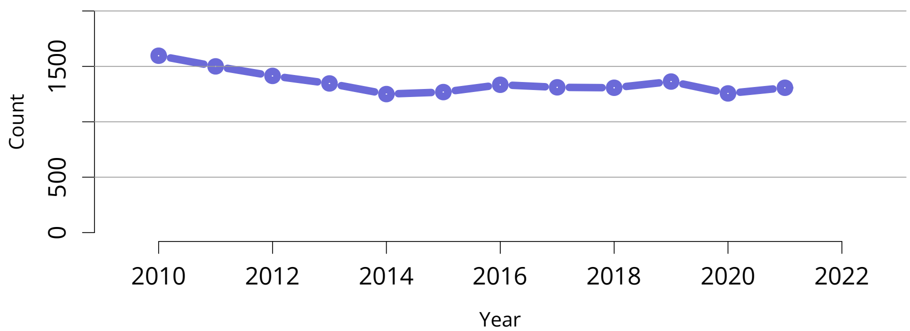

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Figure PA 28: Overall deceased pancreas donor count. Count of deceased donors whose pancreata were recovered for transplant. Pancreata recovered for islet transplant are excluded.

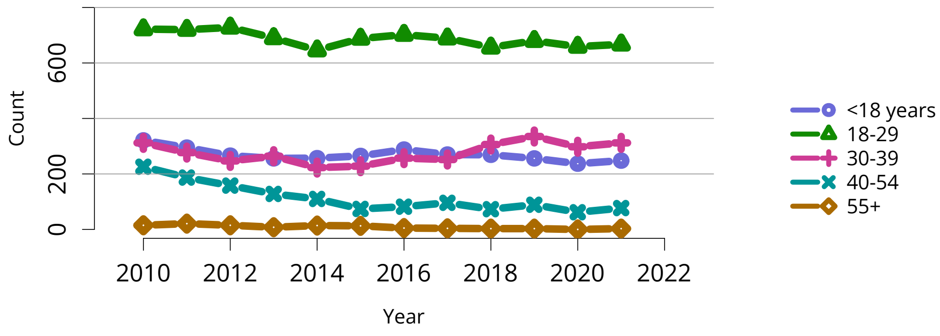

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Figure PA 29: Deceased pancreas donor count by age. Count of deceased donors whose pancreata were recovered for transplant. Pancreata recovered for islet transplant are excluded.

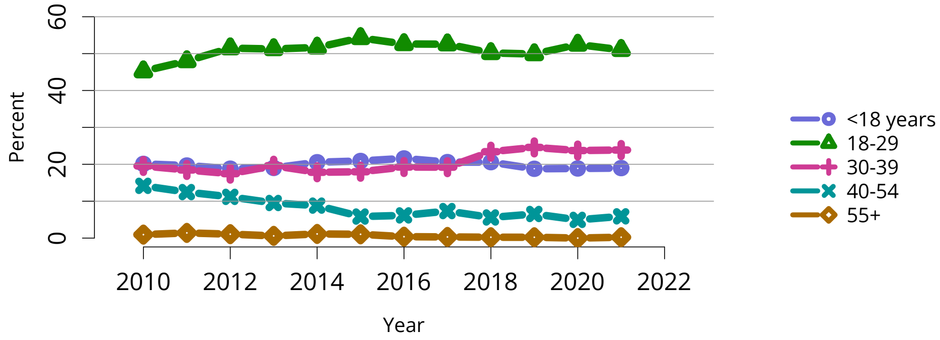

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Figure PA 30: Distribution of deceased pancreas donors by age. Deceased donors whose pancreata were recovered for transplant. Pancreata recovered for islet transplant are excluded.

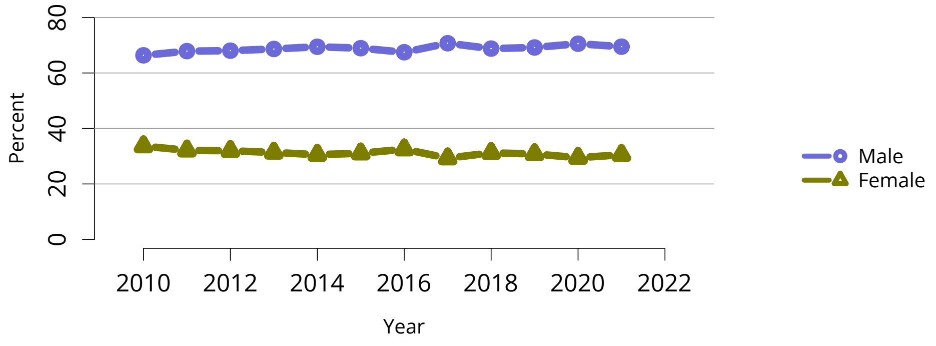

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Figure PA 31: Distribution of deceased pancreas donors by sex. Deceased donors whose pancreata were recovered for transplant. Pancreata recovered for islet transplant are excluded.

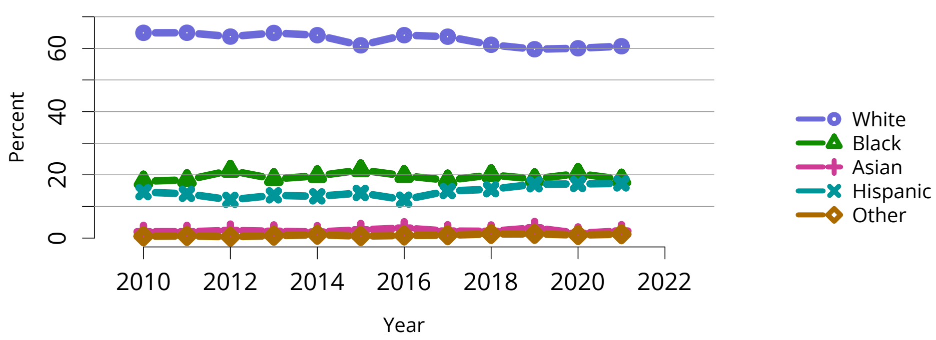

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Figure PA 32: Distribution of deceased pancreas donors by race. Deceased donors whose pancreata were recovered for transplant. Pancreata recovered for islet transplant are excluded.

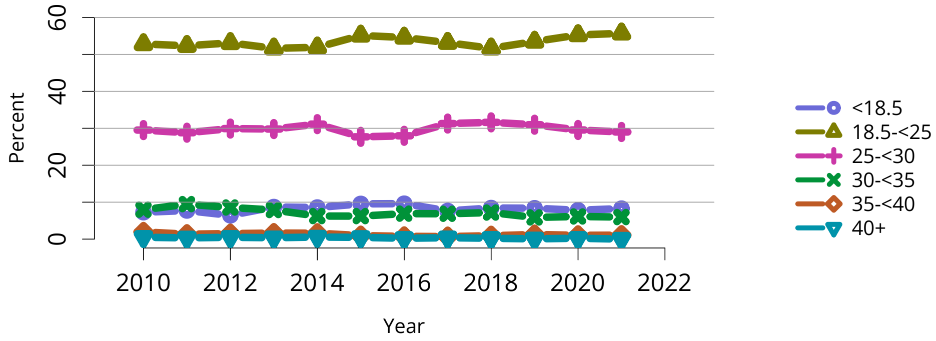

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Figure PA 33: Distribution of deceased pancreas donors by donor BMI. Deceased donors whose pancreata were recovered for transplant. Pancreata recovered for islet transplant are excluded.

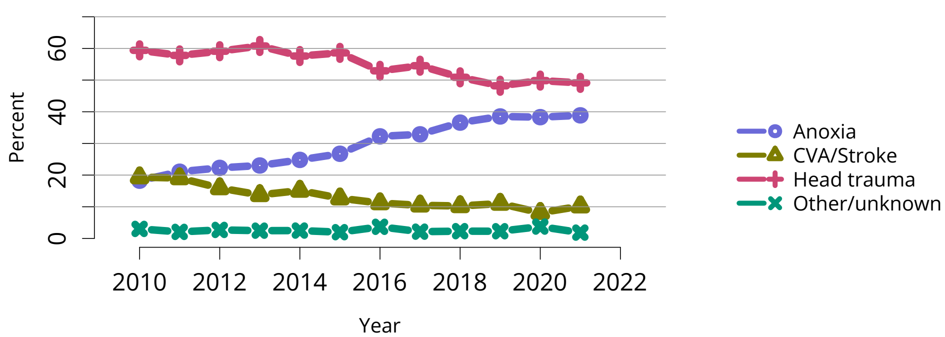

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Figure PA 34: Cause of death among deceased pancreas donors. Donors whose pancreata were transplanted. CVA, cerebrovascular accident.

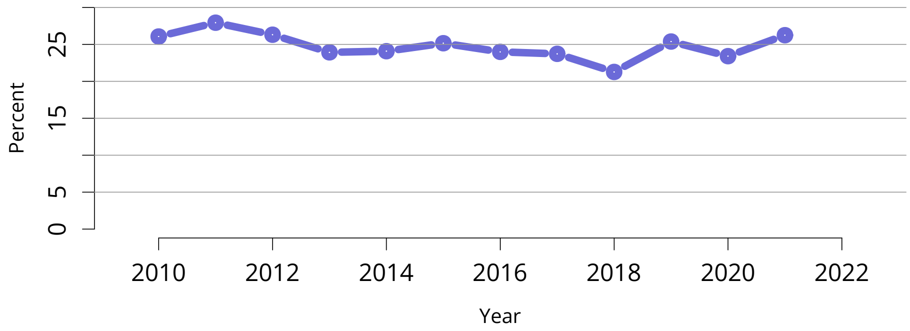

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Figure PA 35: Overall rates of pancreata recovered for transplant and not transplanted. Percentages of pancreata not transplanted out of all pancreata recovered for transplant. Pancreata recovered for islet transplant are excluded.

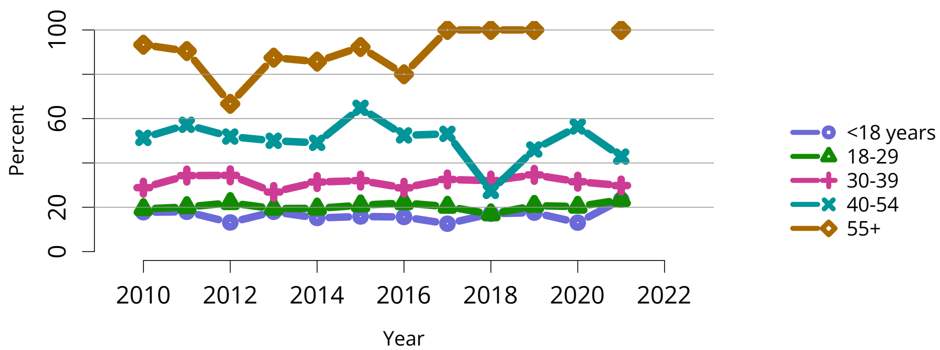

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Figure PA 36: Rates of pancreata recovered for transplant and not transplanted by donor age. Percentages of pancreata not transplanted out of all pancreata recovered for transplant. Pancreata recovered for islet transplant are excluded. Missing dots indicate no pancreata were recovered from donors in the age category in the year.

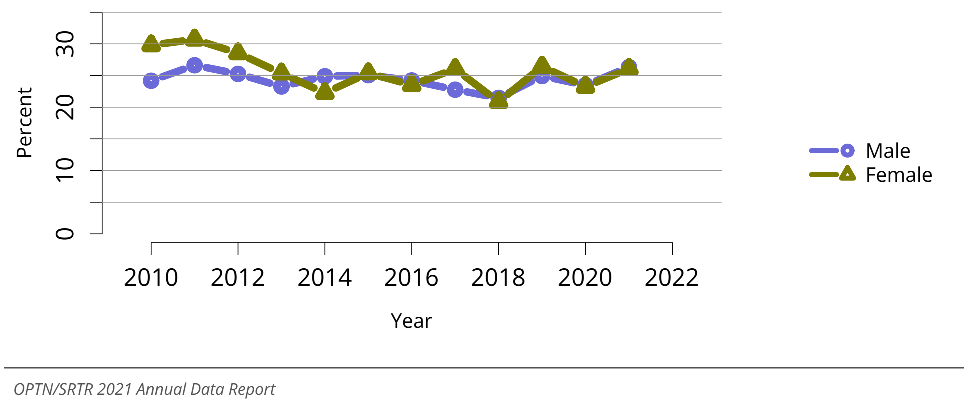

Figure PA 37: Rates of pancreata recovered for transplant and not transplanted by donor sex. Percentages of pancreata not transplanted out of all pancreata recovered for transplant. Pancreata recovered for islet transplant are excluded.

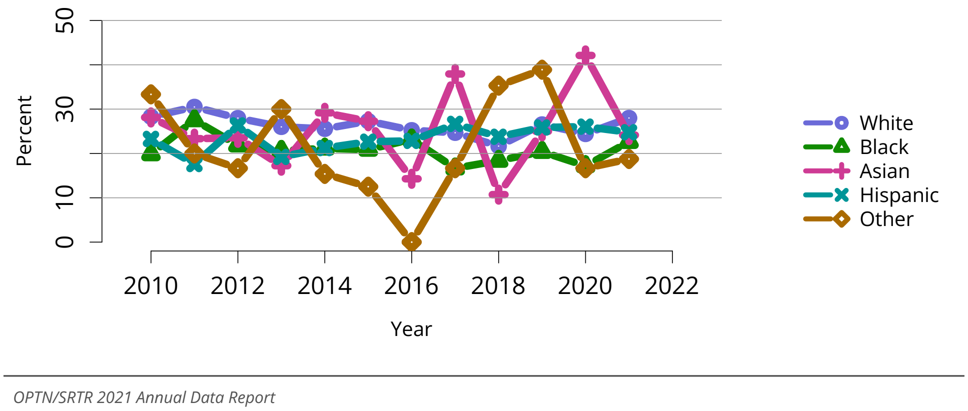

Figure PA 38: Rates of pancreata recovered for transplant and not transplanted by donor race. Percentages of pancreata not transplanted out of all pancreata recovered for transplant. Pancreata recovered for islet transplant are excluded.

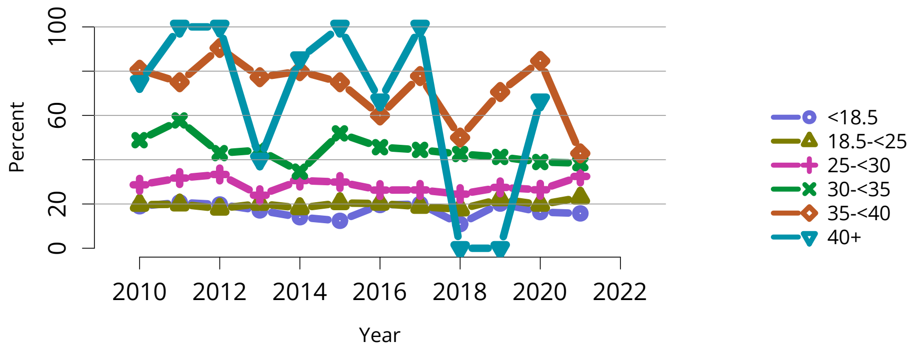

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Figure PA 39: Rates of pancreata recovered for transplant and not transplanted by donor BMI. Percentages of pancreata not transplanted out of all pancreata recovered for transplant. Pancreata recovered for islet transplant are excluded.

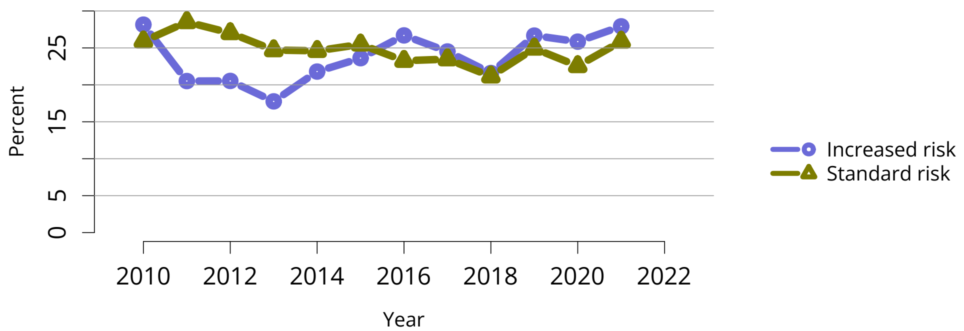

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Figure PA 40: Rates of pancreata recovered for transplant and not transplanted, by donor risk of disease transmission. Percentages of pancreata not transplanted out of all pancreata recovered for transplant. Pancreata recovered for islet transplant are excluded. Risk factors for blood-borne disease transmission are defined by criteria from the US Public Health Service Guidelines as increased risk for HIV, hepatitis B, and hepatitis C transmission.

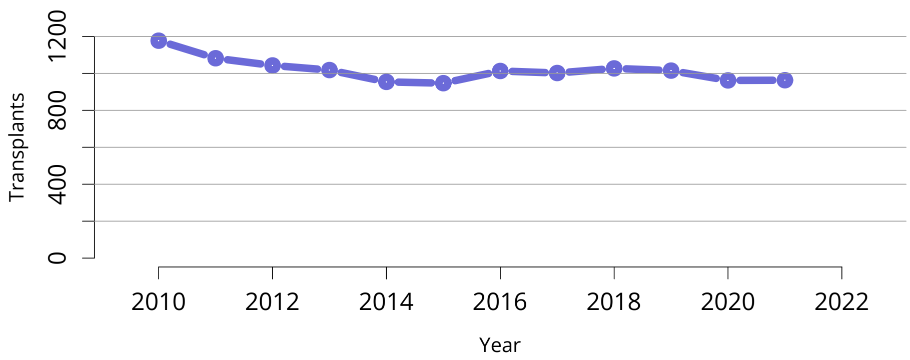

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Figure PA 41: Overall pancreas transplants. All pancreas transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

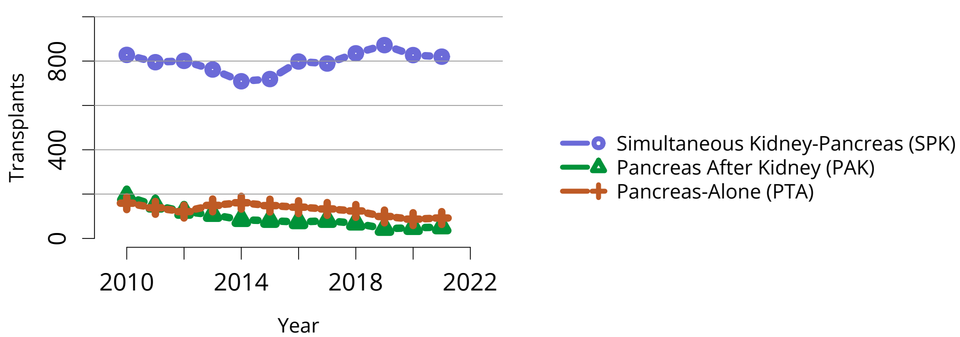

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Figure PA 42: Total pancreas transplants by pancreas transplant type. All pancreas transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

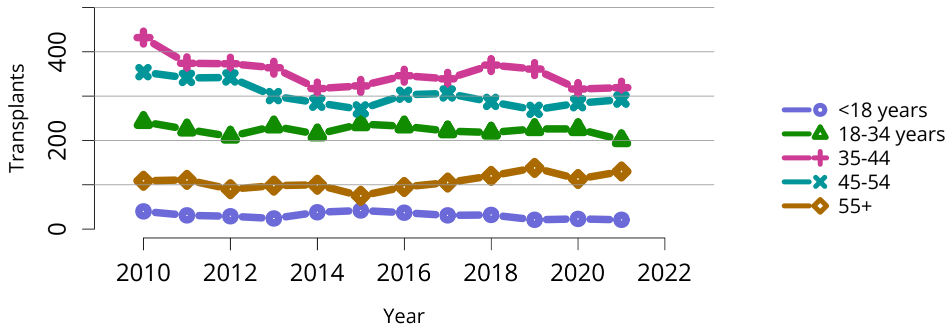

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Figure PA 43: Total pancreas transplants by age. All pancreas transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

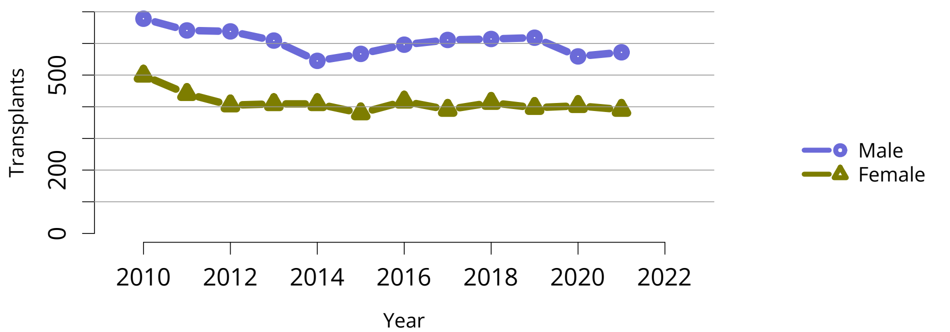

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Figure PA 44: Total pancreas transplants by sex. All pancreas transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

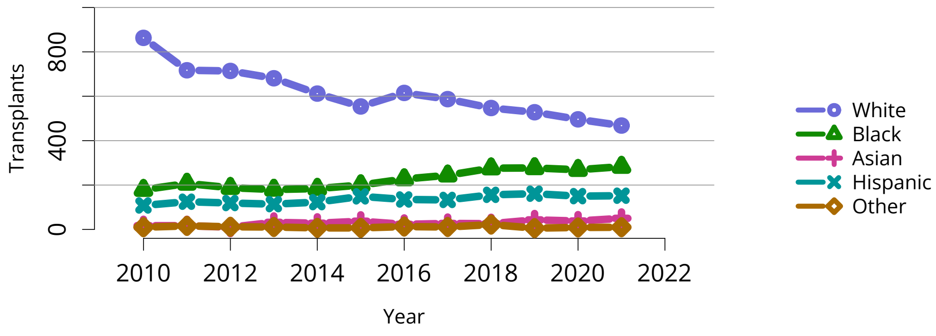

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Figure PA 45: Total pancreas transplants by race. All pancreas transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

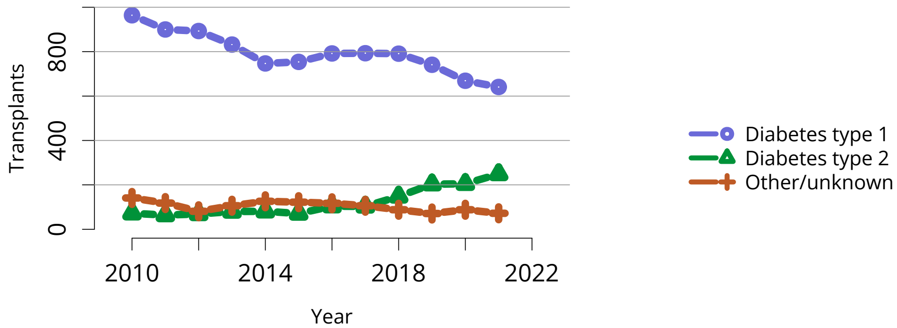

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Figure PA 46: Total pancreas transplants by diagnosis. All pancreas transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

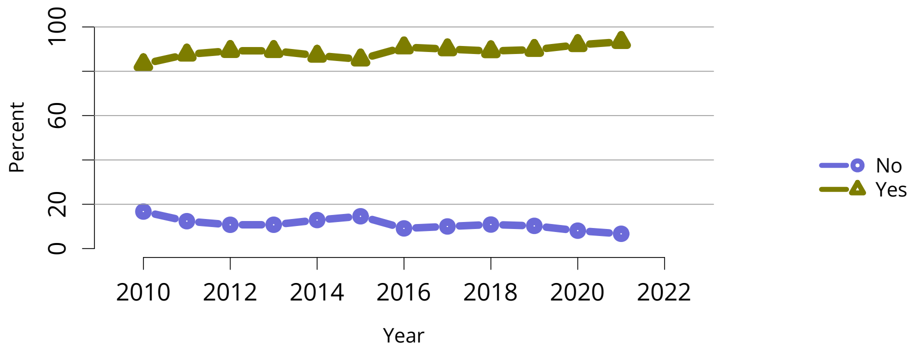

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Figure PA 47: Induction agent use in adult pancreas transplant recipients. Immunosuppression at transplant reported to the OPTN.

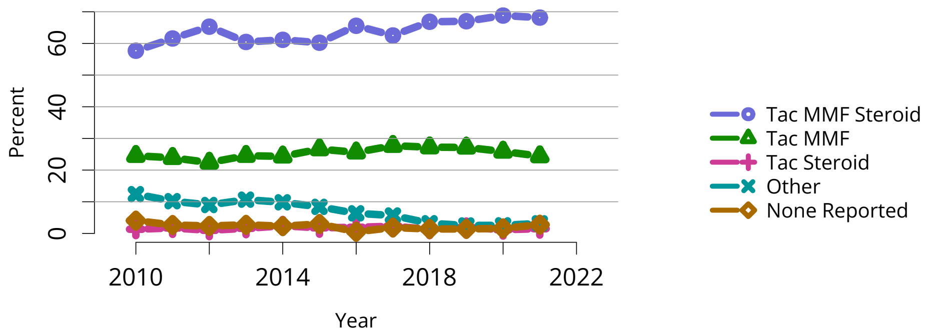

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Figure PA 48: Immunosuppression regimen use in adult pancreas transplant recipients. Immunosuppression regimen at transplant reported to the OPTN. Tac, tacrolimus. MMF, all mycophenolate agents.

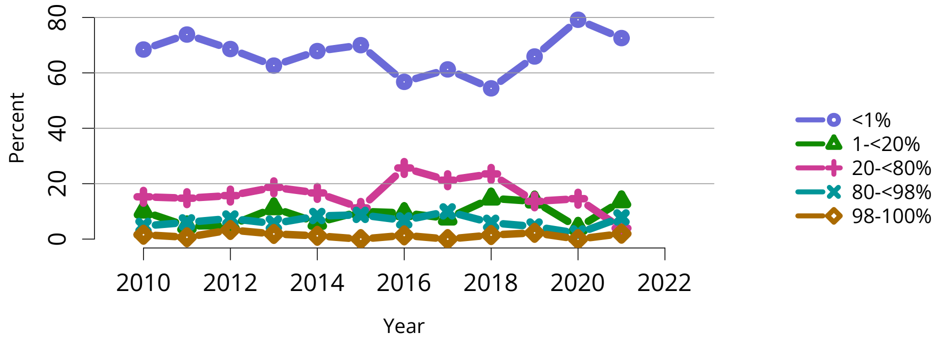

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Figure PA 49: CPRA in adult recipients of pancreas after kidney transplant. Peak cPRA is used.

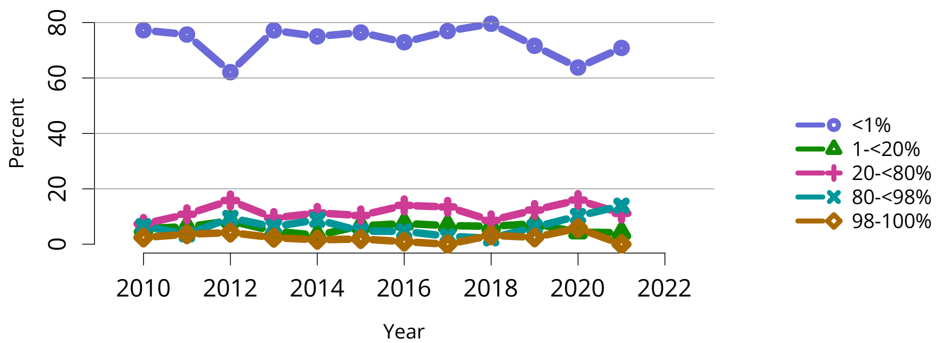

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Figure PA 50: CPRA in adult recipients of pancreas transplant alone. Peak cPRA is used.

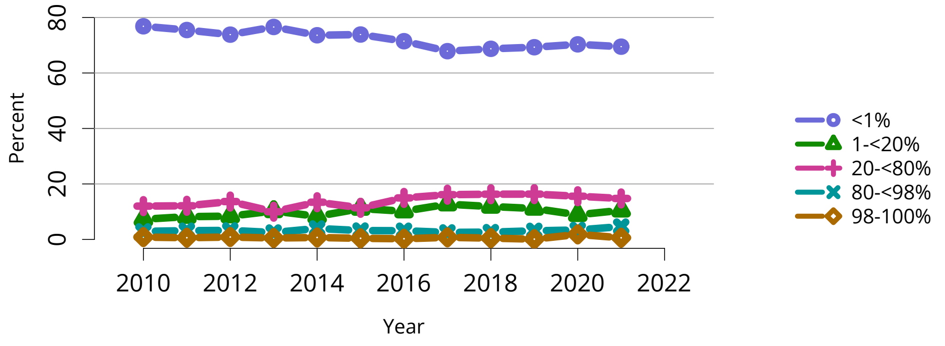

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Figure PA 51: CPRA in adult recipients of simultaneous pancreas-kidney transplant. Peak cPRA is used.

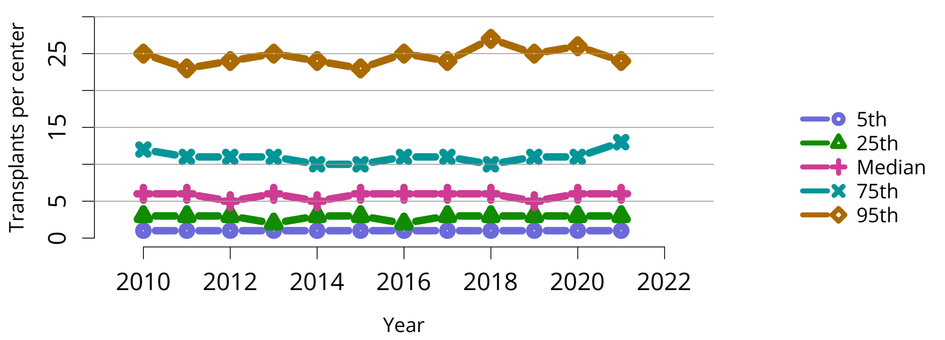

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Figure PA 52: Annual adult pancreas transplant center volumes by percentile. Annual volume data are limited to recipients aged 18 years or older.

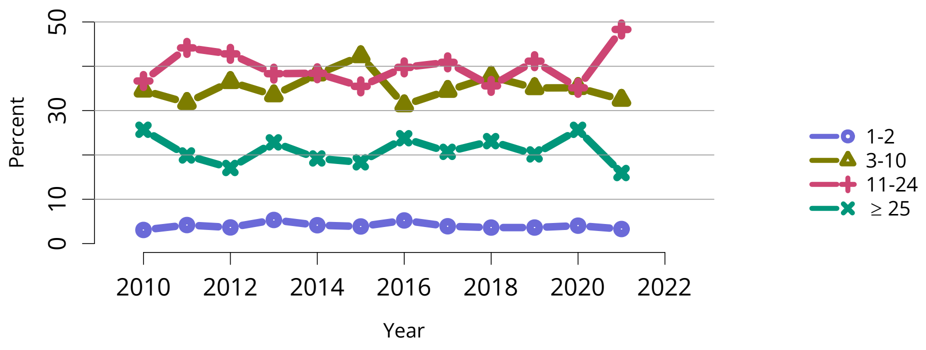

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Figure PA 53: Distribution of adult pancreas transplants by annual center volume. Based on annual volume data among recipients aged 18 or older.

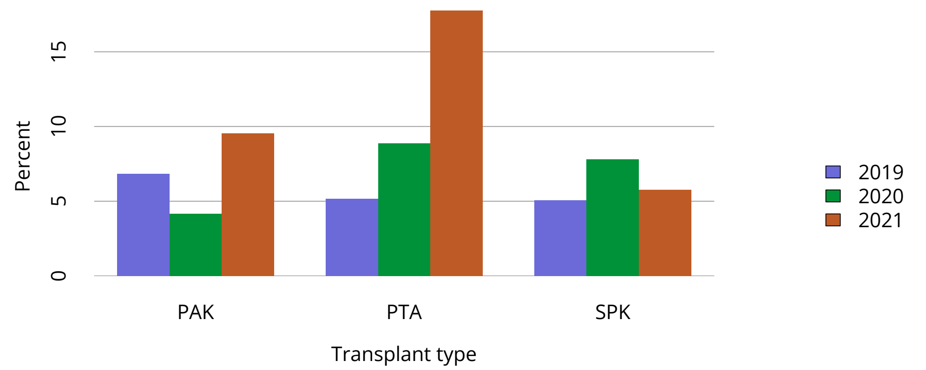

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Figure PA 54: Pancreas graft failure within the first 90 days posttransplant among adult pancreas transplant recipients. All-cause graft failure is identified from multiple data sources, including the OPTN Transplant Recipient Registration Form, the OPTN Transplant Recipient Follow-up Form, and death dates from the Social Security Administration. Transplants after September 30, 2021, are excluded due to insufficient follow-up. Nonrenal multivisceral transplants are excluded. PAK, pancreas after kidney; PTA, pancreas transplant alone; SPK, simultaneous pancreas-kidney transplant.

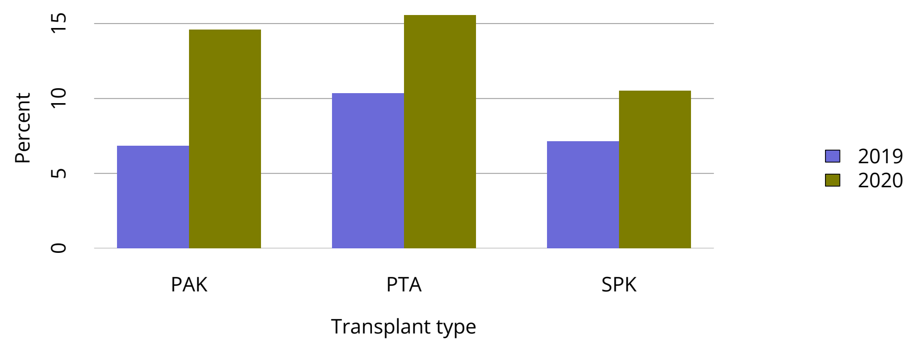

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Figure PA 55: Pancreas graft failure within the first year posttransplant among adult pancreas transplant recipients. All-cause graft failure is identified from multiple data sources, including the OPTN Transplant Recipient Registration Form, the OPTN Transplant Recipient Follow-up Form, and death dates from the Social Security Administration. Nonrenal multivisceral transplants are excluded. PAK, pancreas after kidney; PTA, pancreas transplant alone; SPK, simultaneous pancreas-kidney transplant.

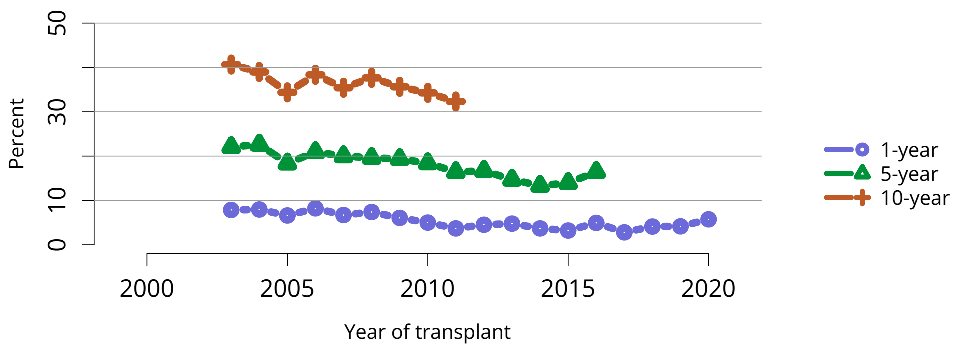

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Figure PA 56: Kidney graft failure among adult SPK transplant recipients. Estimates are unadjusted, computed using Kaplan-Meier methods. SPK transplant recipients are followed from date of transplant to the earliest of kidney graft failure; kidney retransplant; return to dialysis; death; or 1, 5, or 10 years posttransplant. All-cause graft failure is defined as any of the above outcomes prior to 1, 5, or 10 years, respectively. Nonrenal multivisceral transplants are excluded. SPK, simultaneous pancreas-kidney transplant.

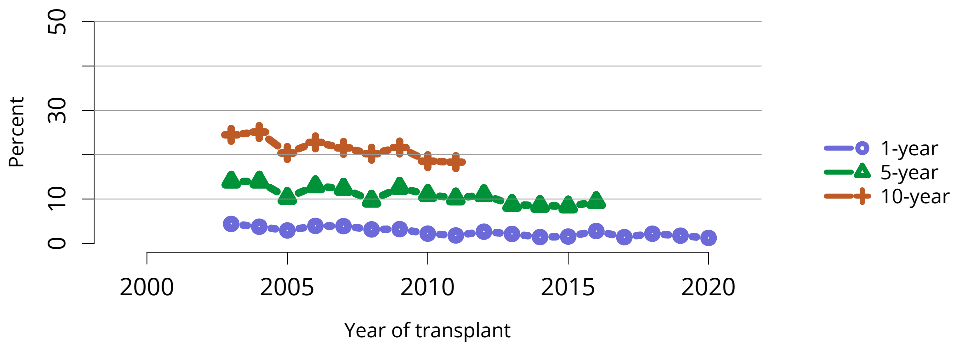

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Figure PA 57: Death censored kidney graft failure among adult SPK transplant recipients. Estimates are unadjusted, computed using Kaplan-Meier competing risk methods. SPK transplant recipients are followed from date of transplant to the earliest of kidney graft failure; kidney retransplant; return to dialysis; death; or 1, 5, or 10 years posttransplant. Death-censored graft failure is defined as return to dialysis, reported graft failure, or kidney retransplant. Nonrenal multivisceral transplants are excluded. SPK, simultaneous pancreas-kidney transplant.

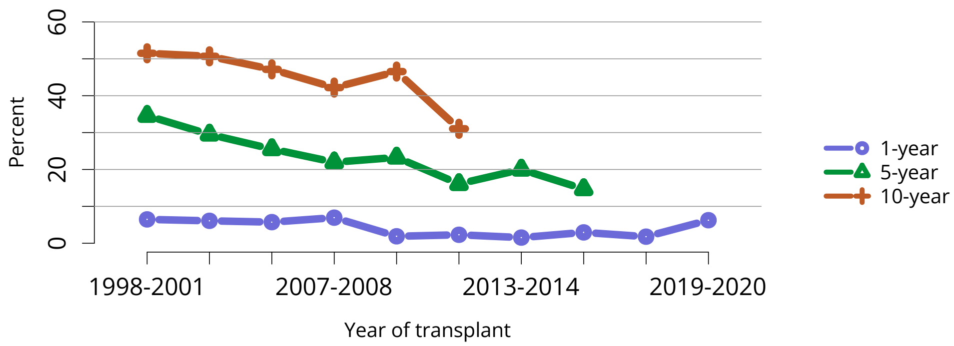

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Figure PA 58: Kidney graft failure among adult PAK transplant recipients with a deceased donor kidney (from time of pancreas transplant). Estimates are unadjusted, computed using Kaplan-Meier methods. PAK transplant recipients who previously underwent deceased donor kidney transplant are followed from the date of pancreas transplant to the earliest of kidney graft failure; kidney retransplant; return to dialysis; death; or 1, 5, or 10 years posttransplant. Only PAK recipients with an OPTN record of previous kidney or kidney-pancreas transplant are included. Multivisceral transplants are excluded. All-cause graft failure is defined as any of the above outcomes prior to 1, 5, or 10 years, respectively. PAK, pancreas after kidney. Time point 1 is years 1998-2001; time point 2 is years 2002-2004; all other time points are 2-year periods.

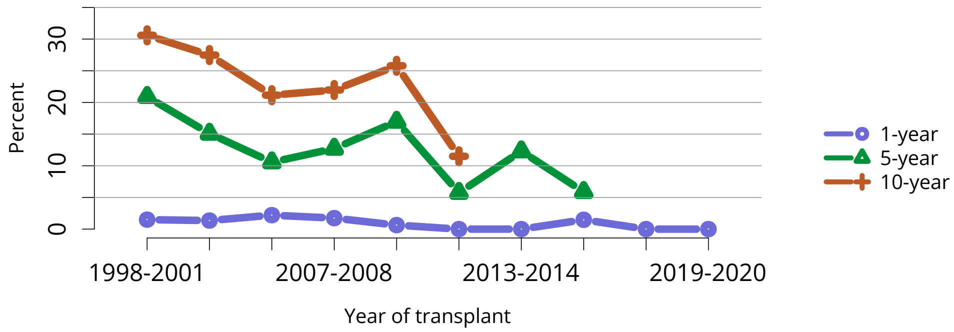

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Figure PA 59: Death-censored kidney graft failure among adult PAK transplant recipients with a deceased donor kidney (from time of pancreas transplant). Estimates are unadjusted, computed using Kaplan-Meier competing risk methods. PAK transplant recipients who previously underwent deceased donor kidney transplant are followed from the date of pancreas transplant to the earliest of kidney graft failure; kidney retransplant; return to dialysis; death; or 1, 5, or 10 years posttransplant. Only PAK recipients with an OPTN record of previous kidney or kidney-pancreas transplant are included. Multivisceral transplants are excluded. Death-censored graft failure is defined as return to dialysis, reported graft failure, or kidney retransplant. PAK, pancreas after kidney. Time point 1 is years 1998-2001; time point 2 is years 2002-2004; all other time points are 2-year periods.

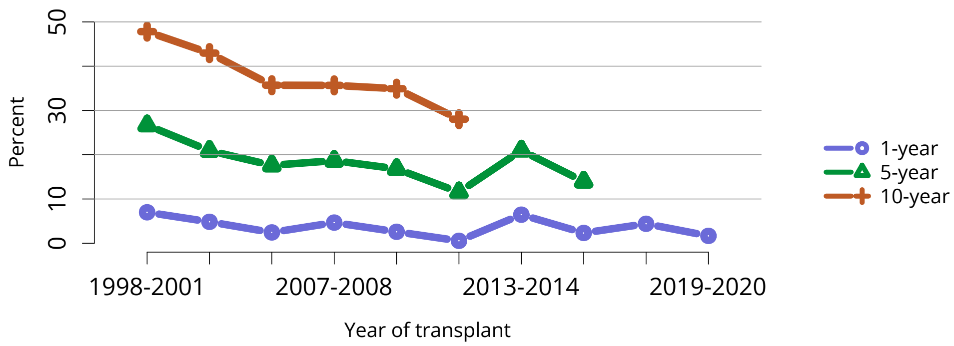

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Figure PA 60: Kidney graft failure among adult PAK transplant recipients with a living donor kidney (from time of pancreas transplant). Estimates are unadjusted, computed using Kaplan-Meier methods. PAK transplant recipients who previously underwent living donor kidney transplant are followed from date of pancreas transplant to the earliest of kidney graft failure; kidney retransplant; return to dialysis; death, or 1, 5, or 10 years posttransplant. Only PAK recipients with an OPTN record of a previous living kidney donor transplant are included. Multivisceral transplants are excluded. All-cause graft failure is defined as any of the above outcomes prior to 1, 5, or 10 years, respectively. PAK, pancreas after kidney. Time point 1 is years 1998-2001; time point 2 is years 2002-2004; all other time points are 2-year periods.

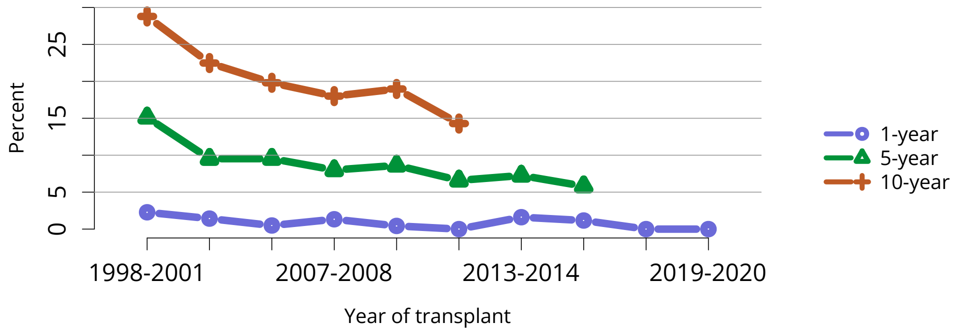

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Figure PA 61: Death-censored kidney graft failure among adult PAK transplant recipients with a living donor kidney (from time of pancreas transplant). Estimates are unadjusted, computed using Kaplan-Meier competing risk methods. PAK transplant recipients who previously underwent living donor kidney transplant are followed from date of pancreas transplant to the earliest of kidney graft failure; kidney retransplant; return to dialysis; death, or 1, 5, or 10 years posttransplant. Only PAK recipients with an OPTN record of a previous living kidney donor transplant are included. Multivisceral transplants are excluded. Death-censored graft failure is defined as return to dialysis, reported graft failure, or kidney retransplant. PAK, pancreas after kidney. Time point 1 is years 1998-2001; time point 2 is years 2002-2004; all other time points are 2-year periods.

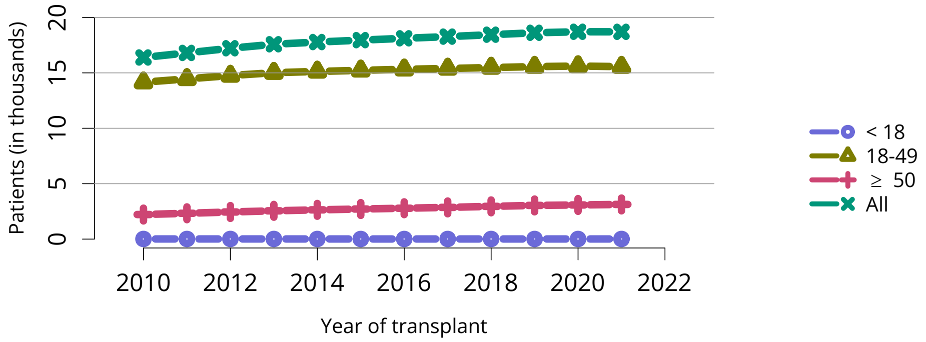

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Figure PA 62: Recipients alive after pancreas transplant on June 30 of the year, by age at transplant. Recipients are not censored at reported graft failure since the uniform definiton of graft failure was not in effect until 2018. However, a recipient may experience a reported graft failure and be removed from the cohort, undergo retransplant, and re-enter the cohort.

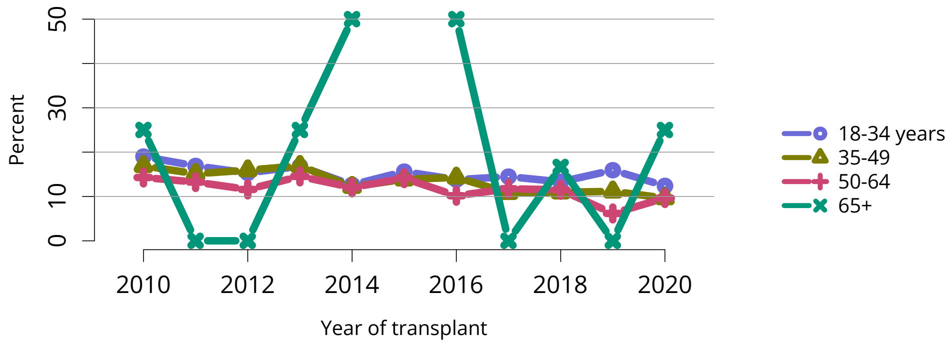

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Figure PA 63: Incidence of acute rejection by 1 year posttransplant among adult pancreas transplant recipients by age. Only the first reported rejection event is counted. Cumulative incidence is estimated using the Kaplan-Meier method.

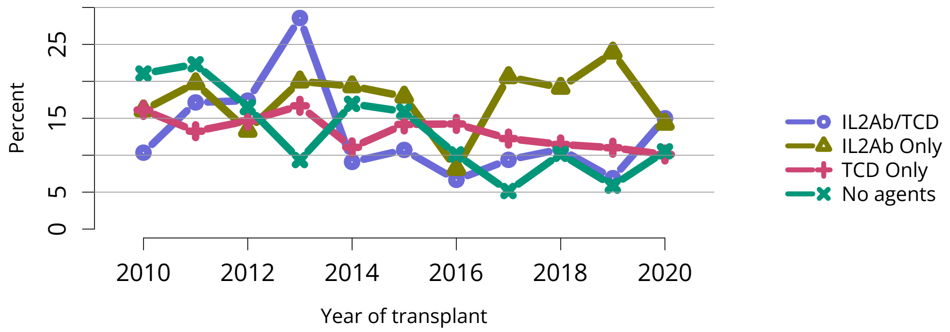

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Figure PA 64: Incidence of acute rejection by 1 year posttransplant among adult pancreas transplant recipients by induction agent. Only the first reported rejection event is counted. Cumulative incidence is estimated using the Kaplan-Meier method. IL2Ab, interleukin 2 receptor antibody; TCD, T-cell depleting.

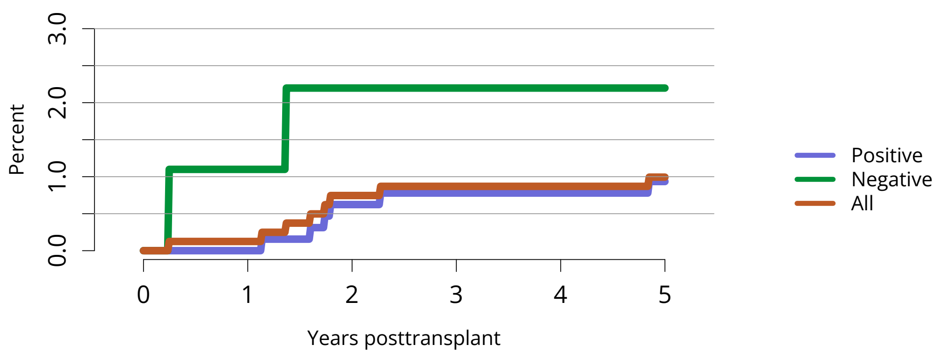

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Figure PA 65: Incidence of PTLD among adult recipients of pancreas after kidney transplant by recipient EBV status at transplant, 2010-2016. Cumulative incidence is estimated using the Kaplan-Meier method. PTLD is identified as a reported complication or cause of death on the OPTN Transplant Recipient Follow-up Form or the Posttransplant Malignancy Form as polymorphic PTLD, monomorphic PTLD, or Hodgkin's disease. Only the earliest date of PTLD diagnosis is considered. EBV, Epstein-Barr virus; PTLD, posttransplant lymphoproliferative disorder.

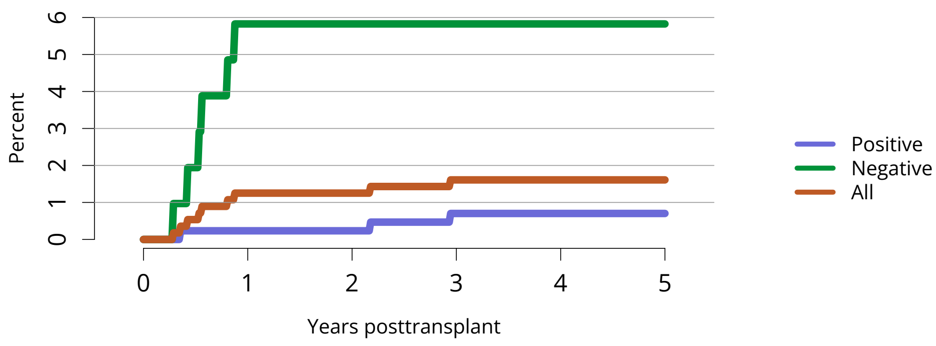

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Figure PA 66: Incidence of PTLD among adult recipients of pancreas transplant alone by recipient EBV status at transplant, 2010-2016. Cumulative incidence is estimated using the Kaplan-Meier method. PTLD is identified as a reported complication or cause of death on the OPTN Transplant Recipient Follow-up Form or the Posttransplant Malignancy Form as polymorphic PTLD, monomorphic PTLD, or Hodgkin's disease. Only the earliest date of PTLD diagnosis is considered. EBV, Epstein-Barr virus; PTLD, posttransplant lymphoproliferative disorder.

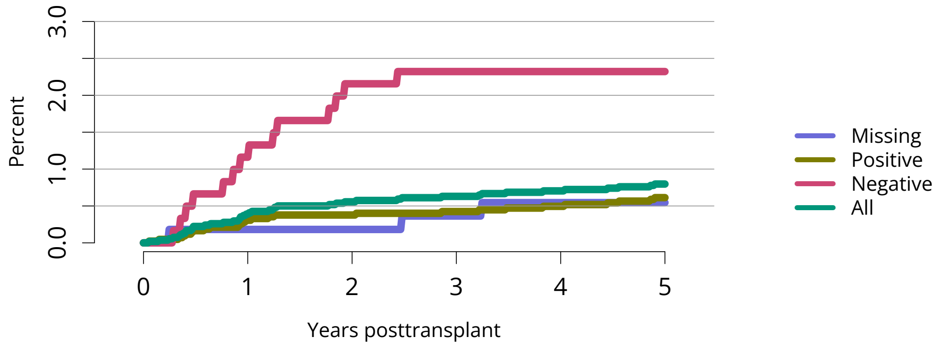

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Figure PA 67: Incidence of PTLD among adult recipients of simultaneous pancreas-kidney transplant by recipient EBV status at transplant, 2010-2016. Cumulative incidence is estimated using the Kaplan-Meier method. PTLD is identified as a reported complication or cause of death on the OPTN Transplant Recipient Follow-up Form or the Posttransplant Malignancy Form as polymorphic PTLD, monomorphic PTLD, or Hodgkin's disease. Only the earliest date of PTLD diagnosis is considered. EBV, Epstein-Barr virus; PTLD, posttransplant lymphoproliferative disorder.

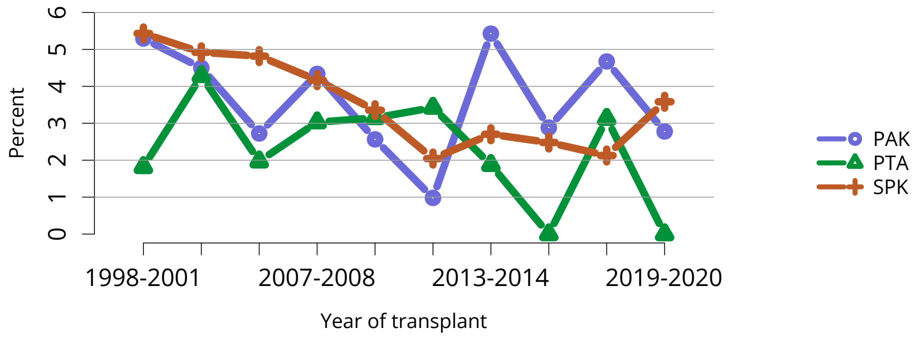

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Figure PA 68: Patient death at one year among adult pancreas transplant recipients. Outcomes are computed using unadjusted Kaplan-Meier methods. Transplant recipients are followed from date of transplant to the earlier of death or 1 year posttransplant. Only first pancreas transplant is considered. PAK recipients without a record of previous kidney or kidney-pancreas transplant are reclassified as PTA. PAK, pancreas after kidney; PTA, pancreas transplant alone; SPK, simultaneous pancreas-kidney transplant. Time point 1 is years 1998-2001; time point 2 is years 2002-2004; all other time points are 2-year periods.

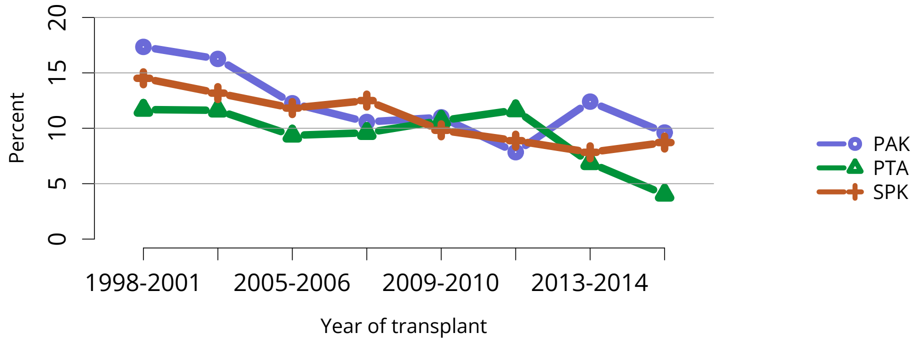

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Figure PA 69: Patient death at five years among adult pancreas transplant recipients. Outcomes are computed using unadjusted Kaplan-Meier methods. Transplant recipients are followed from date of transplant to the earlier of death or 5 years posttransplant. Only first pancreas transplant is considered. PAK recipients without a record of previous kidney or kidney-pancreas transplant are reclassified as PTA. PAK, pancreas after kidney; PTA, pancreas transplant alone; SPK, simultaneous pancreas-kidney transplant. Time point 1 is years 1998-2001; time point 2 is years 2002-2004; all other time points are 2-year periods.

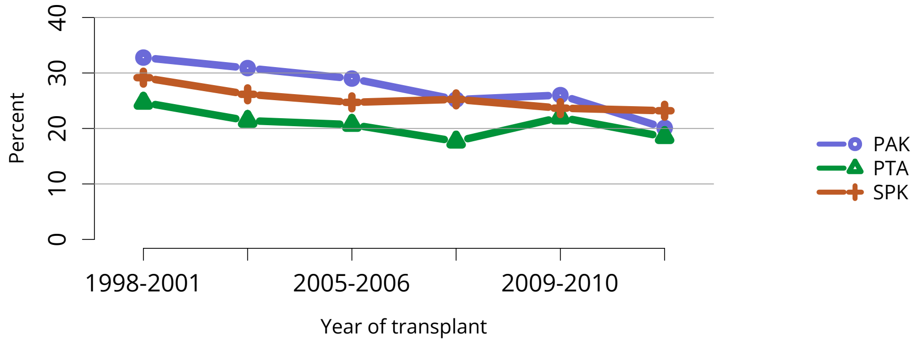

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Figure PA 70: Patient death at ten years among adult pancreas transplant recipients. Outcomes are computed using unadjusted Kaplan-Meier methods. Transplant recipients are followed from date of transplant to the earlier of death or 10 years posttransplant. Only first pancreas transplant is considered. PAK recipients without a record of previous kidney or kidney-pancreas transplant are reclassified as PTA. PAK, pancreas after kidney; PTA, pancreas transplant alone; SPK, simultaneous pancreas-kidney transplant. Time point 1 is years 1998-2001; time point 2 is years 2002-2004; all other time points are 2-year periods.

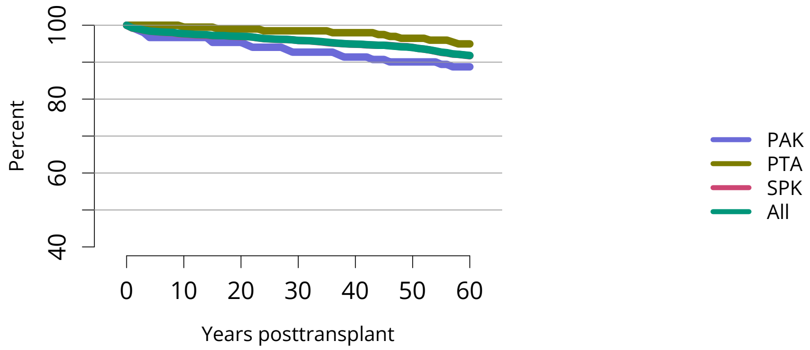

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Figure PA 71: Patient survival among adult deceased donor pancreas transplant recipients, 2014-2016, by transplant type. Patient survival estimated using unadjusted Kaplan-Meier methods. Multivisceral transplants are excluded. PAK, pancreas after kidney; PTA, pancreas transplant alone; SPK, simultaneous pancreas-kidney transplant.

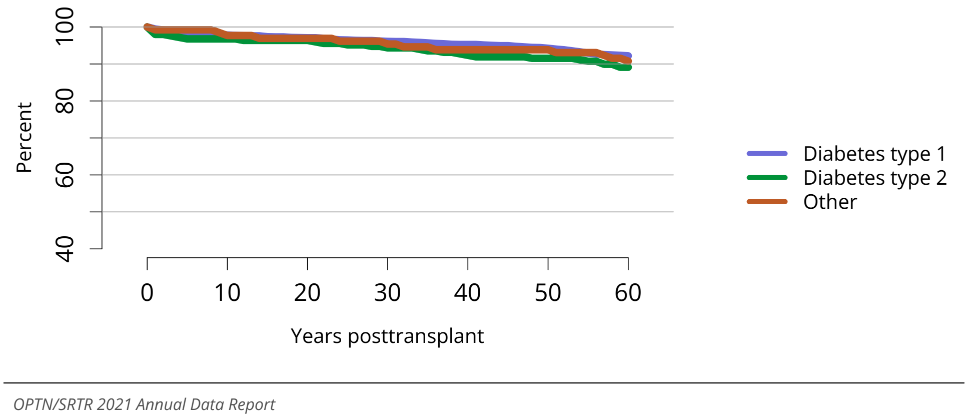

Figure PA 72: Patient survival among adult deceased donor pancreas transplant recipients, 2014-2016, by diagnosis. Patient survival estimated using unadjusted Kaplan-Meier methods. Multivisceral transplants are excluded.

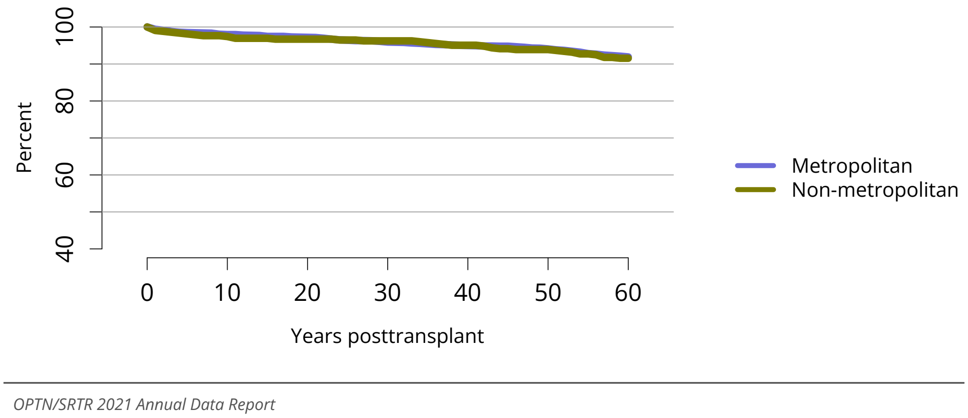

Figure PA 73: Patient survival among adult deceased donor pancreas transplant recipients, 2014-2016, by metropolitan vs. non-metropolitan recipient residence. Patient survival estimated using unadjusted Kaplan-Meier methods. Multivisceral transplants are excluded.

Table PA 1: Demographic characteristics of adults on the pancreas transplant waiting list on December 31, 2021. Candidates waiting for transplant on December 31, 2021, regardless of first listing date. Distance is computed from candidate's home zip code to the transplant center. PAK, pancreas after kidney; PTA, pancreas transplant alone; SPK, simultaneous pancreas-kidney transplant.

	PAK		PTA		SPK		All	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Age (years)								
18-34 years	31	10.8	87	24	364	19.6	482	19.3
35-44	110	38.5	119	32.9	682	36.8	911	36.4
45-54	106	37.1	102	28.2	555	29.9	763	30.5
55+	39	13.6	54	14.9	254	13.7	347	13.9
Sex								
Male	146	51	167	46.1	1023	55.1	1336	53.4
Female	140	49	195	53.9	832	44.9	1167	46.6
Race								
White	156	54.5	268	74	871	47	1295	51.7
Black	69	24.1	43	11.9	541	29.2	653	26.1
Asian	8	2.8	7	1.9	95	5.1	110	4.4
Hispanic	49	17.1	40	11	310	16.7	399	15.9
Other	4	1.4	4	1.1	38	2	46	1.8
Body mass index								
<18.5	3	1	18	5	25	1.3	46	1.8
18.5-<25	99	34.6	131	36.2	621	33.5	851	34
25-<30	105	36.7	134	37	755	40.7	994	39.7
30-<35	66	23.1	61	16.9	374	20.2	501	20
35+	13	4.5	18	5	80	4.3	111	4.4
Geography								
Metropolitan	240	83.9	294	81.2	1548	83.5	2082	83.2
Non-metropolitan	46	16.1	63	17.4	281	15.1	390	15.6
Missing	0	0	5	1.4	26	1.4	31	1.2
Miles between candidate to center								
<50 miles	177	61.9	177	48.9	1145	61.7	1499	59.9
50-<100	54	18.9	63	17.4	371	20	488	19.5
100-<150	27	9.4	34	9.4	154	8.3	215	8.6
150-<250	17	5.9	28	7.7	108	5.8	153	6.1
250+	11	3.8	55	15.2	65	3.5	131	5.2
Missing	0	0	5	1.4	12	0.6	17	0.7
All candidates								
All candidates	286	100	362	100	1855	100	2503	100

Table PA 2: Clinical characteristics of adults on the pancreas transplant waiting list on December 31, 2021. Candidates waiting for transplant on December 31, 2021, regardless of first listing date. PAK, pancreas after kidney; PTA, pancreas transplant alone; SPK, simultaneous pancreas-kidney transplant.

	PAK		PTA		SPK		All	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Diagnosis								
Diabetes type 1	223	78	274	75.7	1317	71	1814	72.5
Diabetes type 2	54	18.9	21	5.8	456	24.6	531	21.2
Other/unknown	9	3.1	67	18.5	82	4.4	158	6.3
Blood Type								
A	103	36	157	43.4	549	29.6	809	32.3
AB	17	5.9	12	3.3	56	3	85	3.4
B	30	10.5	40	11	342	18.4	412	16.5
O	136	47.6	153	42.3	908	48.9	1197	47.8
All candidates								
All candidates	286	100	362	100	1855	100	2503	100

Table PA 3: Listing characteristics of adults on the pancreas transplant waiting list on December 31, 2021. Candidates waiting for transplant on December 31, 2021, regardless of first listing date. PAK, pancreas after kidney; PTA, pancreas transplant alone; SPK, simultaneous pancreas-kidney transplant.

	PAK		PTA		SPK		All	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Waiting time								
<90 days	26	9.1	40	11	286	15.4	352	14.1
3-<6 months	20	7	35	9.7	261	14.1	316	12.6
6-<12 months	42	14.7	57	15.7	400	21.6	499	19.9
1-<2 years	54	18.9	59	16.3	412	22.2	525	21
2+ years	144	50.3	171	47.2	496	26.7	811	32.4
Previous transplant								
No prior transplant	213	74.5	316	87.3	1769	95.4	2298	91.8
Prior transplant	73	25.5	46	12.7	86	4.6	205	8.2
All candidates								
All candidates	286	100	362	100	1855	100	2503	100

Table PA 4: Transplant waitlist activity among adults waiting for a pancreas after kidney transplant. Candidates listed at more than one center are counted one per listing. Candidates who are listed, undergo transplant, and are relisted are counted more than once. Candidates are not considered to be on the list on the day they are removed; counts on January 1 may differ from counts on December 31 of the prior year. Candidates listed for multiorgan transplants are included.

Waiting list state	2019	2020	2021
Waiting list state			
Patients at start of year	286	300	292
Patients added during year	124	103	108
Patients removed during year	110	111	114
Patients at end of year	300	292	286

Table PA 5: Transplant waitlist activity among adults waiting for a pancreas transplant alone. Candidates listed at more than one center are counted one per listing. Candidates who are listed, undergo transplant, and are relisted are counted more than once. Candidates are not considered to be on the list on the day they are removed; counts on January 1 may differ from counts on December 31 of the prior year. Candidates listed for multiorgan transplants are included.

Waiting list state	2019	2020	2021
Waiting list state			
Patients at start of year	379	333	363
Patients added during year	168	175	181
Patients removed during year	214	145	182
Patients at end of year	333	363	362

Table PA 6: Transplant waitlist activity among adults waiting for a simultaneous pancreas-kidney transplant. Candidates listed at more than one center are counted one per listing. Candidates who are listed, undergo transplant, and are relisted are counted more than once. Candidates are not considered to be on the list on the day they are removed; counts on January 1 may differ from counts on December 31 of the prior year. Candidates listed for multiorgan transplants are included.

Waiting list state	2019	2020	2021
Waiting list state			
Patients at start of year	1658	1737	1720
Patients added during year	1479	1307	1487
Patients removed during year	1399	1324	1352
Patients at end of year	1738	1720	1855

Table PA 7: Removal reason among adults waiting for pancreas after kidney transplant. Removal reason as reported to the OPTN. Candidates with death dates that precede removal dates are assumed to have died waiting.

Removal reason	2019	2020	2021
Removal reason			
Deceased donor transplant	33	35	34
Patient died	3	8	6
Patient refused transplant	9	3	4
Improved, transplant not needed	1	0	2
Too sick for transplant	15	10	11
Other	47	53	54
Changed to kidney-pancreas list	2	1	3
Still on waiting list	0	1	0

Table PA 8: Removal reason among adults waiting for pancreas transplant alone. Removal reason as reported to the OPTN. Candidates with death dates that precede removal dates are assumed to have died waiting.

Removal reason	2019	2020	2021
Removal reason			
Deceased donor transplant	90	78	86
Patient died	8	11	7
Patient refused transplant	8	2	5
Improved, transplant not needed	7	2	7
Too sick for transplant	21	11	13
Other	75	33	56
Changed to kidney-pancreas list	5	8	8

Table PA 9: Removal reason among adults waiting for simultaneous pancreas-kidney transplant. Removal reason as reported to the OPTN. Candidates with death dates that precede removal dates are assumed to have died waiting.

Removal reason	2019	2020	2021
Removal reason			
Deceased donor transplant	910	858	858
Living donor transplant	60	49	75
Transplant outside US	0	0	2
Patient died	81	108	98
Patient refused transplant	6	3	6
Improved, transplant not needed	9	3	7
Too sick for transplant	89	71	73
Other	244	230	231
Still on waiting list	0	2	2

Table PA 10: Demographic characteristics of adult pancreas transplant recipients, 2021. Pancreas transplant recipients, including retransplants. Distance is computed from recipient's home zip code to the transplant center. PAK, pancreas after kidney; PTA, pancreas transplant alone; SPK, simultaneous pancreas-kidney transplant.

	PAK		PTA		SPK		All	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Recipient age (years)								
18-34 years	9	17.6	17	23.6	175	21.4	201	21.3
35-49	27	52.9	34	47.2	408	49.8	469	49.8
50-64	14	27.5	18	25	233	28.4	265	28.1
65+	1	2	3	4.2	3	0.4	7	0.7
Sex								
Male	31	60.8	28	38.9	503	61.4	562	59.7
Female	20	39.2	44	61.1	316	38.6	380	40.3
Race								
White	33	64.7	59	81.9	363	44.3	455	48.3
Black	12	23.5	4	5.6	264	32.2	280	29.7
Asian	1	2	1	1.4	46	5.6	48	5.1
Hispanic	5	9.8	7	9.7	137	16.7	149	15.8
Other	0	0	1	1.4	9	1.1	10	1.1
Body mass index								
<18.5	3	5.9	4	5.6	12	1.5	19	2
18.5-<25	22	43.1	26	36.1	295	36	343	36.4
25-<30	17	33.3	27	37.5	340	41.5	384	40.8
30-<35	7	13.7	13	18.1	141	17.2	161	17.1
35+	1	2	1	1.4	13	1.6	15	1.6
Missing	1	2	1	1.4	18	2.2	20	2.1
Insurance								
Private	22	43.1	54	75	297	36.3	373	39.6
Medicare	25	49	11	15.3	424	51.8	460	48.8
Medicaid	3	5.9	6	8.3	68	8.3	77	8.2
Other/unknown	1	2	1	1.4	30	3.7	32	3.4
Geography								
Metropolitan	41	80.4	51	70.8	689	84.1	781	82.9
Non-metropolitan	9	17.6	19	26.4	101	12.3	129	13.7
Missing	1	2	2	2.8	29	3.5	32	3.4
Miles between recipient to center								
<50 miles	29	56.9	28	38.9	501	61.2	558	59.2
50-<100	14	27.5	15	20.8	146	17.8	175	18.6
100-<150	2	3.9	12	16.7	65	7.9	79	8.4
150-<250	3	5.9	7	9.7	52	6.3	62	6.6
250+	2	3.9	8	11.1	36	4.4	46	4.9
Missing	1	2	2	2.8	19	2.3	22	2.3
All recipients								
All recipients	51	100	72	100	819	100	942	100

Table PA 11: Clinical characteristics of adult pancreas transplant recipients, 2021. Pancreas transplant recipients, including retransplants. PAK, pancreas after kidney; PTA, pancreas transplant alone; SPK, simultaneous pancreas-kidney transplant.

	PAK		PTA		SPK		All	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Diagnosis								
Diabetes type 1	42	82.4	45	62.5	554	67.6	641	68
Diabetes type 2	7	13.7	2	2.8	240	29.3	249	26.4
Other/unknown	2	3.9	25	34.7	25	3.1	52	5.5
Blood Type								
A	24	47.1	33	45.8	269	32.8	326	34.6
AB	2	3.9	0	0	30	3.7	32	3.4
B	5	9.8	7	9.7	109	13.3	121	12.8
O	20	39.2	32	44.4	411	50.2	463	49.2
All recipients								
All recipients	51	100	72	100	819	100	942	100

Table PA 12: Transplant characteristics of adult pancreas transplant recipients, 2021. Pancreas transplant recipients, including retransplants. PAK, pancreas after kidney; PTA, pancreas transplant alone; SPK, simultaneous pancreas-kidney transplant.

	PAK		PTA		SPK		All	
Characteristic	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Waiting time								
None	1	2	0	0	5	0.6	6	0.6
<90 days	3	5.9	25	34.7	312	38.1	340	36.1
3-<6 months	2	3.9	7	9.7	142	17.3	151	16
6-<12 months	17	33.3	18	25	132	16.1	167	17.7
1-<2 years	13	25.5	8	11.1	141	17.2	162	17.2
2+	15	29.4	14	19.4	87	10.6	116	12.3
Previous transplant for recipients								
Prior transplant	8	15.7	10	13.9	20	2.4	38	4
No Prior transplant	43	84.3	62	86.1	799	97.6	904	96
All recipients								
All recipients	51	100	72	100	819	100	942	100

OPTN/SRTR 2021 Annual Data Report: Liver

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Abstract

In 2021, liver transplant volume continued to grow, with a record 9,234 transplants performed in the United States, 8,665 (93.8%) from deceased donors and 569 (6.2%) from living donors. There were 8,733 (94.6%) adult and 501 (5.4%) pediatric liver transplant recipients. An increase in the number of deceased donor livers corresponded to an increase in the overall transplant rate and shorter waiting times, although still 10.0% of livers that were recovered were not transplanted. Alcohol-associated liver disease was the leading indication for both waitlist registration and liver transplant in adults, outpacing nonalcoholic steatohepatitis, while biliary atresia remained the leading indication for children. Related to allocation policy changes implemented in 2019, the proportion of liver transplants performed for hepatocellular carcinoma has decreased. Among adult candidates listed for liver transplant

in 2020, 37.7% received a deceased donor liver transplant within 3 months, 43.8% within 6 months, and 53.3% within 1 year. Pretransplant mortality improved for children following implementation of acuity circle–based distribution. Short-term graft and patient survival outcomes up to 1 year worsened for adult deceased and living donor liver transplant recipients, which is a reversal of previous trends and coincided with the onset of the COVID-19 pandemic in early 2020. Longer-term outcomes among adult deceased donor liver transplant recipients were unaffected, with overall posttransplant mortality rates of 13.3% at 3 years, 18.6% at 5 years, and 35.9% at 10 years. Pretransplant mortality improved for children following implementation of acuity circle–based distribution and prioritization of pediatric donors to pediatric recipients in 2020. Pediatric living donor recipients had superior graft and patient survival outcomes compared with deceased donor recipients at all time points.
Keywords: Liver transplant, allocation, distribution, waiting list

1 ADULT LIVER TRANSPLANTATION IN THE UNITED STATES

1.1 Waiting List

There were 11,771 adult candidates on the liver waiting list at the start of 2021, and 13,165 additional candidates were added during the calendar year, representing more new waitlist registrations than in any previous year (Figure LI 1, Table LI 4). Over the course of the year, 13,598 candidates were removed, leaving 11,338 candidates remaining on the liver transplant list on December 31, 2021.

Most adult candidates (48.0%) were 50-64 years of age, still representing the majority but a decrease from 63.9% in 2011. Those aged 65 years or older made up 27.4% of candidates, stable from the year prior but a substantial increase compared with 15.7% in 2011 (Figure LI 3). The sex and racial composition of the waiting list has remained relatively unchanged: 61.3% male, 38.7% female, 68.9% White, 6.8% Black, 18.0% Hispanic, and 4.7% Asian (Figures LI 4 and 5).

Alcohol-associated liver disease was the leading diagnosis among adult liver transplant candidates in 2021, representing 36.3% of waitlist registrations (Figure LI 6). This was followed by nonalcoholic steatohepatitis (19.3%) and other/unknown diagnoses (15.7%). The proportion of candidates with alcohol-associated liver disease and to a lesser extent nonalcoholic steatohepatitis has increased year-over-year, while the prevalence of hepatitis C virus (HCV) continued to decline, representing only 8.3% of diagnoses compared with 29.7% in 2011. The proportion of candidates with diagnoses of acute liver failure and cholestatic liver disease also declined in the past decade, representing only 1.9% and 7.8% of diagnoses, respectively, in 2021. Candidates with a primary diagnosis of hepatocellular carcinoma (HCC) made up 10.7% of new waitlist registrations.

The severity of liver disease, based on the last laboratory model for end-stage liver disease (MELD) score during the calendar year, continued to increase, with a greater proportion being listed with MELD score of 25-34 (15.7%), 35-39 (4.9%), and 40 or greater (4.9%) in 2021 compared with previous years (Figure LI 7). Obesity, defined as a body mass index (BMI) of 30 kg/m^2 or greater, was observed in 41.1% of adult candidates; 17.3% had BMI of 35 kg/m^2 or greater (Figure LI 8). Over the past decade, the proportion of candidates with a prior history of liver transplant declined from 4.0% to 3.1%, despite more transplants being performed overall (Figure LI 10). The distribution of blood types largely mirrored that in the general population: 47.7% O, 38.0% A, 11.3% B, and 3.0% AB (Figure LI 9).

1.2 Waitlist Outcomes

The overall deceased donor transplant rate among adult waitlist candidates continued to rise steadily, with an overall rate of 71.0 transplants per 100 patient-years (Figure LI 11). This increase occurred across all age groups, sexes, major racial and ethnic groups, blood types, and places of residence (metropolitan vs non-metropolitan) (Figures LI 12, 13, 14, 16, and 17). Still, men had higher transplant rates compared with women (73.8 vs 66.5 transplants per 100 patient-years). Candidates living in non-metropolitan areas, based on the rural-urban commuting area (RUCA) designation of their permanent zip code, had a higher transplant rate than those living in metropolitan areas. Candidates with blood type AB had the highest transplant rate (157.7 transplants per 100 patient-years), followed by type B (94.3 transplants per 100 patient-years), and then O and A (66.5 and 65.6 transplants per 100 patient-years, respectively) (Figure LI 14). Whereas candidates with HCC exception points historically had a much higher transplant rate than those without HCC, transplant rates for these two groups were essentially equal in 2021 (Figure LI 15). This observation occurred in the context of a policy change implemented in 2019, which set waitlist priority for HCC exception cases by the local median MELD at transplant minus 3 points.

Of the adults who were listed for liver transplant during 2016-2018, for whom at least 3 years of follow-up data were available, only 7.9% remained on the waiting list after 3 years (Figure LI 18). By the end of 3 years, 59.3% received a liver transplant (including 2.6% from a living donor), 9.3% died, and 23.5% were removed from the list for other reasons. Among candidates who were listed for liver transplant in 2020, 37.7% received a deceased donor liver transplant within 3 months, 43.8% within 6 months, and 53.3% within 1 year—all increases compared with previous years (Figure LI 19). By comparison, only 39.8% of candidates listed in 2011 received a deceased donor liver transplant within 1 year, 49.6% within 5 years, and 50.6% within 10 years.

In 2021, the pretransplant mortality rate was 13.1 deaths per 100 patient-years, compared with 15.5 deaths per 100 patient-years in 2011 (Figure LI 20). The pretransplant mortality rate was higher among women compared with men (14.1 vs 12.5 deaths per 100 patient-years), as well as older (65 years or older) compared with younger candidates, those with acute liver failure or nonalcoholic steatohepatitis compared with other diagnoses, and those living in non-metropolitan versus metropolitan areas (Figures LI 21, 23, 24, and 25). The pretransplant mortality rate has decreased over the past decade for candidates in all MELD groups (based on the first laboratory MELD score during the year) (Figure LI 26). The pretransplant mortality rate among patients waitlisted with an HCC exception remained lower than that observed in patients without HCC exceptions (10.9 vs 13.4 deaths per 100 patient-years) (Figure LI 27). Overall pretransplant mortality rates by donation service area (DSA) remain widely varied, ranging from 7.0 to 28.6 deaths per 100 patient-years (Figure LI 28).

Liver transplant was the most common reason for waitlist removal among adults, including 8,212 from a deceased donor and 492 from a living donor. The next most common reasons were death (1,134), being too sick for transplant (1,177), or condition improved with transplant no longer being needed (1,051) (Table LI 5). Deaths within 6 months after removal from the waiting list for reasons other than transplant or death decreased from 31.5% in 2011 to 15.1% in 2021; this outcome was highest among patients aged 65 years or older compared with other age groups (Figures LI 29 and 31).

1.3 Donation

The number of deceased liver donors continued to increase, reaching an all-time high of 9,540 in 2021, driven by growth in donors aged 30-39, 40-54, and 55 years or older (Figures LI 32 and 33). There were 683 pediatric donors younger than 18 years. This number has remained relatively stable in the past several years and represented 7.2% of deceased liver donors in 2021 (Figure LI 35). The sex and racial composition of donors has remained relatively unchanged: 62.3% male, 37.7% female, 62.7% White, 17.3% Black, 15.8% Hispanic, and 3.1% Asian (Figures LI 36 and 37). The number of livers with positive hepatitis C antibody has not increased as in previous years, but these livers do continue to make up a substantial proportion (9.1%) of deceased donor livers recovered in

2021 (Figures LI 34 and 38). Anoxia remains the most common cause of death among deceased liver donors (45.8%), followed by head trauma (26.6%) and cerebrovascular accident/stroke (25.7%) (Figure LI 47).

Overall, 10.0% of livers were recovered but not transplanted, an increase in the past 4 years, compared with 8.6% in 2018 (Figure LI 39). The trend may be explained at least in part by the increase in donation after circulatory death (DCD) livers (Table LI 8), which remained much less likely to be transplanted than donation after brain death (DBD) livers (29.4% vs 6.9%) (Figure LI 46). Livers from older donors (40 years or older) were also less likely to be transplanted (Figure LI 40). Livers with positive hepatitis C antibody or those at increased risk of disease transmission were not more likely to be unused (Figures LI 44 and 45).

Living donors were more likely to be women (56.3%) and White (77.8%) (Figures LI 50 and 51). Most donors were related to or directed to the recipient (Figure LI 48). In most cases, the right lobe of the liver was used (78.5%), an increasing trend over the past decade (Figure LI 52).

1.4 Transplants

In 2021, a record 9,234 liver transplants (adult and pediatric) were performed in the United States, of which 8,665 (93.8%) were from deceased donors and 569 (6.2%) were from living donors (Figures LI 54 and 55). The recipients were 61.7% male, 69.5% White, 16.7% Hispanic, 7.6% Black, and 4.4% Asian (Figures LI 57 and 58). The largest age group was adults aged 50-64 years, with a growing proportion of patients aged 35-49 years and no increase in the group aged 65 years or older in the past year (Figure LI 56).

Alcohol-associated liver disease was again the most common indication for liver transplant overall (ie, for adult and pediatric combined), making up 37.5% of transplants, followed by nonalcoholic steatohepatitis at 18.6% (Figure LI 59). Some proportion of recipients with other/unknown category, the third most common diagnosis (15.2%), may have also had liver disease due to nonalcoholic steatohepatitis. Liver transplants with a primary diagnosis of HCC declined to 10.9%, from 17.8% in 2011 and 16.1% in 2018. The prevalence of HCV also continued to decrease, representing only 4.7% of liver transplant recipients, compared with 22.6% in 2011.

Among the 8,733 adult recipients, 94.4% received livers from deceased donors and 5.6% from living donors (Table LI 8). The recipients were 62.4% male, 70.6% White, 16.5% Hispanic, 6.9% Black, and 4.2% Asian (Table LI 6). For BMI, 21.0% had BMI 30-<35 kg/m^2, and 15.3% had 35 kg/m^2 or greater. Most liver transplants were covered by private insurance (51.8%), followed by Medicare (26.7%) and Medicaid (17.1%). In terms of place of residence, 83.5% of recipients lived in metropolitan areas, compared with 14.8% in non-metropolitan areas; 56.8% lived less than 50 miles from the transplant center, 17.8% within 50-<100 miles, 9.7% within 100-<150 miles, 7.5% within 150-<250 miles, and 7.1% 250 miles or farther.

Alcohol-associated liver disease was the diagnosis for 39.6% of adult liver transplants, compared with 17.5% in 2011 (Table LI 7). This was followed by nonalcoholic steatohepatitis (19.6%), other/unknown (13.8%) and HCC (11.5%). Cholestatic liver disease (8.0%), HCV (5.0%), and acute liver failure (2.5%) were less frequent. The percentage of transplanted recipients with HCC exception points decreased to 15.8% from 25.4% in 2011. The most common recipient blood type was O (45.5%), followed by A (36.4%), B (13.4%), and AB (4.7%).

Most liver transplant recipients waited fewer than 90 days (62.1%), with only 13.5% waiting longer than 1 year (Table LI 8). Overall, waiting times were shorter compared with 2011. The proportion of adults who received DCD livers increased from 4.6% in 2011 to 10.5% in 2021, while the proportion of those who received split livers decreased from 1.1% to 0.8%. The proportion of recipients with a history of previous transplant decreased from 5.7% in 2011 to 3.6% in 2021.

Induction therapy was used in 31.1% of adult liver transplants in 2021, and 71.8% of adult liver transplant recipients received steroid-containing immunosuppressive regimens (Figures LI 61 and 62).

There were 780 simultaneous liver-kidney transplants in 2021 (adult and pediatric), representing 8.4% of liver transplant recipients during the calendar year (Figure LI 60). This proportion has been stable over the past several years and decreased from a peak of 9.4% in 2016, just prior to the introduction of standardized medical eligibility criteria for simultaneous liver-kidney transplant in 2017.

1.5 Outcomes

Among adult liver transplants performed in 2020, the most recent year for which at least 1 full year of follow-up was available, graft failure occurred in 7.0% of deceased donor liver transplant recipients at 6 months and 9.2% at 1 year, an increase compared with the previous year and reversal of a previous trend of improving short-term outcomes (Figure LI 63). This observation coincided with the onset of the COVID-19 pandemic in early 2020 among other trends. Longer-term graft outcomes for recipients of deceased donor liver transplant in 2018, 2016, and 2011 were similar to previous years, with a graft failure frequency of 15.0% at 3 years for transplants in 2018, 20.7% at 5 years for transplants in 2016, and 38.5% at 10 years for transplants in 2011.

Overall survival for adult liver transplant recipients followed a similar pattern to graft failure (ie, a detectable increase in short-term mortality but similar longer-term survival), with 5.7% mortality at 6 months, 7.8% at 1 year, 13.3% at 3 years, 18.6% at 5 years, and 35.9% at 10 years (Figure LI 65).

Outcomes were similar, if not better, for adult living donor liver transplant recipients, with graft failure occurring in 6.1% at 6 months, 8.7% at 1 year, 14.2% at 3 years, 19.4% at 5 years, and 42.0% at 10 years (Figure LI 64). Graft outcomes, however, were inferior compared with previous years.

Five-year graft survival rates among deceased donor liver transplant recipients who underwent transplant during 2014-2016 exceeded 75% across all categories and surpassed 80% among those aged 35-49 years (81.6%), those with cholestatic liver disease (80.9%), and those with a MELD score of 15-24 at transplant (80.8%) (Figures LI 66, 67, and 68). The 5-year graft survival rate among recipients of DCD livers was 75.9%, compared with 79.2% for recipients of DBD livers (Figure LI 69). Five-year graft outcomes were equivalent between those with and without HCC exception points (Figure LI 70). Patient survival after deceased donor liver transplant largely mirrored that of graft survival, exceeding 80% except for those aged 65 years or older (77.4%) and those with acute liver failure (79.2%), HCC (79.4%), nonalcoholic steatohepatitis (79.7%), and a MELD score of 35-39 (79.6%) or 40 or greater (76.8%) (Figures LI 81, 82, and 83). Survival was similar between metropolitan and non-metropolitan residents (Figure LI 84).

Five-year graft survival among living donor liver transplant recipients was higher among patients with a MELD score 14 or lower (81.5%), compared with MELD 15-24 (79.9%) and 25-34 (69.0%) (Figure LI 76). In terms of patient survival, however, 5-year outcomes were similar between those with a MELD score 14 or lower and those with a MELD score 15-24 (85.6% vs 85.1%) and lower for those with a MELD score 25-34 (75.9%) (Figure LI 88). Five-year graft and patient survival were highest for living donor recipients with cholestatic liver disease and nonalcoholic steatohepatitis, and lowest for those with HCC (Figures LI 75 and 86).

2 PEDIATRIC LIVER TRANSPLANTATION IN THE UNITED STATES

2.1 Summary

In 2021, 36 children died on the waiting list or were removed for being too sick to undergo transplant. While living donor recipients have better long-term graft and patient survival compared with deceased donor recipients, the proportion of children undergoing living donor transplant (15.4%) has not changed significantly in the past decade, nor has the

use of split liver grafts (16.6%). With 83.4% of pediatric liver transplants using whole or partial liver grafts, candidates younger than 1 year continued to have the highest pretransplant mortality rates, which has also not changed over the past decade. Pediatric liver transplant candidates were prioritized for pediatric donors as part of the acuity circles policy implemented in February 2020. This policy allowed offers to be prioritized for children nationally before being offered to adults within a 500–nautical mile acuity circle. Since this policy change, pediatric waitlist mortality in 2020 and 2021 decreased to its lowest rate since 2011. (Simultaneously, in 2020 and 2021, adult waitlist pretransplant mortality rates remained stable despite this policy change.) While long-term patient survival continues to improve, 12% of pediatric liver transplant recipients who underwent transplant in 2011 did not survive to 2021. In 2021, the pretransplant mortality rate for Black children improved to its lowest value since 2014, although this metric does not capture the barriers to transplant evaluation and listing for non-White children. In addition, use of exception narratives, access to living donor transplant, and graft and patient survival data were not further stratified by race. Addressing racial disparities in pediatric liver transplantation is critical to ensuring equitable access and outcomes for all children requiring liver transplant.

2.2 Waiting List

In 2021, 666 new registrants were added to the pediatric liver transplant waiting list (Figure LI 90, Table LI 12). Registrants aged 1-5 years (32.9%) and 12-17 years (22%) in the year 2021 made up the largest age groups, followed by younger than 1 year (19%), 6-11 years (18.1%), and 18 years or older (8.1%) (Figure LI 92). In terms of race and ethnicity, White registrants continued to make up the largest group on the waiting list in 2021 (48.3%), followed by Hispanic (24.5%), Black (17.1%), and Asian registrants (6.5%) (Figure LI 92). For pediatric liver waitlist registrants, from 2011 to 2021, age, sex, race, diagnosis, and geographic distributions did not change substantially (Tables LI 9 and 10). Waiting time has improved in the past decade. In 2021, 29.2% of candidates waited fewer than 90 days, 24.4% waited 3-12 months, 12.7% waited 1-2 years, and 33.7% waited 2 or more years until transplant (Table LI 11).

Pretransplant mortality remained steady at a rate of 5.6 deaths per 100 patient-years in 2021, with the highest mortality rate remaining for candidates younger than 1 year at a rate of 21.7 deaths per 100 patient-years (Figures LI 100 and 101). In 2021, more registrants died on the waiting list (n=20, 3.0%) compared with 2020 (n=17, 2.5%), 12.7% were removed because their condition improved, and 2.4% were considered too sick for transplant. In total in 2021, 36 children died on the waiting list or were removed for being too sick for transplant (Table LI 13). Pretransplant mortality rates were highest in Hispanic registrants (Figure LI 102).

2.3 Transplants

In 2021, 501 pediatric liver transplants were performed in the United States compared with 502 in 2020 and 551 in 2019. The number of annual liver transplants in 2020 and 2021 remained the lowest of the past decade (Figure LI 104), perhaps partially attributable to the COVID-19 pandemic. The overall number of pediatric transplants increased for 1- to 5-year-olds and decreased for 12- to 17-year-olds, reversing the previous year's trend (Figure LI 106). Recipient demographic information, including age at the time of transplant, race or ethnicity, insurance type, and geography, has remained similar over the past decade (Table LI 14). Biliary atresia remains the leading indication for transplant (40.9%) followed by other/unknown diagnosis (22%), metabolic (13%), acute liver failure (10.8%), other cholestatic condition (7%), and hepatoblastoma (6.4%), which remains relatively unchanged over the past decade (Table LI 15). In 2021, no patients received a DCD graft (Table LI 16).

Over the past decade, there has been no significant change in living donor transplants, which accounted for 15.4% of total transplants in 2021 (Figure LI 105). There has additionally been no increase in the use of technical variant grafts over the past decade, and in 2021 61.1% were whole liver, 22.4% were partial liver, and 16.6% were split liver transplants (Figure LI 107, Table LI 16). The plurality of recipients (42%) underwent transplant at a MELD/PELD score of 25 or greater, of which 9.6% underwent transplant at a MELD/PELD score of 40 or greater. The number of recipients who underwent transplant at status 1B (16.8%) or 1A (14.2%) has not changed significantly over the past decade (Table LI 15).

In 2021, 62.3% of pediatric liver transplant recipients received no induction therapy (Figure LI 108). The most common initial immunosuppression regimens were tacrolimus and steroids (39.9%) followed by tacrolimus, mycophenolate agent, and steroids (34.7%) (Figure LI 109).

2.4 Outcomes

Within 1 year of transplant, 19%-24% of transplant recipients had at least one episode of rejection, with the highest incidence in recipients younger than 1 year (Figure LI 116). By 5 years posttransplant, 3.7% of recipients developed posttransplant lymphoproliferative disorder (Figure LI 117).

Graft failure occurred in 5.9% of deceased donor recipients at 6 months, 6.9% at 1 year, 11.4% at 3 years, 15.3% at 5 years, and 21.0% at 10 years from transplant (Figure LI 110). Fewer living donor recipients developed graft failure, occurring in 3.0% at 6 months, 6.1% at 1 year, 9.7% at 3 years, 8.1% at 5 years, and 10.2% at 10 years from transplant (Figure LI 111), compared with deceased donor recipients. Five-year graft survival was highest for deceased donor recipients who were aged 6-11 years at the time of transplant (91.7%) followed by 12-17 years (85.0%), younger than 1 year (83.9%), and 1-5 years (82.3%) (Figure LI 112). By diagnosis, 5-year graft survival was highest for deceased donor recipients with metabolic conditions (90.6%), followed by biliary atresia (89.3%), acute liver failure (82.4%), other/unknown (80.2%), hepatoblastoma (78.2%), and other cholestatic conditions (77.6%) (Figure LI 113). Deceased donor recipients who underwent transplant at a MELD/PELD score of 35-39 had the lowest 5-year graft survival at 70.3% (Figure LI 114). At all time points, living donor recipients had better graft survival compared with deceased donor recipients, with a 5-year graft survival of 91.2% compared with 84.8%, respectively (Figure LI 115).

Recipient mortality remains notable with death occurring in 5.2% of deceased and living donor recipients at 6 months, 6.4% at 1 year, 6.9% at 3 years, 10.1% at 5 years, and 11.9% at 10 years from transplant. Since 2018, deaths at 6 months and 1 year posttransplant are now increasing (Figure LI 118). Five-year patient survival was highest for recipients who were aged 6-11 years at the time of transplant (92.8%), followed by younger than 1 year (91.4%), 12-17 years (88.8%), and 1-5 years (87.8%), for deceased donor recipients (Figure LI 120). By diagnosis, 5-year patient survival was highest for deceased donor recipients with biliary atresia (94.8%), followed by metabolic conditions (94.1%), acute liver failure (89.4%), other/unknown (85.5%), hepatoblastoma (82.3%), and other cholestatic (80.6%) (Figure LI 121). At all time points, living donor recipients had better patient survival compared with deceased donor recipients, with a 5-year patient survival of 95.3% compared with 89.7%, respectively (Figure LI 122).

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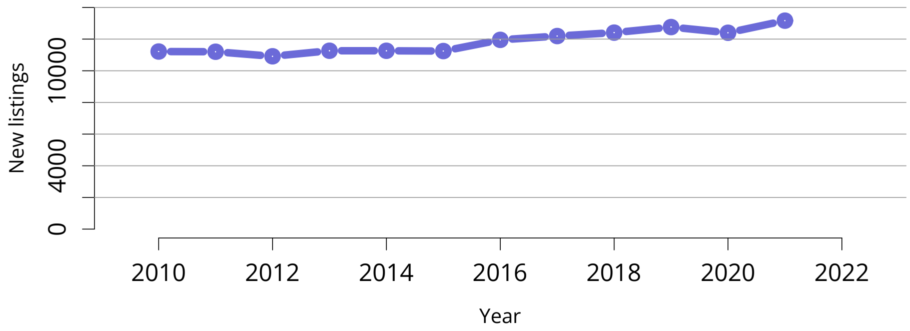

OPTN/SRTR 2021 Annual Data Report

Figure LI 1: New adult candidates added to the liver transplant waiting list. A new candidate is one who first joined the list during the given year, without having been listed in a previous year. Previously listed candidates who underwent transplant and subsequently relisted are considered new. Active and inactive patients are included.

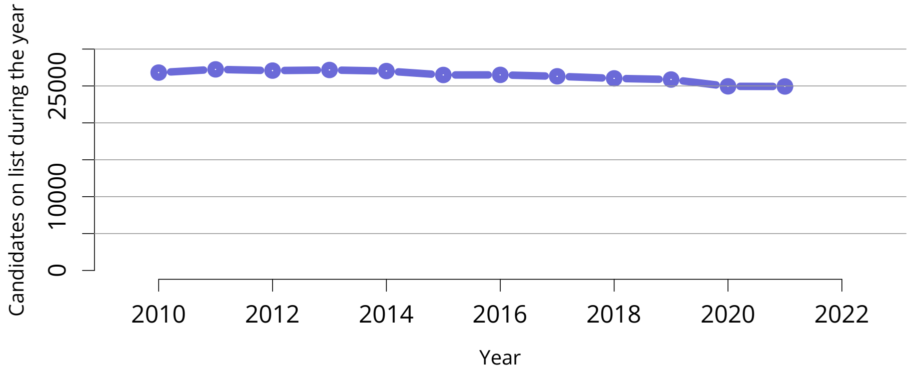

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Figure LI 2: All adult candidates on the liver transplant waiting list. Adult candidates on the list at any time during the year. Candidates listed at more than one center are counted once per listing.

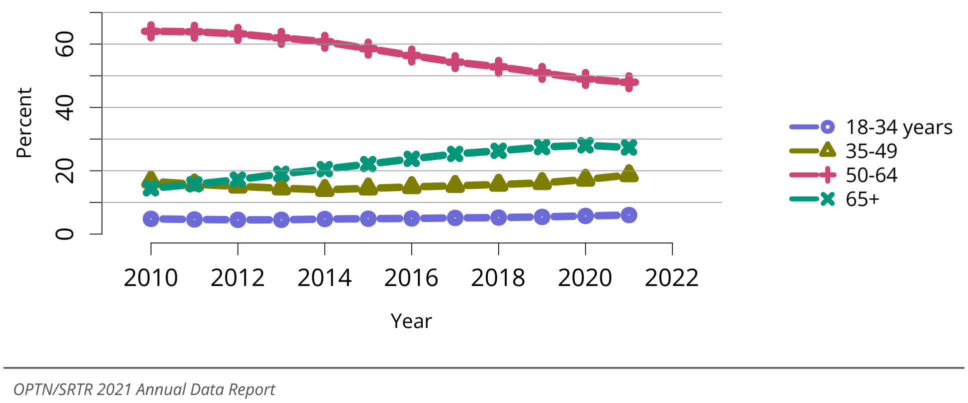


Figure LI 3: Distribution of adults waiting for liver transplant by age. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive candidates are included. Age is determined at the earliest of transplant, death, removal, or December 31 of the year.

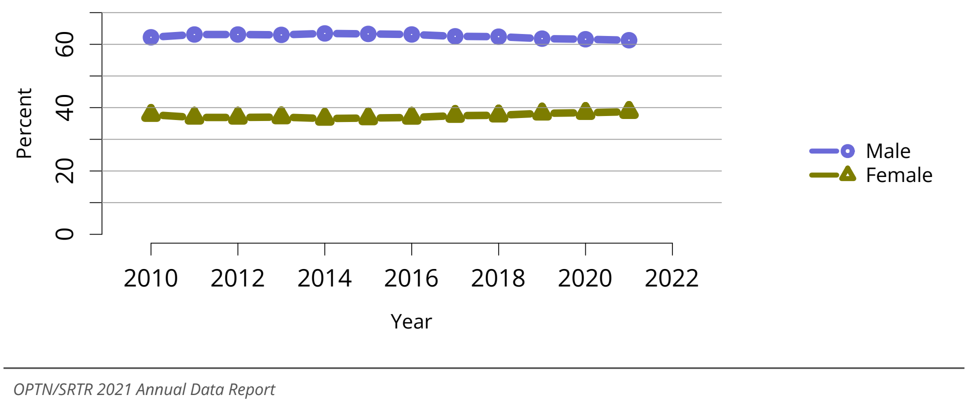
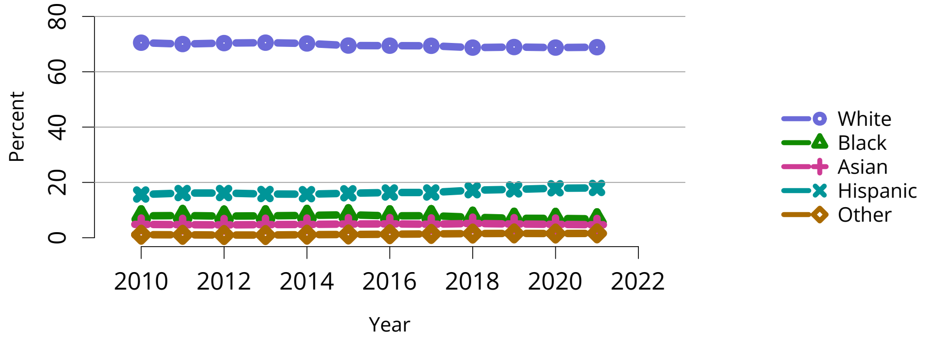
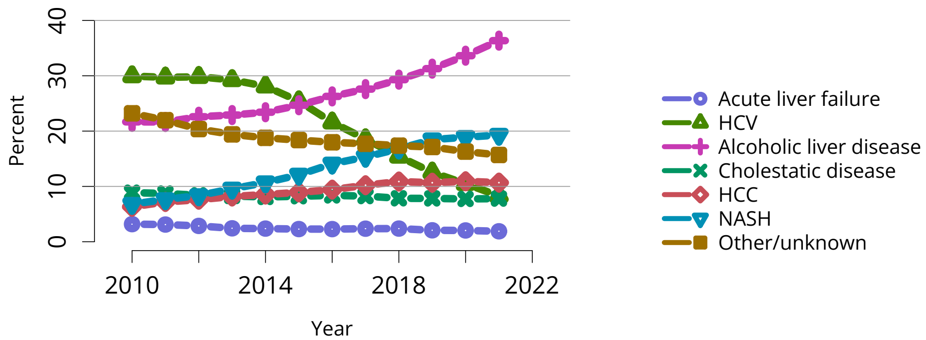


Figure LI 4: Distribution of adults waiting for liver transplant by sex. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.



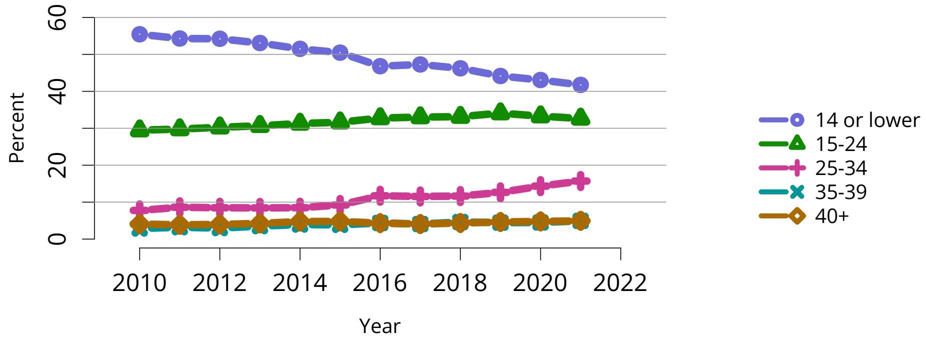
OPTN/SRTR 2021 Annual Data Report

Figure LI 5: Distribution of adults waiting for liver transplant by race. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.



OPTN/SRTR 2021 Annual Data Report

Figure LI 6: Distribution of adults waiting for liver transplant by diagnosis. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included. HCC, hepatocellular carcinoma; HCV, hepatitis C virus; NASH, nonalcoholic steatohepatitis.



OPTN/SRTR 2021 Annual Data Report

Figure LI 7: Distribution of adults waiting for liver transplant by last laboratory MELD score in the year. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

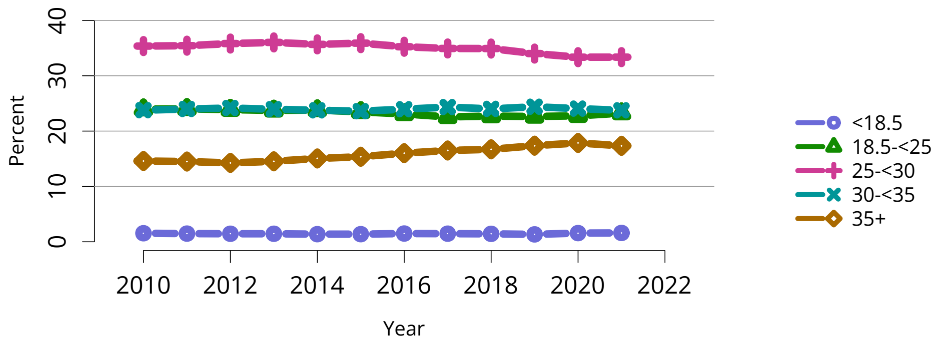


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Figure LI 8: Distribution of adults waiting for liver transplant by BMI. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

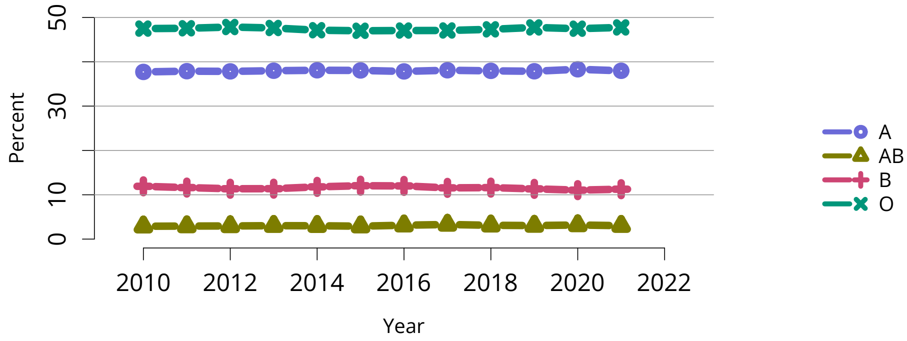

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Figure LI 9: Distribution of adults waiting for liver transplant by blood type. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

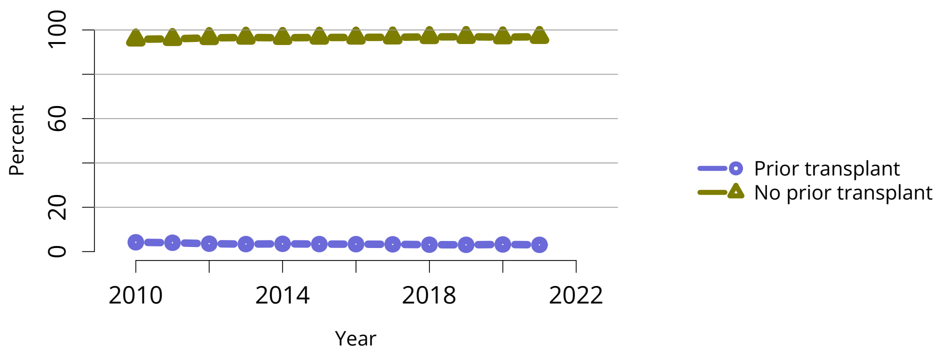

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Figure LI 10: Distribution of adults waiting for liver transplant by prior transplant status. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

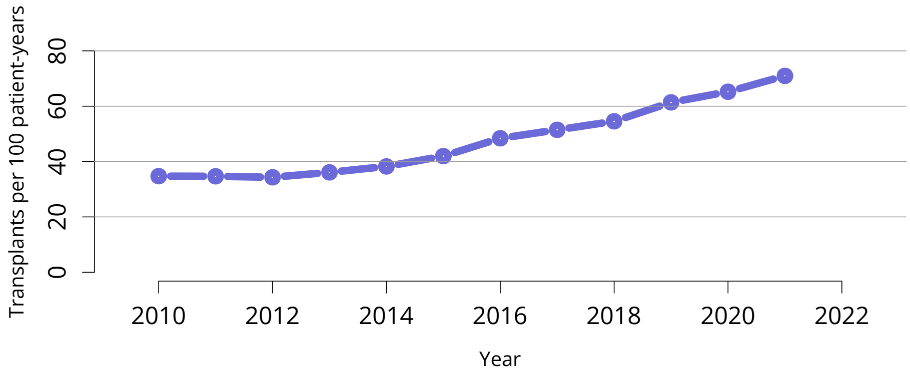

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Figure LI 11: Overall deceased donor liver transplant rates among adult waitlist candidates. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

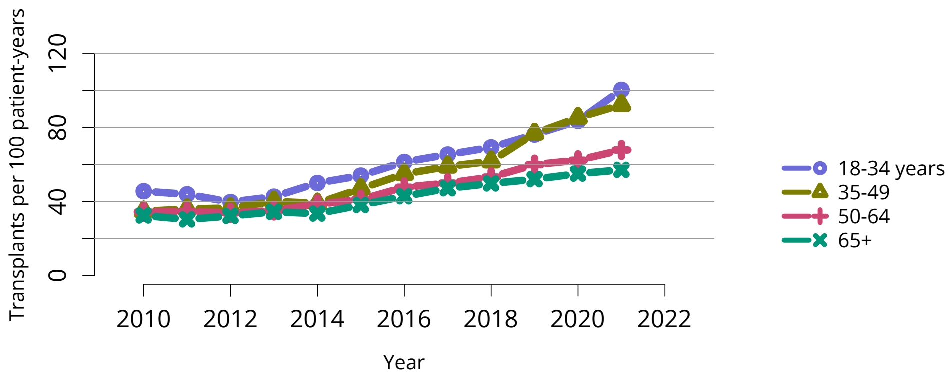

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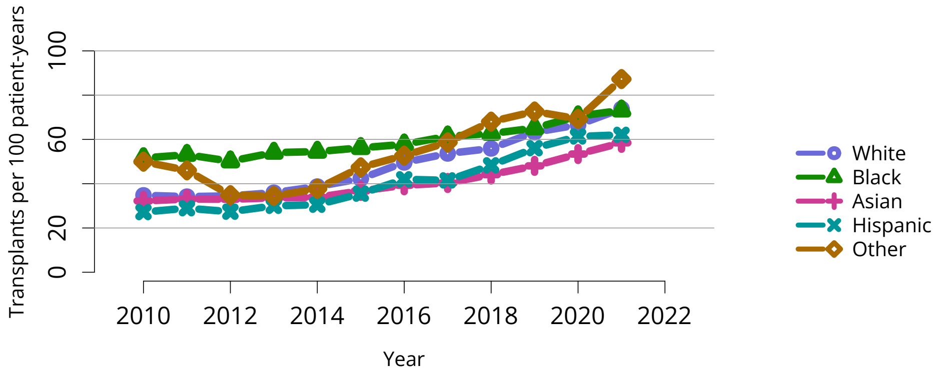
Figure LI 12: Deceased donor liver transplant rates among adult waitlist candidates by age. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.



OPTN/SRTR 2021 Annual Data Report

Figure LI 13: Deceased donor liver transplant rates among adult waitlist candidates by race. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

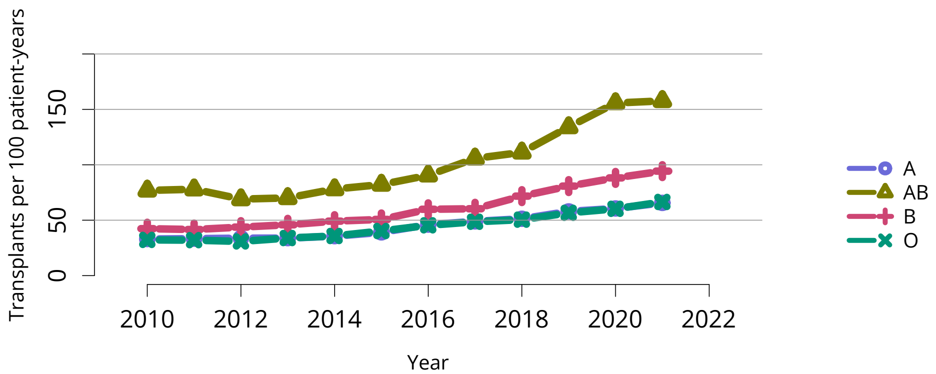


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Figure LI 14: Deceased donor liver transplant rates among adult waitlist candidates by blood type. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

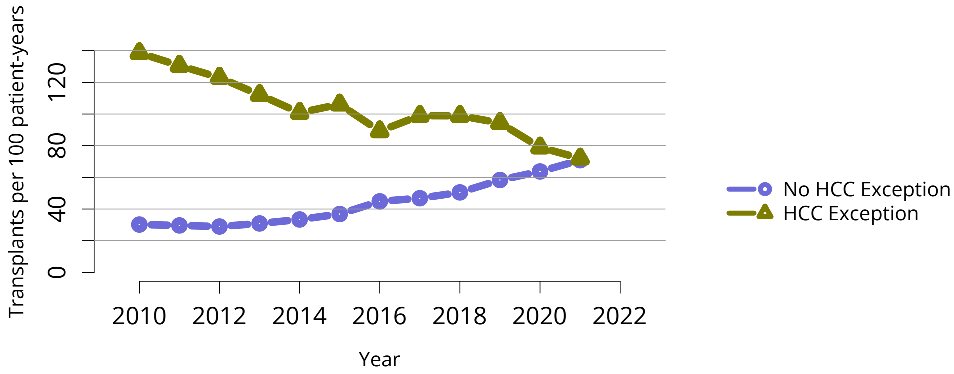

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Figure LI 15: Deceased donor liver transplant rates among adult waitlist candidates by HCC exception status. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately. HCC is determined at the later of listing date and January 1 of the year. HCC, hepatocellular carcinoma.

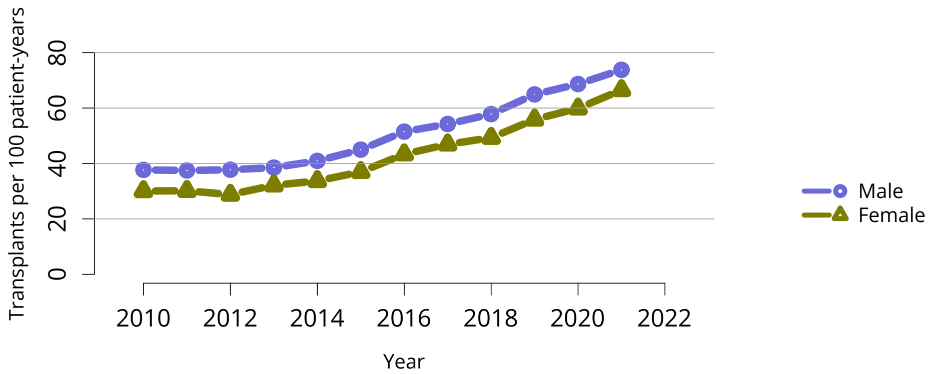

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Figure LI 16: Deceased donor liver transplant rates among adult waitlist candidates by sex. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

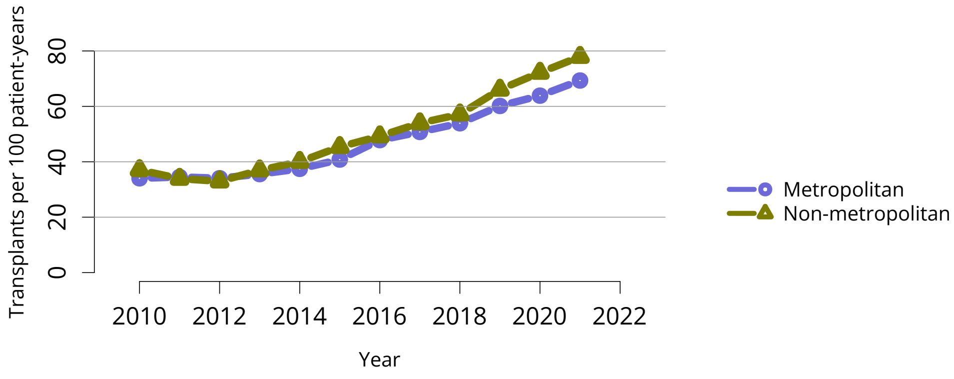

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Figure LI 17: Deceased donor liver transplant rates among adult waitlist candidates by metropolitan vs. non-metropolitan residence. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately. Urban/rural determination is made using the RUCA (rural-urban commuting area) designation of the candidate's permanent zip code.

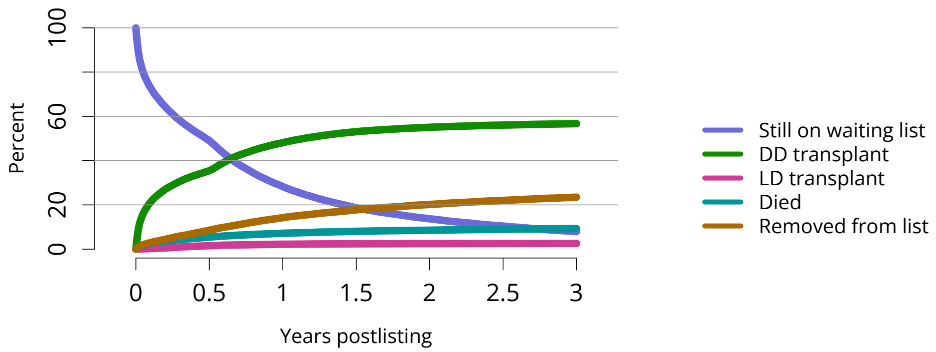

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Figure LI 18: Three-year outcomes for adults waiting for liver transplant, new listings in 2016-2018. Candidates listed at more than one center are counted once per listing. Removed from list includes all reasons except transplant and death. DD, deceased donor; LD, living donor.

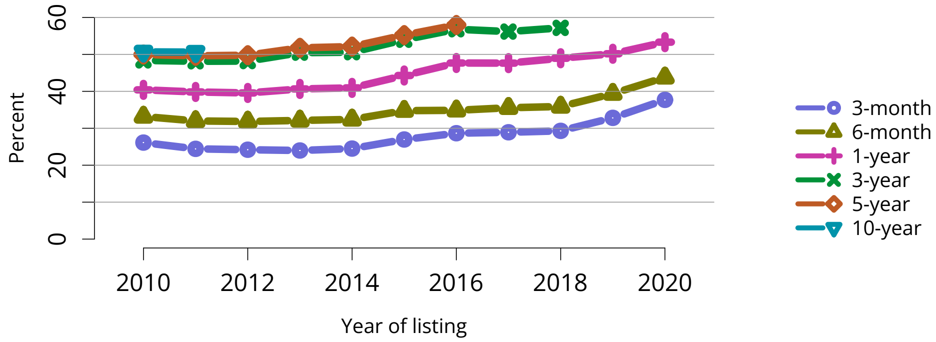

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Figure LI 19: Percentage of adults who underwent deceased donor liver transplant within a given period of listing. Candidates listed at more than one center are counted once per listing.

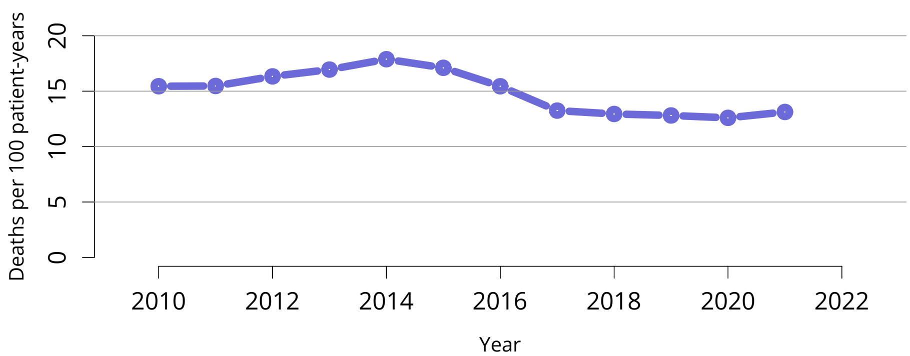

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Figure LI 20: Overall pretransplant mortality rates among adults waitlisted for liver transplant. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

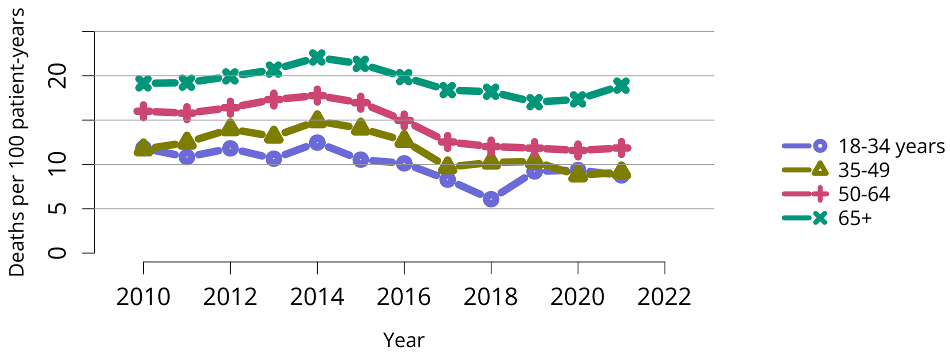

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Figure LI 21: Pretransplant mortality rates among adults waitlisted for liver transplant by age. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.

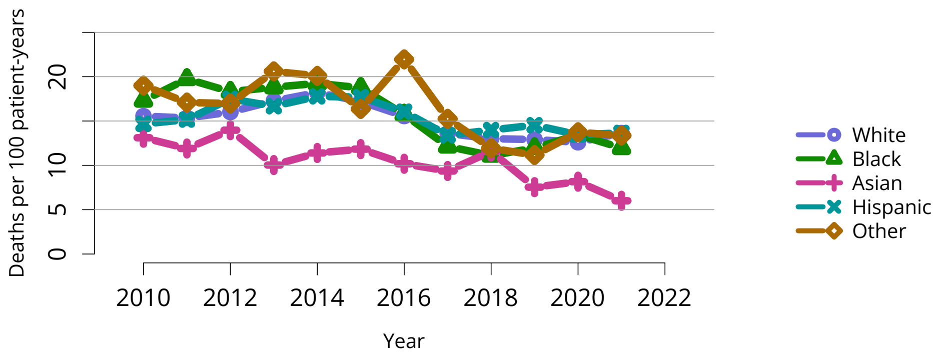

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Figure LI 22: Pretransplant mortality rates among adults waitlisted for liver transplant by race. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

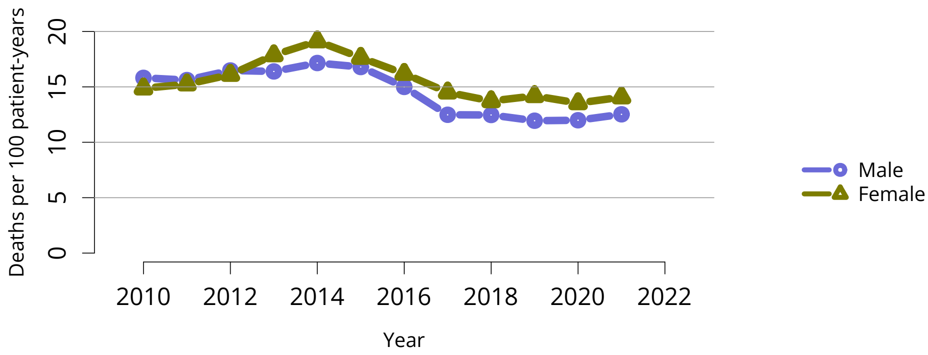

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Figure LI 23: Pretransplant mortality rates among adults waitlisted for liver transplant by sex. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

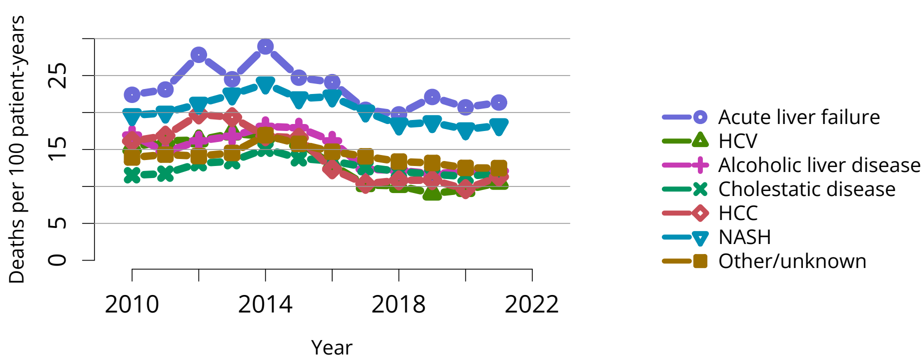

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Figure LI 24: Pretransplant mortality rates among adults waitlisted for liver transplant by diagnosis. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. HCC, hepatocellular carcinoma; HCV, hepatitis C virus; NASH, nonalcoholic steatohepatitis.

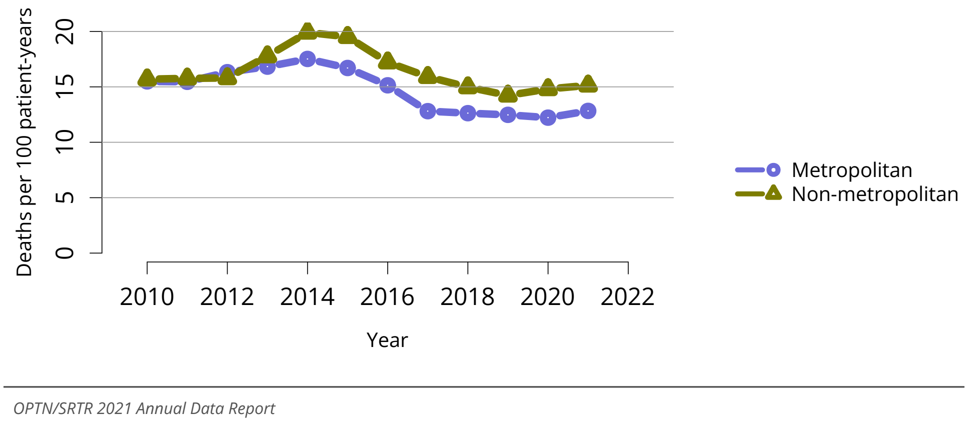

Figure LI 25: Pretransplant mortality rates among adults waitlisted for liver transplant by metropolitan vs. non-metropolitan residence. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Urban/rural determination is made using the RUCA (rural-urban commuting area) designation of the candidate's permanent zip code.

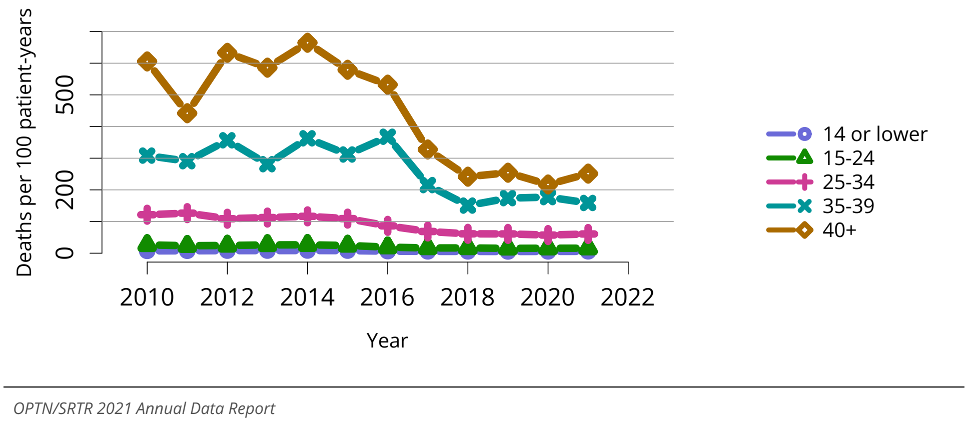

Figure LI 26: Pretransplant mortality rates among adults waitlisted for liver transplant by first laboratory MELD score in the year. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Medical urgency is determined at the later of listing date and January 1 of the year.

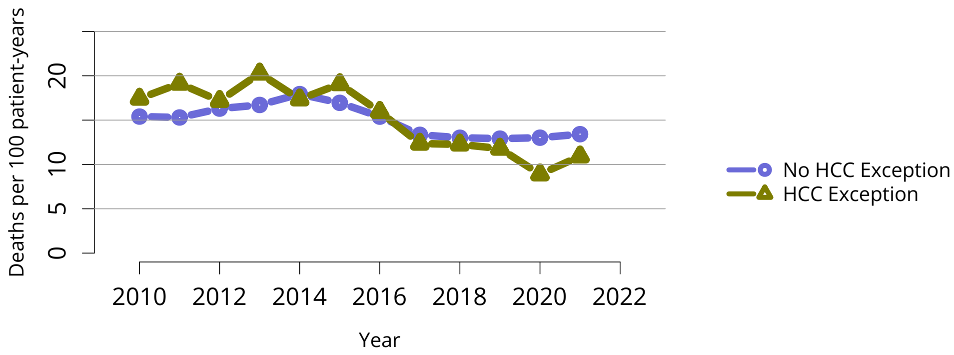

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Figure LI 27: Pretransplant mortality rates among adults waitlisted for liver by HCC exception status. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. HCC is determined at the later of listing date and January 1 of the year. HCC, hepatocellular carcinoma.

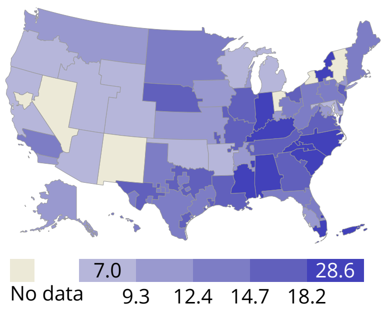

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Figure LI 28: Pretransplant mortality rates among adults waitlisted for liver transplant in 2021 by DSA. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

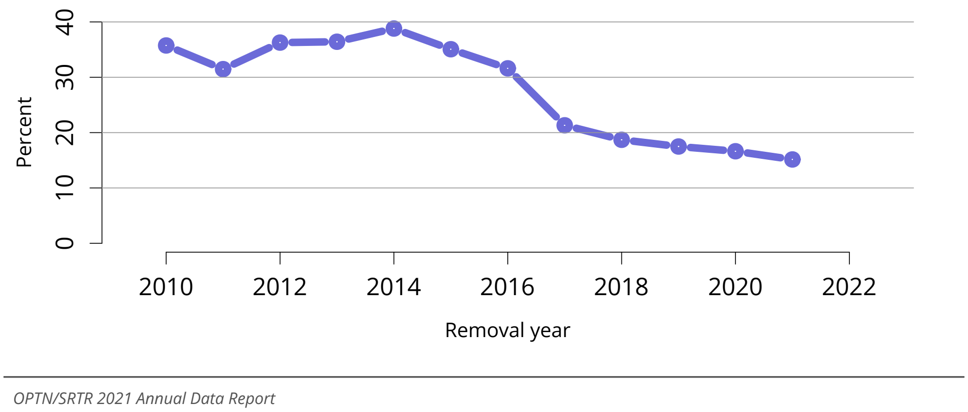

Figure LI 29: Deaths within six months after removal among adult liver waitlist candidates, overall. Denominator includes only candidates removed from the waiting list for reasons other than transplant or death while on the list.

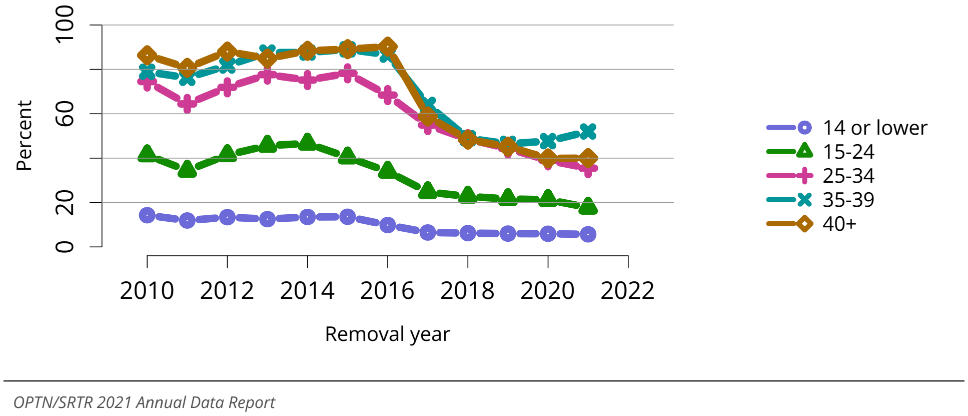

Figure LI 30: Deaths within six months after removal among adult liver waitlist candidates, by laboratory MELD score at removal. Denominator includes only candidates removed from the waiting list for reasons other than transplant or death while on the list.

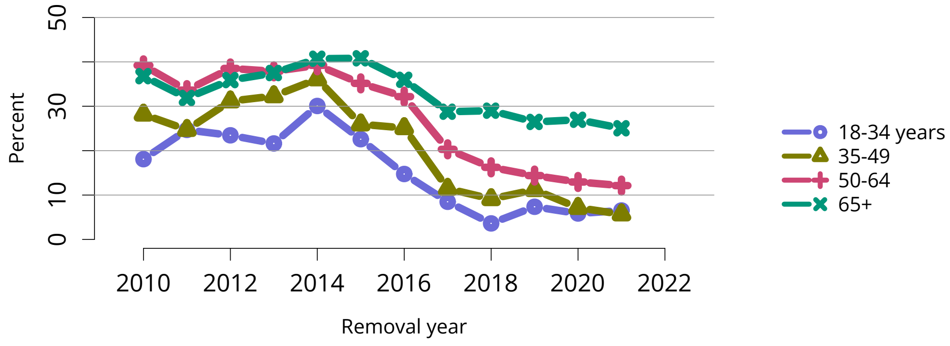

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Figure LI 31: Deaths within six months after removal among adult liver waitlist candidates, by age. Denominator includes only candidates removed from the waiting list for reasons other than transplant or death while on the list. Age is determined at removal.

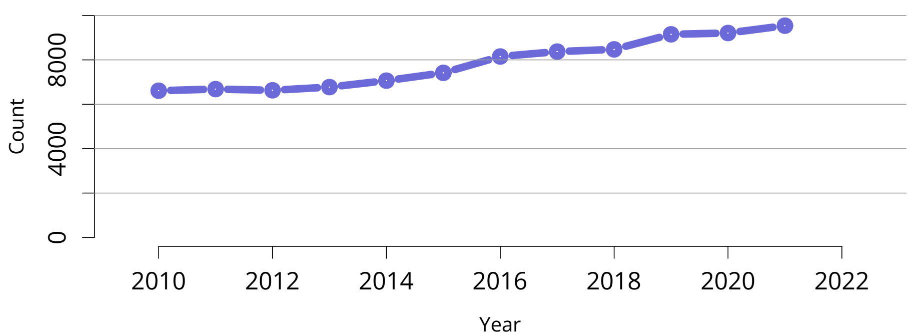

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Figure LI 32: Overall deceased liver donor count. Count of deceased donors whose livers were recovered for transplant.

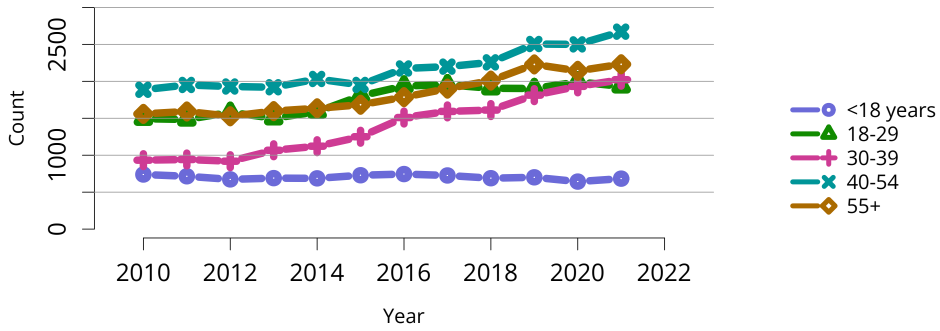

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Figure LI 33: Deceased liver donor count by age. Count of deceased donors whose livers were recovered for transplant.

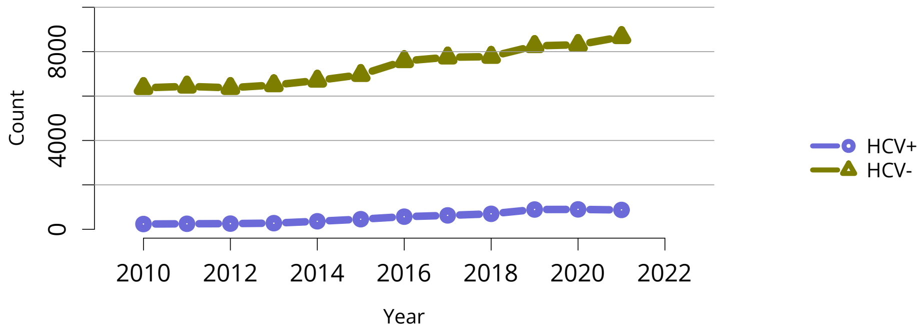

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Figure LI 34: Deceased liver donor count by HCV status. Count of deceased donors whose livers were recovered for transplant. Donor HCV status was based on an antibody test. HCV, hepatitis C virus.

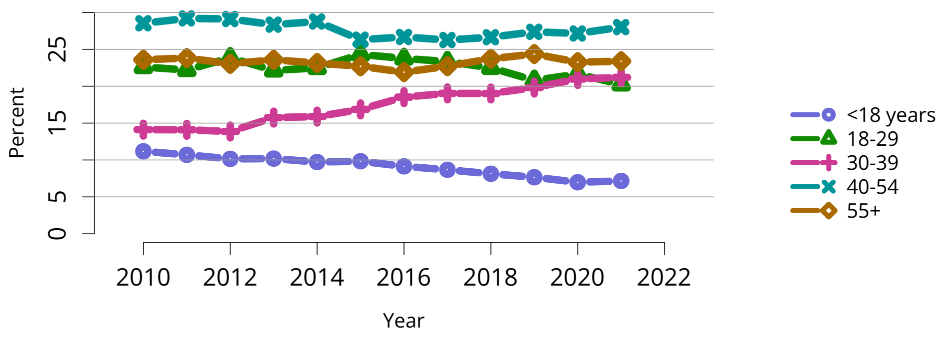

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Figure LI 35: Distribution of deceased liver donors by age. Deceased donors whose livers were recovered for transplant.

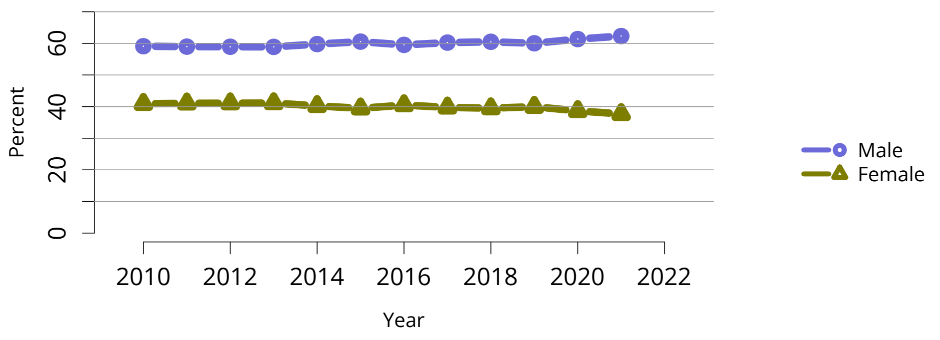

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Figure LI 36: Distribution of deceased liver donors by sex. Deceased donors whose livers were recovered for transplant.

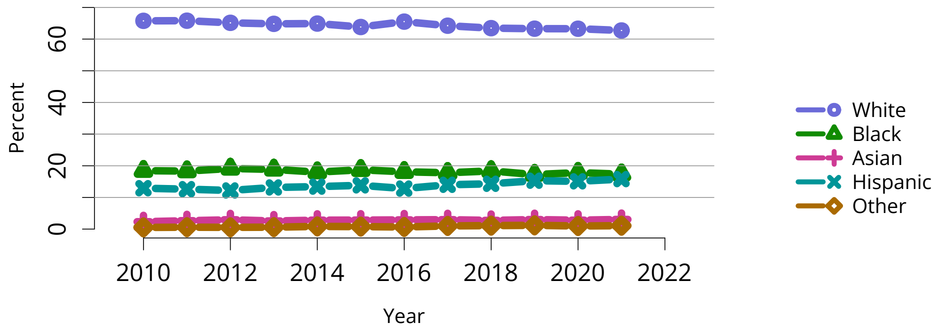

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Figure LI 37: Distribution of deceased liver donors by race. Deceased donors whose livers were recovered for transplant.

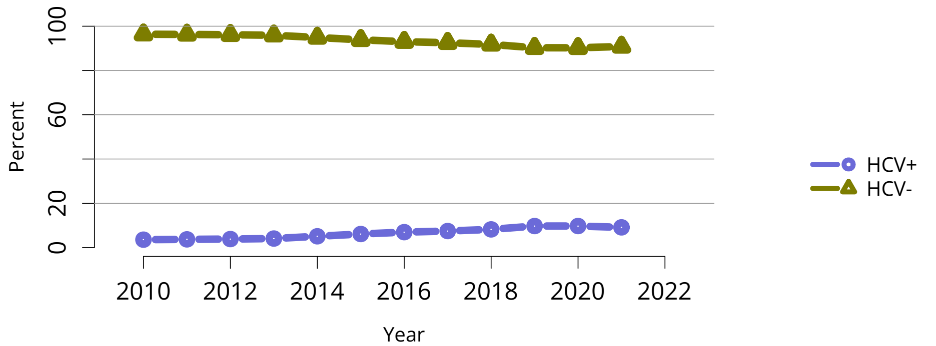

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Figure LI 38: Distribution of deceased liver donors by donor HCV status. Deceased donors whose livers were recovered for transplant. Donor HCV status was based on an antibody test. HCV, hepatitis C virus.

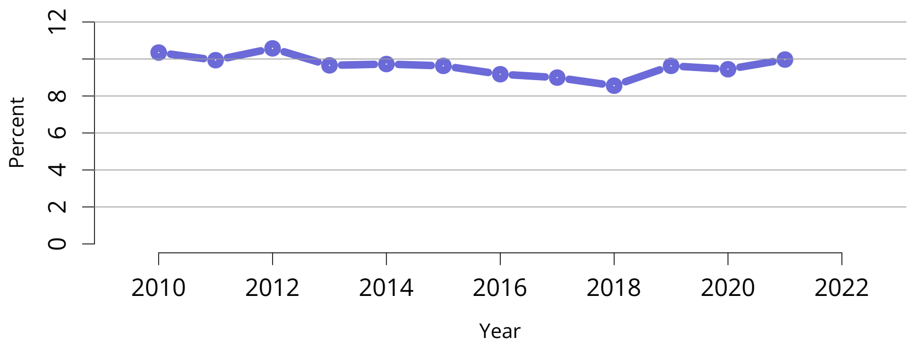

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Figure LI 39: Overall percent of livers recovered for transplant and not transplanted. Percentages of livers not transplanted out of all livers recovered for transplant.

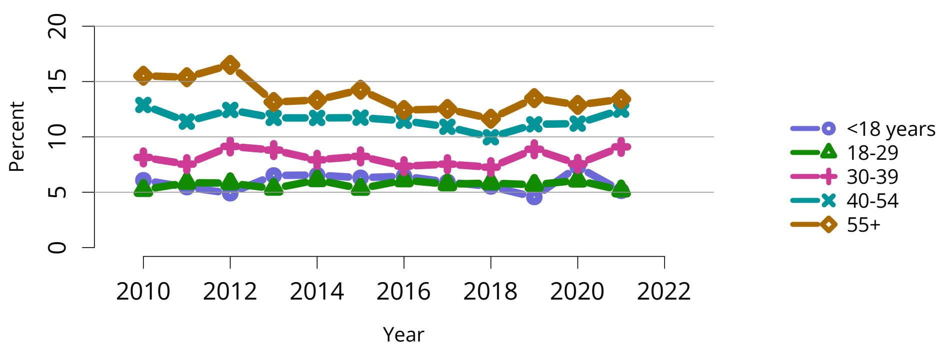

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Figure LI 40: Percent of livers recovered for transplant and not transplanted by donor age. Percentages of livers not transplanted out of all livers recovered for transplant.

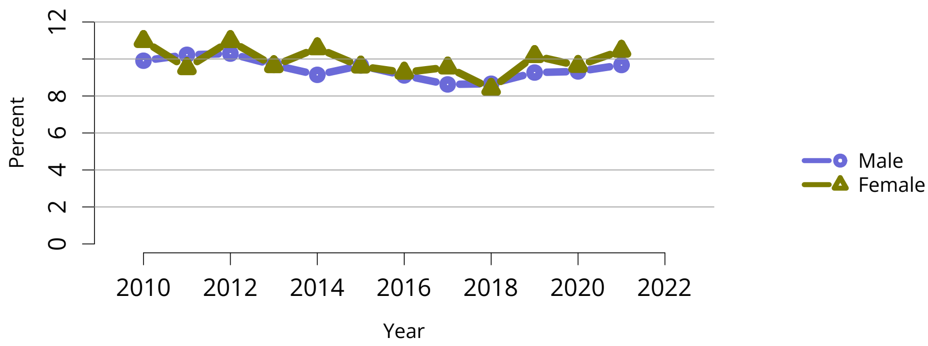

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Figure LI 41: Percent of livers recovered for transplant and not transplanted by donor sex. Percentages of livers not transplanted out of all livers recovered for transplant.

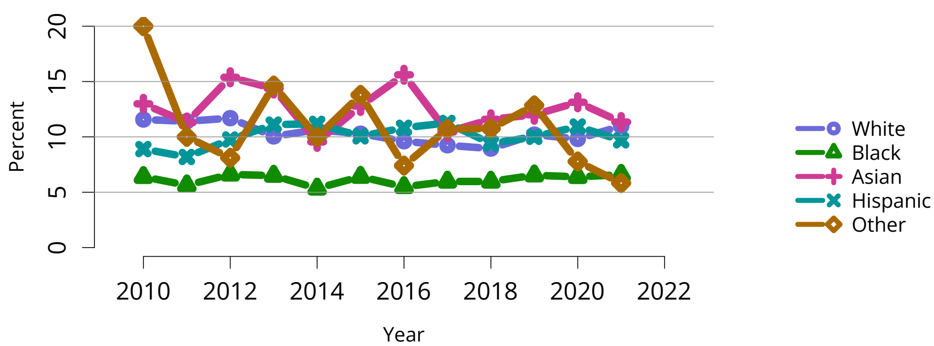

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Figure LI 42: Percent of livers recovered for transplant and not transplanted by donor race. Percentages of livers not transplanted out of all livers recovered for transplant.

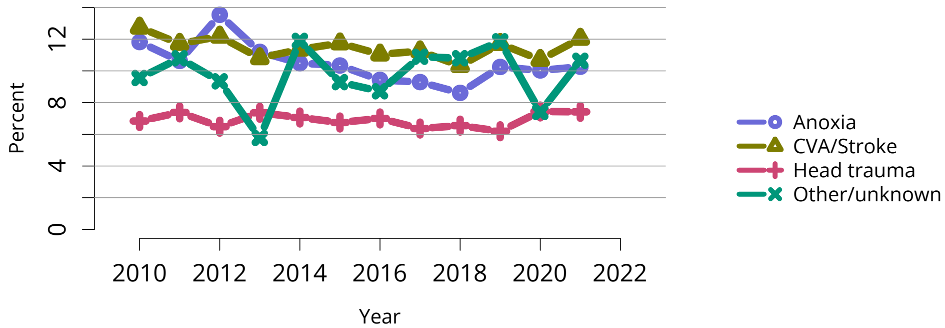

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Figure LI 43: Percent of livers recovered for transplant and not transplanted by donor cause of death. Percentages of livers not transplanted out of all livers recovered for transplant. CVA, cerebrovascular accident.

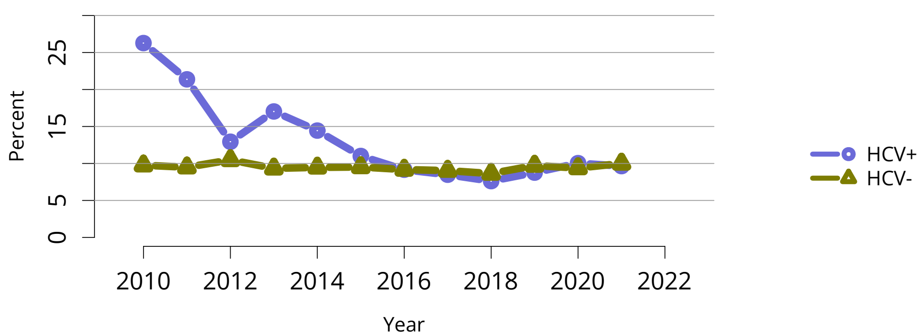

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Figure LI 44: Percent of livers recovered for transplant and not transplanted by donor HCV status. Percentages of livers not transplanted out of all livers recovered for transplant. Donor HCV status was based on an antibody test. HCV, hepatitis C virus.

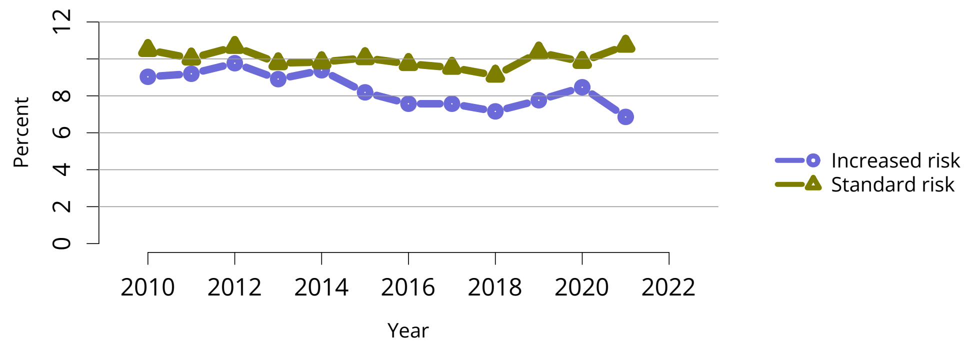

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Figure LI 45: Percent of livers recovered for transplant and not transplanted, by donor risk of disease transmission. Percentages of livers not transplanted out of all livers recovered for transplant. "Increased risk" is defined by criteria from the US Public Health Service Guidelines for increased risk for HIV, hepatitis B, and hepatitis C transmission.

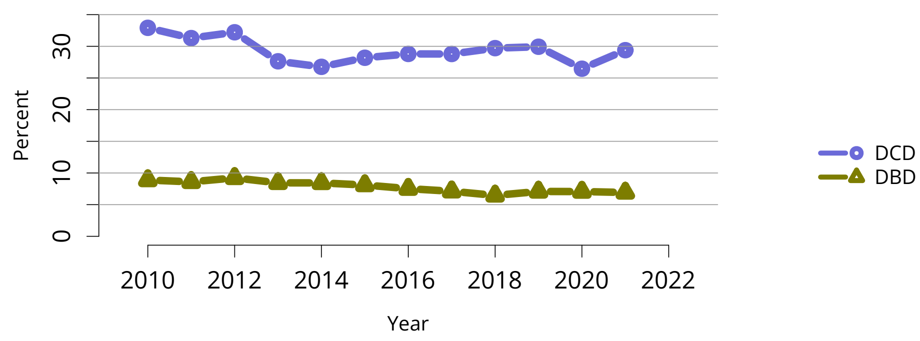

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Figure LI 46: Percent of livers recovered for transplant and not transplanted by DCD status. Percentages of livers not transplanted out of all livers recovered for transplant. DBD, donation after brain death; DCD, donation after circulatory death.

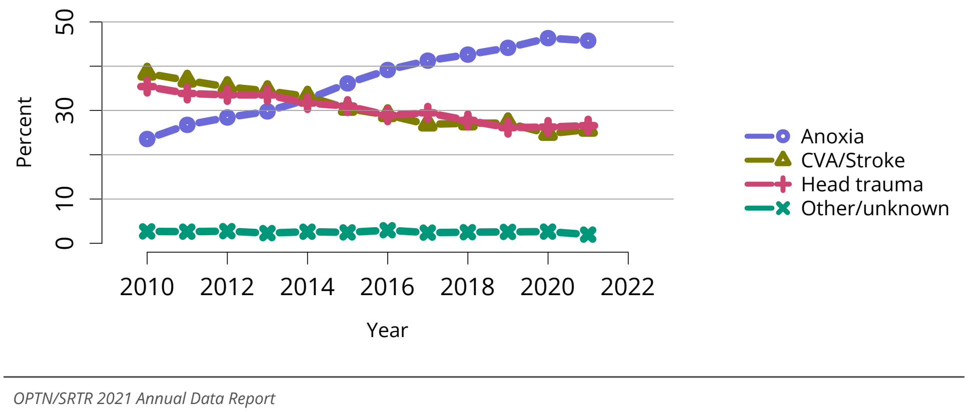

Figure LI 47: Cause of death among deceased liver donors. Deceased donors with a liver recovered for the purposes of transplant. CVA, cerebrovascular accident.

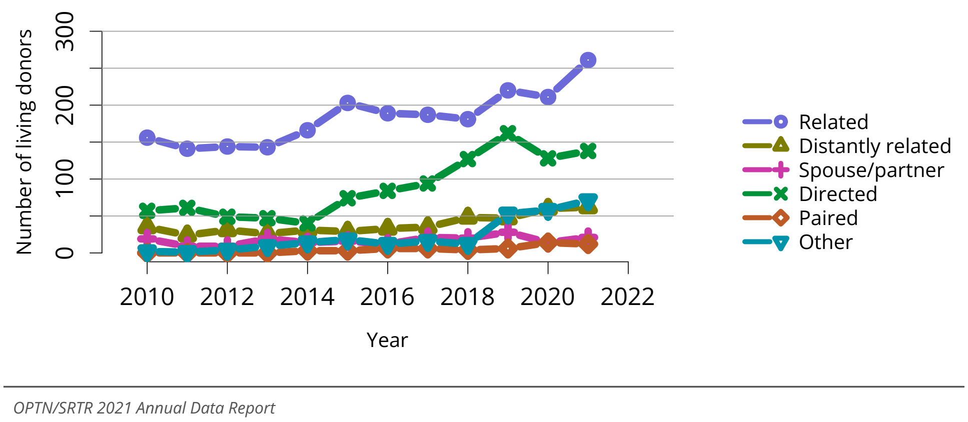

Figure LI 48: Number of living liver transplants by donor relation. Numbers of living donor donations, excluding domino livers, as reported on the OPTN Living Donor Registration Form.

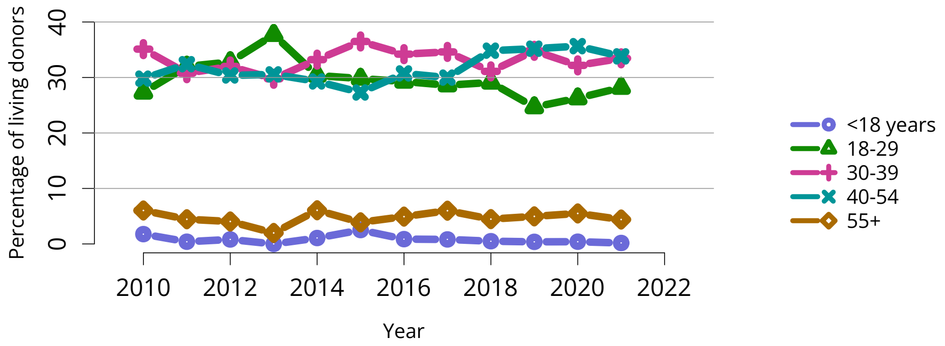

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Figure LI 49: Living liver donors by age. As reported on the OPTN Living Donor Registration Form. Domino liver donors excluded.

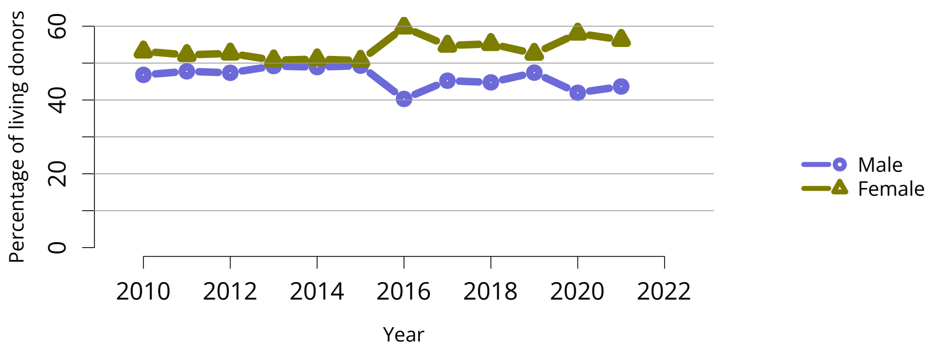

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Figure LI 50: Living liver donors by sex. As reported on the OPTN Living Donor Registration Form. Domino liver donors excluded.

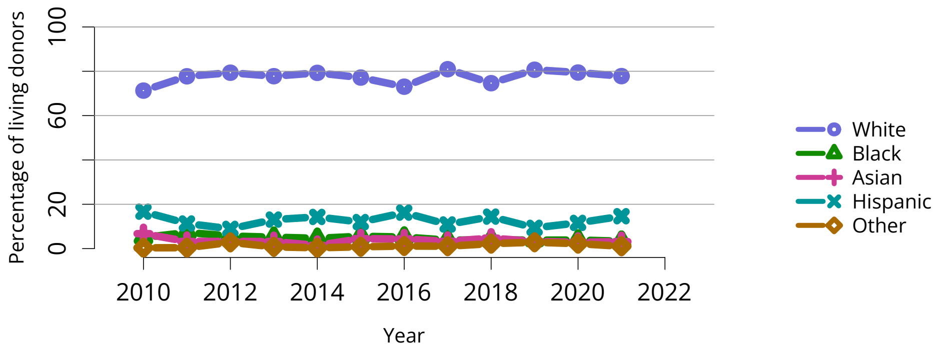

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Figure LI 51: Living liver donors by race. As reported on the OPTN Living Donor Registration Form. Domino liver donors excluded.

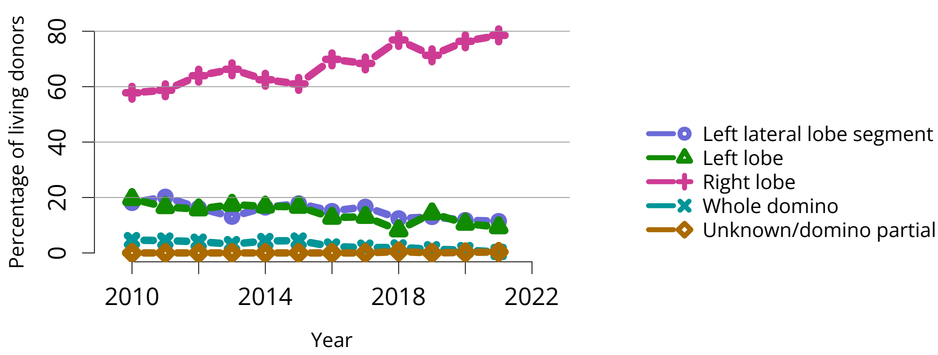

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Figure LI 52: Living donor liver transplant graft type. As reported on the OPTN Living Donor Registration Form.

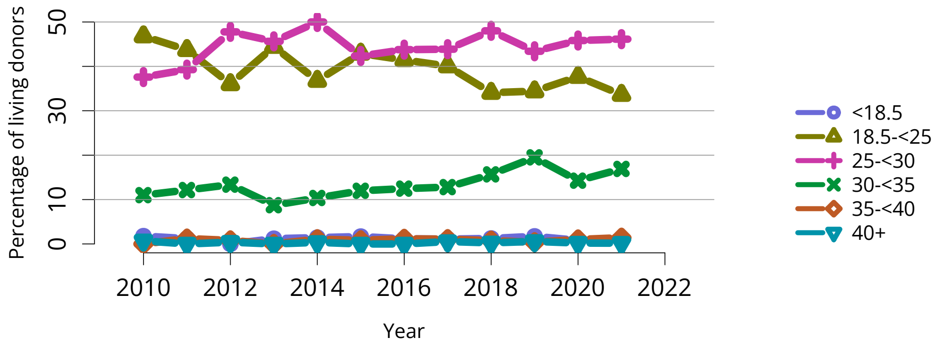

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Figure LI 53: BMI among living liver donors. Donor height and weight reported on the OPTN Living Donor Registration Form. Domino liver donors excluded.

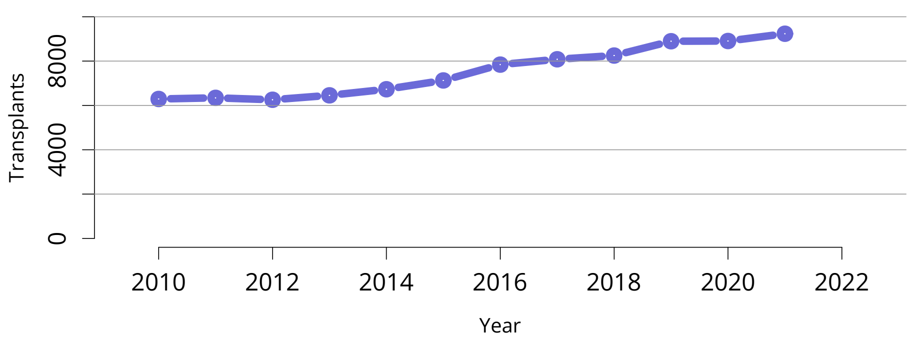

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Figure LI 54: Overall liver transplants. All liver transplant recipients, including adult and pediatric, re-transplant, and multiorgan recipients.

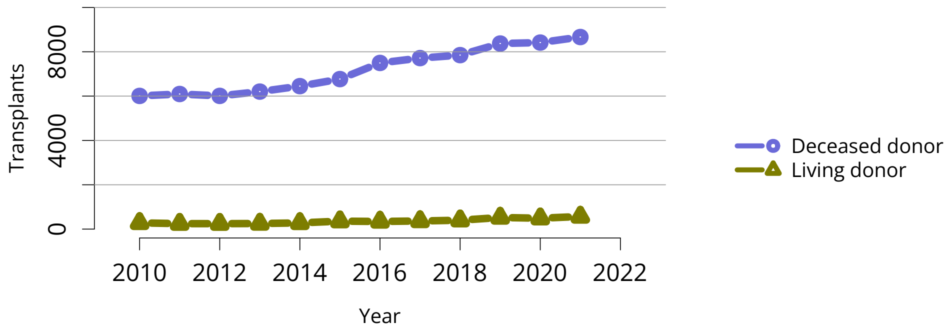

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Figure LI 55: Total liver transplants by donor type. All liver transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

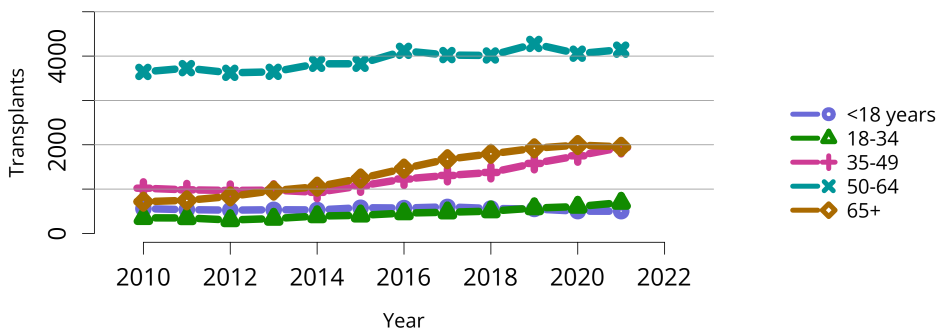

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Figure LI 56: Total liver transplants by age. All liver transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

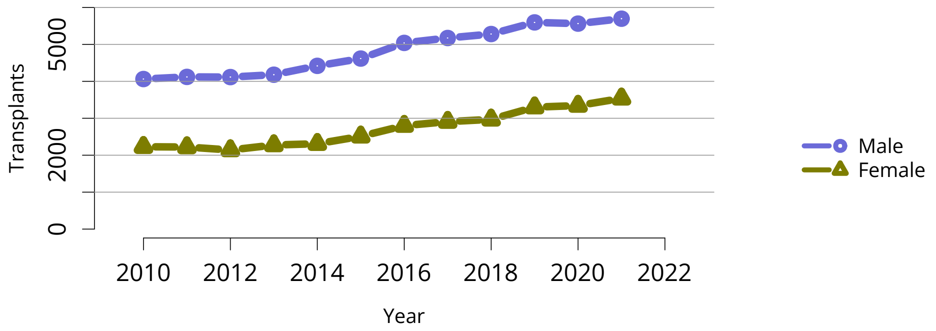

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Figure LI 57: Total liver transplants by sex. All liver transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

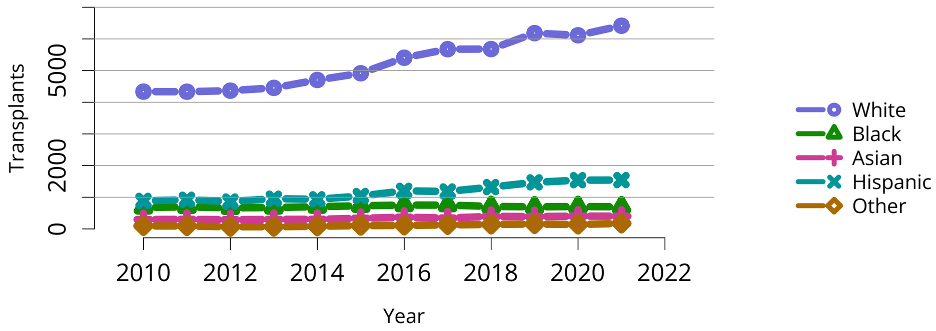

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Figure LI 58: Total liver transplants by race. All liver transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

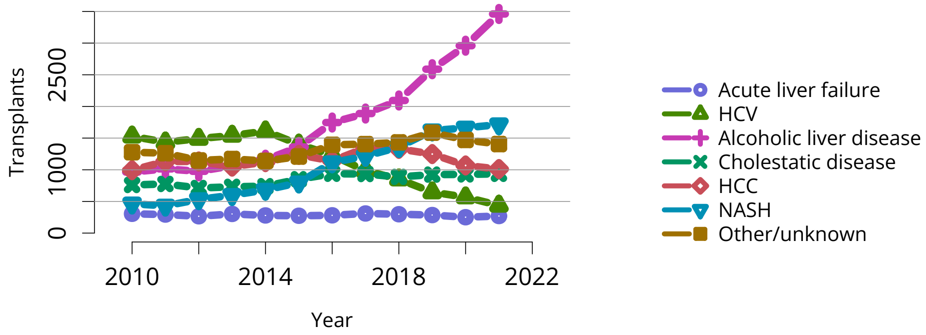

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Figure LI 59: Total liver transplants by diagnosis. All liver transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients. HCC, hepatocellular carcinoma; HCV, hepatitis C virus; NASH, nonalcoholic steatohepatitis.

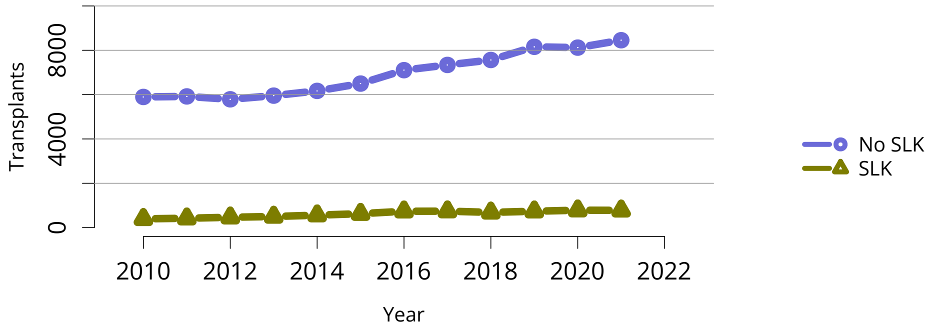

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Figure LI 60: Total liver transplants by simultaneous liver-kidney (SLK). All liver transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients. Simultaneous liver-kidney transplants are recipients with a liver and kidney transplant from the same donor.

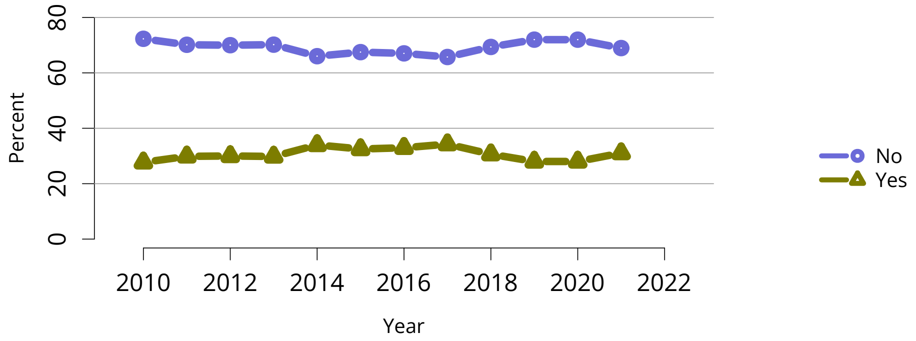

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Figure LI 61: Induction agent use in adult liver transplant recipients. Immunosuppression at transplant reported to the OPTN.

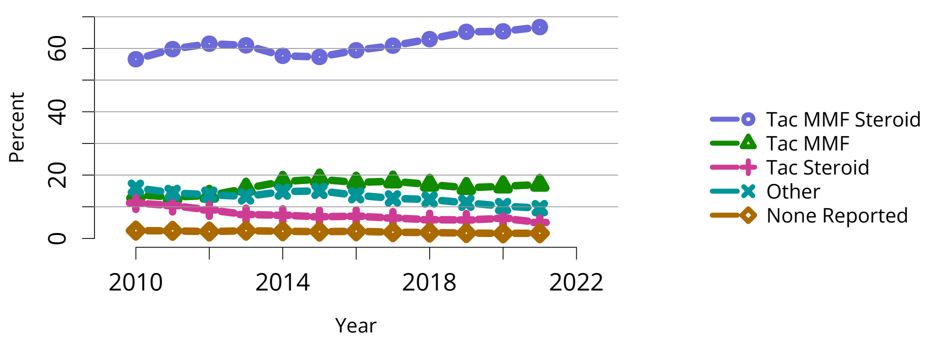

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Figure LI 62: Immunosuppression regimen use in adult liver transplant recipients. Immunosuppression regimen at transplant reported to the OPTN. Tac, tacrolimus. MMF, all mycophenolate agents.

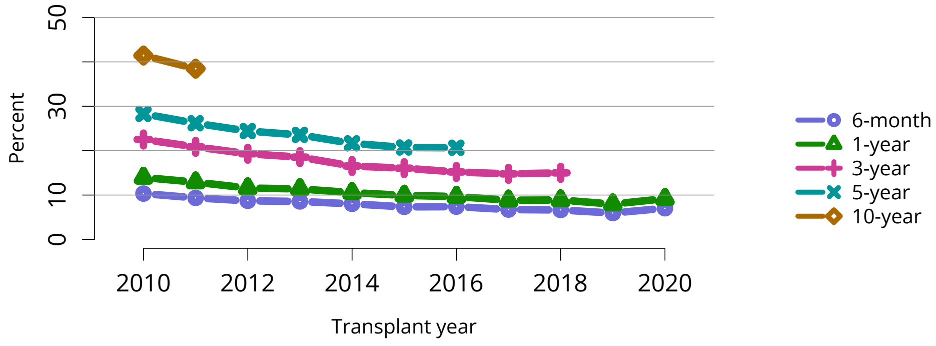

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Figure LI 63: Graft failure among adult deceased donor liver transplant recipients. All adult recipients of deceased donor livers, including multiorgan transplants.

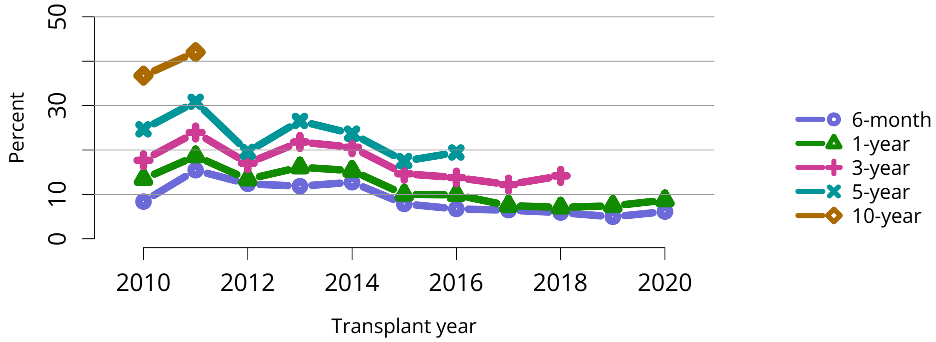

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Figure LI 64: Graft failure among adult living donor liver transplant recipients. All adult recipients of living donor livers, including multiorgan transplants.

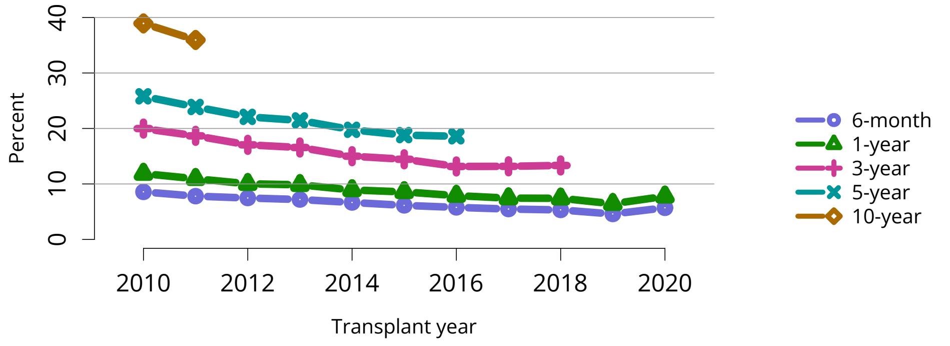

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Figure LI 65: Patient death among adult liver transplant recipients. All adult recipients of deceased donor livers, including multiorgan transplants.

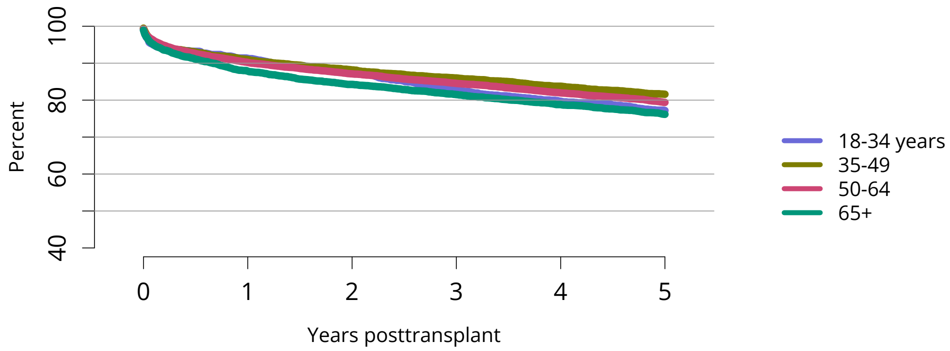

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Figure LI 66: Graft survival among adult deceased donor liver transplant recipients, 2014-2016, by age. Graft survival estimated using unadjusted Kaplan-Meier methods.

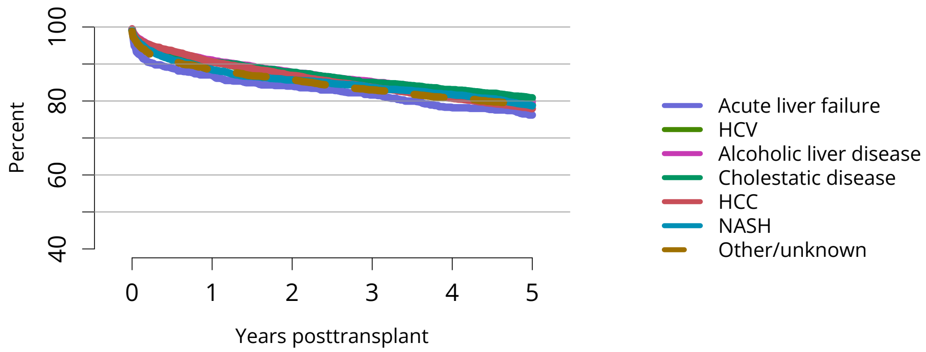

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Figure LI 67: Graft survival among adult deceased donor liver transplant recipients, 2014-2016, by diagnosis. Graft survival estimated using unadjusted Kaplan-Meier methods. HCC, hepatocellular carcinoma; HCV, hepatitis C virus; NASH, nonalcoholic steatohepatitis.

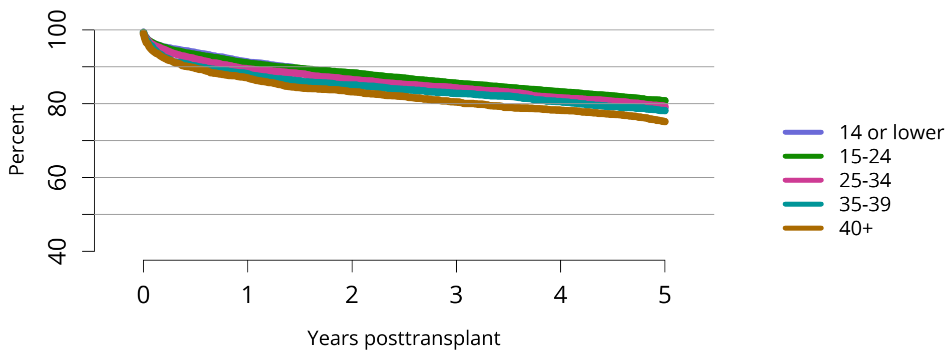

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Figure LI 68: Graft survival among adult deceased donor liver transplant recipients, 2014-2016, by laboratory MELD score. Graft survival estimated using unadjusted Kaplan-Meier methods.

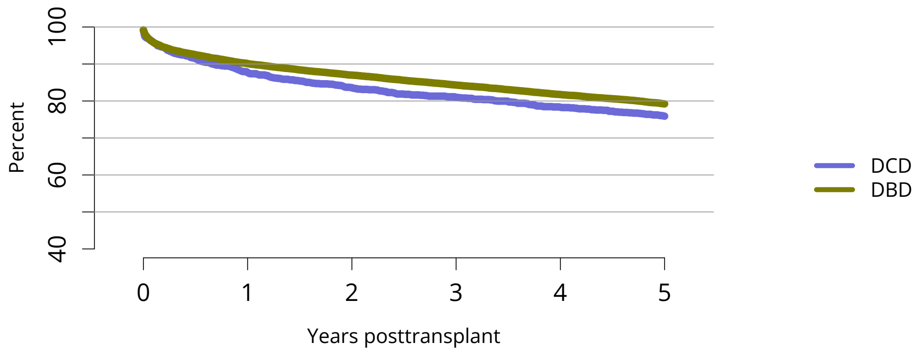

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Figure LI 69: Graft survival among adult deceased donor liver transplant recipients, 2014-2016, by DCD status. Graft survival estimated using unadjusted Kaplan-Meier methods. DCD, donation after circulatory death; DBD, donation after brain death.

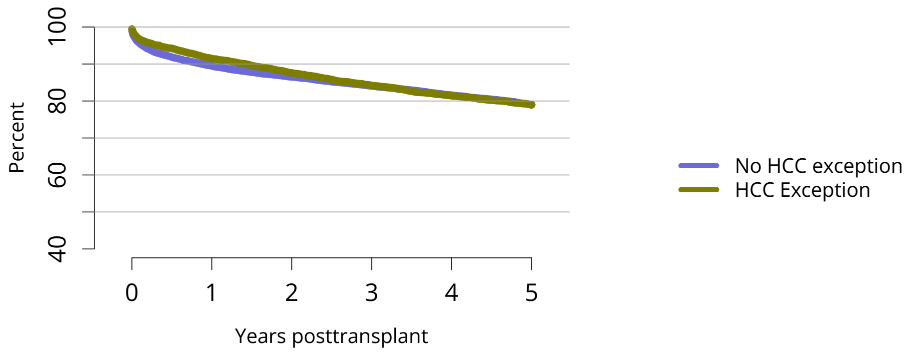

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Figure LI 70: Graft survival among adult deceased donor liver transplant recipients, 2014-2016, by HCC status. Graft survival estimated using unadjusted Kaplan-Meier methods. HCC, hepatocellular carcinoma.

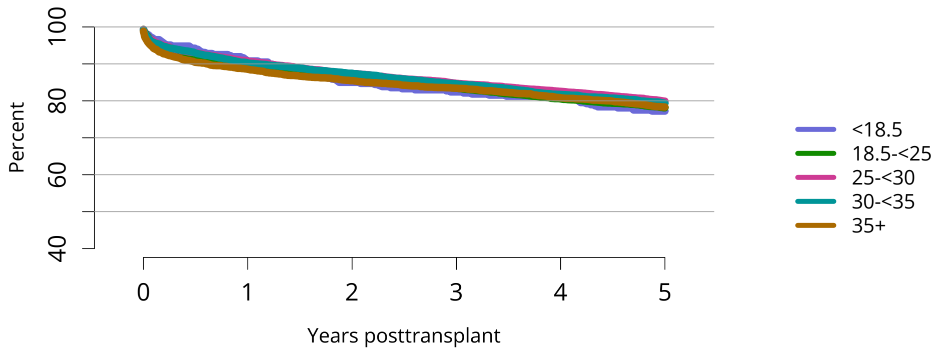

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Figure LI 71: Graft survival among adult deceased donor liver transplant recipients, 2014-2016, by BMI. Graft survival estimated using unadjusted Kaplan-Meier methods.

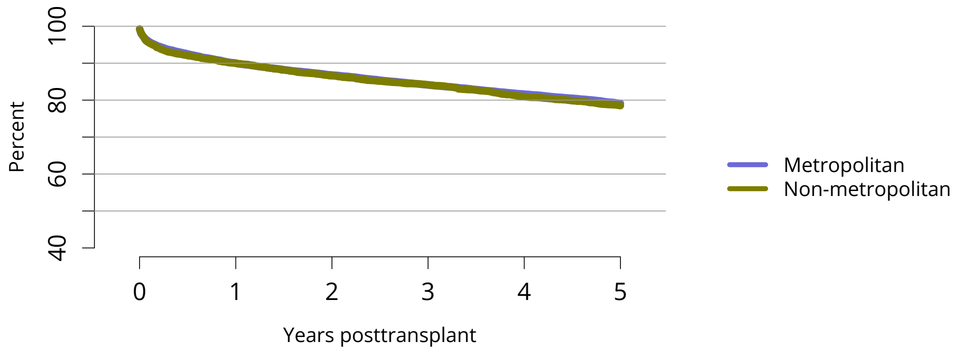

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Figure LI 72: Graft survival among adult deceased donor liver transplant recipients, 2014-2016, by metropolitan vs. non-metropolitan recipient residence. Graft survival estimated using unadjusted Kaplan-Meier methods.

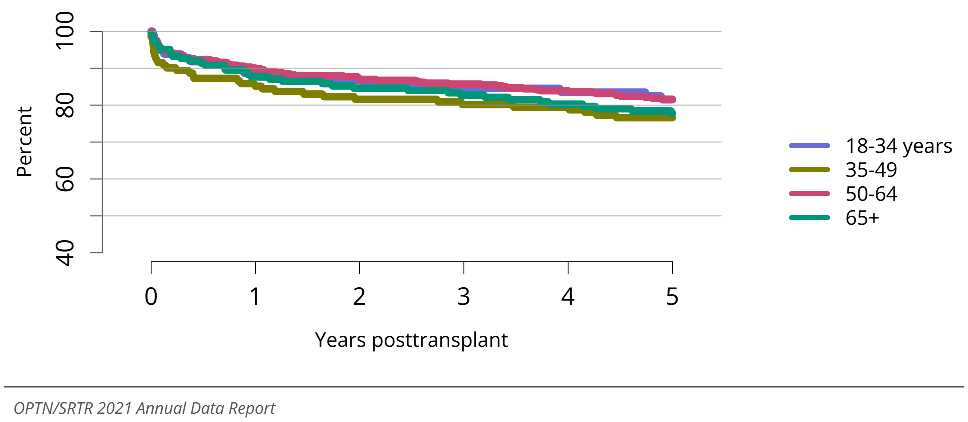

Figure LI 73: Graft survival among adult living donor liver transplant recipients, 2014-2016, by age. Graft survival estimated using unadjusted Kaplan-Meier methods.

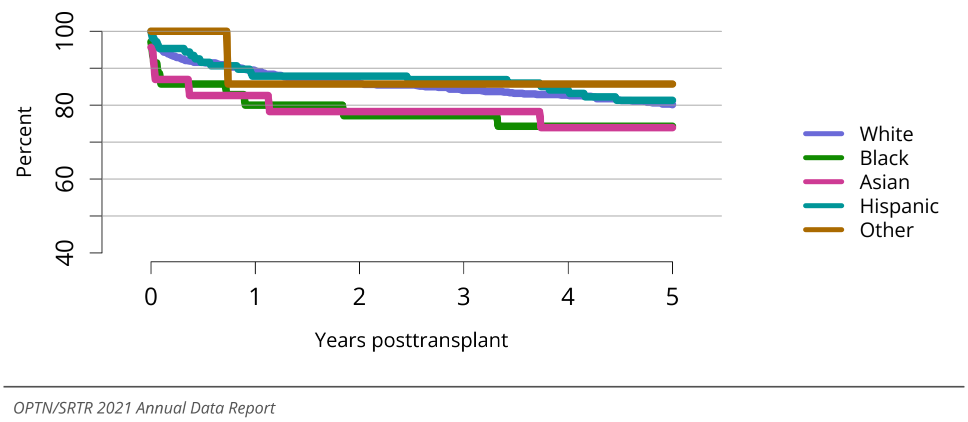

Figure LI 74: Graft survival among adult living donor liver transplant recipients, 2014-2016, by race. Graft survival estimated using unadjusted Kaplan-Meier methods.

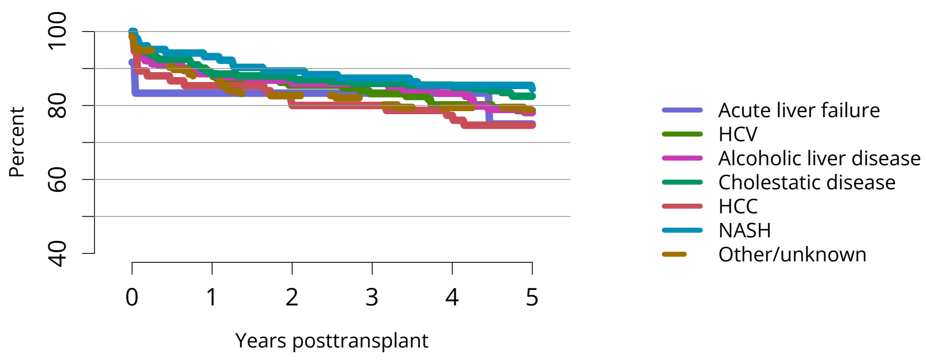

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Figure LI 75: Graft survival among adult living donor liver transplant recipients, 2014-2016, by diagnosis. Graft survival estimated using unadjusted Kaplan-Meier methods. HCC, hepatocellular carcinoma; HCV, hepatitis C virus; NASH, nonalcoholic steatohepatitis.

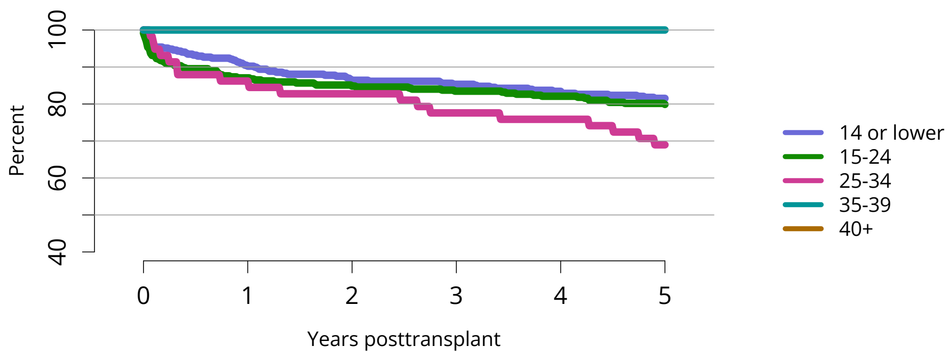

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Figure LI 76: Graft survival among adult living donor liver transplant recipients, 2014-2016, by laboratory MELD score. Graft survival estimated using unadjusted Kaplan-Meier methods.

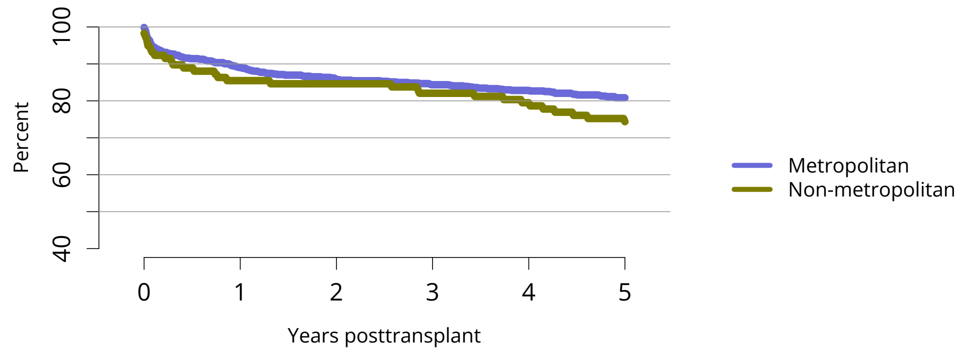

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Figure LI 77: Graft survival among adult living donor liver transplant recipients, 2014-2016, by metropolitan vs. non-metropolitan recipient residence. Graft survival estimated using unadjusted Kaplan-Meier methods.

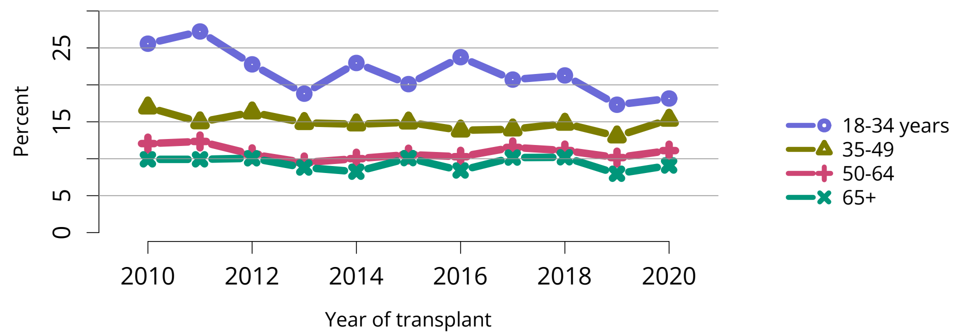

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Figure LI 78: Incidence of acute rejection by 1 year posttransplant among adult liver transplant recipients by age. Only the first reported rejection event is counted. Cumulative incidence is estimated using the Kaplan-Meier method.

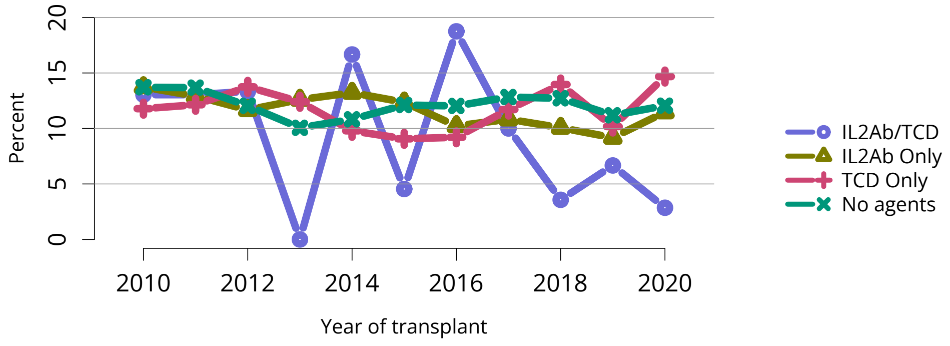

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Figure LI 79: Incidence of acute rejection by 1 year posttransplant among adult liver transplant recipients by induction agent. Only the first reported rejection event is counted. Cumulative incidence is estimated using the Kaplan-Meier method. IL2Ab, interleukin-2 receptor antibody; TCD, T-cell depleting.

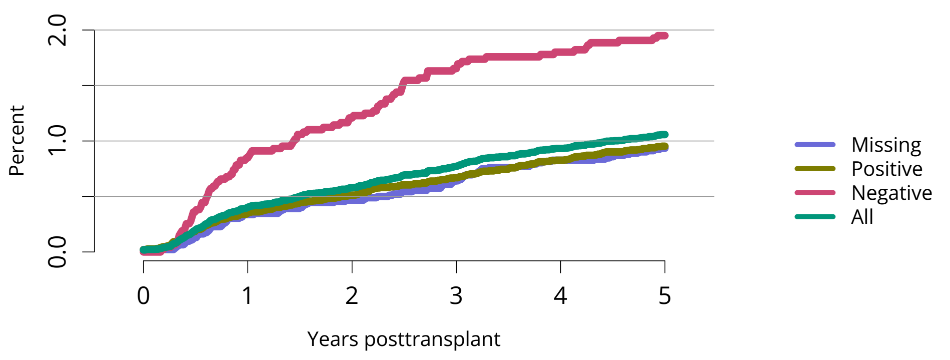

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Figure LI 80: Incidence of PTLD among adult liver transplant recipients by recipient EBV status at transplant, 2010-2016. Cumulative incidence is estimated using the Kaplan-Meier method. PTLD is identified as a reported complication or cause of death on the OPTN Transplant Recipient Follow-up Form or the Posttransplant Malignancy Form as polymorphic PTLD, monomorphic PTLD, or Hodgkin's disease. Only the earliest date of PTLD diagnosis is considered. EBV, Epstein-Barr virus; PTLD, posttransplant lymphoproliferative disorder.

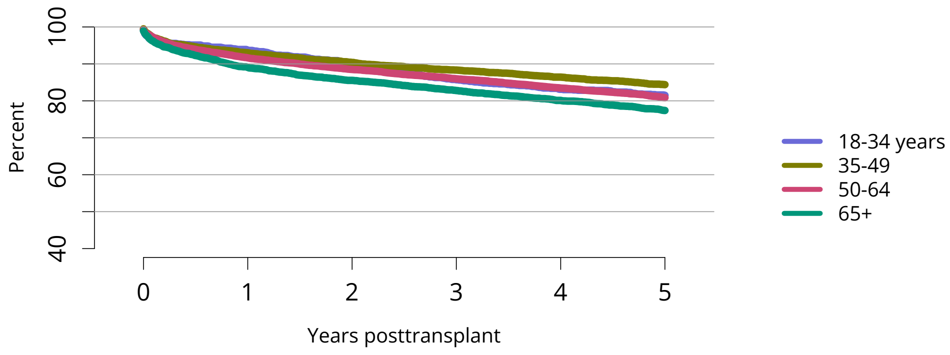

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Figure LI 81: Patient survival among adult deceased donor liver transplant recipients, 2014-2016, by age. Patient survival estimated using unadjusted Kaplan-Meier methods.

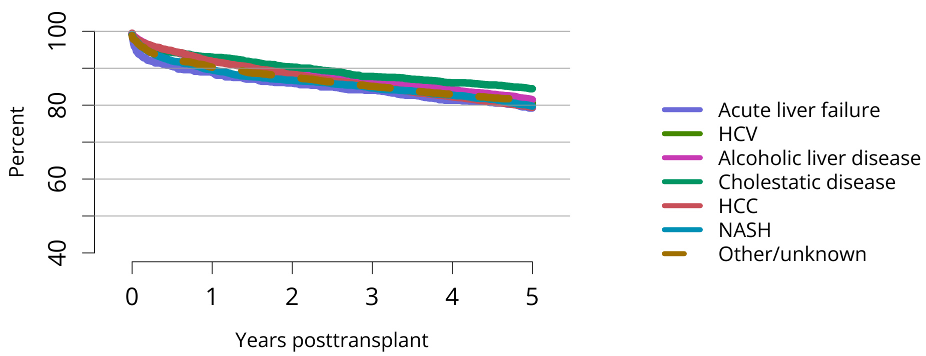

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Figure LI 82: Patient survival among adult deceased donor liver transplant recipients, 2014-2016, by diagnosis. Patient survival estimated using unadjusted Kaplan-Meier methods. HCC, hepatocellular carcinoma; HCV, hepatitis C virus; NASH, nonalcoholic steatohepatitis.

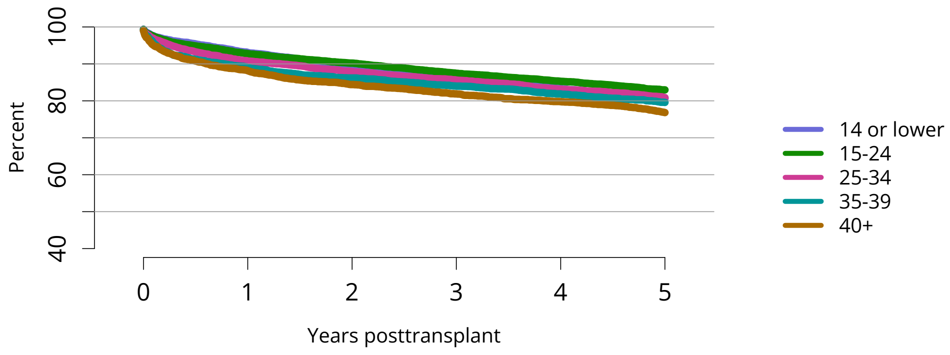

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Figure LI 83: Patient survival among adult deceased donor liver transplant recipients, 2014-2016, by laboratory MELD score. Patient survival estimated using unadjusted Kaplan-Meier methods.

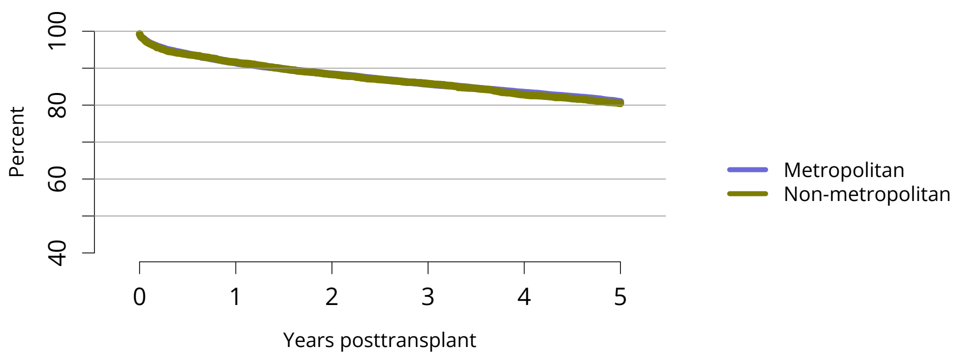

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Figure LI 84: Patient survival among adult deceased donor liver transplant recipients, 2014-2016, by metropolitan vs. non-metropolitan recipient residence. Patient survival estimated using unadjusted Kaplan-Meier methods.

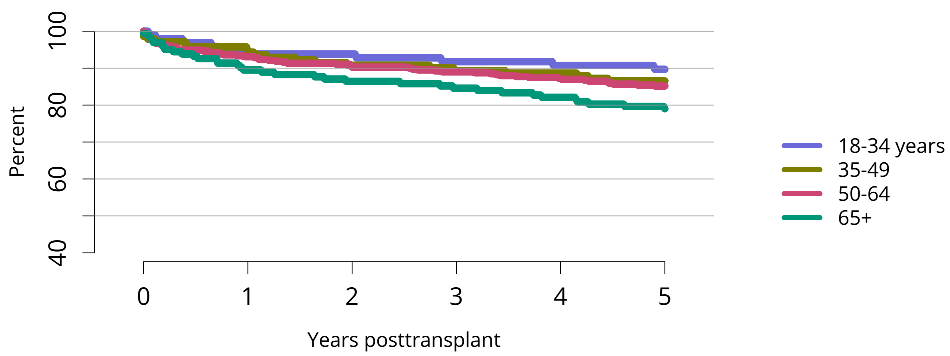

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Figure LI 85: Patient survival among adult living donor liver transplant recipients, 2014-2016, by age. Patient survival estimated using unadjusted Kaplan-Meier methods.

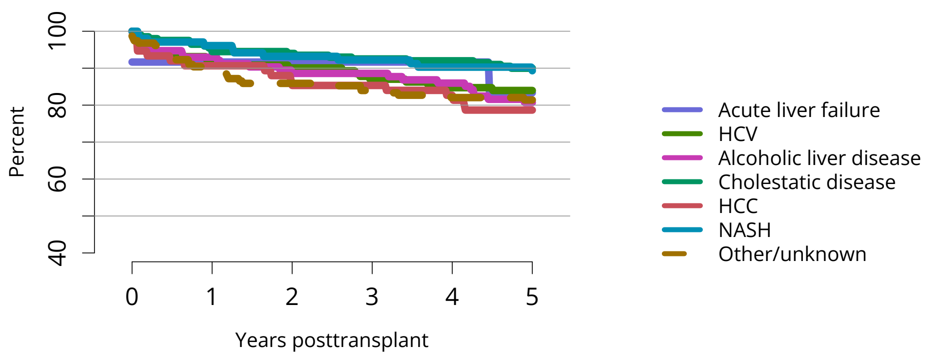

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Figure LI 86: Patient survival among adult living donor liver transplant recipients, 2014-2016, by diagnosis. Patient survival estimated using unadjusted Kaplan-Meier methods. HCC, hepatocellular carcinoma; HCV, hepatitis C virus; NASH, nonalcoholic steatohepatitis.

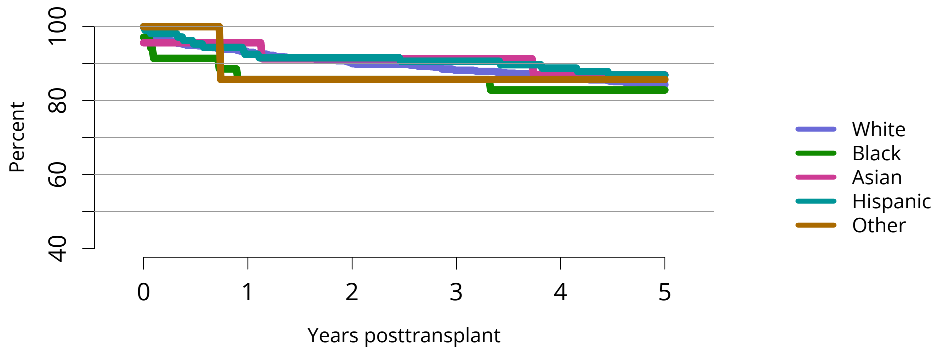

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Figure LI 87: Patient survival among adult living donor liver transplant recipients, 2014-2016, by race. Patient survival estimated using unadjusted Kaplan-Meier methods.

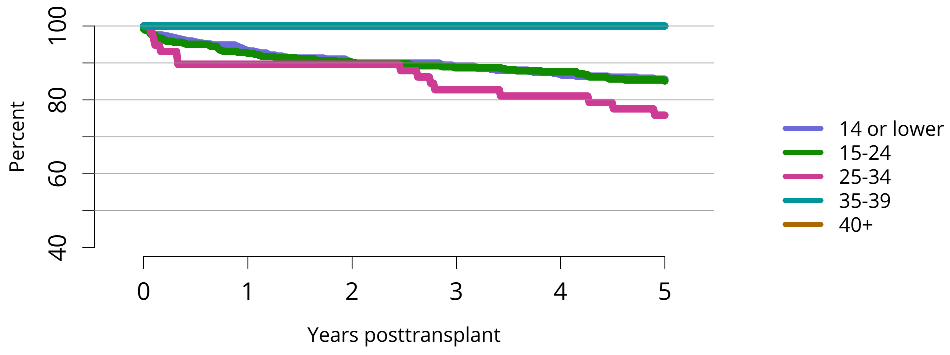

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Figure LI 88: Patient survival among adult living donor liver transplant recipients, 2014-2016, by laboratory MELD score. Patient survival estimated using unadjusted Kaplan-Meier methods.

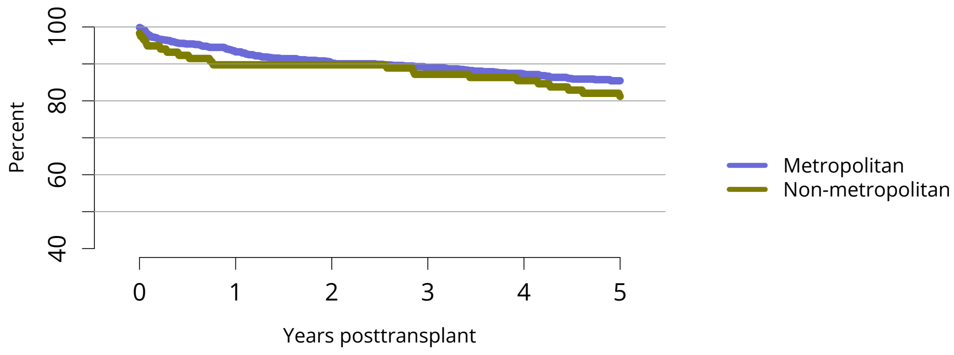

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Figure LI 89: Patient survival among adult living donor liver transplant recipients, 2014-2016, by metropolitan vs. non-metropolitan recipient residence. Patient survival estimated using unadjusted Kaplan-Meier methods.

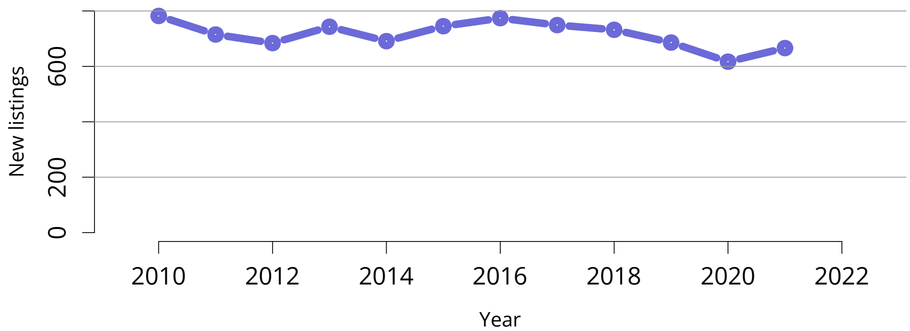

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Figure LI 90: New pediatric candidates added to the liver transplant waiting list. A new candidate is one who first joined the list during the given year, without having been listed in a previous year. Previously listed candidates who underwent transplant and subsequently relisted are considered new. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

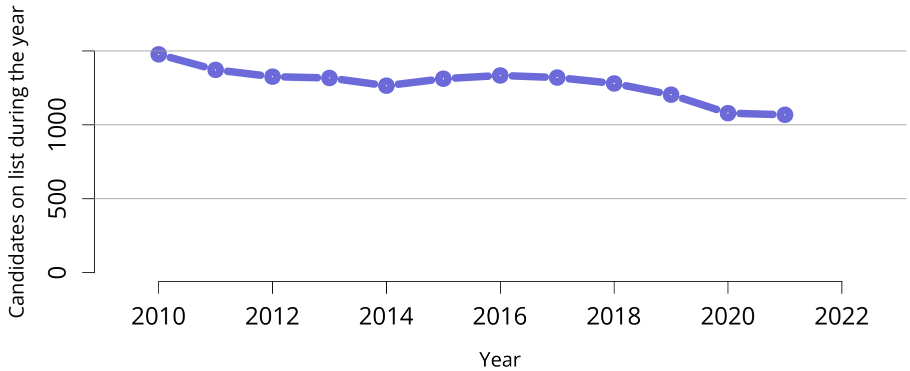

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Figure LI 91: All pediatric candidates on the liver transplant waiting list. Pediatric candidates listed at any time during the year. Candidates listed at more than one center are counted once per listing.

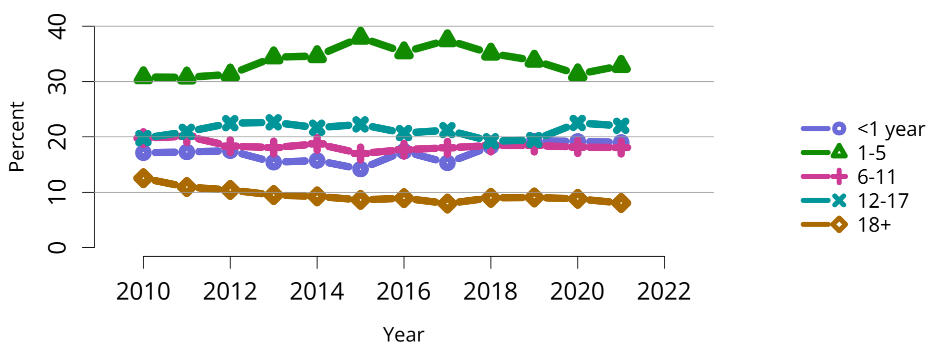

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Figure LI 92: Distribution of pediatric candidates waiting for liver transplant by age. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive candidates are included. Age is determined at the earliest of transplant, death, removal, or December 31 of the year.

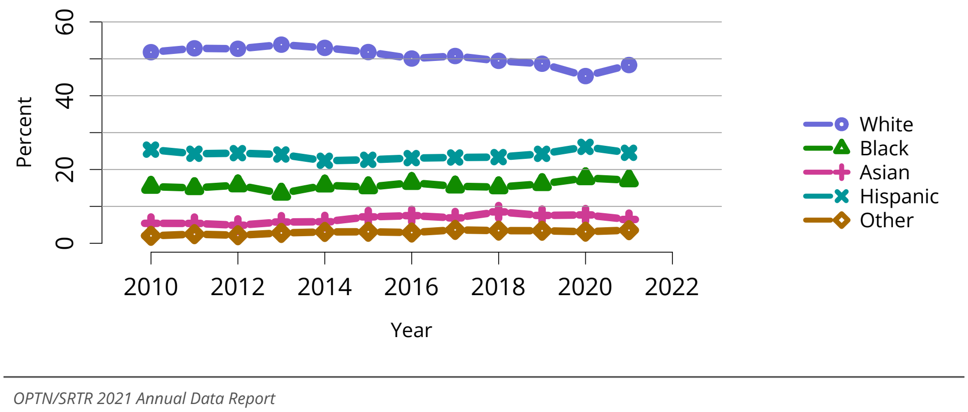

Figure LI 93: Distribution of pediatric candidates waiting for liver transplant by race. Candidates waiting for transplant any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive candidates are included.

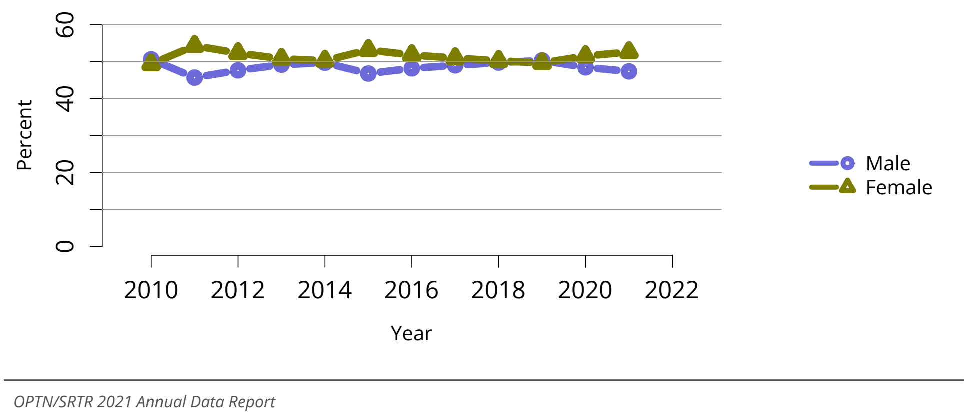

Figure LI 94: Distribution of pediatric candidates waiting for liver transplant by sex. Candidates waiting for transplant any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

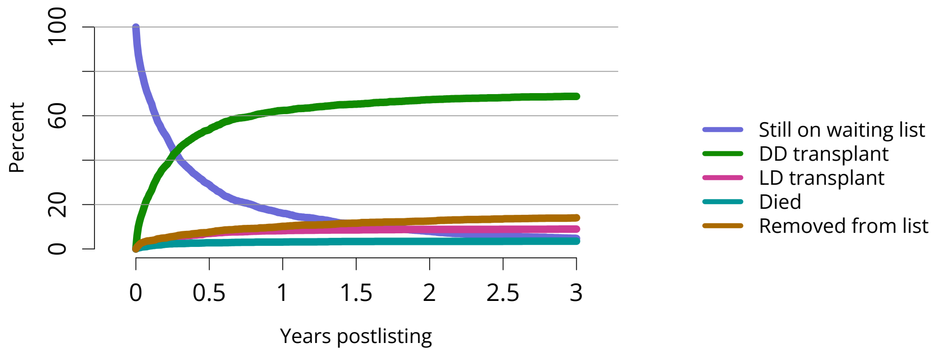

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Figure LI 95: Three-year outcomes for newly listed pediatric candidates waiting for liver transplant, 2016-2018. Pediatric candidates who joined the waiting list in 2016-2018. Candidates listed at more than one center are counted once per listing. DD, deceased donor; LD, living donor.

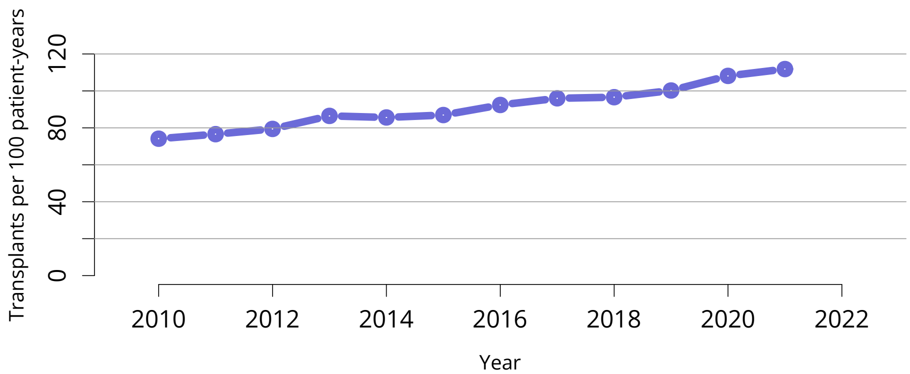

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Figure LI 96: Overall deceased donor liver transplant rates among pediatric waitlist candidates. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given year. Individual listings are counted separately.

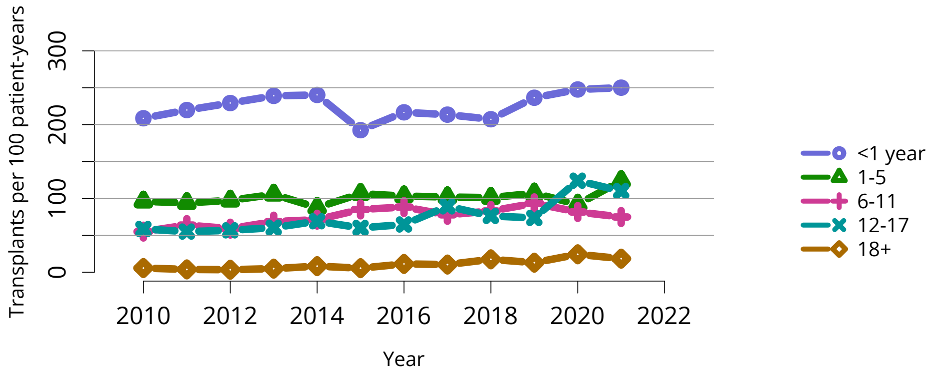

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Figure LI 97: Deceased donor liver transplant rates among pediatric waitlist candidates by age. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given year. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.

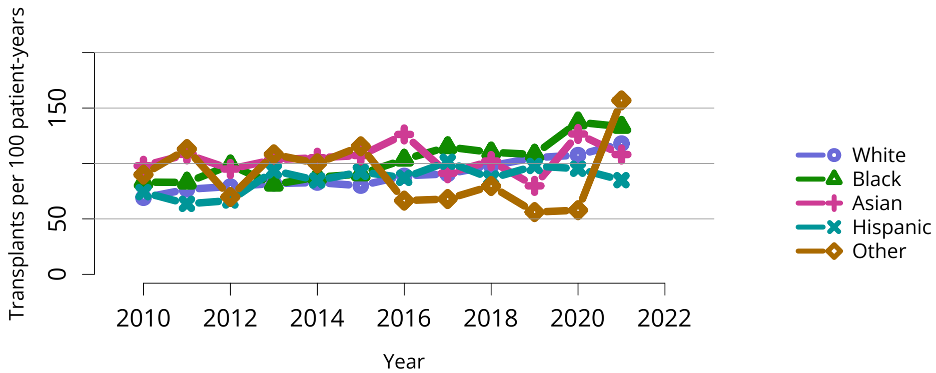

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Figure LI 98: Deceased donor liver transplant rates among pediatric waitlist candidates by race. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given year. Individual listings are counted separately.

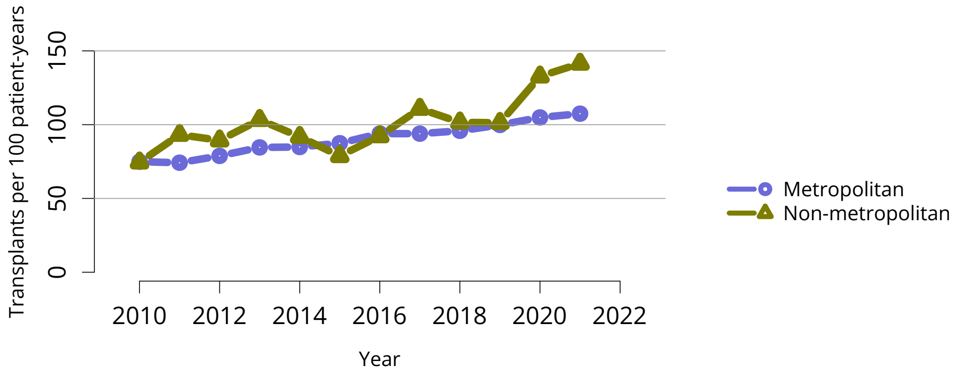

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Figure LI 99: Deceased donor liver transplant rates among pediatric waitlist candidates by metropolitan vs. non-metropolitan residence. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given year. Individual listings are counted separately.

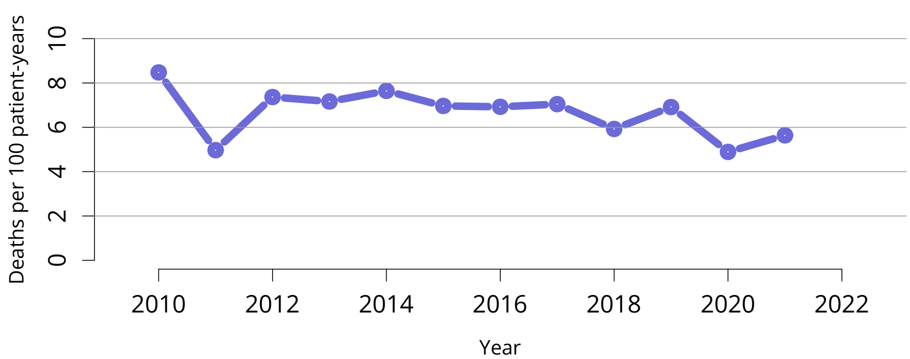

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Figure LI 100: Overall pretransplant mortality rates among pediatric candidates waitlisted for liver. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

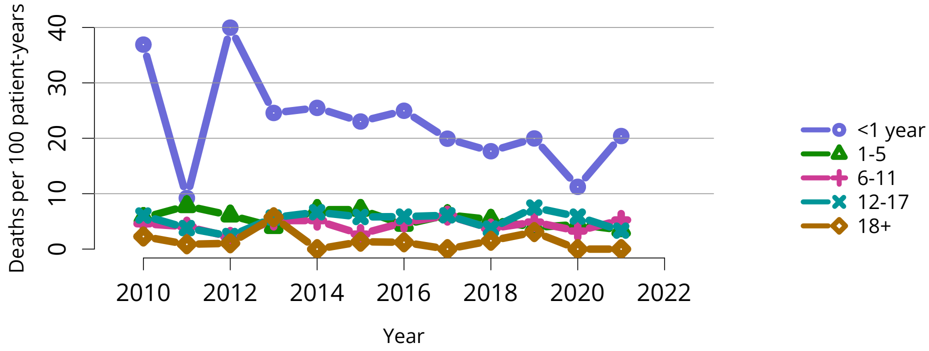

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Figure LI 101: Pretransplant mortality rates among pediatric candidates waitlisted for liver transplant by age. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.

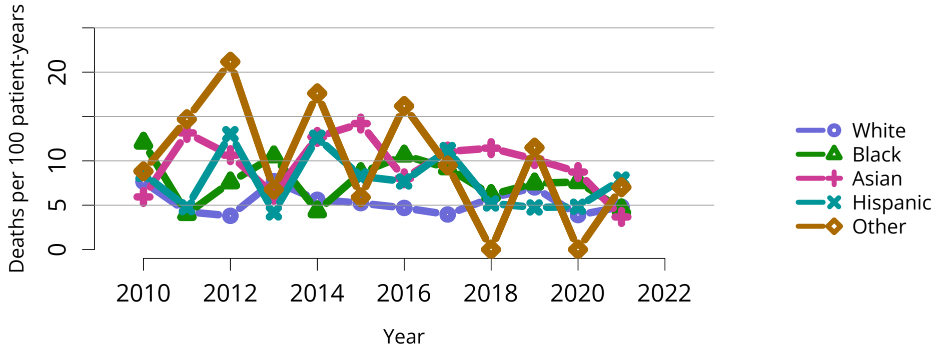

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Figure LI 102: Pretransplant mortality rates among pediatric candidates waitlisted for liver transplant by race. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

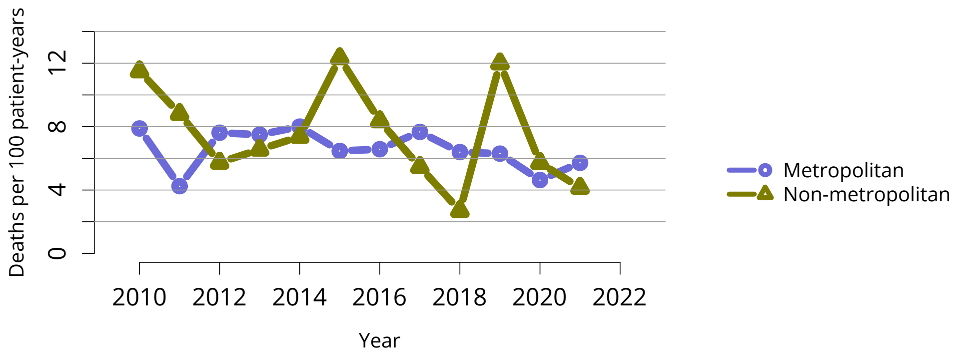

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Figure LI 103: Pretransplant mortality rates among pediatric candidates waitlisted for liver transplant by metropolitan vs. non-metropolitan residence. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Urban/rural determination is made using the RUCA (rural-urban commuting area) designation of the candidate's permanent zip code.

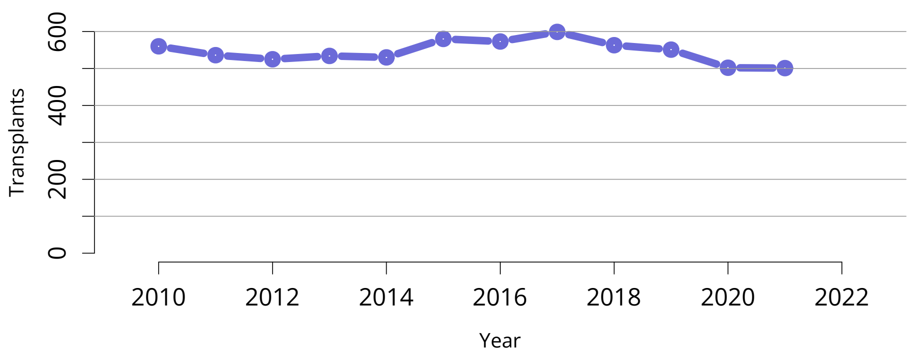

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Figure LI 104: Overall pediatric liver transplants. All pediatric liver transplant recipients, including retransplant, and multiorgan recipients.

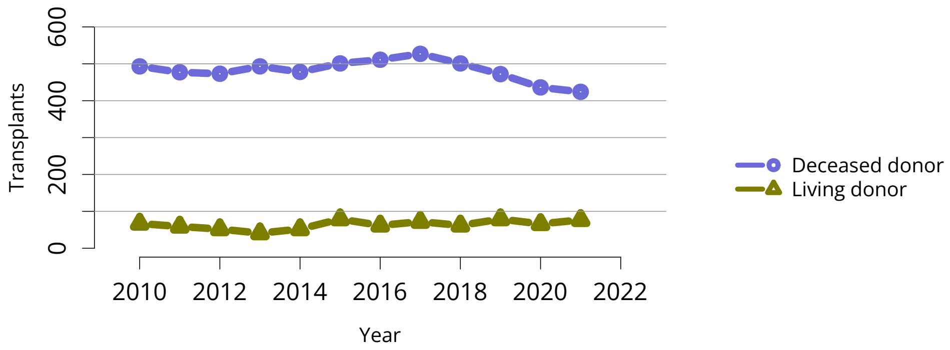

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Figure LI 105: Pediatric liver transplants by donor type. All pediatric liver transplant recipients, including retransplant, and multiorgan recipients.

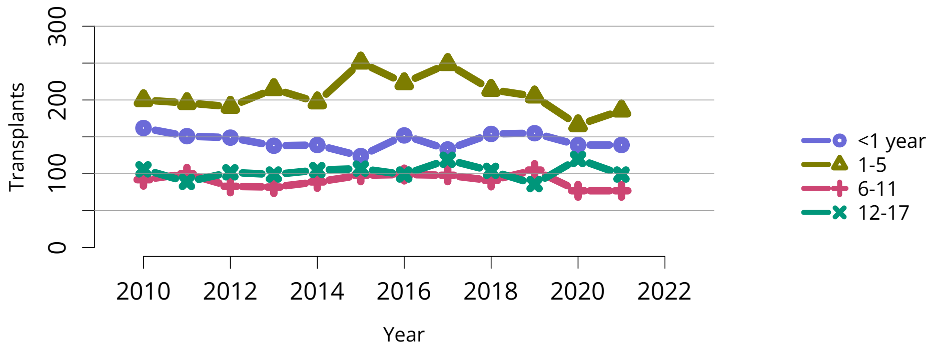

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Figure LI 106: Pediatric liver transplants by recipient age. All pediatric liver transplant recipients, including retransplant, and multiorgan recipients.

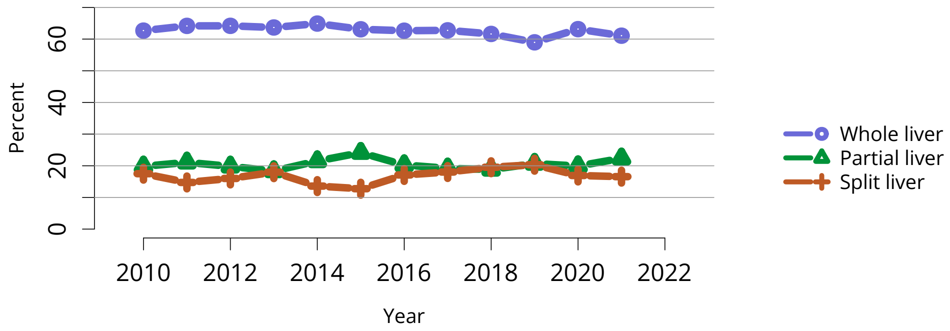

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Figure LI 107: Split or partial liver transplants in children. Percent of transplants from a split liver.

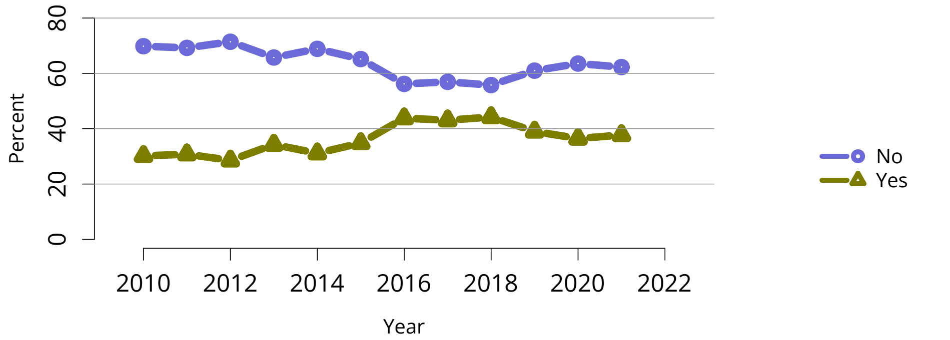

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Figure LI 108: Induction agent use in pediatric liver transplant recipients. Immunosuppression at transplant reported to the OPTN.

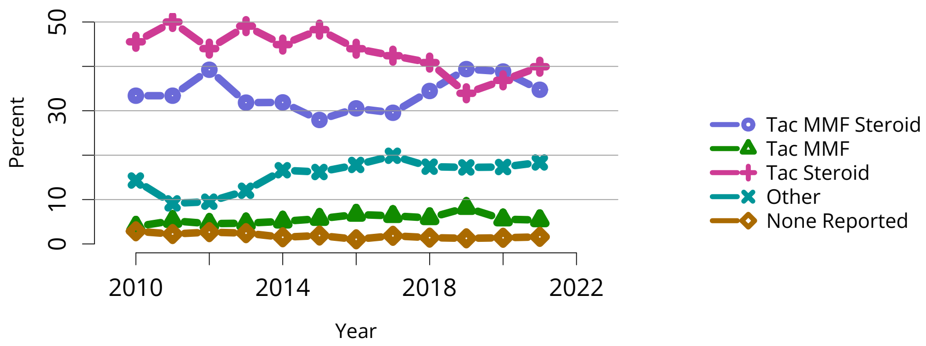

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Figure LI 109: Immunosuppression regimen use in pediatric liver transplant recipients. Immunosuppression regimen at transplant reported to the OPTN. Tac, tacrolimus. MMF, all mycophenolate agents.

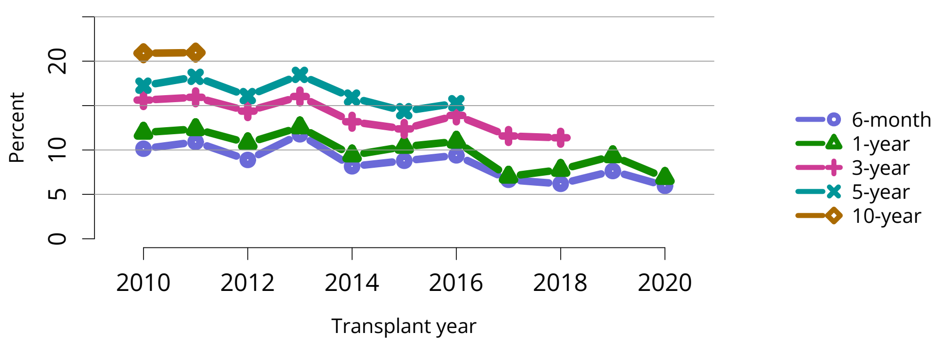

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Figure LI 110: Graft failure among pediatric deceased donor liver transplant recipients. All pediatric recipients of deceased donor livers, including multiorgan transplants. Estimates are unadjusted, computed using Kaplan-Meier methods. Recipients are followed to the earliest of retransplant; death; or 6 months, 1, 3, 5, or 10 years posttransplant. All-cause graft failure is defined as any of the prior outcomes prior to 6 months, 1, 3, 5, or 10 years, respectively.

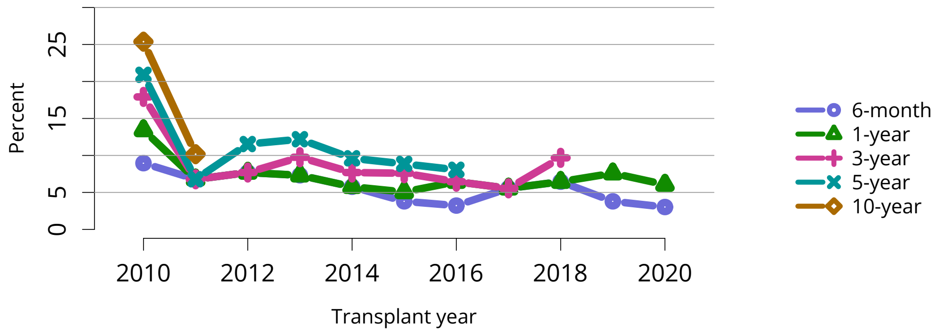

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Figure LI 111: Graft failure among pediatric living donor liver transplant recipients. All pediatric recipients of living donor livers, including multiorgan transplants. Estimates are unadjusted, computed using Kaplan-Meier methods. Recipients are followed to the earliest of retransplant; death; or 6 months, 1, 3, 5, or 10 years posttransplant. All-cause graft failure is defined as any of the prior outcomes prior to 6 months, 1, 3, 5, or 10 years, respectively.

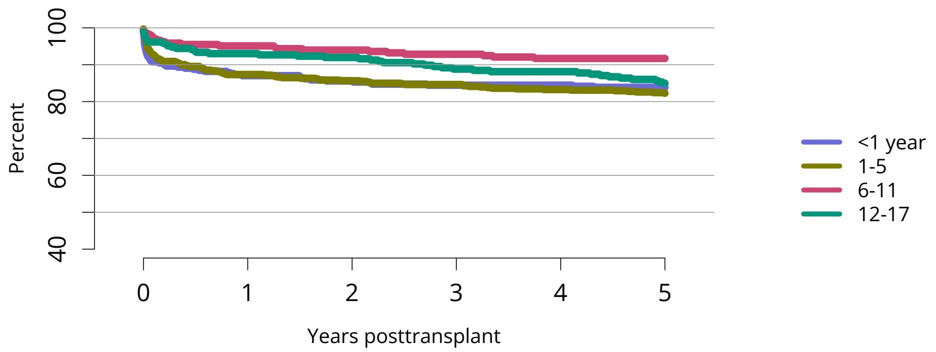

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Figure LI 112: Graft survival among pediatric deceased donor liver transplant recipients, 2014-2016, by age. Recipient survival estimated using unadjusted Kaplan-Meier methods.

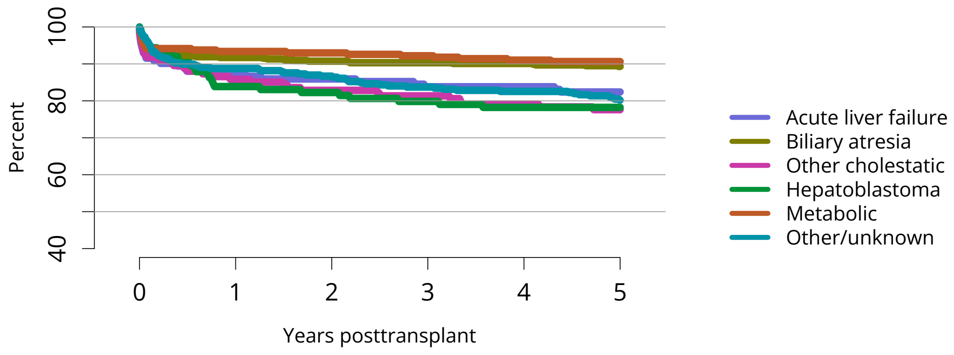

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Figure LI 113: Graft survival among pediatric deceased donor liver transplant recipients, 2014-2016, by diagnosis. Graft survival estimated using unadjusted Kaplan-Meier methods.

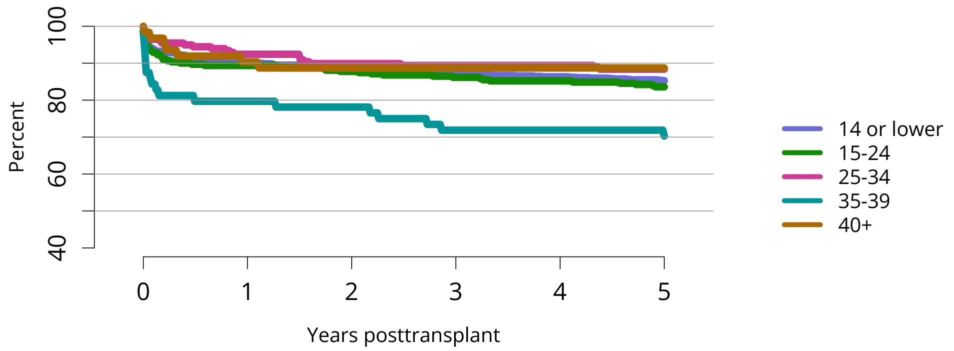

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Figure LI 114: Graft survival among pediatric deceased donor liver transplant recipients, 2014-2016, by laboratory MELD score. Graft survival estimated using unadjusted Kaplan-Meier methods. Pediatric candidates aged 12 to 17 years can be assigned MELD or PELD scores.

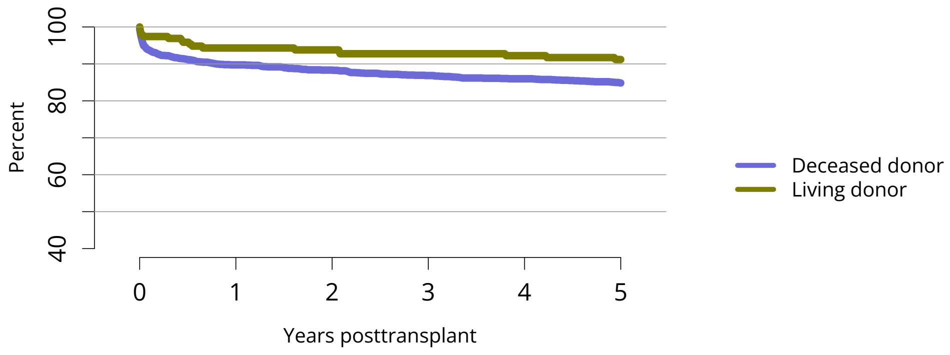

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Figure LI 115: Graft survival among pediatric liver transplant recipients, 2014-2016, by donor type. Recipient survival estimated using unadjusted Kaplan-Meier methods.

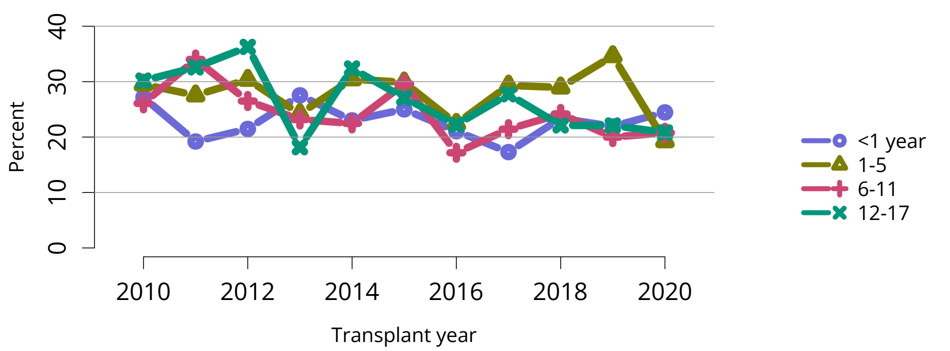

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Figure LI 116: Incidence of acute rejection by 1 year posttransplant among pediatric liver transplant recipients by age. Only the first reported rejection event is counted. Cumulative incidence is estimated using the Kaplan-Meier method.

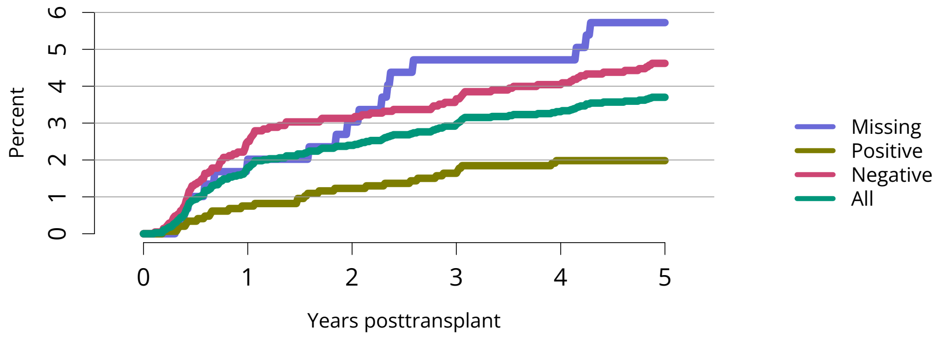

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Figure LI 117: Incidence of PTLD among pediatric liver transplant recipients by recipient EBV status at transplant, 2010-2016. Cumulative incidence is estimated using the Kaplan-Meier method. PTLD is identified as a reported complication or cause of death on the OPTN Transplant Recipient Follow-up Form or on the Posttransplant Malignancy Form as polymorphic PTLD, monomorphic PTLD, or Hodgkin's disease. Only the earliest date of PTLD diagnosis is considered. EBV, Epstein-Barr virus. PTLD, posttransplant lymphoproliferative disorder.

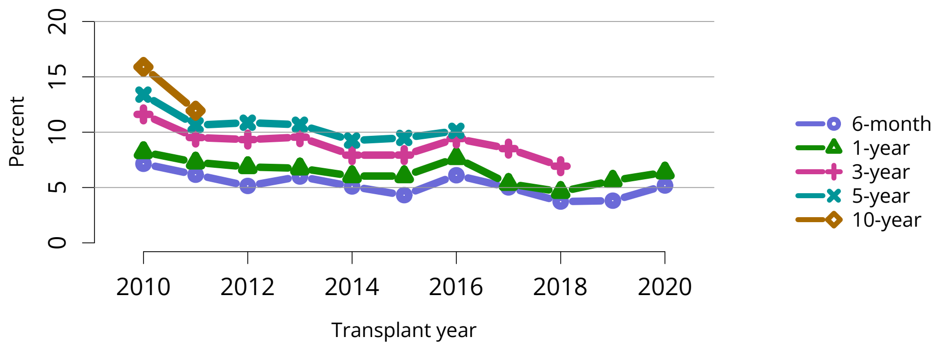

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Figure LI 118: Patient death among pediatric liver transplant recipients. All pediatric recipients of deceased donor livers, including multiorgan transplants. Estimates are unadjusted, computed using unadjusted Kaplan-Meier methods.

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Figure LI 119: Overall patient survival among pediatric deceased donor liver transplant recipients, 2014-2016. Recipient survival estimated using unadjusted Kaplan-Meier methods.

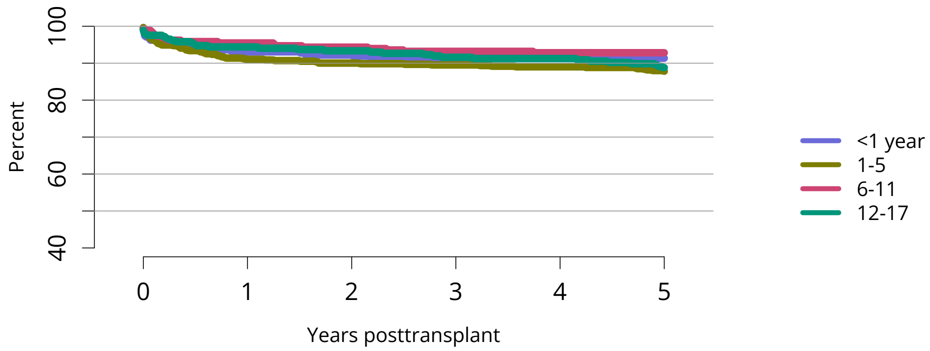

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Figure LI 120: Patient survival among pediatric deceased donor liver transplant recipients, 2014-2016, by recipient age. Recipient survival estimated using unadjusted Kaplan-Meier methods.

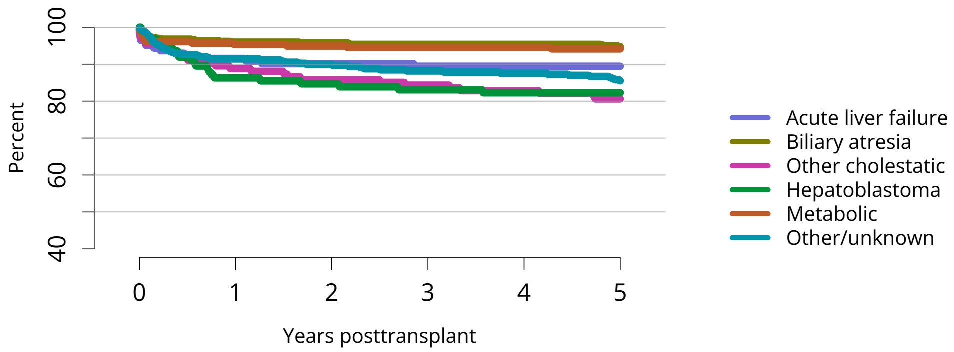

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Figure LI 121: Patient survival among pediatric deceased donor liver transplant recipients, 2014-2016, by diagnosis. Recipient survival estimated using unadjusted Kaplan-Meier methods.

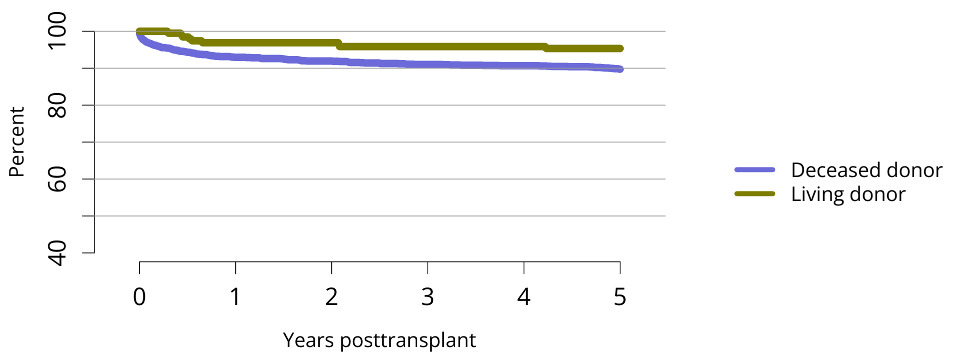

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Figure LI 122: Patient survival among pediatric liver transplant recipients, 2014-2016, by donor type. Recipient survival estimated using unadjusted Kaplan-Meier methods.

Table LI 1: Demographic characteristics of adults on the liver transplant waiting list on December 31, 2011, and December 31, 2021. Candidates waiting for transplant on December 31 of the given year, regardless of first listing date. Distance is computed from candidate's home zip code to the transplant center. Age is determined on December 31 of the year.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Age (years)				
18-34 years	691	4.3	574	5.1
35-49	2521	15.6	1906	16.8
50-64	10422	64.4	5612	49.5
65+	2540	15.7	3246	28.6
Sex				
Male	10068	62.2	6894	60.8
Female	6106	37.8	4444	39.2
Race				
White	11357	70.2	7637	67.4
Black	1139	7	757	6.7
Asian	788	4.9	598	5.3
Hispanic	2728	16.9	2174	19.2
Other	162	1	172	1.5
Geography				
Metropolitan	13550	83.8	9663	85.2
Non-metropolitan	2421	15	1563	13.8
Missing	203	1.3	112	1
Miles between candidate to center				
<50 miles	9168	56.7	6676	58.9
50-<100	2744	17	2019	17.8
100-<150	1446	8.9	957	8.4
150-<250	1334	8.2	888	7.8
250+	1345	8.3	715	6.3
Missing	137	0.8	83	0.7
All candidates				
All candidates	16174	100	11338	100

Table LI 2: Clinical characteristics of adults on the liver transplant waiting list on December 31, 2011, and December 31, 2021. Candidates waiting for transplant on December 31 of the given year, regardless of first listing date. HCC, hepatocellular carcinoma; HCV, hepatitis C virus; NASH, nonalcoholic steatohepatitis.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Diagnosis				
Acute liver failure	371	2.3	132	1.2
HCV	4944	30.6	1110	9.8
Alcoholic liver disease	3710	22.9	3840	33.9
Cholestatic disease	1502	9.3	932	8.2
HCC	849	5.2	1259	11.1
NASH	1227	7.6	2175	19.2
Other/unknown	3571	22.1	1890	16.7
Blood Type				
A	6146	38	4401	38.8
AB	391	2.4	236	2.1
B	1781	11	1166	10.3
O	7856	48.6	5535	48.8
Urgency Status				
14 or lower	8112	50.2	4762	42
15-24	4060	25.1	2958	26.1
25-34	994	6.1	1035	9.1
35-39	35	0.2	34	0.3
40+	26	0.2	15	0.1
Status 1A	2	0	5	0
Inactive	2925	18.1	2529	22.3
Missing	20	0.1	0	0
HCC status for liver candidates				
No HCC Exception	14941	92.4	9604	84.7
HCC Exception	1213	7.5	1734	15.3
Missing	20	0.1	0	0
All candidates				
All candidates	16174	100	11338	100

Table LI 3: Listing characteristics of adults on the liver transplant waiting list on December 31, 2011, and December 31, 2021. Candidates waiting for transplant on December 31 of the given year, regardless of first listing date.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Previous transplant				
No prior transplant	15725	97.2	11066	97.6
Prior transplant	449	2.8	272	2.4
Waiting time				
<90 days	2087	12.9	1913	16.9
3-<6 months	1560	9.6	1523	13.4
6-<12 months	2370	14.7	2056	18.1
1-<2 years	3018	18.7	2154	19
2+ years	7139	44.1	3692	32.6
All candidates				
All candidates	16174	100	11338	100

Table LI 4: Liver transplant waitlist activity among adults. Candidates listed at more than one center are counted once per listing. Candidates who are listed, undergo transplant, and are relisted are counted more than once. Candidates are not considered to be on the list on the day they are removed; counts on January 1 may differ from counts on December 31 of the prior year. Candidates listed for multiorgan transplants are included.

Waiting list state	2019	2020	2021
Waiting list state			
Patients at start of year	13115	12551	11771
Patients added during year	12761	12401	13165
Patients removed during year	13324	13179	13598
Patients at end of year	12552	11773	11338

Table LI 5: Removal reason among adult liver transplant candidates. Removal reason as reported to the OPTN. Candidates with death dates that precede removal dates are assumed to have died waiting.

Removal reason	2019	2020	2021
Removal reason			
Deceased donor transplant	7868	7930	8212
Living donor transplant	442	425	492
Transplant outside US	1	1	1
Patient died	1213	1117	1134
Patient refused transplant	117	121	135
Improved, transplant not needed	890	902	1051
Too sick for transplant	1188	1226	1177
Other	1602	1452	1387
Still on waiting list	3	5	9

Table LI 6: Demographic characteristics of adult liver transplant recipients, 2011 and 2021. Liver transplant recipients, including retransplants. Distance is computed from recipient's home zip code to the transplant center.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Recipient age (years)				
18-34 years	349	6	696	8
35-49	983	16.9	1938	22.2
50-64	3728	64.2	4145	47.5
65+	746	12.8	1954	22.4
Sex				
Male	3870	66.7	5453	62.4
Female	1936	33.3	3280	37.6
Race				
White	4042	69.6	6169	70.6
Black	610	10.5	605	6.9
Asian	264	4.5	370	4.2
Hispanic	814	14	1437	16.5
Other	76	1.3	152	1.7
Body mass index				
<18.5	94	1.6	178	2
18.5-<25	1679	28.9	2278	26.1
25-<30	2001	34.5	2784	31.9
30-<35	1210	20.8	1833	21
35+	772	13.3	1340	15.3
Missing	50	0.9	320	3.7
Insurance				
Private	3278	56.5	4525	51.8
Medicare	1466	25.2	2335	26.7
Medicaid	828	14.3	1497	17.1
Other/unknown	234	4	376	4.3
Geography				
Metropolitan	4886	84.2	7293	83.5
Non-metropolitan	809	13.9	1289	14.8
Missing	111	1.9	151	1.7
Miles between recipient to center				
<50 miles	3302	56.9	4959	56.8
50-<100	955	16.4	1551	17.8
100-<150	500	8.6	849	9.7
150-<250	460	7.9	655	7.5
250+	528	9.1	618	7.1
Missing	61	1.1	101	1.2
All recipients				
All recipients	5806	100	8733	100

Table LI 7: Clinical characteristics of adult liver transplant recipients, 2011 and 2021. Liver transplant recipients, including retransplants. HCC, hepatocellular carcinoma; HCV, hepatitis C virus; NASH, nonalcoholic steatohepatitis.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Diagnosis				
Acute liver failure	228	3.9	216	2.5
HCV	1435	24.7	437	5
Alcoholic liver disease	1014	17.5	3460	39.6
Cholestatic disease	533	9.2	696	8
HCC	1127	19.4	1002	11.5
NASH	430	7.4	1714	19.6
Other/unknown	1039	17.9	1208	13.8
Blood Type				
A	2138	36.8	3179	36.4
AB	304	5.2	411	4.7
B	779	13.4	1167	13.4
O	2585	44.5	3976	45.5
Urgency Status at transplant				
14 or lower	184	3.2	638	7.3
15-24	1931	33.3	2402	27.5
25-34	2408	41.5	3501	40.1
35-39	485	8.4	1038	11.9
40+	582	10	936	10.7
Status 1A	215	3.7	208	2.4
Inactive	1	0	8	0.1
Status 1B	0	0	2	0
HCC status for liver recipients				
No HCC exception	4331	74.6	7356	84.2
HCC Exception	1475	25.4	1377	15.8
All recipients				
All recipients	5806	100	8733	100

Table LI 8: Transplant characteristics of adult liver transplant recipients, 2011 and 2021. Liver transplant recipients, including retransplants. DBD, donation after brain death; DCD, donation after circulatory death.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Waiting time				
None	272	4.7	833	9.5
<90 days	2540	43.7	4592	52.6
3-<6 months	910	15.7	884	10.1
6-<12 months	910	15.7	1249	14.3
1-<2 years	706	12.2	706	8.1
2+	468	8.1	469	5.4
Donor type				
Deceased donor	5618	96.8	8241	94.4
Living donor	188	3.2	492	5.6
Split versus whole liver transplant				
Whole liver	5560	95.8	8168	93.5
Partial liver	182	3.1	492	5.6
Split liver	64	1.1	73	0.8
Donation after circulatory death				
DBD	5352	92.2	7327	83.9
DCD	266	4.6	914	10.5
Living donor	188	3.2	492	5.6
Previous transplant for recipients				
Prior transplant	332	5.7	313	3.6
No Prior transplant	5474	94.3	8420	96.4
All recipients				
All recipients	5806	100	8733	100

Table LI 9: Demographic characteristics of pediatric candidates on the liver transplant waiting list on December 31, 2011, and December 31, 2021. Candidates younger than 18 years at listing waiting for transplant on December 31 of the given year, regardless of first listing date. Age is determined on December 31 of the year. Distance is computed from candidate's home zip code to the transplant center.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Age (years)				
<1 year	59	9.2	44	11
1-5	171	26.6	112	27.9
6-11	141	21.9	94	23.4
12-17	164	25.5	94	23.4
18+	108	16.8	57	14.2
Sex				
Male	292	45.4	191	47.6
Female	351	54.6	210	52.4
Race				
White	344	53.5	189	47.1
Black	94	14.6	62	15.5
Asian	25	3.9	25	6.2
Hispanic	166	25.8	114	28.4
Other	14	2.2	11	2.7
Geography				
Metropolitan	549	85.4	350	87.3
Non-metropolitan	77	12	42	10.5
Missing	17	2.6	9	2.2
Miles between candidate to center				
<50 miles	330	51.3	187	46.6
50-<100	84	13.1	72	18
100-<150	55	8.6	43	10.7
150-<250	68	10.6	46	11.5
250+	93	14.5	45	11.2
Missing	13	2	8	2
All candidates				
All candidates	643	100	401	100

Table LI 10: Clinical characteristics of pediatric candidates on the liver transplant waiting list on December 31, 2011, and December 31, 2021. Candidates younger than 18 years at listing waiting for transplant on December 31 of the given year, regardless of first listing date. Pediatric candidates aged 12 to 17 years can be assigned MELD or PELD scores. HCC, hepatocellular carcinoma.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Pediatric diagnosis				
Acute liver failure	45	7	31	7.7
Biliary atresia	207	32.2	139	34.7
Other cholestatic	52	8.1	31	7.7
Hepatoblastoma	9	1.4	5	1.2
Metabolic	70	10.9	49	12.2
Other/unknown	260	40.4	146	36.4
Blood Type				
A	189	29.4	122	30.4
AB	15	2.3	5	1.2
B	88	13.7	51	12.7
O	351	54.6	223	55.6
Urgency Status				
14 or lower	168	26.1	93	23.2
15-24	82	12.8	41	10.2
25-34	72	11.2	44	11
35-39	7	1.1	30	7.5
40+	20	3.1	8	2
Status 1B	12	1.9	25	6.2
Status 1A	4	0.6	1	0.2
Inactive	262	40.7	159	39.7
Missing	16	2.5	0	0
HCC status for liver candidates				
No HCC Exception	626	97.4	400	99.8
HCC Exception	1	0.2	1	0.2
Missing	16	2.5	0	0
All candidates				
All candidates	643	100	401	100

Table LI 11: Listing characteristics of pediatric candidates on the liver transplant waiting list on December 31, 2011, and December 31, 2021. Candidates younger than 18 years at listing waiting for transplant on December 31 of the given year, regardless of first listing date.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Previous transplant				
No prior transplant	588	91.4	368	91.8
Prior transplant	55	8.6	33	8.2
Waiting time				
<90 days	125	19.4	117	29.2
3-<6 months	62	9.6	37	9.2
6-<12 months	80	12.4	61	15.2
1-<2 years	97	15.1	51	12.7
2+ years	279	43.4	135	33.7
All candidates				
All candidates	643	100	401	100

Table LI 12: Liver transplant waitlist activity among pediatric candidates. Candidates who are listed, undergo transplant, and are relisted are counted more than once. Candidates are not considered to be on the list on the day they are removed; counts on January 1 may differ from counts on December 31 of the prior year. Candidates listed for multiorgan transplants are included.

Waiting list state	2019	2020	2021
Waiting list state			
Patients at start of year	518	462	402
Patients added during year	686	617	666
Patients removed during year	742	677	667
Patients at end of year	462	402	401

Table LI 13: Removal reason among pediatric liver transplant candidates. Removal reason as reported to the OPTN. Candidates with death dates that precede removal dates are assumed to have died waiting.

Removal reason	2019	2020	2021
Removal reason			
Deceased donor transplant	483	456	435
Living donor transplant	82	66	77
Transplant outside US	0	0	1
Patient died	28	17	20
Patient refused transplant	1	3	5
Improved, transplant not needed	87	74	85
Too sick for transplant	16	16	16
Other	45	45	28

Table LI 14: Demographic characteristics of pediatric liver transplant recipients, 2011 and 2021. Pediatric liver transplant recipients, including retransplants. Distance is computed from recipient's home zip code to the transplant center.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Recipient age (years)				
<1 year	151	28.2	139	27.7
1-5	196	36.6	186	37.1
6-11	100	18.7	77	15.4
12-17	89	16.6	99	19.8
Sex				
Male	250	46.6	242	48.3
Female	286	53.4	259	51.7
Race				
White	291	54.3	247	49.3
Black	86	16	94	18.8
Asian	37	6.9	32	6.4
Hispanic	107	20	106	21.2
Other	15	2.8	22	4.4
Insurance				
Private	252	47	202	40.3
Medicare	2	0.4	3	0.6
Medicaid	217	40.5	228	45.5
Other/unknown	65	12.1	68	13.6
Geography				
Metropolitan	439	81.9	417	83.2
Non-metropolitan	78	14.6	69	13.8
Missing	19	3.5	15	3
Miles between recipient to center				
<50 miles	246	45.9	235	46.9
50-<100	79	14.7	85	17
100-<150	57	10.6	44	8.8
150-<250	63	11.8	65	13
250+	78	14.6	59	11.8
Missing	13	2.4	13	2.6
All recipients				
All recipients	536	100	501	100

Table LI 15: Clinical characteristics of pediatric liver transplant recipients, 2011 and 2021. Pediatric liver transplant recipients, including retransplants. Pediatric candidates aged 12 to 17 years can be assigned MELD or PELD scores. HCC, hepatocellular carcinoma.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Diagnosis				
Acute liver failure	65	12.1	54	10.8
Biliary atresia	198	36.9	205	40.9
Other cholestatic	45	8.4	35	7
Hepatoblastoma	42	7.8	32	6.4
Metabolic	75	14	65	13
Other/unknown	111	20.7	110	22
Blood Type				
A	168	31.3	171	34.1
AB	25	4.7	20	4
B	74	13.8	47	9.4
O	269	50.2	263	52.5
Urgency Status at transplant				
14 or lower	83	15.5	81	16.2
15-24	104	19.4	55	11
25-34	109	20.3	79	15.8
35-39	25	4.7	83	16.6
40+	55	10.3	48	9.6
Status 1B	79	14.7	84	16.8
Status 1A	81	15.1	71	14.2
HCC status for liver recipients				
No HCC exception	530	98.9	495	98.8
HCC Exception	6	1.1	6	1.2
All recipients				
All recipients	536	100	501	100

Table LI 16: Transplant characteristics of pediatric liver transplant recipients, 2011 and 2021. Pediatric liver transplant recipients, including retransplants. DBD, donation after brain death; DCD, donation after circulatory death.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Waiting time				
None	38	7.1	29	5.8
<90 days	298	55.6	298	59.5
3-<6 months	89	16.6	100	20
6-<12 months	62	11.6	41	8.2
1-<2 years	36	6.7	21	4.2
2+	13	2.4	12	2.4
ABO-Incompatible transplant				
Compatible/Identical	522	97.4	480	95.8
Incompatible	14	2.6	21	4.2
Donor type				
Deceased donor	477	89	424	84.6
Living donor	59	11	77	15.4
Split versus whole liver transplant				
Whole liver	344	64.2	306	61.1
Partial liver	113	21.1	112	22.4
Split liver	79	14.7	83	16.6
Donation after circulatory death				
DBD	474	88.4	424	84.6
DCD	3	0.6	0	0
Living donor	59	11	77	15.4
Previous transplant for recipients				
Prior transplant	51	9.5	26	5.2
No Prior transplant	485	90.5	475	94.8
All recipients				
All recipients	536	100	501	100

OPTN/SRTR 2021 Annual Data Report: Intestine

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Abstract

There has been just over 30 years of experience in clinical intestine transplant. A rise in demand until 2007 with improving transplant outcomes preceded a subsequent fall in demand due, at least in part, to improvements in pretransplant care of patients with intestinal failure. Over the past 10 to 12 years, there has been no suggestion of an increase in demand and, particularly for adult transplant, there may be a continued trend toward fewer additions to the waiting list and fewer transplants, especially in those needing combined intestine-liver transplant. In addition, over the same period there has been no noticeable improvement in graft survival, with 1- and 5-year graft failure rates averaging 21.6% and 52.5%, respectively, for intestine-alone transplants and 28.6% and 47.2%, respectively, for combined intestine-liver allografts.

Keywords: Intestinal failure, intestine transplant, intestine-liver transplant, waiting list

1 INTRODUCTION

Intestine transplant remains the least common form of solid organ transplant and one of the most challenging. Despite 30 years of clinical experience, long-term outcomes for grafts and patients are considerably lower than those for other major organ transplants, with the possible exception of lung transplant, but intestine transplant has been demonstrated to be lifesaving and to improve quality of life for very many patients. The number of intestines transplanted per year peaked in 2007 and has declined since then. Initially this was most marked for pediatric populations with intestinal failure, because of improved intestinal rehabilitation; however, over the past few years, pediatric intestine transplant rates have plateaued. For the past decade, numbers of intestine transplants for adults have exceeded those for children, but adult intestine transplant rates have been falling, and this is most notable for those in need of combined intestine-liver transplant. A potential reason for this decrease may be due to changes in liver allocation policy and the 10% model for end-stage liver disease (MELD) increase afforded to adult patients requiring combined intestine-liver transplant, an increase which may no longer provide these patients sufficient priority.

There is much discussion regarding excessive nonuse rates for other organs, but for intestine there were 97 intestines procured for transplant in 2021 and 96 transplants carried out. It will be important to continue to monitor this trend, as more organ offers are needed to serve these candidates who often have very long waiting times once placed on the waitlist.

Another concern is how the COVID-19 pandemic may have influenced intestine transplant activity. With the small increases in waitlist additions, overall intestine transplant rates, and overall intestine transplants undertaken in 2020 and 2021 compared with those done in 2019, and no change in pretransplant mortality rates, it may be fair, albeit on the basis of limited nongranular data, to suggest that the overall effect of COVID-19 on intestine transplant activity in the United States has been negligible.

If we look at equity in intestine waiting lists and transplant numbers, understanding that these limited data do not tell the full story, there are no glaring differences in waitlist and transplant proportions based on race and ethnicity compared with the overall US population. Information on the waiting list, transplants, and outcomes is presented for intestine transplants either alone or in combination with liver. Both types include multivisceral transplants distinguished by inclusion or exclusion of liver.

2 WAITING LIST

Waitlist additions were similar in total to the previous year (144 in 2020 and 143 in 2021), although with 239 waitlist additions in 2010, the trend over 12 years is clearly toward fewer listings (Figure IN 1). This trend is also reflected in the number of prevalent patients awaiting intestine transplant: 466 candidates in 2010 (225 for intestine alone and 241 for combined intestine and liver) compared with 364 candidates waiting in 2021 (180 and 184 for isolated intestine and combined intestine and liver, respectively) (Figure IN 2). Over the preceding decade, there has been a gradual increase in the number of adults waiting for intestine transplant compared with candidates younger than 18 years, and in 2021 the adult numbers surpassed those of pediatric candidates for the first time ever with 56% of the waiting list aged 18 years or older (Figure IN 3). The racial and ethnic mix of the waiting list has been relatively consistent since 2010, with White patients making up between 59% and 64% of the list; Black patients, 15% to 21%; Hispanic patients, 14% to 18%; and Asian patients, 2% to 4% (Figure IN 5). Purely for reference, the US population in 2020 was 59.7% White, 12.6% Black, 18.6% Hispanic, and 5.9% Asian.[1] The most common etiology of intestinal failure on the waiting list remained short-gut syndrome (SGS; 47%), which encompasses both congenital and noncongenital SGS, as well as necrotizing enterocolitis and probably a significant number in the other/unknown group (Figure IN 6). Enteropathies and intestinal pseudo-obstruction syndromes are rare and account for only about 10% of all indications for listing for intestine transplant (Figure IN 6).

Table IN 1 shows the demographic characteristics of intestine transplant candidates by whether they are simultaneously awaiting a liver transplant. Generally, these characteristics are similar between the two cohorts, although it appears that listing for combined intestine and liver is more common in male candidates and older patients. Candidates, in the main, come from metropolitan areas either close to the transplant center or from distances greater than 150 miles, presumably other metropolitan centers without an intestine transplant program. Medical characteristics of the two groups are shown in Table IN 2, and other than individuals with chronic intestinal pseudo-obstruction who were more likely to be listed for isolated intestine, other diagnostic groups were equally likely to be listed for isolated intestine and combined intestine-liver transplant. Major ABO blood groups were equally represented between intestine alone and combined intestine and liver, and approximately in line with the average distribution of blood groups in the US population.

The proportion of candidates with waiting times fewer than 90 days has increased in the past 2 years but remains lower than in 2010 (20.3% waiting fewer than 90 days in 2021 compared with 31.1% in 2010), and the trend for those waiting more than 2 years appears to be toward greater numbers (36.5% waiting more than 2 years in 2021 compared with 27.5% in 2010) (Figure IN 7). Transplant rates have risen over the past 2 years from the nadir in 2019 of 34.8 transplants per 100 patient-years to 44.9 transplants per 100 patient-years in 2021, suggesting that maybe the COVID-19 restrictions did not prevent intestine transplants from happening; but, again, this rate is lower than that seen in 2010 of 60.3 transplants per 100 patient-years (Figure IN 9). Transplant rates for children and adolescents have been fairly stable during the 12-year period (range, 20-35 transplants per 100 patient-years), whereas those for adults have varied widely from year to year (range, 60-130 transplants per 100 patient-years) (Figure IN 10). Transplant rates are not clearly different by race and ethnicity (Figure IN 11), nor among candidates awaiting either isolated intestine or combined intestine-liver transplant (Figure IN 12).

In 2021, 88 candidates were removed from the isolated intestine waiting list: 57 (64.8%) underwent deceased donor transplant, 3 (3.4%) died, 16 (18.2%) were removed from the list because their condition improved, and 11 (12.5%) were removed for other, unspecified reasons (Table IN 5). Outcomes at 3 years for newly listed candidates for isolated intestine transplant in 2016 through 2018 show that 67.4% underwent deceased donor transplant, 3.8% died, 14.2% were removed from the list, and 14.6% were still waiting 3 years after listing (Figure IN 13). Likewise, 75 candidates were removed from the intestine-liver waiting list in 2021: 38 (50.7%) underwent deceased donor transplant, 12 (16.0%) died, 7 (9.3%) were removed from the list because their condition improved, and 10 (13.3%) were considered too sick to undergo transplant (Table IN 5). Of intestine-liver candidates listed from 2016 through 2018, 67.8% underwent deceased donor transplant within 3 years, 11.4% were removed from the list, 10.2% died, and 10.6% were still waiting (Figure IN 14).

The overall pretransplant mortality for intestinal transplant candidates has ranged from 6 to 12 deaths per 100 patient-years since 2010 (Figure IN 15), and rates vary by age. Pretransplant mortality is higher for adult candidates, ranging from 9.6 deaths per 100 patient-years in 2017 to 24.5 deaths per 100 patient-years in 2014. For pediatric candidates, the range was from a low of 2.0 deaths per 100 patient-years in 2020 up to 5.4 deaths per 100 patient-years in 2012 (Figure IN 16). Noticeably, there was no increase in pretransplant mortality seen with the appearance of COVID-19. Pretransplant mortality in 2021 was, as has always been seen previously, higher for combined intestine-liver (14.1 deaths per 100 patient-years) than for isolated intestine transplant candidates (2.8 deaths per 100 patient-years) (Figure IN 19).

3 DONATION

In 2021, 97 intestines were recovered from deceased donors (Figure IN 21). The greatest proportion of intestine donors in 2021 were aged younger than 18 years (56.7%) (Figure IN 23). Most intestine donors were White (60.8%) (Figure IN 25). The overall rate of intestines recovered for transplant and not transplanted was only 1% in 2021 (Figure IN 26). The most common cause of death among deceased intestine donors has historically always been head trauma, and this was again the case in 2021 with 56.7% of deceased intestine donors being as the result of head injury, although in 2020 there was a clear increase in the proportion of donors who died of anoxia (Figure IN 28).

4 TRANSPLANT

The lowest number of intestine transplants done in any 1 year since 2010 was 81 in 2019 (Figure IN 29). An increase in transplant activity has been seen in the past 2 years, with 91 intestine transplants performed in 2020 and 96 in 2021. Of the 96 transplants done in the past year, 58 were intestine alone and 38 were liver-inclusive transplants (Figure IN 30).

Pediatric recipients of intestine transplants outnumbered adult recipients for at least the first 20 years of intestine transplantation, but since the late 2000s the number of intestine transplant recipients older than 18 years has overtaken that of recipients who are children or adolescents. Pediatric recipient counts declined from 62 in 2010 to a low of 32 in 2019, with only a slight rebound to 36 in 2021; adult recipient counts fell from 89 in 2010 to 60 in 2021 (Figure IN 31). In 2021, a little more than half of intestine-liver recipients were aged younger than 18 years (55.3% vs 25.9% of intestine-alone recipients) (Table IN 6). Most recipients had private insurance and resided in metropolitan areas (Table IN 6). Short-gut syndrome was the main cause of disease leading to both intestine and intestine-liver transplant (Table IN 7).

Most recipients of an intestine-containing allograft in 2021 waited less than a year from listing to their transplant: 75.8% of isolated intestine recipients and 65.8% of intestine-liver recipients (Table IN 8).

5 IMMUNOSUPPRESSION

The use of induction immunosuppression with antithymocyte globulin or interleukin 2 receptor blocking antibody is common in intestine transplant and was used in almost 80% of cases in 2021 (Figure IN 35). Tacrolimus remains the mainstay for maintenance immunosuppression, used mainly in combination with corticosteroids or mycophenolate mofetil or both (Figure IN 36). There also appears to be a decrease in the use of steroid-free regimens, although Figure IN 36 only specifies the combination of tacrolimus and mycophenolate agents without steroids, which was used in almost 30% of cases in 2012 and less than 10% in 2021.

6 OUTCOMES

There has been no noticeable change in graft survival at any time point after intestine transplant (with or without liver) across the period from 2010 through 2021 (Figure IN 37 and Figure IN 38). Graft survival at 5 years for the cohort who underwent transplant in the period 2014 through 2016 is better for those who underwent transplant at a younger age, with recipients younger than 18 years having a 62% graft survival at 5 years compared with adults having 43% survival (Figure IN 39). Graft survival for this same cohort based on whether the allograft contained the liver is essentially similar (Figure IN 40), as is the outcome for residence in a metropolitan versus non-metropolitan area (Figure IN 41).

Patient survival for the 2014-2016 cohort based on whether a patient received the liver along with the intestine shows better survival short term for intestine-alone recipients (1-year patient survival 86.4% for isolated intestine recipients vs 75.2% for recipients of combined intestine and liver), but this difference narrowed considerably by 5 years (61.2% vs 58.1%, respectively) (Figure IN 46).

REFERENCES

[1] Our changing population: United States. USAFacts. Accessed September 22, 2022. https://usafacts.org/data/topics/people-society/population-and-demographics/our-changing-population

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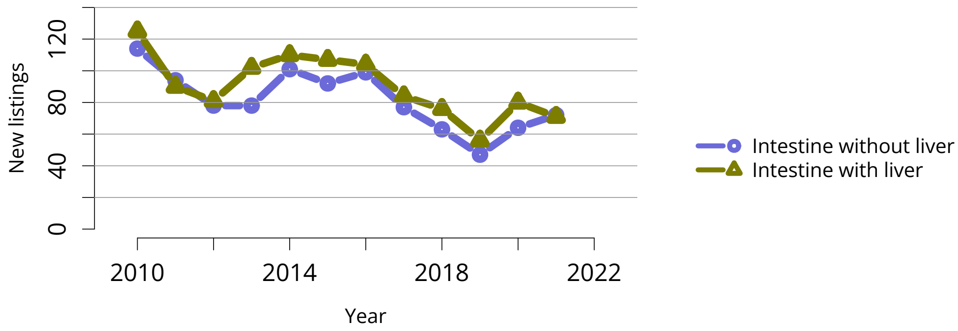

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Figure IN 1: New candidates added to the intestine transplant waiting list by liver colisting. A new candidate is one who first joined the list during the given year, without having been listed in a previous year. Previously listed candidates who underwent transplant and subsequently relisted are considered new. Active and inactive patients are included. Candidates listed at more than one center are counted once per listing. New intestine-liver candidates are those listed for both organs on the same day.

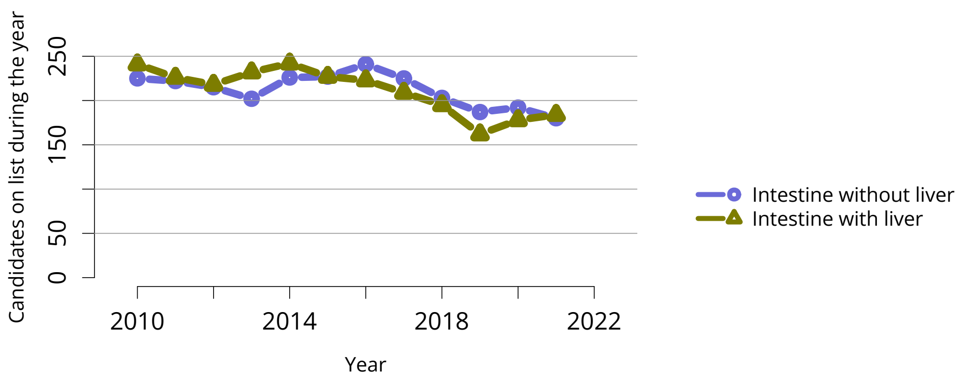

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Figure IN 2: All candidates on the intestine transplant waiting list by liver colisting. Candidates on the list at any time during the year. Candidates listed at more than one center are counted once per listing.

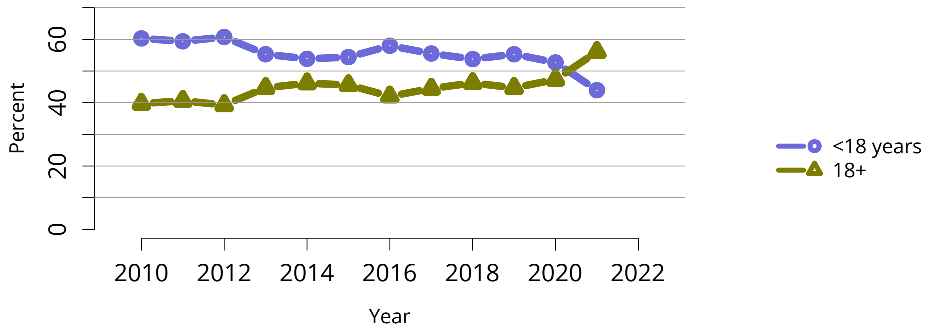

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Figure IN 3: Distribution of candidates waiting for intestine transplant by age. Candidates waiting for transplant at any time in the given year. Active and inactive candidates are included. Candidates listed at more than one center are counted once per listing. Age is determined at the earliest of transplant, death, removal, or December 31 of the year.

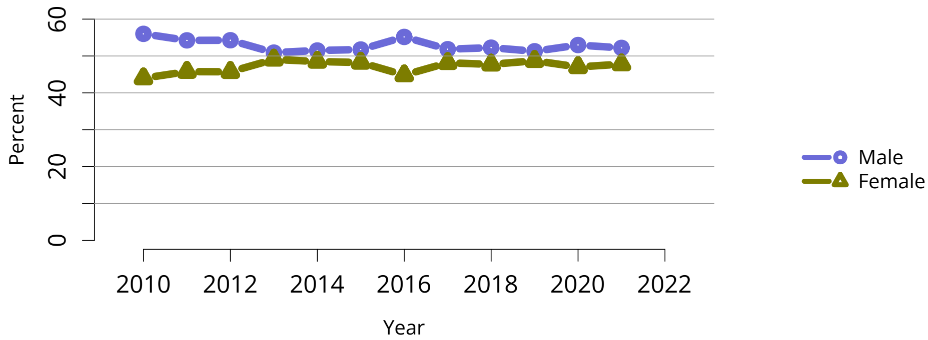

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Figure IN 4: Distribution of candidates waiting for intestine transplant by sex. Candidates waiting for transplant at any time in the given year. Active and inactive patients are included. Candidates listed at more than one center are counted once per listing.

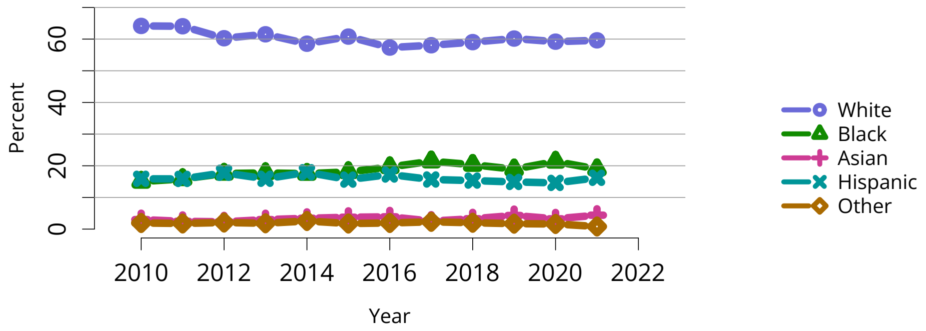

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Figure IN 5: Distribution of candidates waiting for intestine transplant by race. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

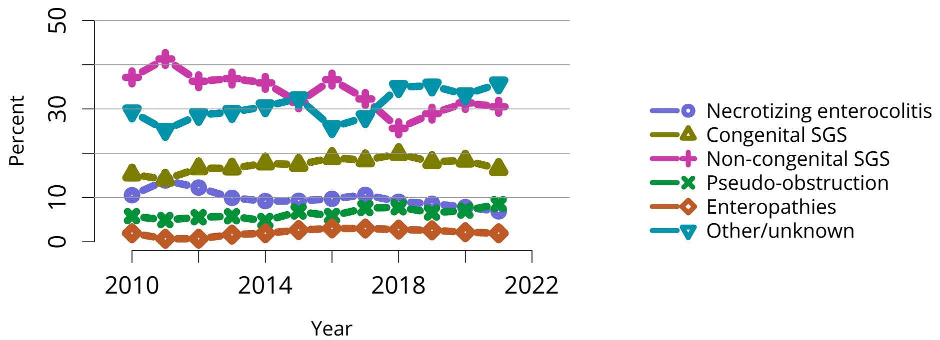

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Figure IN 6: Distribution of candidates waiting for intestine transplant by diagnosis. Candidates waiting for transplant at any time in the given year. Active and inactive patients are included. Candidates listed at more than one center are counted once per listing.

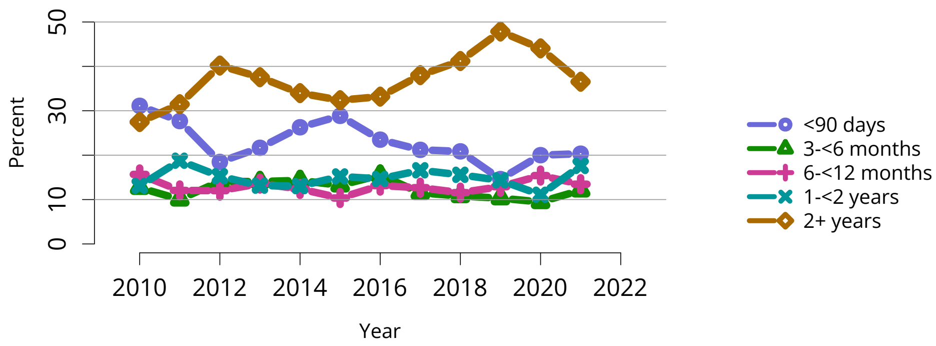

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Figure IN 7: Distribution of candidates waiting for intestine transplant by waiting time. Candidates waiting for transplant at any time in the given year. Time on the waiting list is determined at the earliest of transplant, death, removal, or December 31 of the year. Active and inactive candidates are included. Candidates listed at more than one center are counted once per listing.

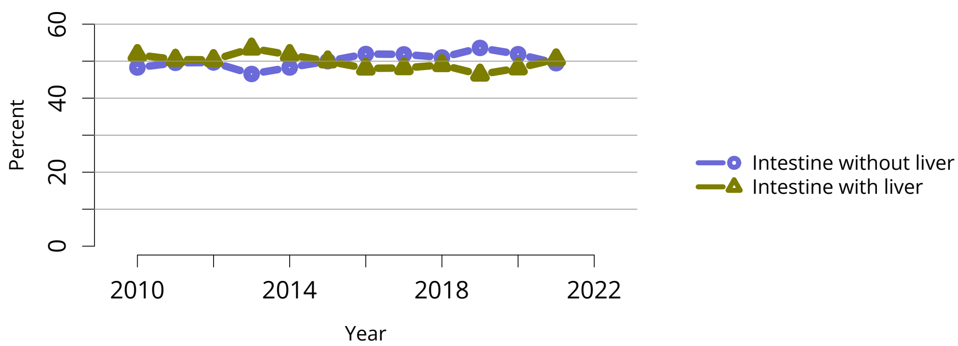

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Figure IN 8: Distribution of candidates waiting for intestine transplant by liver colisting. Candidates waiting for transplant at any time in the given year. Intestine-liver candidates were dually listed on at least one day during the year. Active and inactive patients are included. Candidates listed at more than one center are counted once per listing.

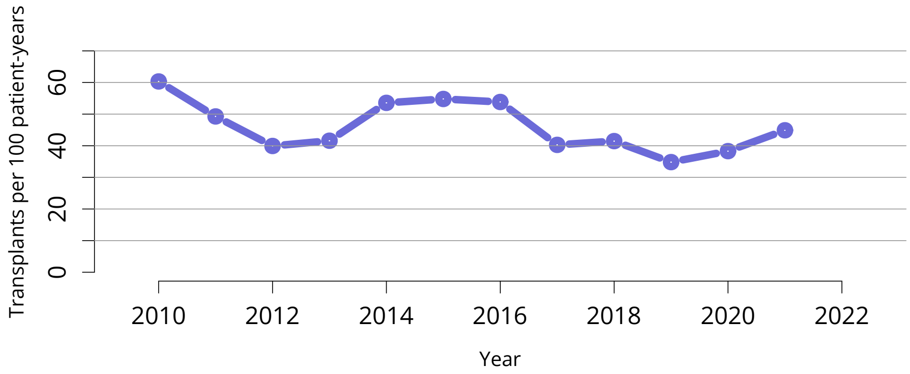

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Figure IN 9: Overall donor intestine transplant rates among waitlist candidates. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

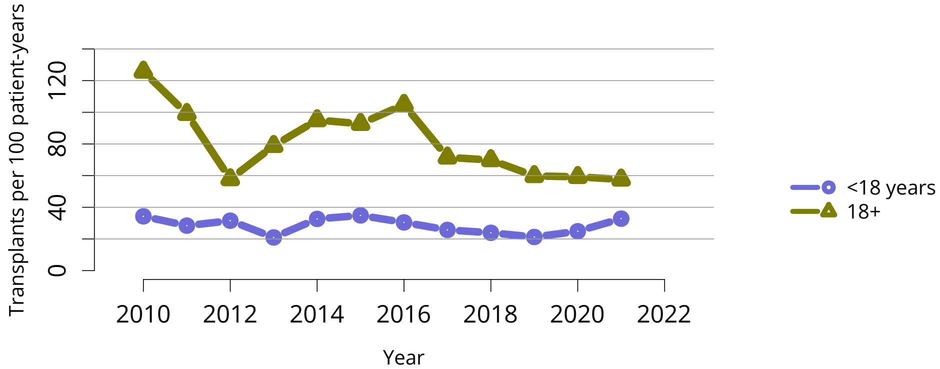

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Figure IN 10: Deceased donor intestine transplant rates among waitlist candidates by age. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.

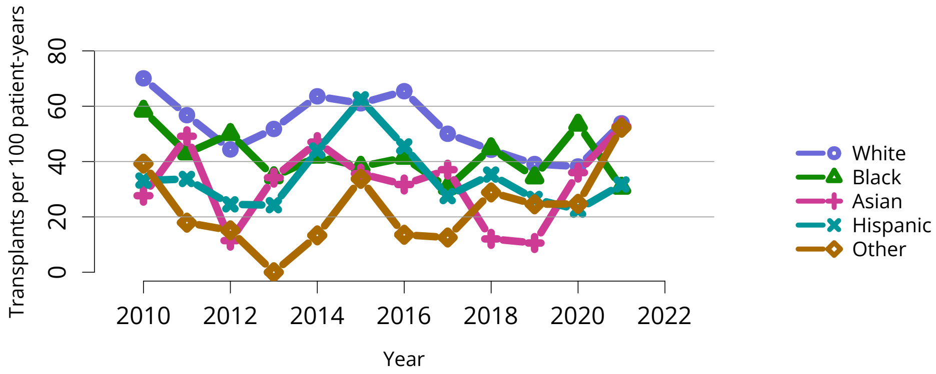

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Figure IN 11: Deceased donor intestine transplant rates among waitlist candidates by race. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

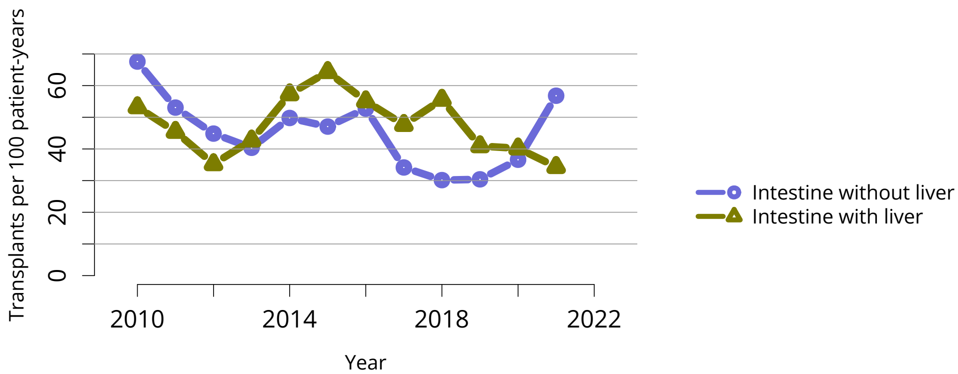

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Figure IN 12: Deceased donor intestine transplant rates among waitlisted adult candidates by liver colisting. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given year. Individual listings are counted separately. Intestine-liver colisting is determined at the time of listing.

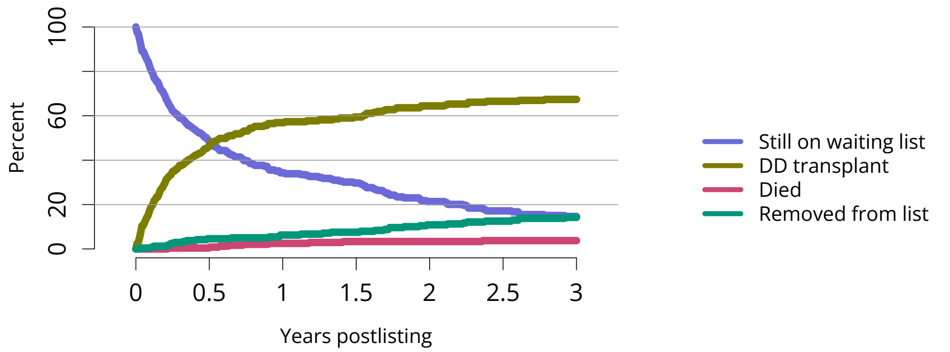

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Figure IN 13: Three-year outcomes for candidates waiting for intestine transplant without liver, new listings in 2016-2018. Candidates listed at more than one center are counted once per listing. Removed from list includes all reasons except transplant and death. DD, deceased donor.

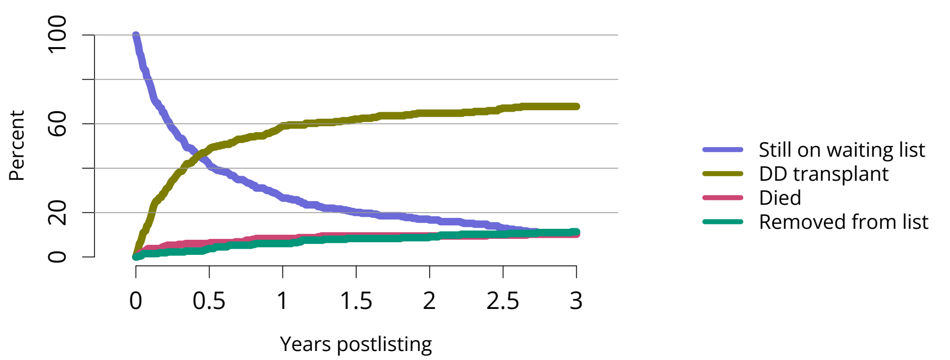

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Figure IN 14: Three-year outcomes for candidates waiting for intestine transplant with liver, new listings in 2016-2018. Candidates listed at more than one center are counted once per listing. Removed from list includes all reasons except transplant and death. DD, deceased donor.

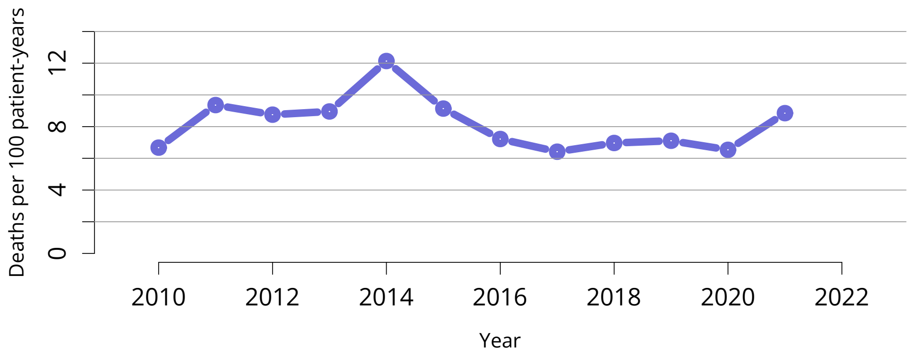

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Figure IN 15: Overall pretransplant mortality rates among candidates waitlisted for intestine transplant. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Candidates listed at more than one center are counted once per listing.

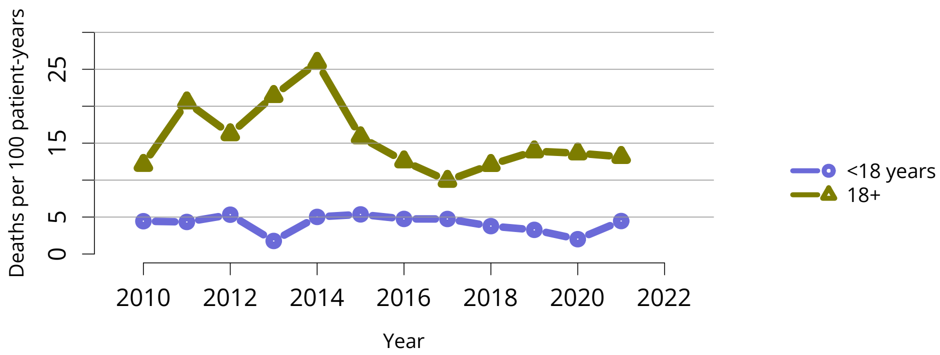

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Figure IN 16: Pretransplant mortality rates among candidates waitlisted for intestine transplant by age. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Candidates listed at more than one center are counted once per listing. Age is determined at the later of listing date or January 1 of the given year.

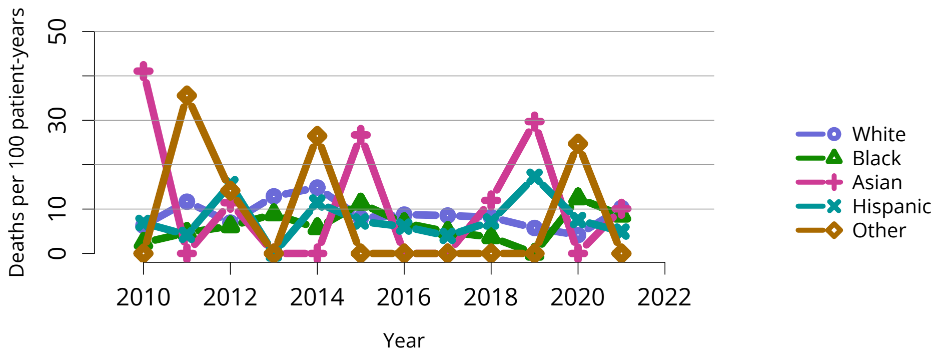

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Figure IN 17: Pretransplant mortality rates among candidates waitlisted for intestine transplant by race. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Candidates listed at more than one center are counted once per listing.

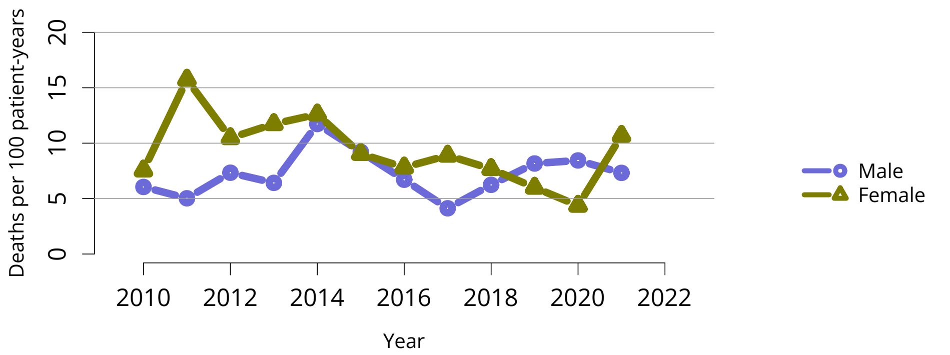

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Figure IN 18: Pretransplant mortality rates among candidates waitlisted for intestine transplant by sex. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Candidates listed at more than one center are counted once per listing.

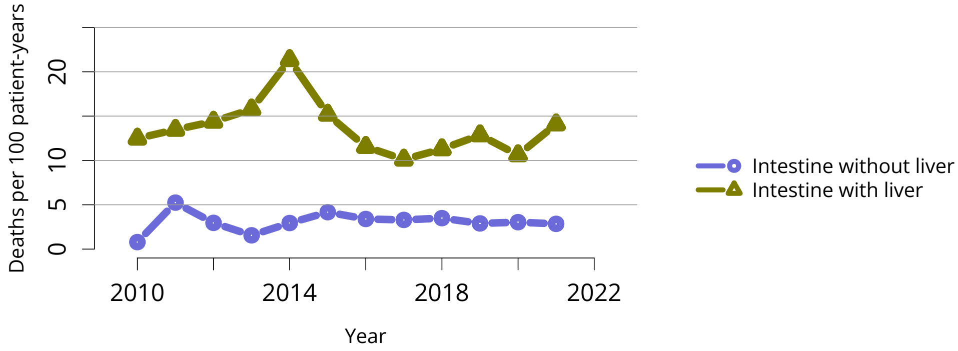

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Figure IN 19: Pretransplant mortality rates among candidates waitlisted for intestine transplant by liver colisting. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Candidates listed at more than one center are counted once per listing. Intestine-liver colisting is determined at the later of listing date and January 1 of the year.

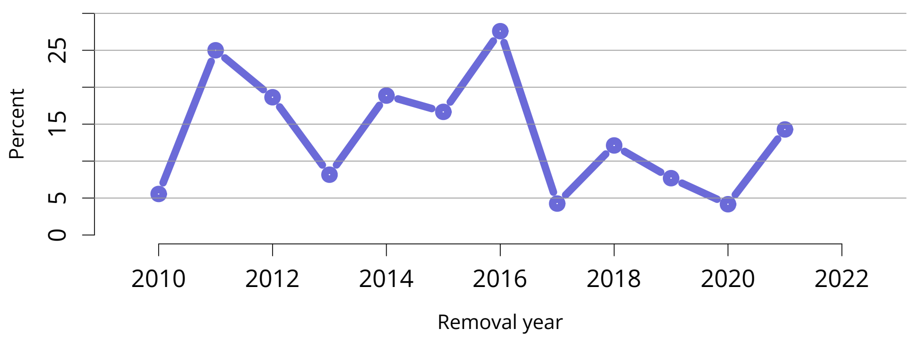

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Figure IN 20: Overall deaths within six months after removal among intestine waitlist candidates. Denominator includes only candidates removed from the waiting list for reasons other than transplant or death while on the list.

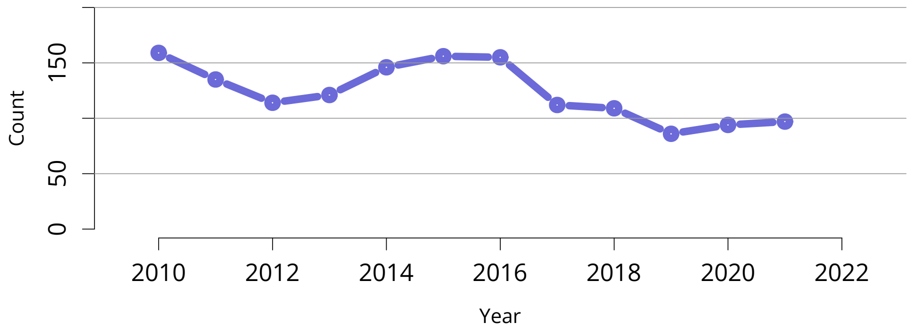

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Figure IN 21: Overall deceased intestine donor count. Count of deceased donors whose intestines were recovered for transplant.

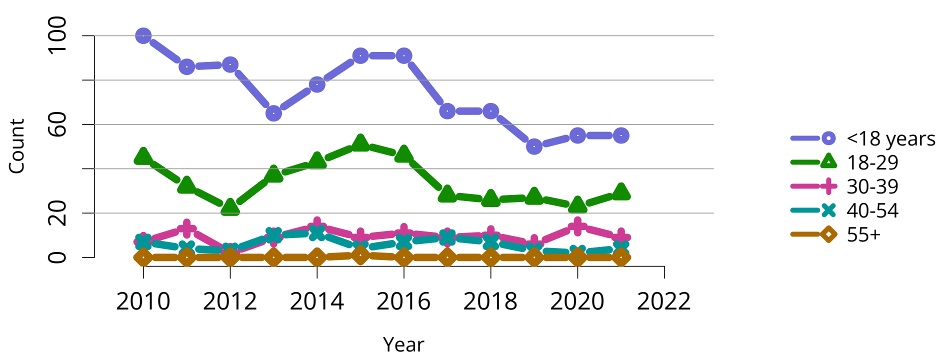

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Figure IN 22: Deceased intestine donor count by age. Count of deceased donors whose intestines were recovered for transplant.

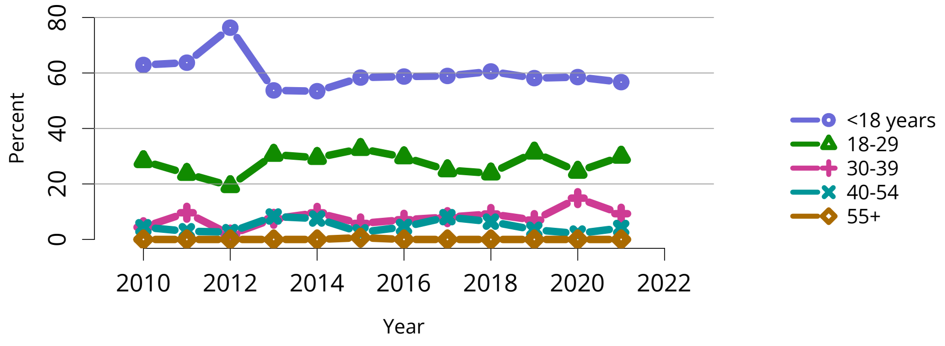

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Figure IN 23: Distribution of deceased intestine donors by age. Deceased donors whose intestines were recovered for transplant.

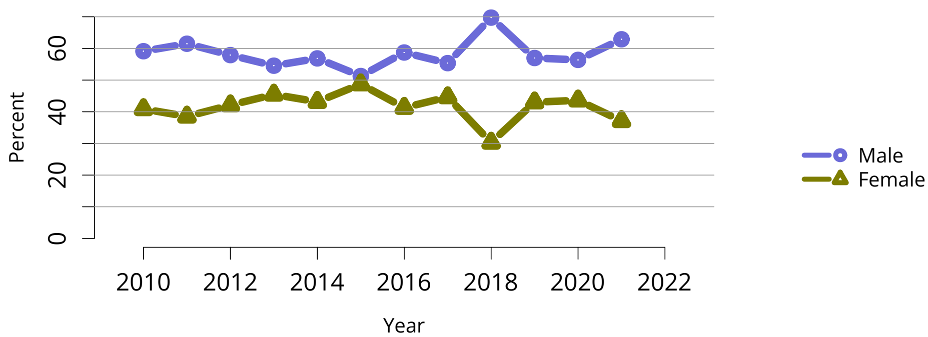

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Figure IN 24: Distribution of deceased intestine donors by sex. Deceased donors whose intestines were recovered for transplant.

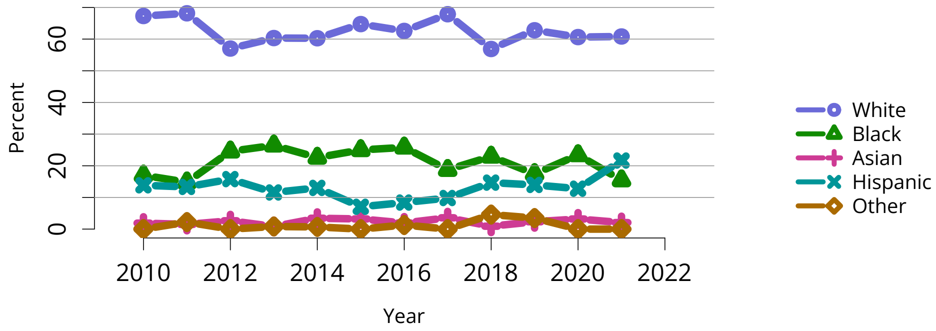

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Figure IN 25: Distribution of deceased intestine donors by race. Deceased donors whose intestines were recovered for transplant.

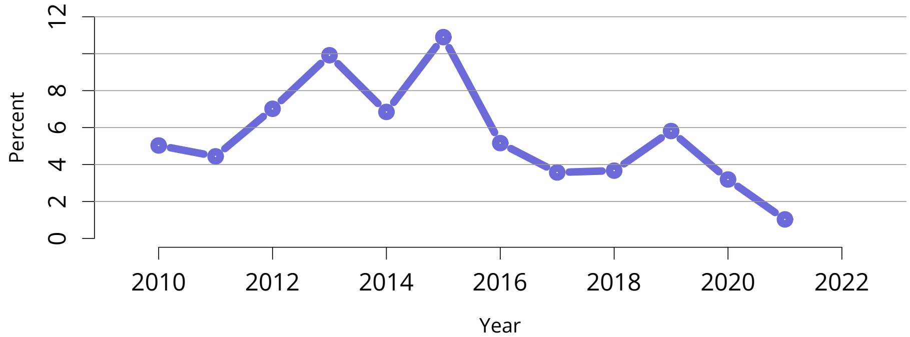

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Figure IN 26: Overall percent of intestines recovered for transplant and not transplanted. Percentages of intestines not transplanted out of all intestines recovered for transplant.

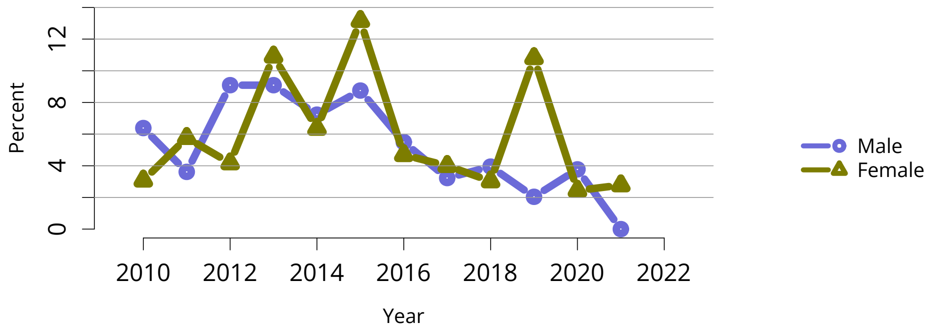

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Figure IN 27: Percent of intestines recovered for transplant and not transplanted by donor sex. Percentages of intestines not transplanted out of all intestines recovered for transplant.

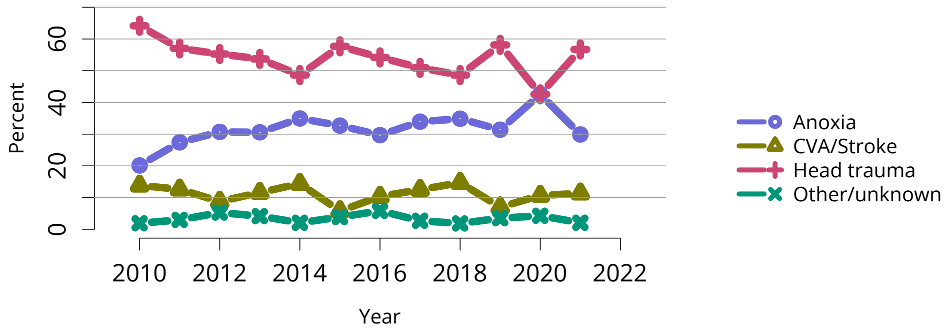

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Figure IN 28: Cause of death among deceased intestine donors. Deceased donors whose intestines were transplanted. CVA, cerebrovascular accident.

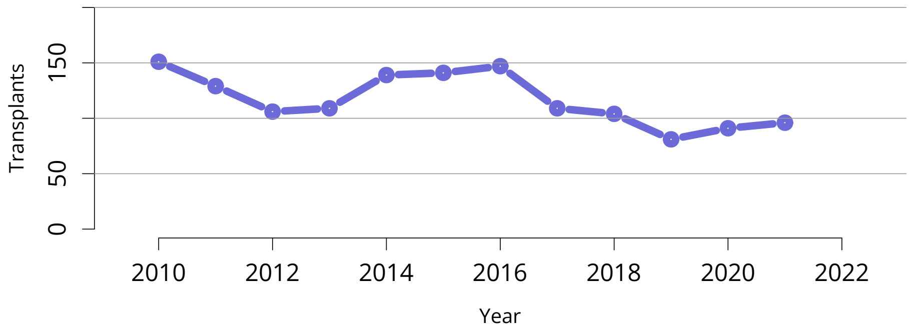

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Figure IN 29: Overall intestine transplants. All intestine transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

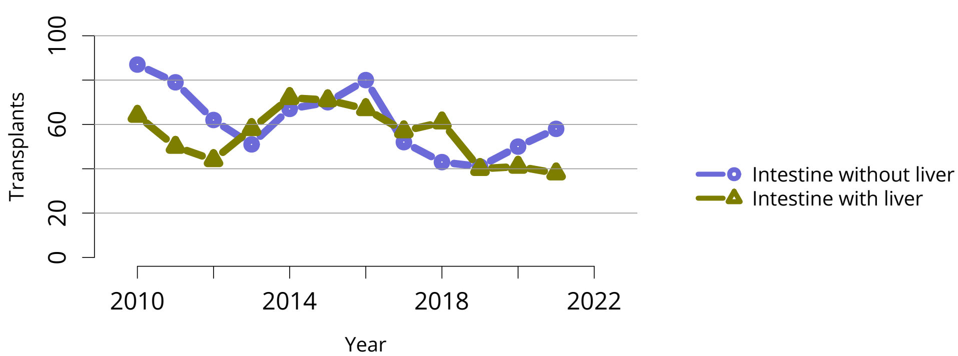

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Figure IN 30: Total intestine transplants by transplant type. All intestine transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

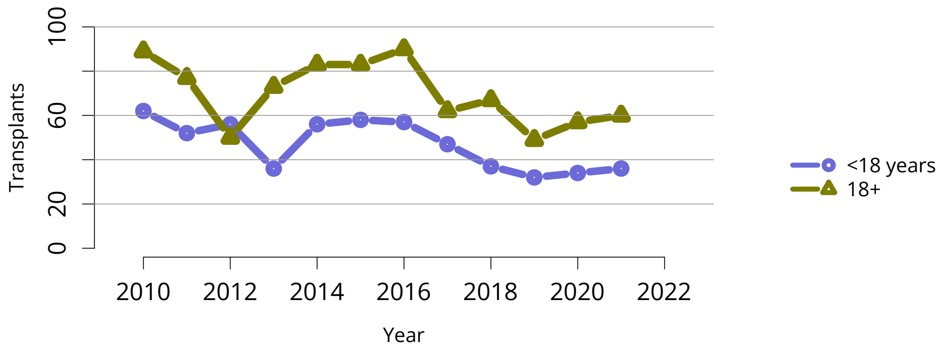

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Figure IN 31: Total intestine transplants by age. All intestine transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

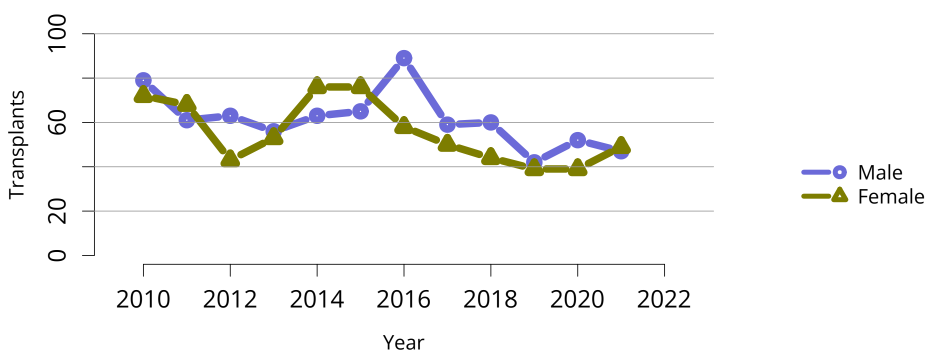

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Figure IN 32: Total intestine transplants by sex. All intestine transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

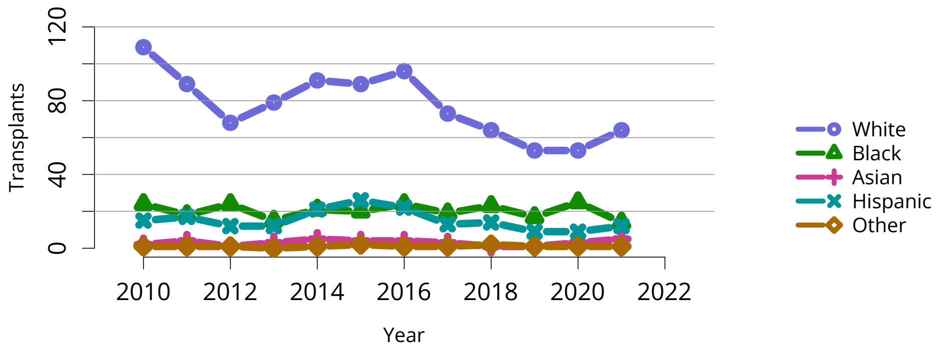

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Figure IN 33: Total intestine transplants by race. All intestine transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

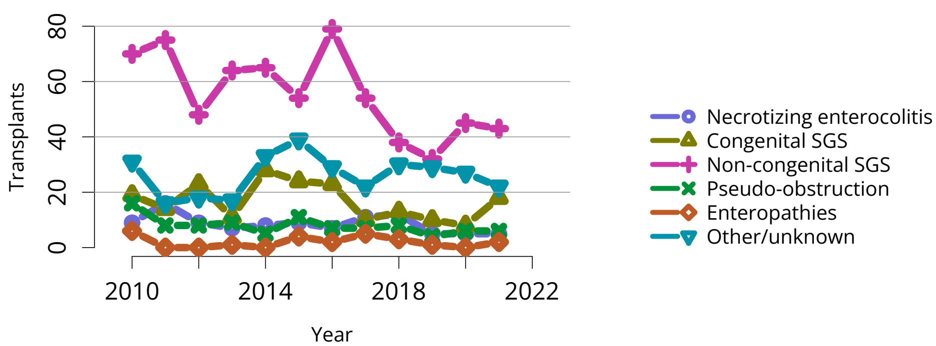

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Figure IN 34: Total intestine transplants by diagnosis. All intestine transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients. SGS, short-gut syndrome.

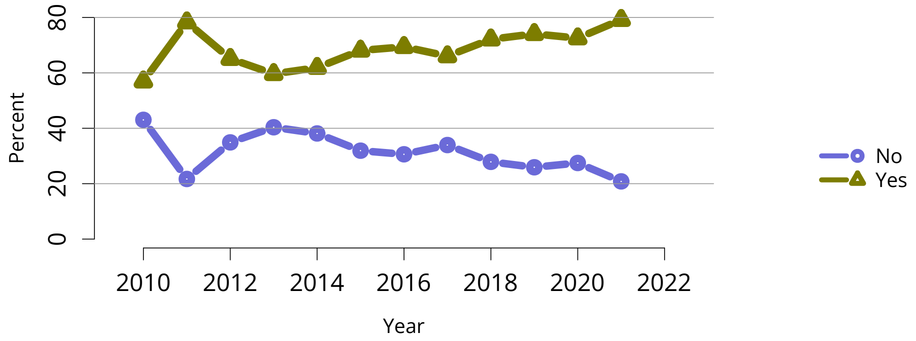

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Figure IN 35: Induction agent use in intestine transplant recipients. Immunosuppression at transplant reported to the OPTN.

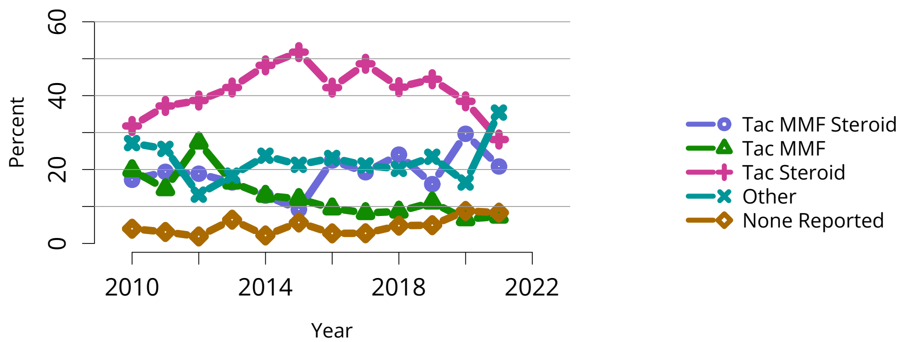

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Figure IN 36: Distribution of immunosuppression regimen use in intestine transplant recipients. Immunosuppression regimen at transplant reported to the OPTN. Tac, tacrolimus. MMF, all mycophenolate agents.

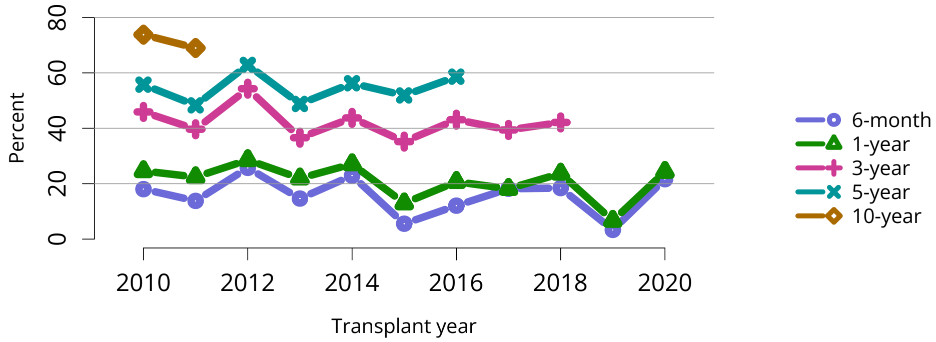

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Figure IN 37: Graft failure among transplant recipients of intestine without liver. All recipients of deceased donor intestines, including multiorgan transplants.

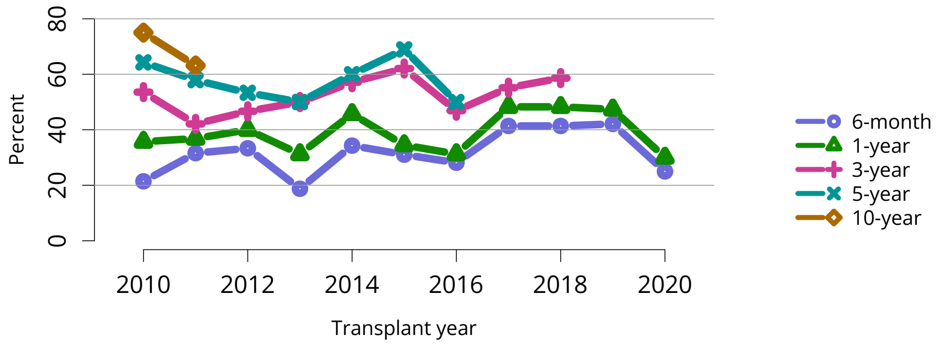

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Figure IN 38: Graft failure among transplant recipients of intestine with liver. All recipients of deceased donor intestines, including multiorgan transplants.

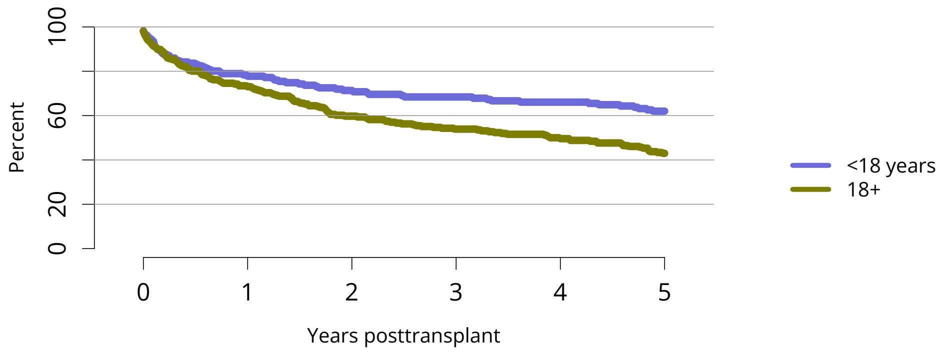

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Figure IN 39: Graft survival among deceased donor intestine transplant recipients, 2014-2016, by age. Graft survival estimated using unadjusted Kaplan-Meier methods.

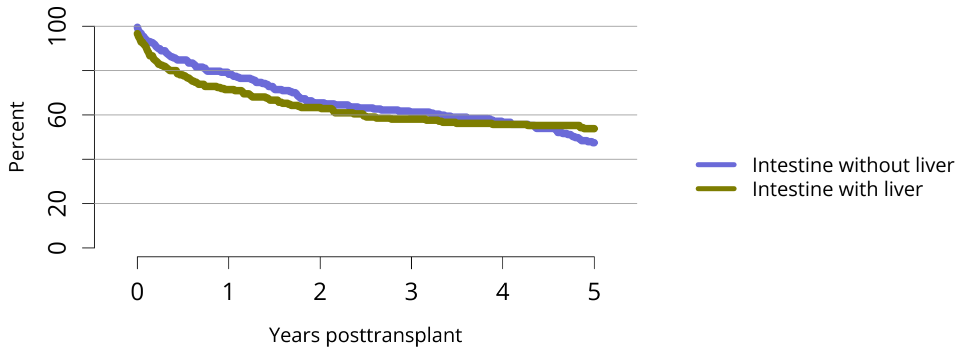

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Figure IN 40: Graft survival among deceased donor intestine transplant recipients, 2014-2016, by transplant type. Intestine graft survival estimated using unadjusted Kaplan-Meier methods.

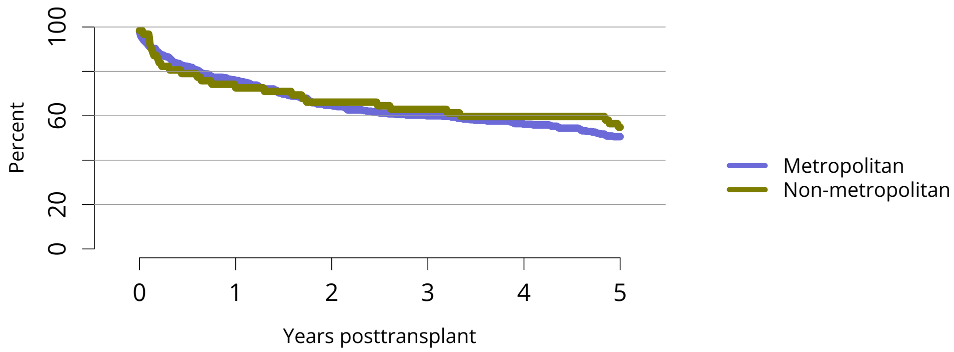

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Figure IN 41: Graft survival among deceased donor intestine transplant recipients, 2014-2016, by metropolitan vs. non-metropolitan recipient residence. Graft survival estimated using unadjusted Kaplan-Meier methods.

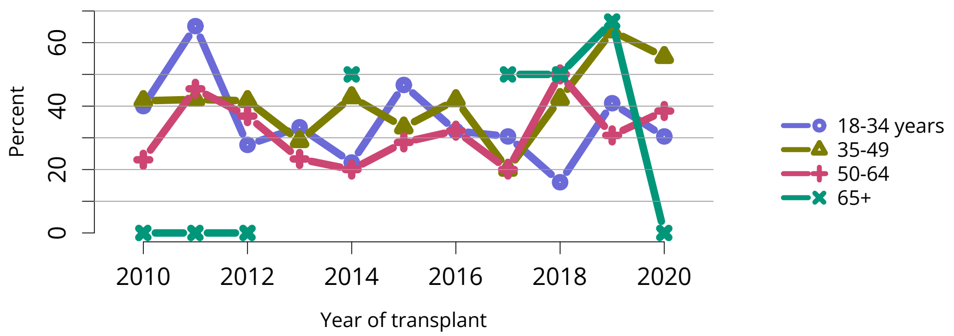

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Figure IN 42: Incidence of acute rejection by 1 year posttransplant among adult intestine transplant recipients by age. Only the first reported rejection event is counted. Cumulative incidence is estimated using the Kaplan-Meier method.

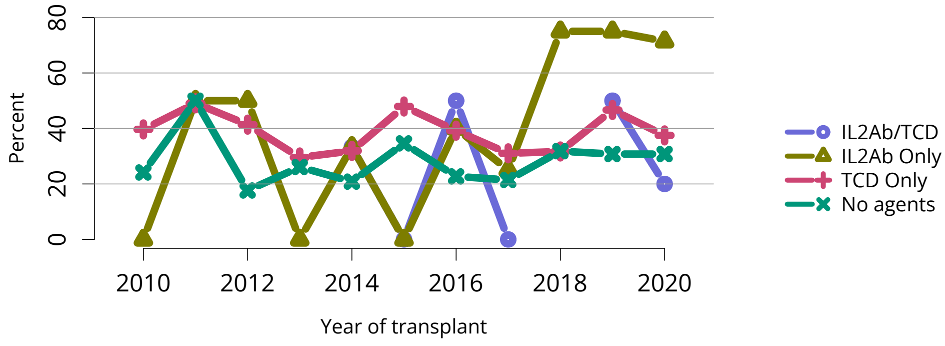

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Figure IN 43: Incidence of acute rejection by 1 year posttransplant among adult intestine transplant recipients by induction agent. Only the first reported rejection event is counted. Cumulative incidence is estimated using the Kaplan-Meier method. IL2Ab, interleukin-2 receptor antibody; TCD, T-cell depleting.

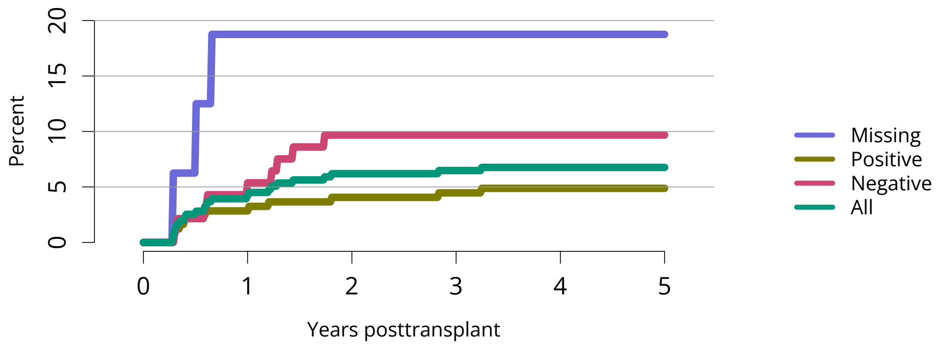

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Figure IN 44: Incidence of PTLD among recipients of intestine transplant without liver by recipient EBV status at transplant, 2010-2016. Cumulative incidence is estimated using the Kaplan-Meier method. PTLD is identified as a reported complication or cause of death on the OPTN Transplant Recipient Follow-up Form or the Posttransplant Malignancy Form as polymorphic PTLD, monomorphic PTLD, or Hodgkin's disease. Only the earliest date of PTLD diagnosis is considered. EBV, Epstein-Barr virus; PTLD, posttransplant lymphoproliferative disorder.

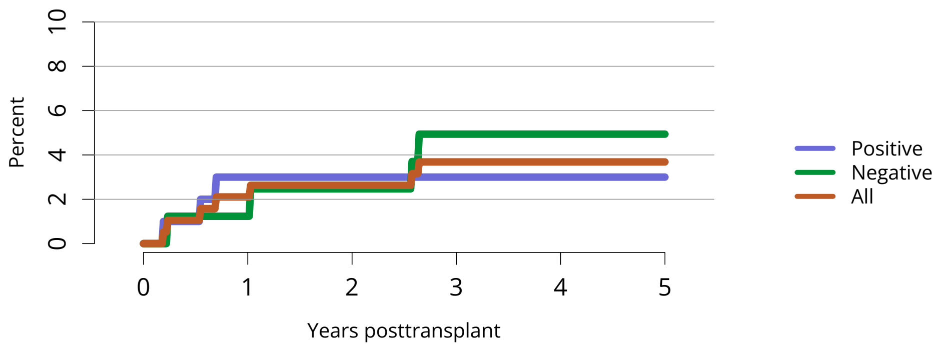

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Figure IN 45: Incidence of PTLD among recipients of intestine transplant with liver by recipient EBV status at transplant, 2010-2016. Cumulative incidence is estimated using the Kaplan-Meier method. PTLD is identified as a reported complication or cause of death on the OPTN Transplant Recipient Follow-up Form or the Posttransplant Malignancy Form as polymorphic PTLD, monomorphic PTLD, or Hodgkin's disease. Only the earliest date of PTLD diagnosis is considered. EBV, Epstein-Barr virus; PTLD, posttransplant lymphoproliferative disorder.

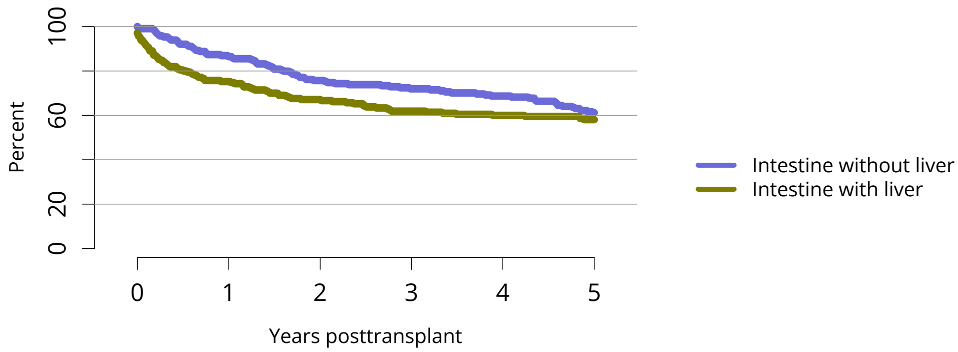

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Figure IN 46: Patient survival among deceased donor intestine transplant recipients, 2014-2016, by transplant type. Patient survival estimated using unadjusted Kaplan-Meier methods.

Table IN 1: Demographic characteristics of candidates on the intestine transplant waiting list on December 31, 2021. Candidates waiting for intestines with and without liver on December 31, 2021, regardless of first listing date. Distance is computed from candidate's home zip code to the transplant center.

	IN		IN-LI	
Characteristic	**N**	**Percent**	**N**	**Percent**
Age (years)				
<18 years	46	50	47	43.1
18-34	17	18.5	24	22
35-49	18	19.6	20	18.3
50-64	11	12	16	14.7
65+	0	0	2	1.8
Sex				
Male	41	44.6	67	61.5
Female	51	55.4	42	38.5
Race				
White	49	53.3	61	56
Black	20	21.7	23	21.1
Asian	5	5.4	3	2.8
Hispanic	17	18.5	22	20.2
Other	1	1.1	0	0
Geography				
Metropolitan	81	88	92	84.4
Non-metropolitan	9	9.8	13	11.9
Missing	2	2.2	4	3.7
Miles between candidate to center				
<50 miles	26	28.3	36	33
50-<100	8	8.7	13	11.9
100-<150	5	5.4	11	10.1
150-<250	15	16.3	18	16.5
250+	36	39.1	27	24.8
Missing	2	2.2	4	3.7
All candidates				
All candidates	92	100	109	100

Table IN 2: Clinical characteristics of candidates on the intestine transplant waiting list on December 31, 2021. Candidates waiting for intestines with and without liver on December 31, 2021, regardless of first listing date. SGS, short-gut syndrome.

	IN		IN-LI	
Characteristic	**N**	**Percent**	**N**	**Percent**
Diagnosis				
Necrotizing enterocolitis	7	7.6	8	7.3
Congenital SGS	16	17.4	19	17.4
Non-congenital SGS	31	33.7	36	33
Pseudo-obstruction	14	15.2	6	5.5
Enteropathies	1	1.1	3	2.8
Other/unknown	23	25	37	33.9
Blood Type				
A	34	37	41	37.6
AB	5	5.4	1	0.9
B	13	14.1	14	12.8
O	40	43.5	53	48.6
All candidates				
All candidates	92	100	109	100

Table IN 3: Listing characteristics of candidates on the intestine transplant waiting list on December 31, 2021. Candidates waiting for intestines with and without liver on December 31, 2021, regardless of first listing date.

	IN		IN-LI	
Characteristic	**N**	**Percent**	**N**	**Percent**
Waiting time				
<90 days	14	15.2	11	10.1
3-<6 months	7	7.6	7	6.4
6-<12 months	11	12	20	18.3
1-<2 years	19	20.7	24	22
2+ years	41	44.6	47	43.1
Previous transplant				
No prior transplant	81	88	90	82.6
Prior transplant	11	12	19	17.4
All candidates				
All candidates	92	100	109	100

Table IN 4: Intestine transplant waitlist activity, 2021. Candidates listed at more than one center are counted once per listing. Candidates who are listed, undergo transplant, and are relisted are counted more than once. Candidates are not considered to be on the list on the day they are removed; counts on January 1 may differ from counts on December 31 of the prior year. Candidates listed for multiorgan transplants are included.

Waiting list state	IN	IN-LI
Waiting list state		
Patients at start of year	108	113
Patients added during year	72	71
Patients removed during year	88	75
Patients at end of year	92	109

Table IN 5: Removal reason among intestine transplant candidates, 2021. Removal reason as reported to the OPTN. Candidates with death dates that precede removal dates are assumed to have died waiting.

Removal reason	IN	IN-LI
Removal reason		
Deceased donor transplant	57	38
Patient died	3	12
Patient refused transplant	1	0
Improved, transplant not needed	16	7
Too sick for transplant	0	10
Other	11	8

Table IN 6: Demographic characteristics of intestine transplant recipients, 2021. Intestine transplant recipients, including retransplants. Distance is computed from recipient's home zip code to the transplant center.

	IN		IN-LI	
Characteristic	**N**	**Percent**	**N**	**Percent**
Recipient age (years)				
<18 years	15	25.9	21	55.3
18-34	15	25.9	3	7.9
35-49	15	25.9	9	23.7
50-64	11	19	5	13.2
65+	2	3.4	0	0
Sex				
Male	26	44.8	21	55.3
Female	32	55.2	17	44.7
Race				
White	40	69	24	63.2
Black	9	15.5	5	13.2
Asian	3	5.2	2	5.3
Hispanic	5	8.6	7	18.4
Other	1	1.7	0	0
Insurance				
Private	32	55.2	17	44.7
Medicare	11	19	5	13.2
Medicaid	11	19	12	31.6
Other/unknown	4	6.9	4	10.5
Geography				
Metropolitan	53	91.4	29	76.3
Non-metropolitan	3	5.2	6	15.8
Missing	2	3.4	3	7.9
Miles between recipient to center				
<50 miles	26	44.8	13	34.2
50-<100	4	6.9	2	5.3
100-<150	8	13.8	4	10.5
150-<250	4	6.9	5	13.2
250+	14	24.1	11	28.9
Missing	2	3.4	3	7.9
All recipients				
All recipients	58	100	38	100

Table IN 7: Clinical characteristics of intestine transplant recipients, 2021. Intestine transplant recipients, including retransplants. SGS, short-gut syndrome. MELD scores are given for intestine-liver candidates.

	IN		IN-LI	
Characteristic	**N**	**Percent**	**N**	**Percent**
Diagnosis				
Necrotizing enterocolitis	3	5.2	2	5.3
Congenital SGS	6	10.3	12	31.6
Non-congenital SGS	33	56.9	10	26.3
Pseudo-obstruction	5	8.6	1	2.6
Other/unknown	9	15.5	13	34.2
Enteropathies	2	3.4	0	0
Blood Type				
A	20	34.5	14	36.8
B	11	19	1	2.6
O	26	44.8	23	60.5
AB	1	1.7	0	0
All recipients				
All recipients	58	100	38	100

Table IN 8: Transplant characteristics of intestine transplant recipients, 2021. Intestine transplant recipients, including retransplants.

	IN		IN-LI	
Characteristic	**N**	**Percent**	**N**	**Percent**
Waiting time				
<90 days	29	50	8	21.1
3-<6 months	10	17.2	10	26.3
6-<12 months	5	8.6	7	18.4
1-<2 years	8	13.8	4	10.5
2+	6	10.3	9	23.7
Donor type				
Deceased donor	58	100	38	100
Previous transplant for recipients				
Prior transplant	3	5.2	6	15.8
No Prior transplant	55	94.8	32	84.2
All recipients				
All recipients	58	100	38	100

OPTN/SRTR 2021 Annual Data Report: Heart

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Abstract

The past 5 years have posed challenges to the field of heart transplantation. The 2018 heart allocation policy revision was accompanied by anticipated practice adjustments and increased use of short-term circulatory support, changes that may ultimately serve to advance the field. The COVID-19 pandemic also had an impact on heart transplantation. While the number of heart transplants in the United States continued to increase, the number of new candidates decreased slightly during the pandemic. There were slightly more deaths following removal from the waiting list for reasons other than transplant during 2020, and a decline in transplants among candidates listed as status 1, 2, or 3 compared with the other statuses. Heart transplant rates decreased among pediatric candidates, most notably among those younger than 1 year. Despite this, pretransplant mortality has declined for both pediatric and adult candidates, particularly candidates younger than 1 year. Transplant rates have increased in adults. The prevalence of ventricular assist device use has increased among pediatric heart transplant recipients, while the prevalence of short-term mechanical circulatory support, particularly intra-aortic balloon pump and extracorporeal membrane oxygenation, has increased among adult recipients.

Keywords: Allocation, donor, heart failure, heart transplant, left ventricular assist device, mechanical circulatory support, outcomes

1 INTRODUCTION

Heart transplantation continues to provide selected patients with advanced heart failure substantially better quality of life and survival than left ventricular assist devices, the only other viable therapy for patients with stage D heart failure. Donor availability, disparities in access, and optimal risk stratification remain challenges. As we enter the fifth year of the 2018 Organ Procurement and Transplantation Network (OPTN) heart allocation policy, it is apparent that heart allocation practices have shifted toward the use of short-term mechanical circulatory support, the most expeditious route for heart transplant. The Annual Data Report provides an evaluation of trends in US adult and pediatric heart transplant waiting lists, donation, transplants, and outcomes. Although data following the policy change are available, inherent differences in calculations during 2018 should be considered when assessing rates and other data obtained during that year (ie, data for 2018 should be interpreted with caution). An additional consideration is that when the new policy took effect on October 18, 2018, new statuses were assigned to candidates who remained on the waiting list. Because these candidates were only counted under the newly assigned statuses, the number of candidates who were awaiting transplant under the prior statuses (1A, 1B, or 2) may be lower or greater than expected in 2018.

2 ADULT HEART TRANSPLANT

2.1 Waiting List

Despite successful medical therapies for heart failure, the number of new heart transplant candidates continues to grow. The COVID-19 pandemic had a small impact on new listings. Following a plateau in 2018 through 2020, with a slight decrease in 2020 (from 4,087 in 2019 to 4,000 in 2020), the number of new listings increased to 4,373 in 2021, the largest increase in the past decade (Figure HR 1). The number of candidates prevalent on the list increased 32.3% from 2010 through 2016, peaking at 7,684 candidates, then declined from 2018 through 2020, likely due to higher transplant rates and fewer listings during the COVID-19 pandemic (Figure HR 2). Although the largest age group on the waiting list in 2021 was 50-64 years, there has been a gradual decrease in this age group since 2010. Candidates aged 65 years or older made up 20.4% of the list in 2021, an increase from 16.5% in 2010. Trends among other age groups have been stable since 2016 (Figure HR 3). Sex distribution remains relatively constant, with women constituting 24.9% in 2021 (Figure HR 4). There has been an increasing prevalence of non-White candidates. White candidates decreased from 69.4% in 2010 to 57.9% in 2021, while Black candidates increased from 20.4% to 27.4% and Hispanic candidates (includes candidates who are categorized as White and Hispanic or solely Hispanic) increased from 7.0% to 10.1%. Asian candidates have similarly increased, making up 3.6% of candidates in 2021 (Figure HR 5).

Coronary artery disease has become a less common primary diagnosis for heart transplant, and cardiomyopathy remains the most common diagnosis for heart transplant. In 2021, only 28.6% of all candidates, compared with 38.2% in 2010, were listed for coronary artery disease. Despite a change in allocation policy that provides a status for candidates with congenital heart disease, listings for congenital heart disease were infrequent, 4.7% in 2021, and overall stable since 2010. Listings for valvular heart disease are rare, 1.1% in 2021 (Figure HR 6).

Prior to the new policy, the proportion of candidates who were listed as status 2 declined from 2010 through 2017, whereas that of candidates listed as status 1A continued to gradually increase and candidates listed as status 1B reached a plateau (Figure HR 8). Following implementation of the new policy, most candidates were listed as status 4 (28.9% in 2021), followed by status 2 (24.7% in 2021). A major concern regarding the policy change was the potential increase in patients with extracorporeal membrane oxygenation (ECMO), and subsequently in status 1 listings. As anticipated, status 1 listings have increased since 2019; 5.5% of candidates were awaiting transplant as status 1 in 2021 (Figure HR 9). It is anticipated that this trend will continue.

While the age and sex of the typical heart transplant candidate in 2021 have not changed compared with 2011, there are substantially more Black and Hispanic candidates (Table HR 1), fewer with coronary artery disease, more with ventricular assist devices (VADs) (Table HR 2), and fewer who reside 150 miles or farther from the transplant center (Table HR 1).

2.2 Transplant Rates

Overall transplant rates were stable until 2016, after which there was a steady increase to 106.2 transplants per 100 patient-years in 2021, the highest rate this past decade (Figure HR 13). A similar trend was seen among all groups (excluding statuses), with the greatest 10-year increases occurring in candidates with the following attributes: aged

65 years or older, White, congenital heart disease, blood type B, female, and height of 150-<160 cm. Overall transplant rates increased 37.7% since 2017; however, marked increases (49.2% or greater) occurred among candidates aged 65 years or older, who are Asian or Hispanic, who have congenital heart disease or coronary artery disease, with blood type AB or B, and who are 150-<160 cm tall. Candidates in metropolitan and non-metropolitan areas have had similar transplant rates. Candidates aged 35-49 years, 180 cm or taller, Black candidates, those with congenital heart disease, and those of blood type O undergo transplant at substantially lower rates than others in their categories. Candidates with congenital heart disease continue to undergo transplant markedly slower than those with other diagnoses, 80.6 transplants per 100 patient-years, and slower than all other subgroups assessed in this report except blood group O, 72.7 transplants per 100 patient-years (Figures HR 14, 15, 16, 17, 18, 21, and 22).

It was anticipated that under the revised policy, transplant rates would increase, particularly among the highest-urgency candidates. Rates calculated during 2018 must be interpreted with caution due to variations created by relisting under new statuses and variations in exposure times for all statuses compared with 2017 and 2019. For this reason, 2018 will be excluded in this evaluation, although the data are available in the supporting information file (F19 and F20 tabs). Prior to the policy change, transplant rates among status 1A and 1B candidates reached a nadir of 212 and 66 transplants per 100 patient-years, respectively, in 2014, after which rates began to increase again. Status 2 transplant rates steadily declined until 2015 (Figure HR 19). Among the new status categories, transplant rates have fluctuated since 2019. As anticipated, the highest-urgency candidates undergo transplant the fastest: in 2021, status 1 candidates underwent transplant at a rate of 1,491.6 transplants per 100 patient-years; status 2, 1,069.7 per 100 patient-years; and status 3, 253.2 per 100 patient-years. Status 4 candidates have a much slower rate of transplant (73.3 transplants per 100 patient-years) followed by statuses 6 and 5 (62.9 and 49.6 transplants per 100 patient-years, respectively). A small proportion of adult patients were assigned to the pediatric listing statuses after October 18, 2018 (Figure HR 20). The transplant rates of these candidates fluctuated following the policy change.

Among adults listed for heart transplant during 2016-2018, 56.2% had undergone transplant by 1 year, 27.8% were still waiting, 5.0% died, and 11.0% had been removed. By 3 years, 66.7% had undergone transplant, 7.8% were still waiting, 6.3% died, and 19.2% had been removed (Figure HR 23). Candidates who underwent transplant within 3 months, 6 months, and 1 year of listing have increased since 2010 after reaching a nadir in 2014. There was a marked increase following the policy change, and, in 2020, 54% of candidates underwent transplant within 3 months of listing. Still, close to 30% of candidates have not undergone transplant by years 5 and 10 (Figure HR 24). The number of patients remaining on the waiting list at end of year has decreased from 2019 through 2021, despite increasing numbers being added because of an increase in donors and subsequently increased transplant rates (Table HR 4). More patients were removed for transplant or death in 2021 compared with 2019, and fewer were removed due to being too ill for transplant (Table HR 5).

2.3 Pretransplant Mortality

Following a plateau in 2010-2015, the overall pretransplant mortality rate declined 39.4% from 14.2 deaths per 100 patient-years in 2015 to 8.5 deaths per 100 patient-years in 2019 (Figure HR 25). Since then, the pretransplant mortality rate has been stable and was 8.6 deaths per 100 patient-years in 2021. There was a downward trajectory for all ages, races and ethnicities, sexes, and residential settings (metropolitan vs non-metropolitan). Candidates whose race was categorized as other had wide fluctuations in pretransplant mortality, with a peak of 40.9 deaths per 100 patient-years in 2017; however, this may be a spurious value and due to a small sample size (Figure HR 27). Candidates aged 18-34 years had a large decline in pretransplant mortality and now have the lowest mortality rate of all age groups: 6.5 deaths per 100 patient-years in 2021. Pretransplant mortality in candidates aged 65 years or older has declined but remains slightly higher than in other age groups: 11.1 deaths per 100 patient-years in 2021 (Figure HR 26). Among the diagnoses, there were wide fluctuations in pretransplant mortality among candidates with congenital heart disease and valvular heart disease. Valvular heart disease and other (as diagnosis) tend to have higher pretransplant mortality relative to other diagnoses. Despite having the lowest transplant rate of the diagnosis groups, patients with congenital heart disease also tend to have the lowest pretransplant mortality (Figure HR 29). Although pretransplant rates have been similar between candidates residing in metropolitan and non-metropolitan areas, since 2017 pretransplant mortality has trended slightly higher among candidates who reside in non-metropolitan areas (Figure HR 30).

Due to the aforementioned characteristics of rate calculations by status in 2018, the year 2018 will be excluded from this assessment of pretransplant mortality trends by status even though it is shown in the graphs (Figures HR 31 and 32). The pretransplant mortality of temporarily inactive candidates gradually declined since 2015. Among active candidates, those listed at the highest-urgency status tend to have the highest pretransplant mortality, both before and after the updated heart allocation policy. Under the prior policy, there was substantial decline in pretransplant mortality from 2010 through 2017 for status 1A and 1B candidates: 59.2% and 56.2%, respectively. There was little change in pretransplant mortality for candidates listed as status 2 under the prior system (Figure HR 31). Under the new system, candidates listed as status 1 have a markedly higher pretransplant mortality rate compared with other statuses; following a peak of 127.3 deaths per 100 patient-years in 2020 (excluding 2018), pretransplant mortality for status 1 candidates declined to 70.7 deaths per 100 patient-years in 2021. A similar trend was seen among status 2 candidates: 43.7 deaths per 100 patient-years in 2021. Candidates listed as status 3 had the third highest pretransplant mortality (among active listings): 17.4 deaths per 100 patient-years in 2021 (Figure HR 32). Despite broader sharing under the new heart allocation policy, there remains wide geographic variability in pretransplant mortality. Two donation service areas (DSAs) had pretransplant mortality of 0 and one DSA had a pretransplant mortality of 46.2 in 2021. Variability in pretransplant mortality rates may reflect center-specific practices and differences in patient selection, in addition to geographic variability in access (Figure HR 33).

The percentage of candidates who died within 6 months of removal from the waiting list for reasons other than transplant or death has declined from 27.9% in 2010 to 12.5% in 2021 (Figure HR 34). The trend persisted across age groups, although there was a slight increase over the past 5 years for the oldest age group (65 years or older). Candidates aged 50-64 years had a marked decline compared with other age groups, despite having had the highest mortality after removal for several years. Candidates aged 50-64 years have a comparable distribution of mortality to candidates aged 18-34 years (Figure HR 35). Prior to the policy change, there was a clear decline in mortality within 6 months of removal from the waiting list for reasons other than transplant or death; however, trends are less clear among the new statuses. Since 2019, there appears to have been an increase in mortality after removal for candidates listed as statuses 1, 2, or 6 and no change to a slight decrease for statuses 3 and 5, although, if we compare with 2018, there was a decline in mortality for all statuses except status 6. There was a noticeable decline in mortality for status 4 candidates, from 16.2% in 2019 to 5.3% in 2021. More time is required to fully assess trends in mortality after removal (Figure HR 36).

2.4 Donation

Despite the pandemic, the number of donors from whom a heart was recovered continued to increase, especially among the age groups 18-29 and 30-39 years. In 2021, 3,901 hearts were recovered for transplant (Figure HR 37). Most donors continue to be aged 18-29 years (35.1%) and 30-39 years (29.8%) (Figure HR 38). Pediatric donors and donors aged 55 years or older declined to a nadir of 13.4% and 1.8%, respectively (Figure HR 39). There are slightly fewer female donors compared with 2010; racial and ethnic distribution remains unchanged (Figures HR 40 and 41). Hearts recovered for transplant from donors who died from anoxia has steadily increased over the past decade, with no change between 2020 and 2021. Death from anoxia is the most common cause of death for donors, 45.0% in 2021, followed by head trauma, 40.8% (Figure HR 42).

The proportion of hearts recovered for transplant but not transplanted remains low, and in 2021, the rate of nonuse was 1.02% (Figure HR 43). There were similar trends seen by age, sex, race, hypertension status, body mass index (BMI), donor cause of death, and donor risk, with an overall increase over the past decade (Figures HR 44, 46, 47, 48, 49, and 50). In 2021, all hearts from Asian and pediatric donors were used. Nonuse was highest among donors with the following attributes: aged 30-39 years (1.7%), male (1.2%), hypertension (1.9%), BMI 40 kg/m^2 or greater (4.3%), cerebrovascular accident/stroke (1.7%), or other/unknown cause of death (2.3%) (Figures HR 44, 45, 46, 47, 48, and 49). Hearts from donors with hypertension were not used at twice the rate of those from donors without hypertension. Despite the trends among heart donors, rates of nonuse are extremely low compared with other organ groups.

2.5 Transplants

The upward trajectory in the number of heart transplants continued despite the COVID-19 pandemic. Heart transplants increased 67.4% from 2010 to 2021 (Figure HR 51). Increases were seen across all ages, sexes, races and ethnicities, and causes of heart failure except valvular heart disease, which declined to 22 transplants in 2021 (Figure HR 55). Notably, recipients aged 65 years or older increased 127.0%, from 322 in 2010 to 731 in 2021 (Figure HR 52). From 2010 to 2021, the numbers of Asian and Hispanic recipients increased 146.9% and 149.3%, respectively (Figure HR 54). When compared with adult heart transplant recipients in 2011, adult recipients in 2021 were older, more often male, and more often White, although there were more non-Whites than in 2011. The prevalence of recipients with Medicaid as the primary payer increased from 9.8% to 14.4% (Table HR 7). In general, adult recipients received a heart transplant for cardiomyopathy and were most likely to have blood type O or A. Fifty-nine percent of patients had calculated panel-reactive antibody < 20% in 2021; however, this value was missing for 28.2% of recipients, a marked increase from 3.3% missingness in panel-reactive antibody in 2011 (Table HR 8).

The number of recipients who received a transplant as status 1A increased from 2010 to 2017, whereas the number of status 2 recipients declined. In 2018, there was a decline in status 1A and 1B recipients, but an increase in status 2 recipients. The number of transplants under the new statuses is expectedly low in 2018; however, from 2019 through 2021, there was an increase in transplants among all statuses except 3, 4, and 5. In 2021, recipients were most often status 2 (50.2%) at the time of transplant, followed by status 4 (18.8%). In 2020, some centers elected to perform transplant in only the highest-urgency candidates due to the pandemic; however, heart transplants among status 1, 2, and 3 recipients declined nationwide and increased among the other statuses during 2020 compared with 2019 (Figure HR 56). Waiting times may be decreasing. Compared with 2011, more patients in 2021 underwent transplant within 90 days of listing (63.5%), and fewer waited 3 months to <2 years (Table HR 9). Trends in life support continue with an increasing prevalence of short-term devices. The number of patients with any life support increased, although the proportion declined from 81.9% in 2018 to 76.3% in 2021. In 2021, fewer patients had left ventricular assist devices before transplant (31.4%), while the prevalence of intra-aortic balloon use increased to 27.6% from 9.4% in 2018. ECMO prior to transplant also increased more than 3-fold (Table HR 6).

The use of induction therapy has varied over time. In 2013 through 2018, there was slightly more use of induction therapy, but this has declined again. In 2021, 49.0% of recipients received induction therapy (Figure HR 57). Triple immunosuppressive therapy (ie, tacrolimus, mycophenolate mofetil [MMF], and steroids) is the most common regimen at the time of transplant, and its use has increased from 73.3% to 83.9% from 2010 to 2021. The use of only tacrolimus and MMF also increased slightly to 8.0% in 2021 (Figure HR 58).

2.6 Outcomes

Six-month and 1-year mortality trends have fluctuated slightly since 2010 but remained constant in 2020. Six-month mortality peaked at 8.8% in 2014 and reached a nadir of 6.5% in 2018. One-year mortality was lowest at 7.9% in 2018 and peaked at 10.8% in 2014. In the transplant year 2020, 6-month mortality was 7.4%. One-year mortality followed a similar trend and in 2020 was 9.2%. Both 3-year and 5-year mortality have declined (Figure HR 59). Five-year survival is comparable between age groups. During the first year of transplant, candidates aged 65 years or older had the greatest decrease in survival, 11.8% (Figure HR 60). Hispanic recipients had an early decline in survival from 99.7% to 88.0% in the first year, while recipients categorized as other race and ethnicity tended to have a slight survival advantage throughout 5 years (Figure HR 61).

Survival varied by cause of heart failure. Recipients with valvular heart disease and other/unknown cause tended to have better survival throughout the first 4 years of transplant, whereas candidates with congenital heart disease had the lowest survival. Survival declined early among recipients with congenital heart disease to 88.7% at 3 months compared with >90% in other categories. This trend persisted, and at 5 years survival was 74.3% in recipients with congenital heart disease, the lowest of the diagnosis groups (Figure HR 62). Recipients with VADs had lower survival at 5 years than those without VADs (78.4% vs 82.3%, respectively), with curves separating at approximately 6 months (Figure HR 64). Recipients who received a heart transplant as status 2 in 2014-2016 (prior policy) had an early decrease in survival compared with statuses 1A and 1B; by 5 years, survival for status 2 recipients was 75.5% compared with 82.1% for status 1B and 79.9% for status 1A (Figure HR 65). Five-year survival did not vary by sex or place of residence (Figures HR 63 and 66).

The incidence of acute rejection at 1-year posttransplant has not changed appreciably over the past decade and occurred in 31.8% of 18- to 34-year old recipients who received a transplant in 2020 and in 18.6% of recipients aged 65 years or older (Figure HR 67). The cumulative incidence of posttransplant lymphoproliferative disorder at 5 years remains constant, 1.1%, occurring 3 times more frequently among recipients who are Epstein-Barr virus (EBV) seronegative (Figure HR 68).

3 PEDIATRIC HEART TRANSPLANT

3.1 Pediatric Waitlist Trends

In 2021, 703 new pediatric candidates were added to the heart transplant waiting list, and a total of 1,146 candidates aged 17 years or younger were awaiting heart transplant, which is a 39.8% increase from 2010 (Figures HR 69 and 70). The largest pediatric age groups on the waiting list in 2021 were 1-5 years (26.4%) and 12-17 years (28.4%), followed by younger than 1 year (21.3%) and 6-11 years (18.0%) (Figure HR 71). Just over half of pediatric heart transplant candidates were White (51.3%), 21.0% were Hispanic, 19.6% were Black, and 4.2% were Asian (Figure HR 72). Congenital defects continued to be the leading diagnosis among pediatric heart transplant candidates, at 57.3% in 2021, an increase of 23.7% since 2010 (Figure HR 73). Over the past decade, the proportion of candidates who were White has decreased from 58.5% in 2011 to 49.3% in 2021 (Table HR 10). For candidates waiting on December 31, 2021, congenital defect was the leading cause of heart disease, at 64.1%, compared with 46.3% in 2011 (Table HR 11). The proportion of candidates listed with a VAD increased from 3.8% in 2011 to 8.5% in 2021 (Table HR 11). Among the 661 candidates removed from the waiting list in 2021, 505 (76.4%) were removed due to undergoing transplant, 46 (7.0%) died, 40 (6.1%) were removed due to improved condition, and 33 (5.0%) were considered too sick to undergo transplant (Tables HR 13 and 14).

In 2021, 40.7% of pediatric heart transplant candidates on the waiting list had been waiting for fewer than 90 days (Figure HR 75). Almost half (48.2%) of these were status 1A candidates in 2021, followed by 18% status 1B and 11.0% status 2 (Figure HR 76). Just over 70% of pediatric candidates newly listed during 2016-2018 underwent transplant within 3 years, 10.1% died, 15.0% were removed from the list, and 4.6% were still waiting (Figure HR 77). After decreasing to its lowest rate in the past decade in 2020 (107.7 transplants per 100 patient-years), the pediatric heart transplant rate in 2021 increased to 113.0 transplants per 100 patient-years (Figure HR 78). Transplant rates in 2021 varied by age, with the highest rates for candidates aged 12-17 years (166.7 transplants per 100 patient-years), followed by younger than 1 year (161.8 transplants per 100 patient-years), 6-11 years (105.5 transplants per 100 patient-years), and 1-5 years (65.4 transplants per 100 patient-years) (Figure HR 79). Transplant rates in 2021 were similar among pediatric waitlist candidates by race (Figure HR 80). The pretransplant mortality decreased by 50.2%, from 21.9 deaths per 100 patient-years in 2010 to 10.9 deaths per 100 patient-years in 2021 (Figure HR 82). Pretransplant mortality rates in 2021 varied by age, with the highest rates in candidates younger than 1 year, at 29.8 deaths per 100 patient-years, followed by 8.7 for ages 1-5 years, 8.3 for 12-17 years, and 1.1 for 6-11 years (Figure HR 83). Looking at pretransplant mortality by race in 2021, rates were 12.4 deaths per 100 patient-years among Black candidates, 11.9 deaths per 100 patient-years among Hispanic candidates, 10.7 deaths per 100 patient-years among White candidates, and 5.2 deaths per 100 patient-years among Asian candidates (Figure HR 84). Pretransplant mortality in 2021 was highest for status 1A (30.1 deaths per 100 patient-years) candidates followed by status 1B (5.8 deaths per 100 patient-years) and status 2 (4.2 deaths per 100 patient-years) candidates among active statuses (Figure HR 86). Pretransplant mortality rates were similar for heart transplant candidates listed in metropolitan and non-metropolitan areas in 2021 (Figure HR 87).

3.2 Pediatric Trends in Heart Transplant

The number of pediatric heart transplants performed increased to 490 in 2021, a 36.1% increase from 2010 (Figure HR 88). There were 184 (37.6%) heart transplants performed in recipients aged 12-17 years, 111 (22.7%) in recipients younger than 1 year, 107 (21.8%) in recipients aged 1-5 years, and 88 (18.0%) in recipients aged 6-11 years (Figure HR 89). Over the past few years, the proportion of transplant recipients aged 12-17 years has increased (30.5% in 2016 compared with 37.6% in 2021) (Table HR 16). Sex, as well as race and ethnicity, of pediatric heart transplant recipients has remained stable (Table HR 16). Just over half of pediatric heart transplant recipients in 2021 had congenital defect as their primary cause of disease (Table HR 17). The proportion who underwent transplant at status 1A declined from 89.3% in 2011 to 81.8% in 2021, while the proportion at status 1B increased from 6.9% to 16.7% and the proportion at status 2 declined from 3.7% to 1.4%. The proportion of heart transplant recipients with a VAD at transplant increased by 89.9%, from 18.9% in 2011 to 35.9% in 2021 (Table HR 17). The proportion of ABO-incompatible transplants has increased from 3.7% in 2011 to 8.6% in 2021 (Table HR 18).

Over the past decade, induction therapy use has increased, to 84.9% of pediatric heart transplant recipients in 2021 (Figure HR 94). The initial immunosuppression regimens used most commonly in 2021 were tacrolimus, MMF, and steroids in 48.8% of pediatric heart transplant recipients (Figure HR 95). There has been a steady increase in the use of a tacrolimus and MMF regimen, to almost 40% in 2021 (Figure HR 95).

3.3 Pediatric Posttransplant Survival and Morbidity

Among pediatric heart transplant recipients in 2020, the rate of acute rejection in the first year was 23.0% in recipients aged 1-5 years, 19.9% in those aged 12-17 years, 16.1% in those younger than 1 year, and 13.0% in those aged 6-11 years (Figure HR 96).

Recipient death occurred in 4.7% of patients at 6-months posttransplant and in 6.9% at 1-year posttransplant among pediatric heart transplants performed in 2020, in 13.1% at 3 years for transplants performed in 2018, in 13.7% at 5 years for transplants performed in 2016, and in 31.5% at 10 years for transplants performed in 2011 (Figure HR 98). Overall, 1- and 5-year patient survival rates were 92.7% and 84.3%, respectively, among recipients who underwent transplant in 2014-2016 (Figure HR 99). By age, 5-year patient survival was 82.2% for recipients younger than 1 year, 83.4% for those aged 1-5 years, 88.0% for those aged 6-11 years, and 84.9% for those aged 12-17 years (Figure HR 100).

Among pediatric heart transplant recipients in 2010-2016, the overall incidence of posttransplant lymphoproliferative disorder was 4.7% at 5 years; incidence was 6.1% among EBV-negative recipients and 3.3% among EBV-positive recipients (Figure HR 97).

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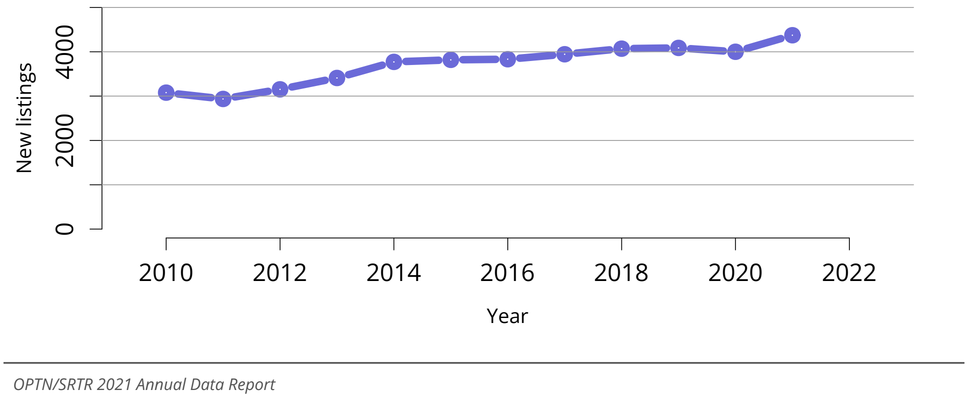

Figure HR 1: New adult candidates added to the heart transplant waiting list. A new adult candidate is one who first joined the list during the given year, without having been listed in a previous year. Previously listed candidates who underwent transplant and subsequently relisted are considered new. Active and inactive patients are included.

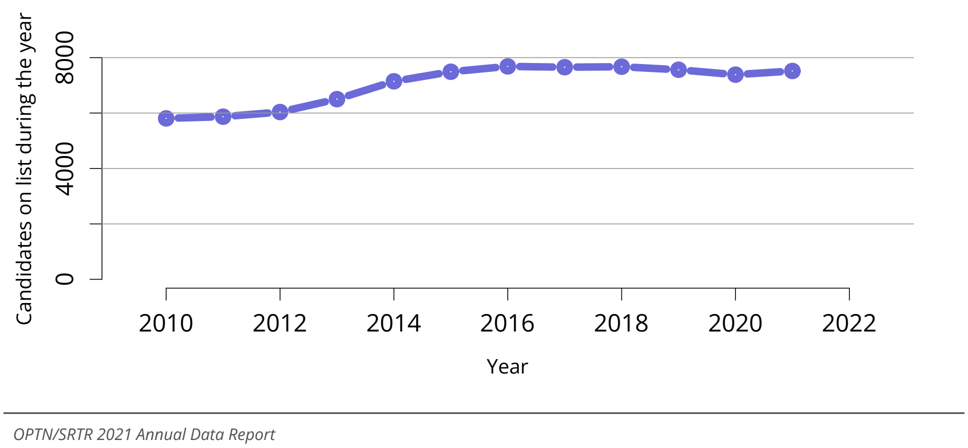

Figure HR 2: All adult candidates on the heart transplant waiting list. Adult candidates on the list at any time during the year. Candidates listed at more than one center are counted once per listing.

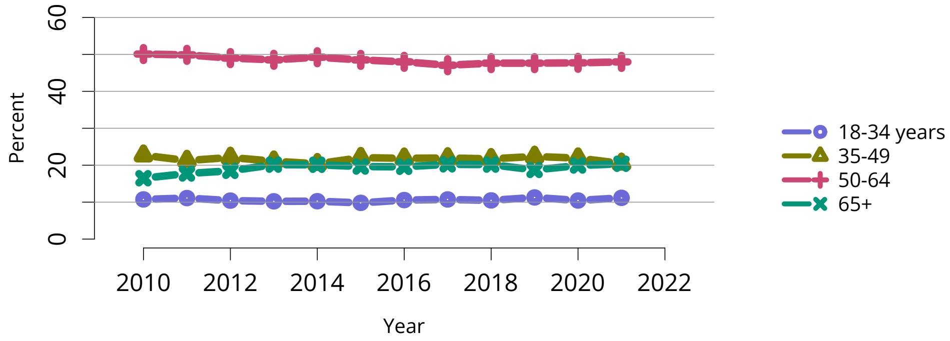

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Figure HR 3: Distribution of adults waiting for heart transplant by age. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive candidates are included. Age is determined at the earliest of transplant, death, removal, or December 31 of the year.

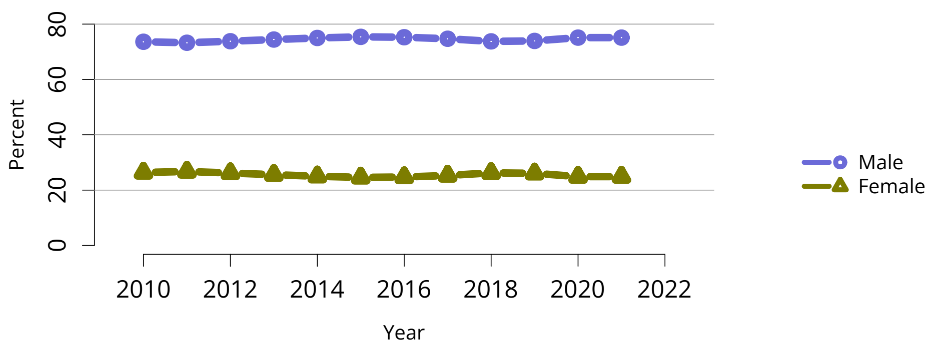

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Figure HR 4: Distribution of adults waiting for heart transplant by sex. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

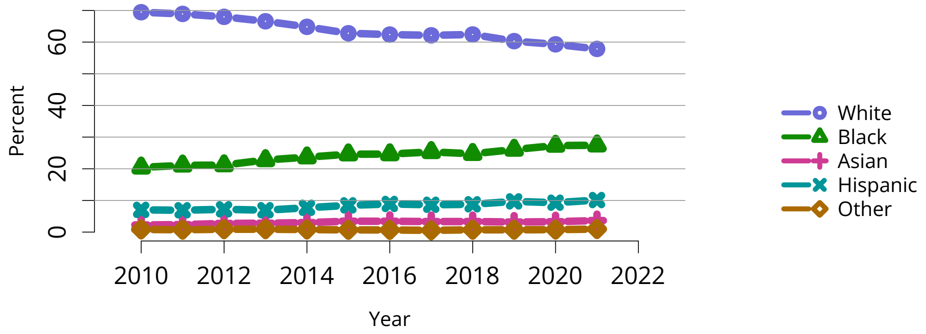

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Figure HR 5: Distribution of adults waiting for heart transplant by race. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

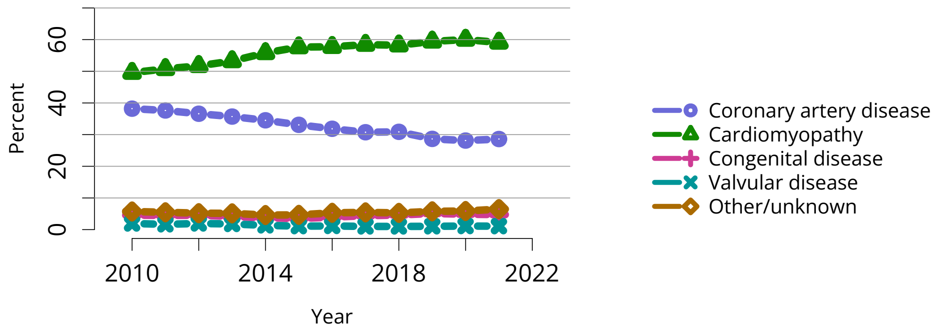

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Figure HR 6: Distribution of adults waiting for heart transplant by diagnosis. Candidates waiting for transplant at any time in the given year. Active and inactive patients are included. Candidates listed at more than one center are counted once per listing.

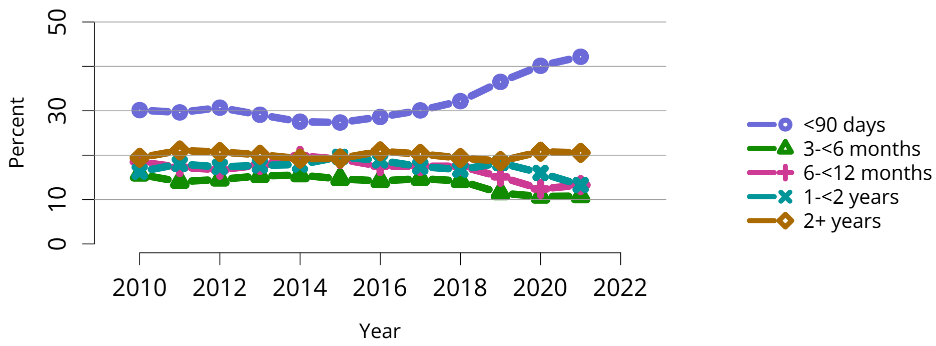

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Figure HR 7: Distribution of adults waiting for heart transplant by waiting time. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Time on the waiting list is determined at the earliest of transplant, death, removal, or December 31 of the year. Active and inactive candidates are included.

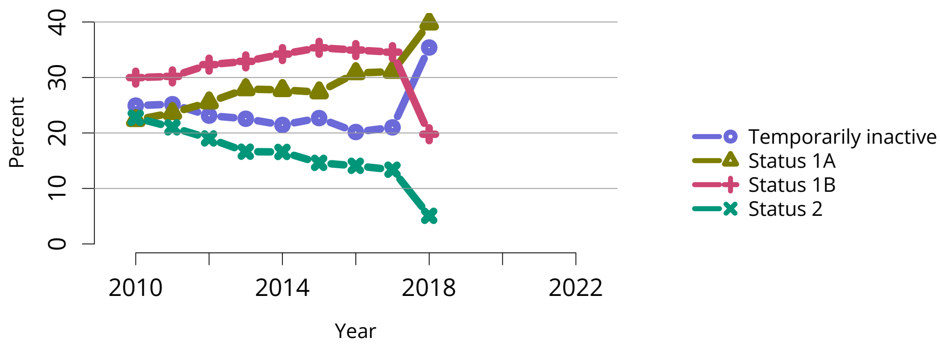

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Figure HR 8: Distribution of adults waiting for heart transplant by former medical urgency groups through October 17, 2018. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive candidates are included. The October 2018 OPTN heart allocation policy update changed the status groups. Medical urgency for 2017 and earlier is determined at the earliest of transplant, death, removal, or December 31 of the year. For 2018 medical urgency statuses, statuses 1A, 1B, and 2 were determined at the earliest of transplant, death, or removal. For candidates who stayed active on the waiting list on or after October 18, 2018, and for candidates who were newly waitlisted on or after that date through 2021, their statuses are shown in Figure HR 9. Inactive statuses with new listings on or after October 18, 2018, are excluded here in Figure HR 8.

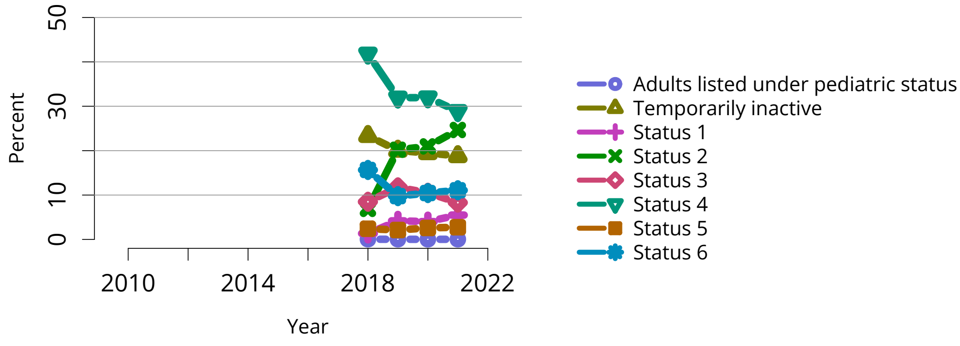

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Figure HR 9: Distribution of adults waiting for heart transplant by new medical urgency groups, October 18, 2018, through 2021. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive candidates are included. The October 2018 OPTN heart allocation policy update changed the status groups. Medical urgency is determined at the earliest of transplant, death, removal, or December 31 of the year. For 2018 medical urgency statuses, statuses 1-6 and inactive status contain new listings on or after October 18, 2018, or existing listings from before the policy change.

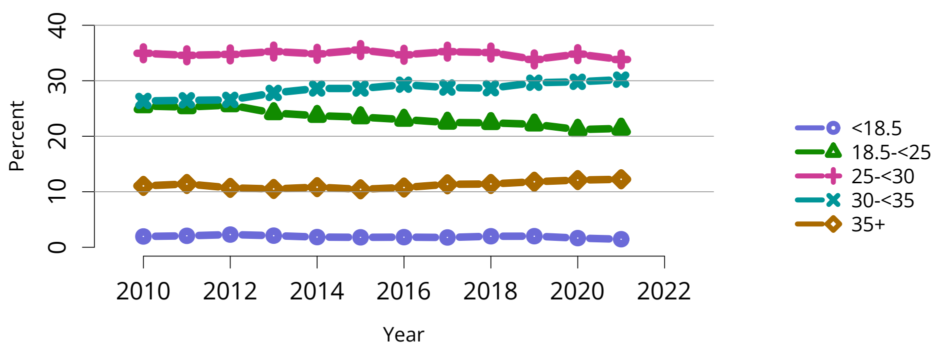

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Figure HR 10: Distribution of adults waiting for heart transplant by BMI. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

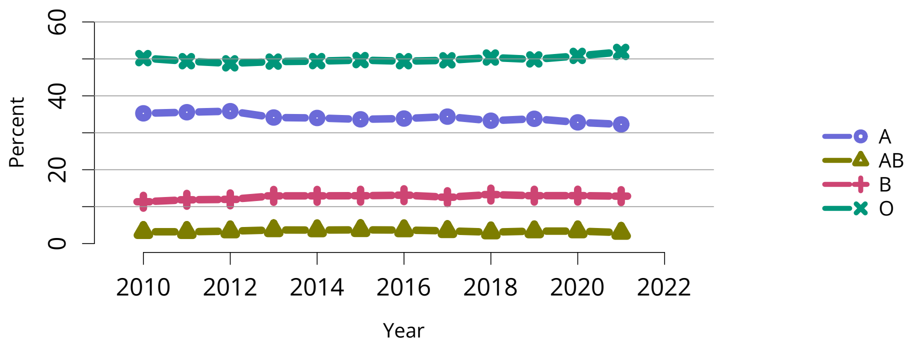

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Figure HR 11: Distribution of adults waiting for heart transplant by blood type. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

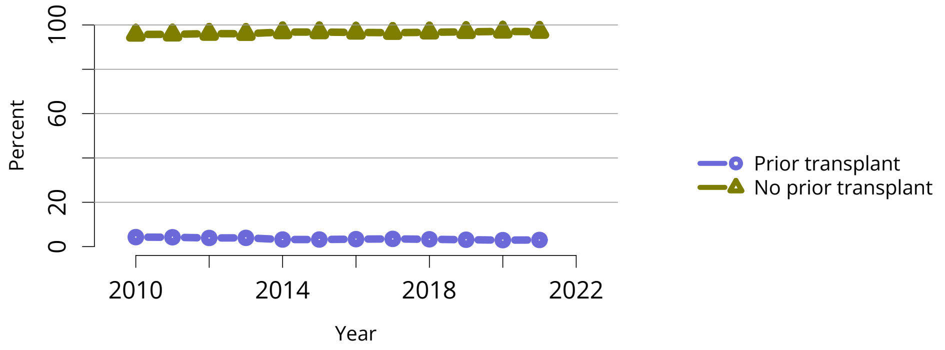

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Figure HR 12: Distribution of adults waiting for heart transplant by prior transplant status. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

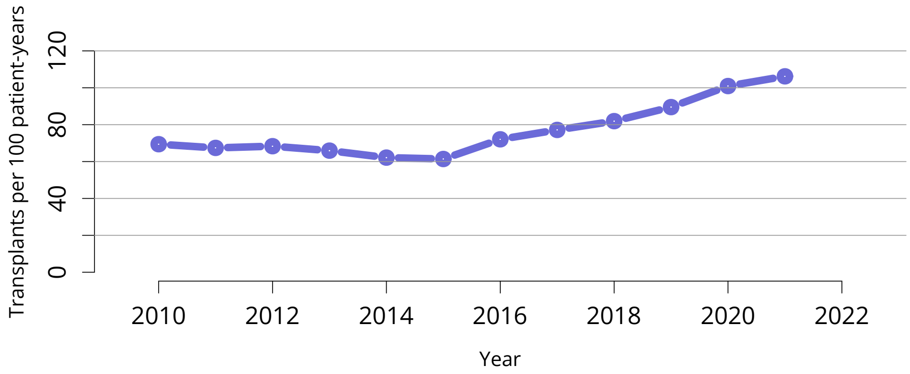

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Figure HR 13: Overall deceased donor heart transplant rates among adult waitlist candidates. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

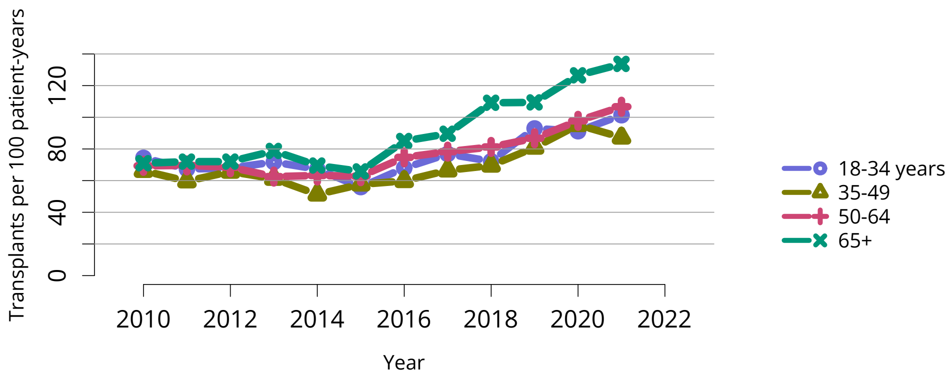

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Figure HR 14: Deceased donor heart transplant rates among adult waitlist candidates by age. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.

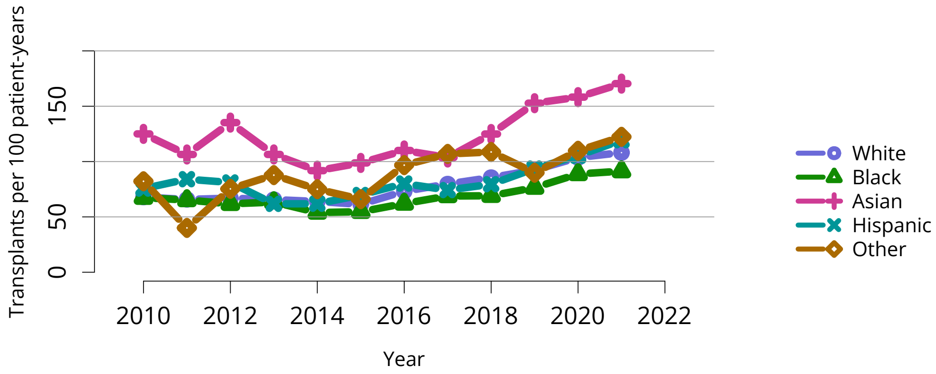

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Figure HR 15: Deceased donor heart transplant rates among adult waitlist candidates by race. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

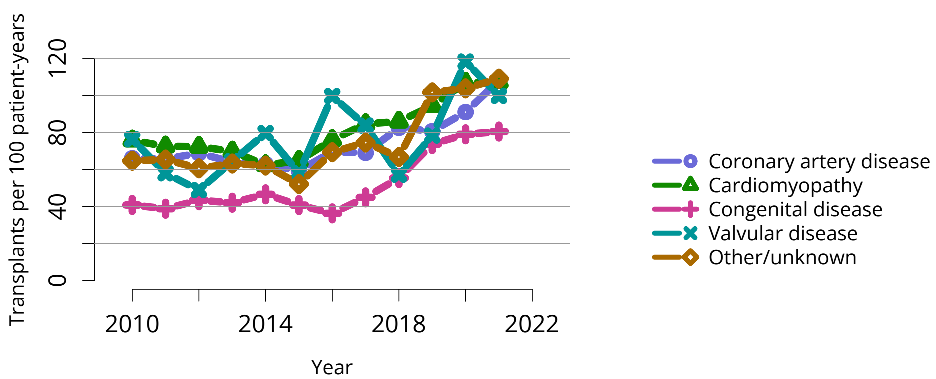

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Figure HR 16: Deceased donor heart transplant rates among adult waitlist candidates by diagnosis. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

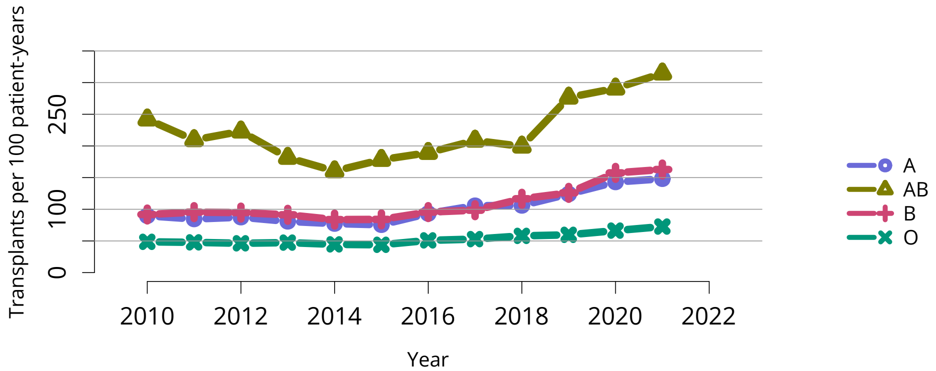

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Figure HR 17: Deceased donor heart transplant rates among adult waitlist candidates by blood type. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

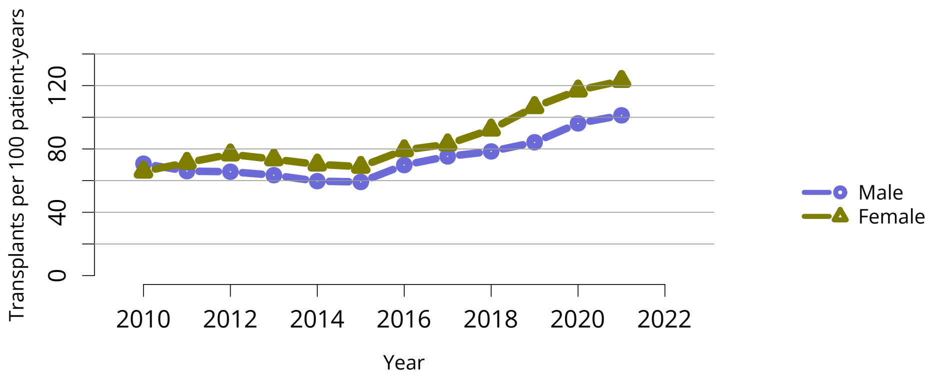

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Figure HR 18: Deceased donor heart transplant rates among adult waitlist candidates by sex. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

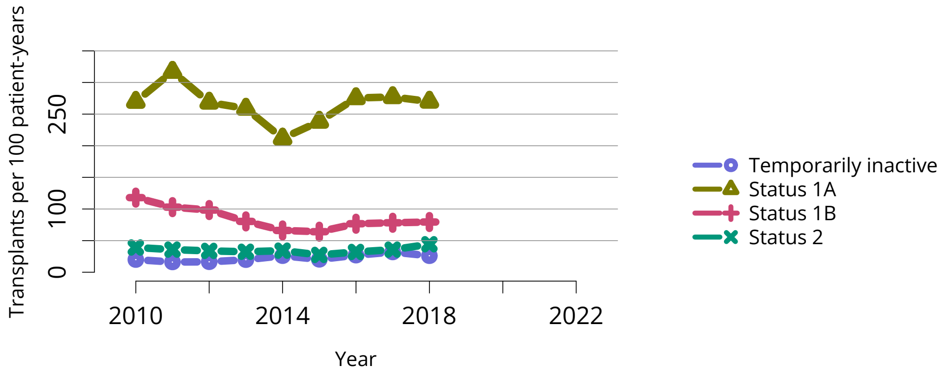

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Figure HR 19: Deceased donor heart transplant rates among adult waitlist candidates by former medical urgency groups through October 17, 2018. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately. The October 2018 OPTN heart allocation policy update changed the status groups. Medical urgency is determined at the later of listing date or January 1 of the given year. For new listings on or after October 18, 2018, and for candidates who were newly waitlisted on or after that date through 2021, their medical urgency statuses are shown in Figure HR 20. Inactive statuses with new listings on or after October 18, 2018, are excluded here in Figure HR 19.

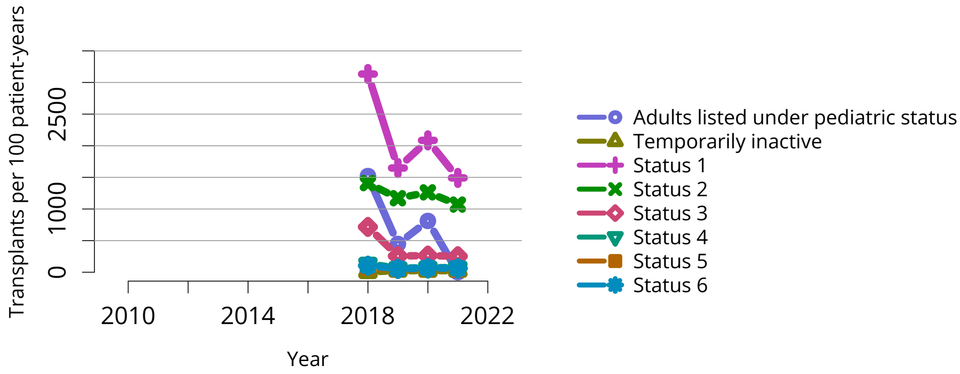

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Figure HR 20: Deceased donor heart transplant rates among adult waitlist candidates by new medical urgency groups, October 18, 2018, through 2021. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately. The October 2018 OPTN heart allocation policy update changed the status groups. Medical urgency is determined at the later of listing date or January 1 of the given year. For 2018 medical urgency statuses, statuses 1-6 and inactive status contain new listings on or after October 18, 2018.

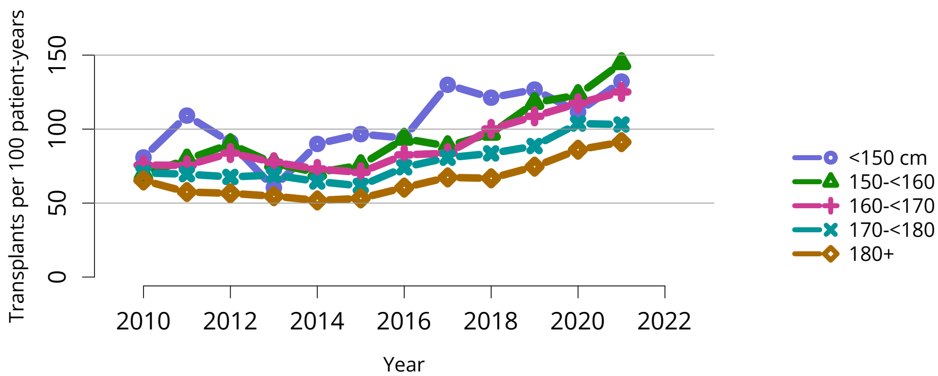

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Figure HR 21: Deceased donor heart transplant rates among adult waitlist candidates by height. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

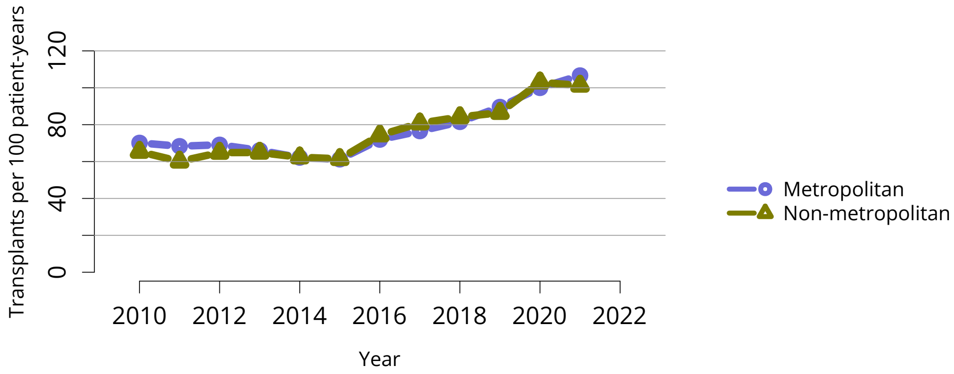

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Figure HR 22: Deceased donor heart transplant rates among adult waitlist candidates by metropolitan vs. non-metropolitan residence. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately. Urban/rural determination is made using the RUCA (rural-urban commuting area) designation of the candidate's permanent zip code.

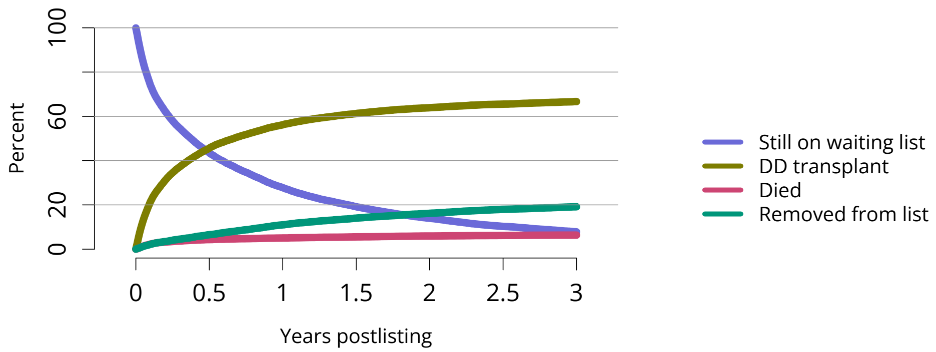

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Figure HR 23: Three-year outcomes for adults waiting for heart transplant, new listings in 2016-2018. Candidates listed at more than one center are counted once per listing. Removed from list includes all reasons except transplant and death. DD, deceased donor.

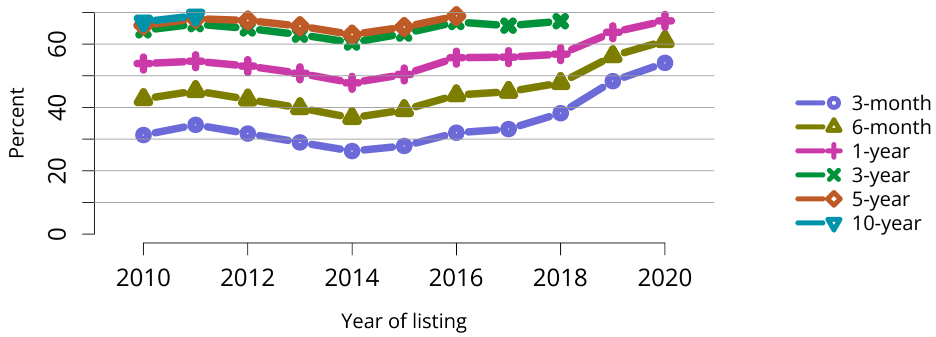

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Figure HR 24: Percentage of adults who underwent deceased donor heart transplant within a given period of listing. Candidates listed at more than one center are counted once per listing.

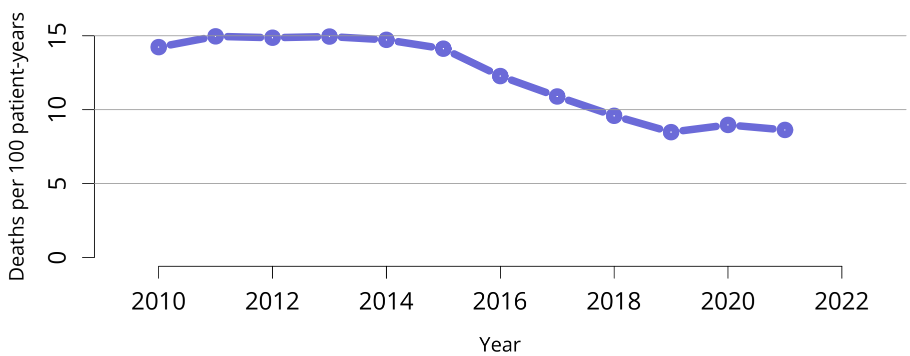

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Figure HR 25: Overall pretransplant mortality rates among adults waitlisted for heart transplant. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

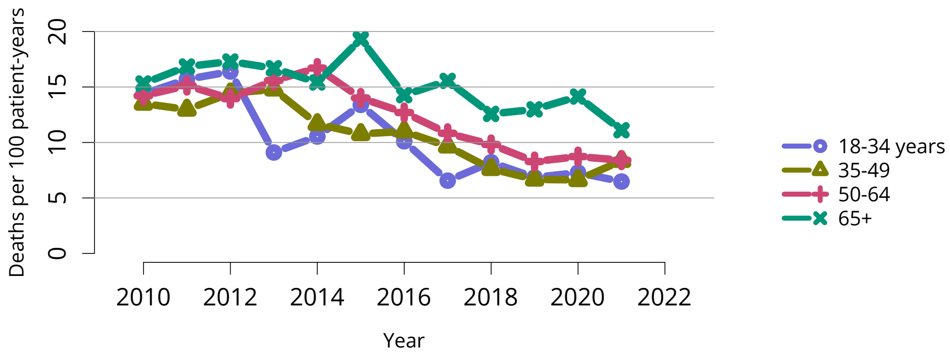

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Figure HR 26: Pretransplant mortality rates among adults waitlisted for heart transplant by age. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.

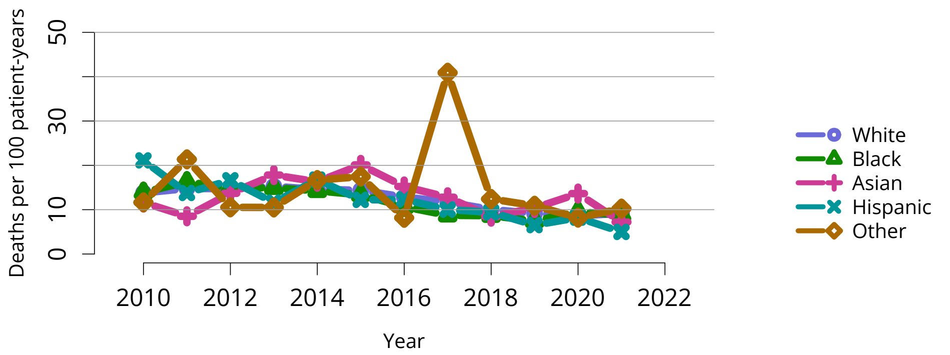

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Figure HR 27: Pretransplant mortality rates among adults waitlisted for heart transplant by race. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

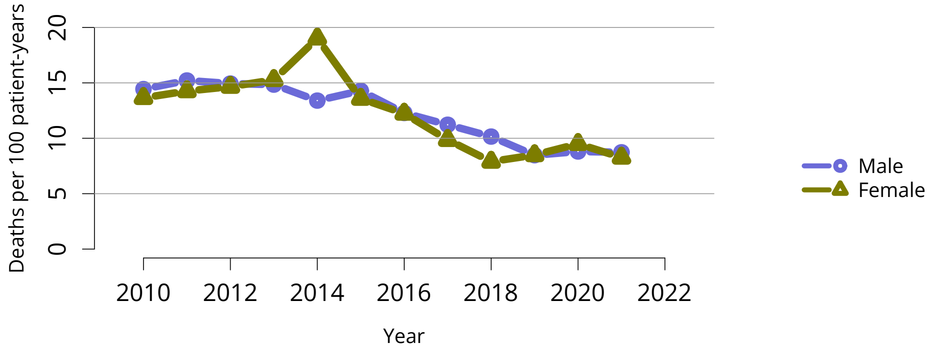

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Figure HR 28: Pretransplant mortality rates among adults waitlisted for heart transplant by sex. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

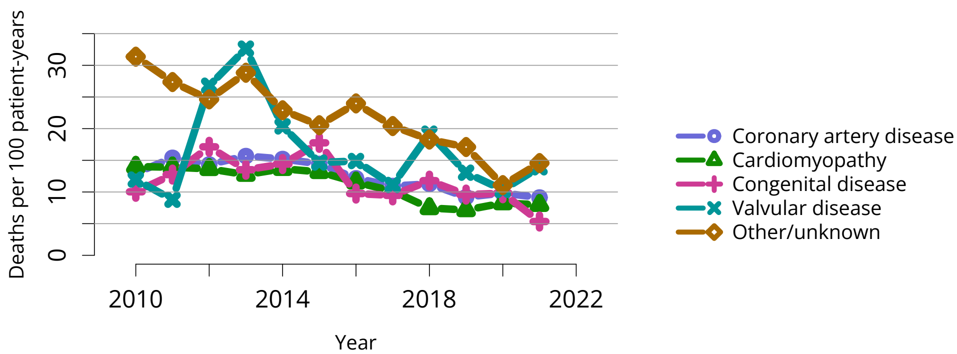

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Figure HR 29: Pretransplant mortality rates among adults waitlisted for heart transplant by diagnosis. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

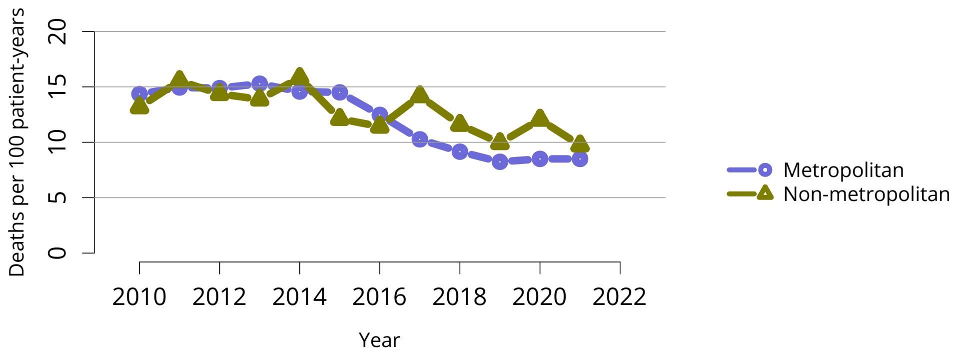

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Figure HR 30: Pretransplant mortality rates among adults waitlisted for heart transplant by metropolitan vs. non-metropolitan residence. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Urban/rural determination is made using the RUCA (rural-urban commuting area) designation of the candidate's permanent zip code.

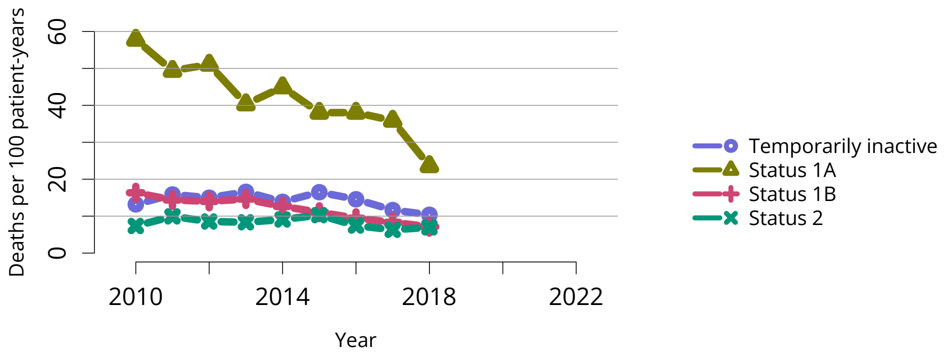

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Figure HR 31: Pretransplant mortality rates among adults waitlisted for heart transplant by former medical urgency groups through October 17, 2018. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Medical urgency is determined at the later of listing date or January 1 of the given year. The October 2018 OPTN heart allocation policy update changed the status groups. For 2018 medical urgency statuses, new listings on or after October 18, 2018, are not shown in this figure.

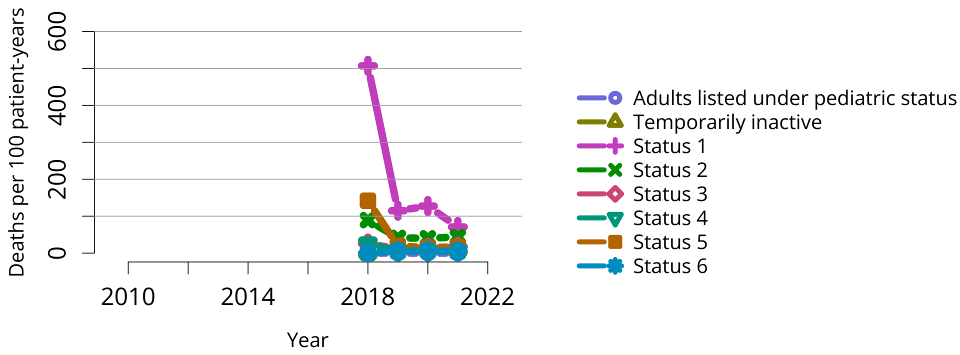

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Figure HR 32: Pretransplant mortality rates among adults waitlisted for heart transplant by new medical urgency groups, October 18, 2018, through 2021. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Medical urgency is determined at the later of listing date or January 1 of the given year. The October 2018 OPTN heart allocation policy update changed the status groups. For 2018 medical urgency statuses, statuses 1-6 and inactive status contain new listings on or after October 18, 2018.

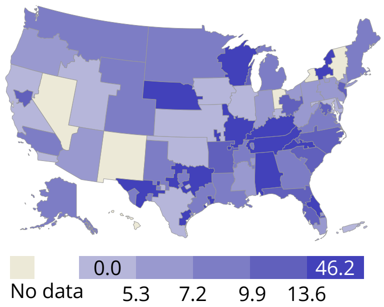

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Figure HR 33: Pretransplant mortality rates among adults waitlisted for heart transplant in 2021 by DSA. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

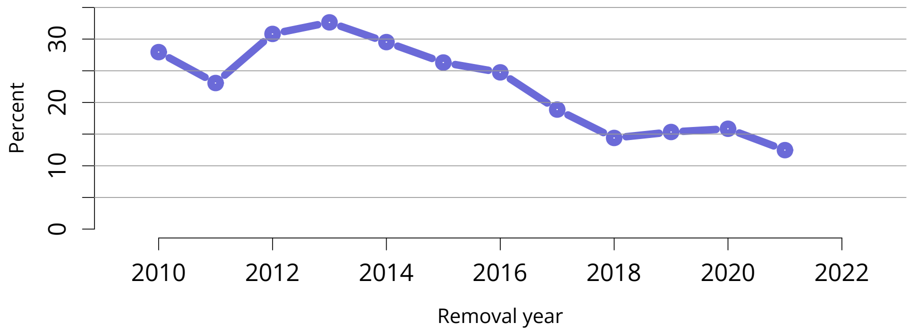

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Figure HR 34: Deaths within six months after removal among adult heart waitlist candidates, overall. Denominator includes only candidates removed from the waiting list for reasons other than transplant or death while on the list.

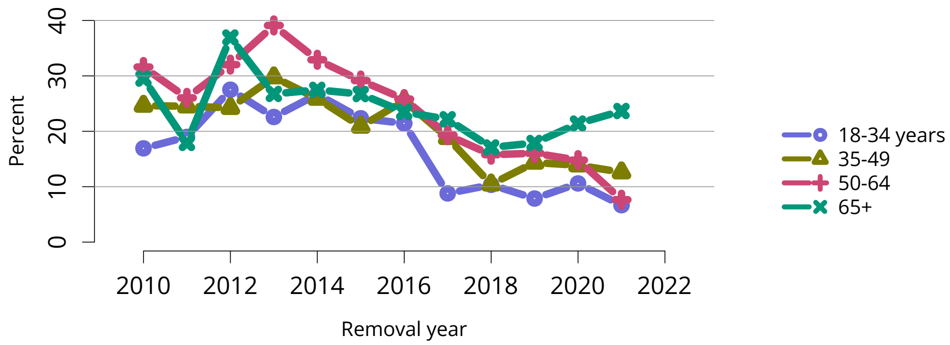

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Figure HR 35: Deaths within six months after removal among adult heart waitlist candidates, by age. Denominator includes only candidates removed from the waiting list for reasons other than transplant or death while on the list. Age is determined at removal.

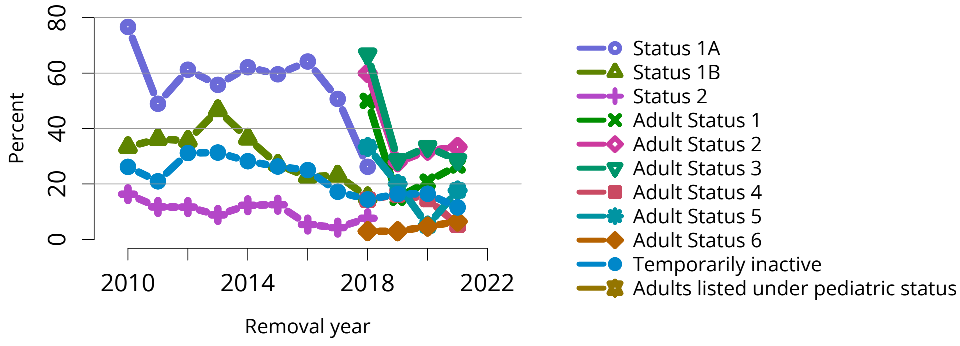

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Figure HR 36: Deaths within six months after removal among adult heart waitlist candidates, by status at removal. Denominator includes only candidates removed from the waiting list for reasons other than transplant or death while on the list. The October 2018 OPTN heart allocation policy update changed the status groups. The statuses 1A, 1B, and 2 listed first are through October 17, 2018, the last day before the policy update; the adult statuses listed are for October 18, 2018, and onward. Medical urgency is determined at the earliest of transplant, death, removal, or December 31 of the year.

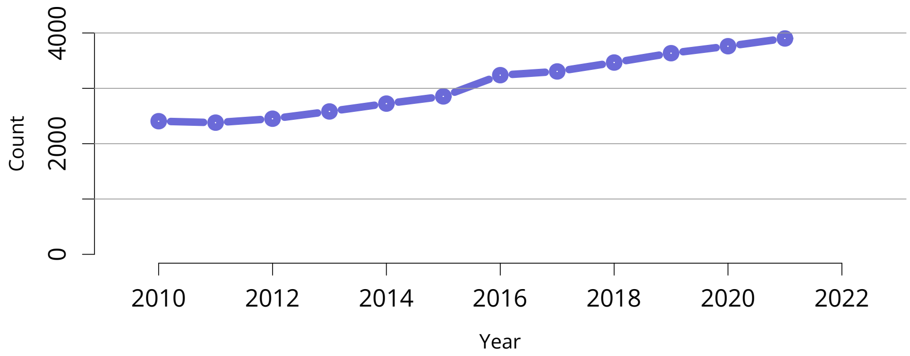

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Figure HR 37: Overall deceased heart donor count. Count of deceased donors whose hearts were recovered for transplant.

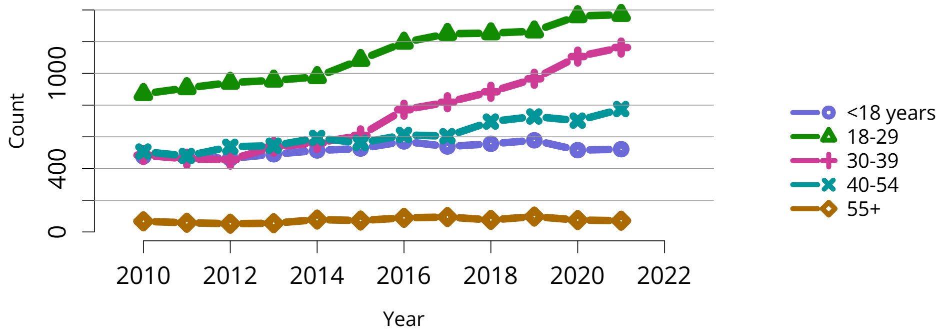

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Figure HR 38: Deceased heart donor count by age. Count of deceased donors whose hearts were recovered for transplant.

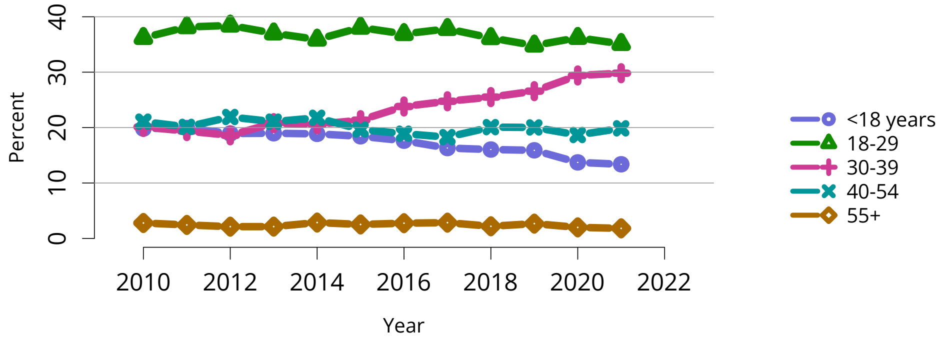

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Figure HR 39: Distribution of deceased heart donors by age. Deceased donors whose hearts were recovered for transplant.

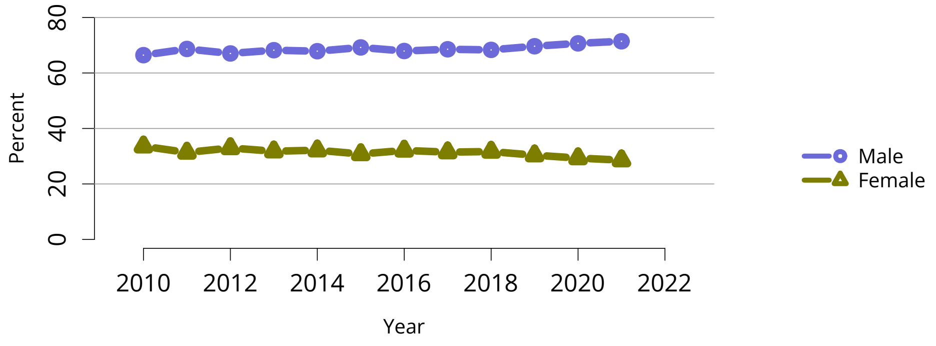

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Figure HR 40: Distribution of deceased heart donors by sex. Deceased donors whose hearts were recovered for transplant.

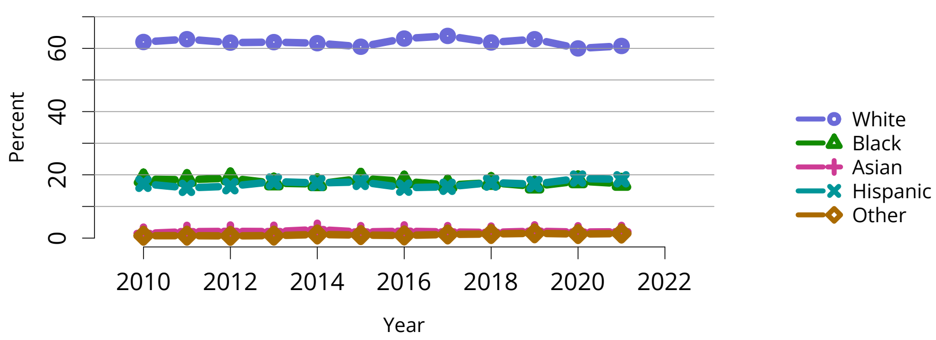

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Figure HR 41: Distribution of deceased heart donors by race. Deceased donors whose hearts were recovered for transplant.

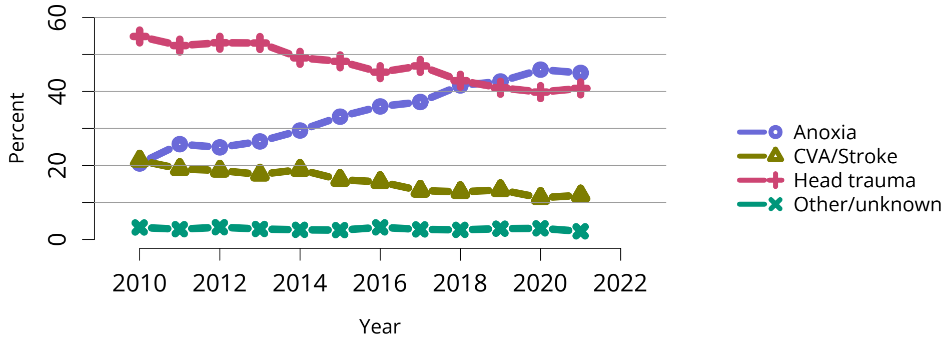

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Figure HR 42: Cause of death among deceased heart donors. Deceased donors with a heart recovered for the purposes of transplant. CVA, cerebrovascular accident.

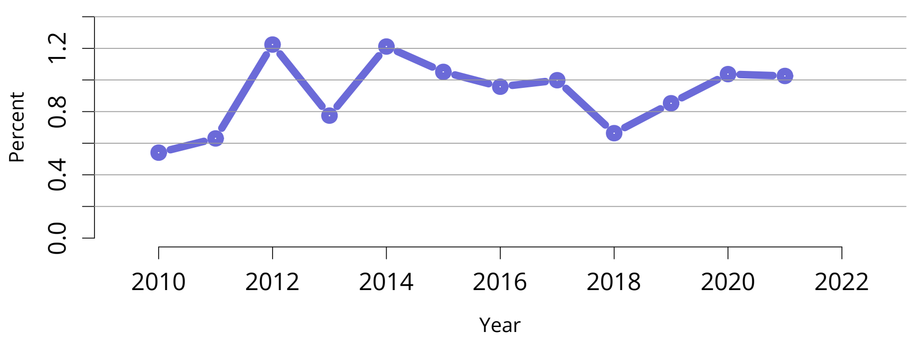

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Figure HR 43: Overall percent of hearts recovered for transplant and not transplanted. Percentages of hearts not transplanted out of all hearts recovered for transplant.

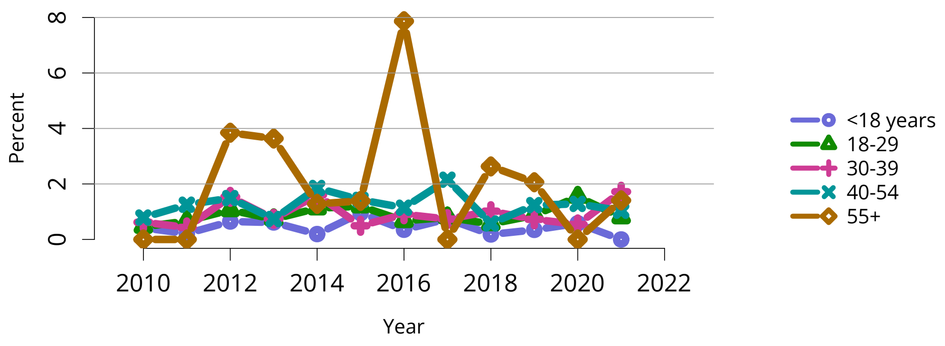

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Figure HR 44: Percent of hearts recovered for transplant and not transplanted by donor age. Percentages of hearts not transplanted out of all hearts recovered for transplant.

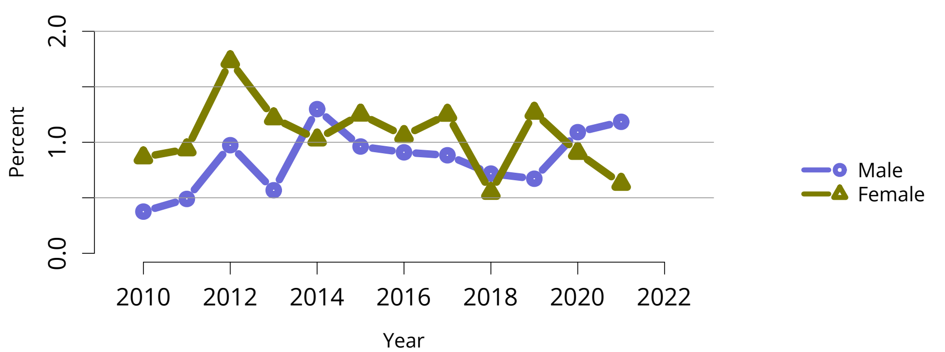

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Figure HR 45: Percent of hearts recovered for transplant and not transplanted by donor sex. Percentages of hearts not transplanted out of all hearts recovered for transplant.

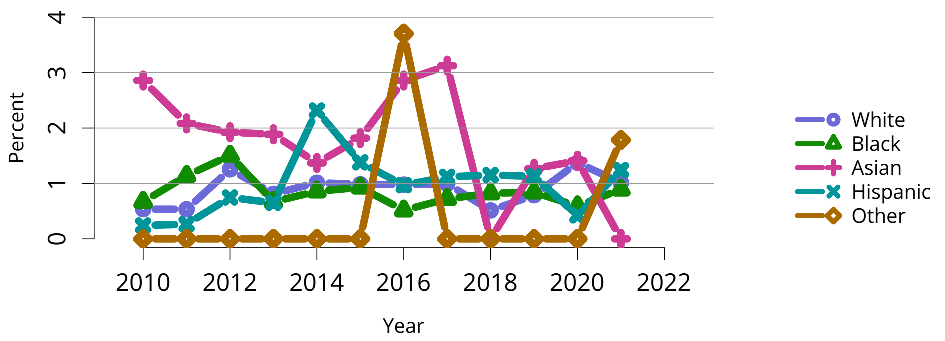

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Figure HR 46: Percent of hearts recovered for transplant and not transplanted by donor race. Percentages of hearts not transplanted out of all hearts recovered for transplant.

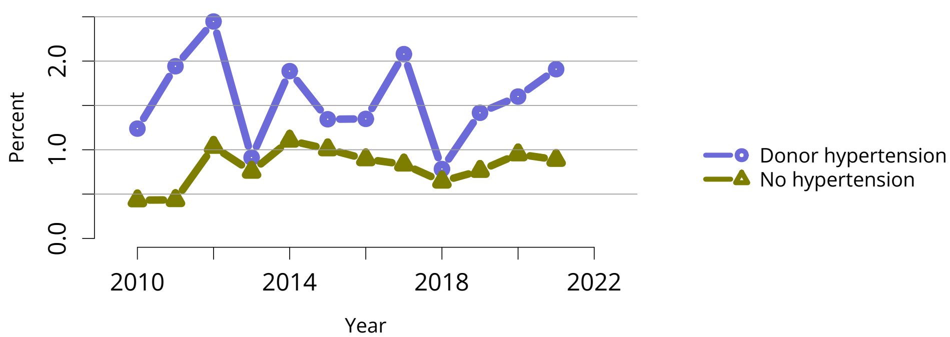

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Figure HR 47: Percent of hearts recovered for transplant and not transplanted by donor hypertension status. Percentages of hearts not transplanted out of all hearts recovered for transplant.

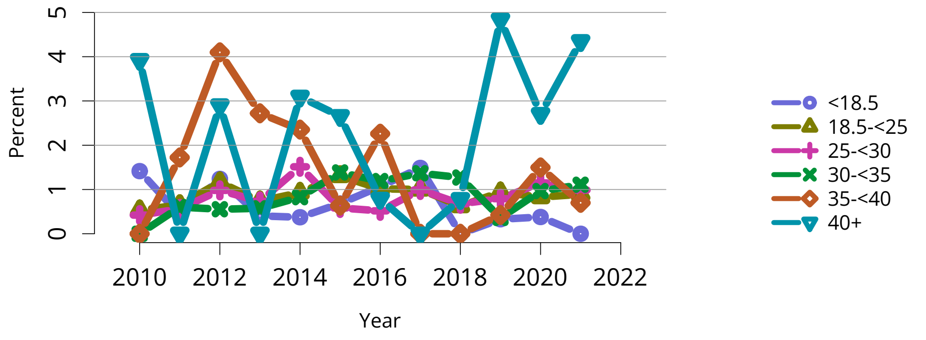

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Figure HR 48: Percent of hearts recovered for transplant and not transplanted by donor BMI. Percentages of hearts not transplanted out of all hearts recovered for transplant.

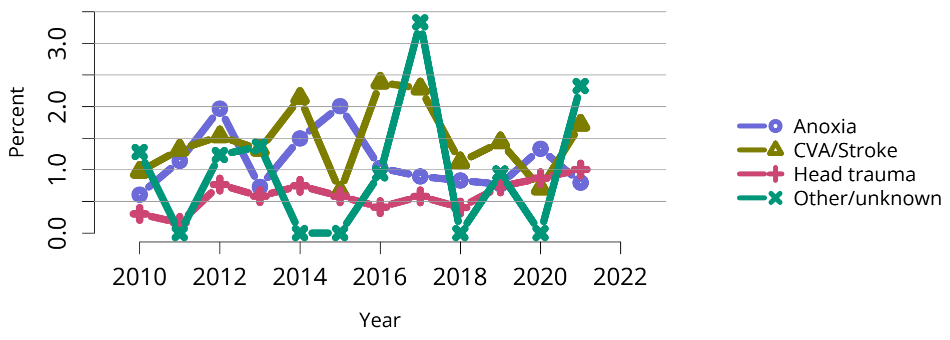

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Figure HR 49: Percent of hearts recovered for transplant and not transplanted by donor cause of death. Percentages of hearts not transplanted out of all hearts recovered for transplant. CVA, cerebrovascular accident.

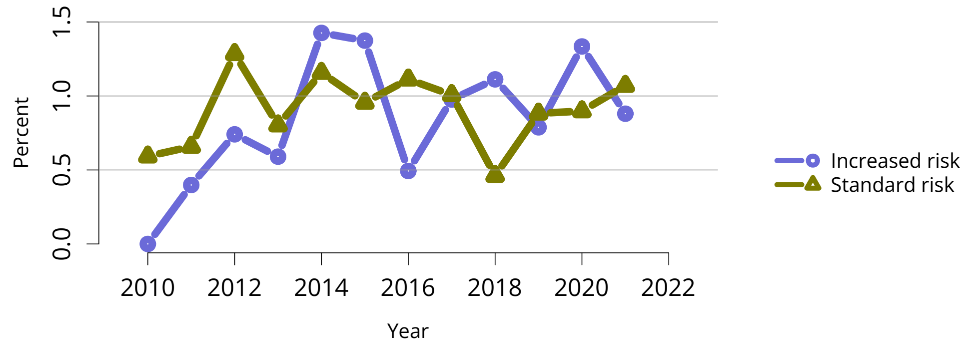

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Figure HR 50: Percent of hearts recovered for transplant and not transplanted, by donor risk of disease transmission. Percentages of hearts not transplanted out of all hearts recovered for transplant. "Increased risk" is defined by criteria from the US Public Health Service Guidelines for increased risk for HIV, hepatitis B, and hepatitis C transmission.

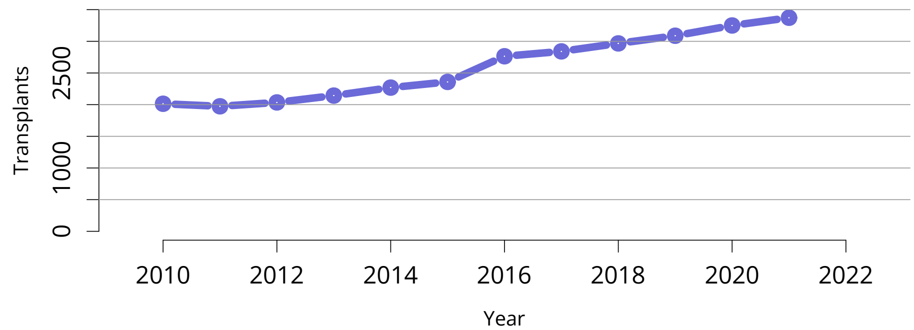

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Figure HR 51: Overall adult heart transplants. All adult heart transplant recipients, including retransplant, and multiorgan recipients.

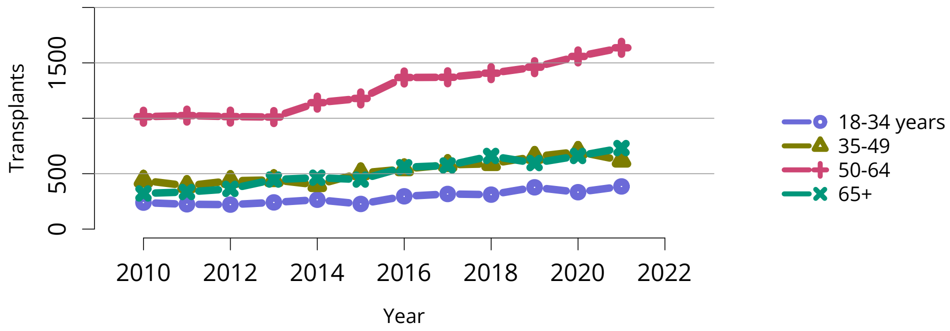

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Figure HR 52: Adult heart transplants by age. All adult heart transplant recipients, including retransplant, and multiorgan recipients.

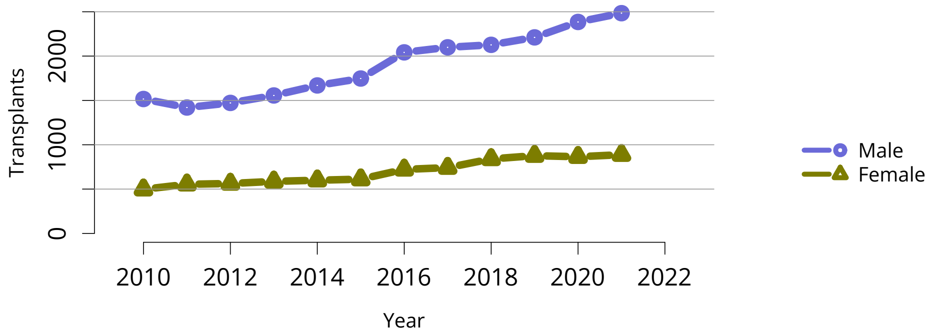

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Figure HR 53: Adult heart transplants by sex. All adult heart transplant recipients, including retransplant, and multiorgan recipients.

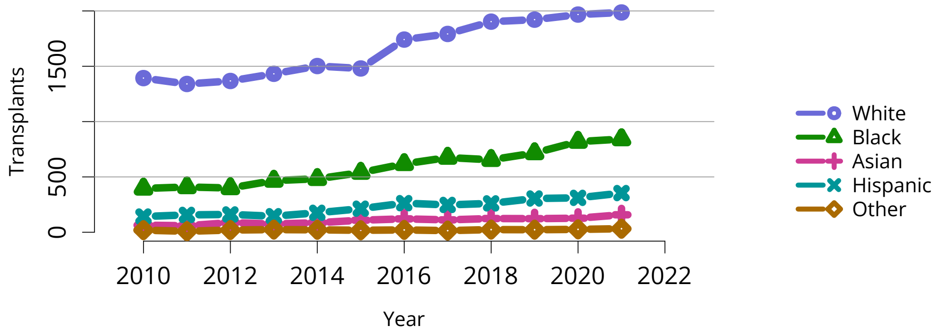

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Figure HR 54: Adult heart transplants by race. All adult heart transplant recipients, including retransplant, and multiorgan recipients.

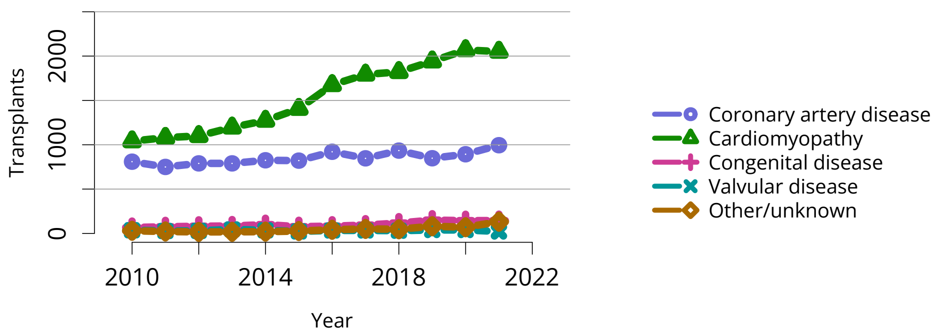

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Figure HR 55: Adult heart transplants by diagnosis. All adult heart transplant recipients, including retransplant, and multiorgan recipients.

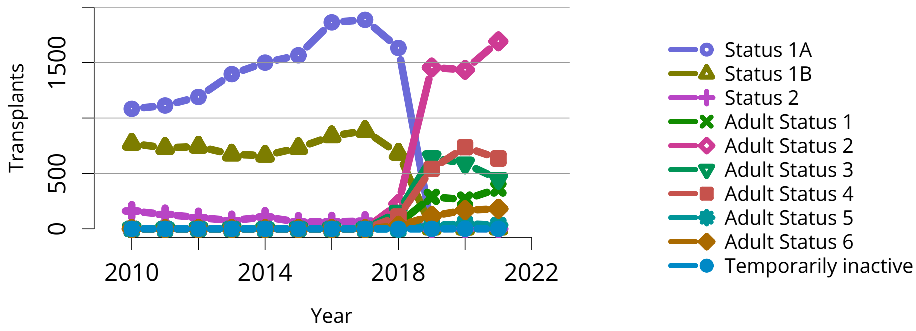

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Figure HR 56: Adult heart transplants by medical urgency. All adult heart transplant recipients, including retransplant, and multiorgan recipients. The October 2018 OPTN heart allocation policy update changed the status groups. The statuses 1A, 1B, and 2 listed first are through October 17, 2018, the last day before the policy update; the adult statuses listed are for October 18, 2018, and onward.

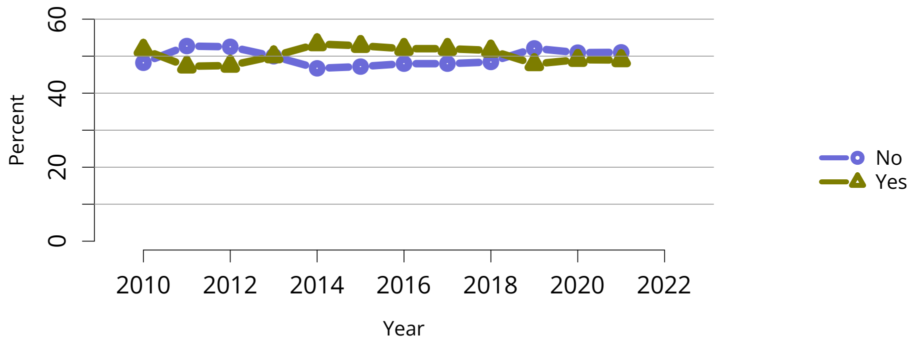

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Figure HR 57: Induction agent use in adult heart transplant recipients. Immunosuppression at transplant reported to the OPTN.

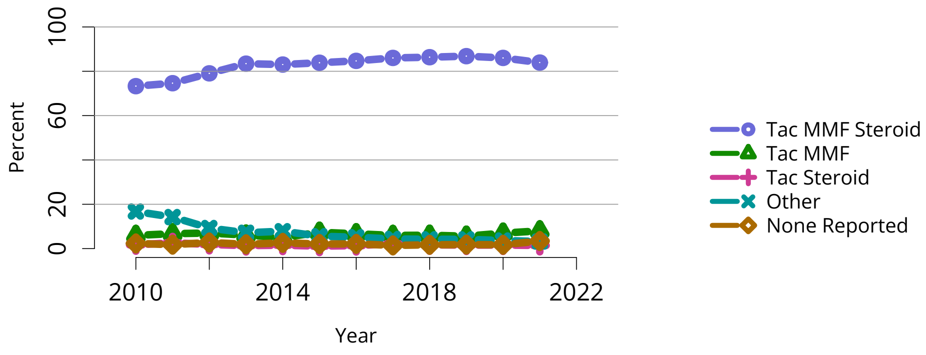

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Figure HR 58: Immunosuppression regimen use in adult heart transplant recipients. Immunosuppression regimen at transplant reported to the OPTN. Tac, tacrolimus. MMF, all mycophenolate agents.

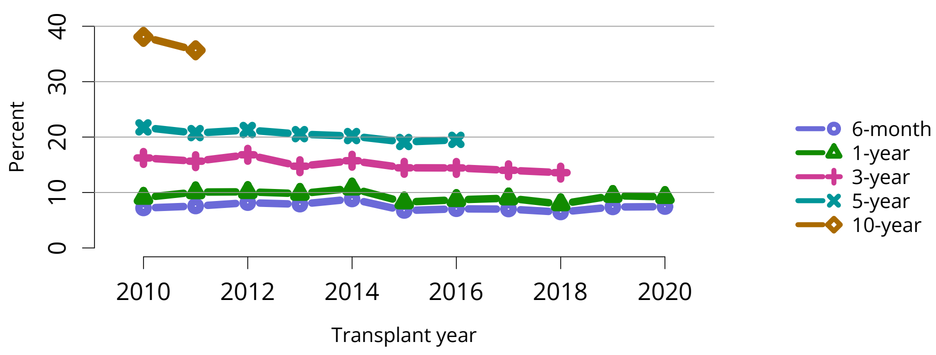

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Figure HR 59: Patient death among adult heart transplant recipients. All adult recipients of deceased donor hearts, including multiorgan transplants.

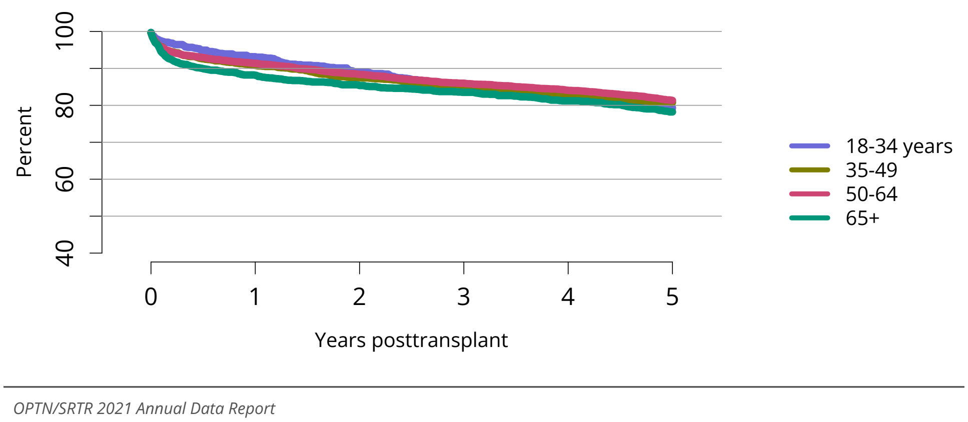

Figure HR 60: Patient survival among adult heart transplant recipients, 2014-2016, by age. Patient survival estimated using unadjusted Kaplan-Meier methods.

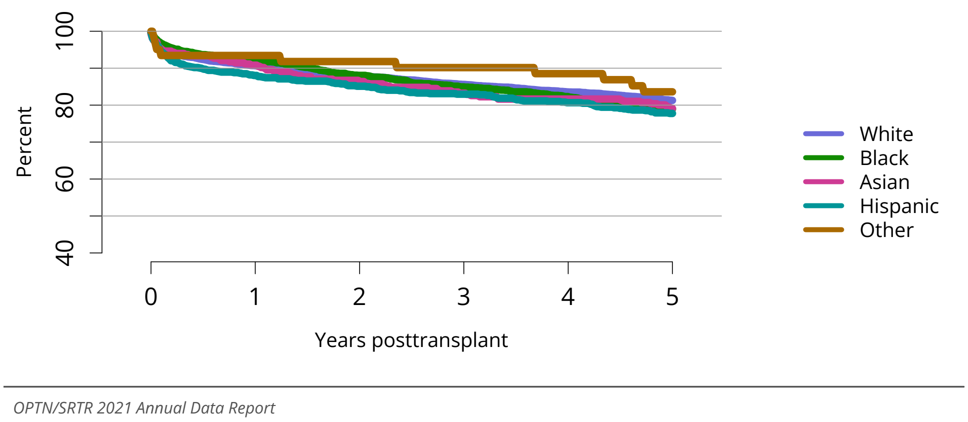

Figure HR 61: Patient survival among adult heart transplant recipients, 2014-2016, by race. Patient survival estimated using unadjusted Kaplan-Meier methods.

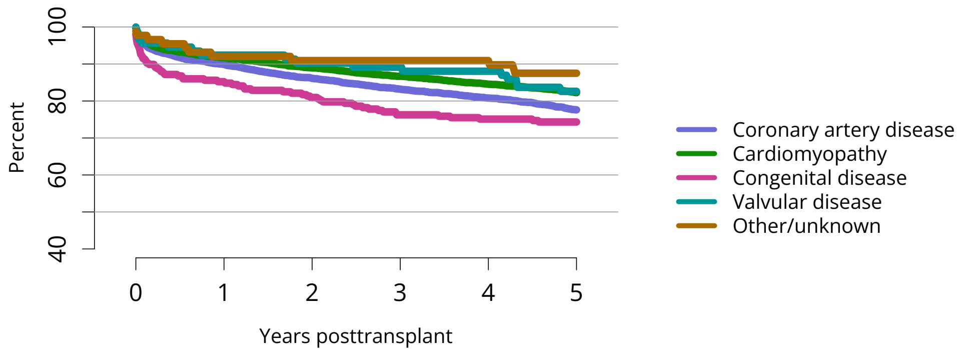

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Figure HR 62: Patient survival among adult heart transplant recipients, 2014-2016, by diagnosis group. Patient survival estimated using unadjusted Kaplan-Meier methods.

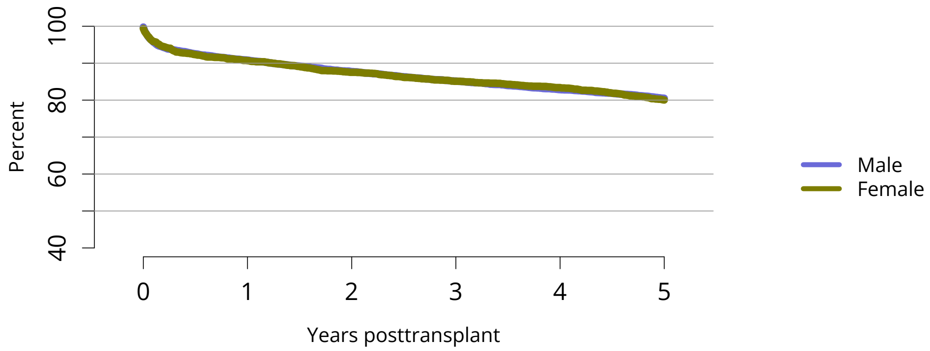

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Figure HR 63: Patient survival among adult heart transplant recipients, 2014-2016, by sex. Patient survival estimated using unadjusted Kaplan-Meier methods.

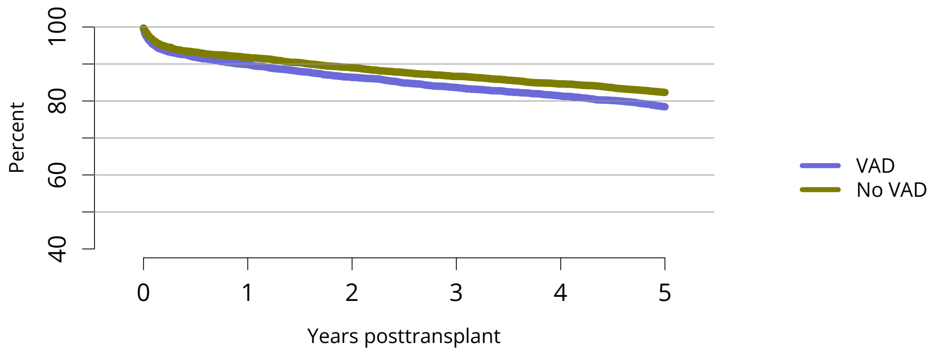

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Figure HR 64: Patient survival among adult heart transplant recipients, 2014-2016, by VAD status. Patient survival estimated using unadjusted Kaplan-Meier methods. Ventricular assist device (VAD) status at time of transplant.

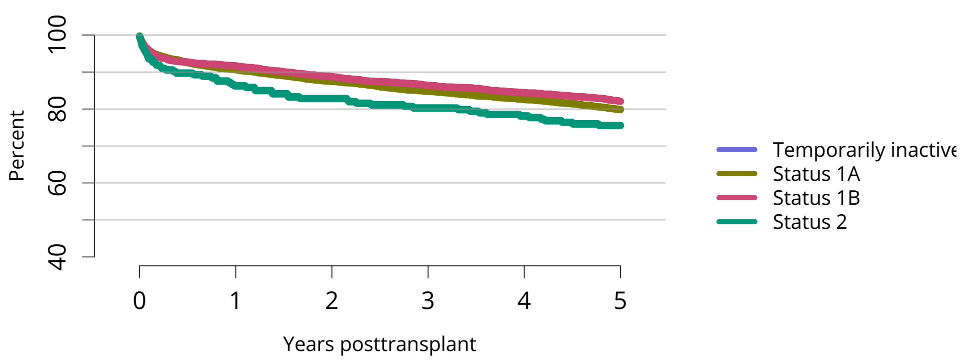

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Figure HR 65: Patient survival among adult heart transplant recipients, 2014-2016, by medical urgency. Patient survival estimated using unadjusted Kaplan-Meier methods.

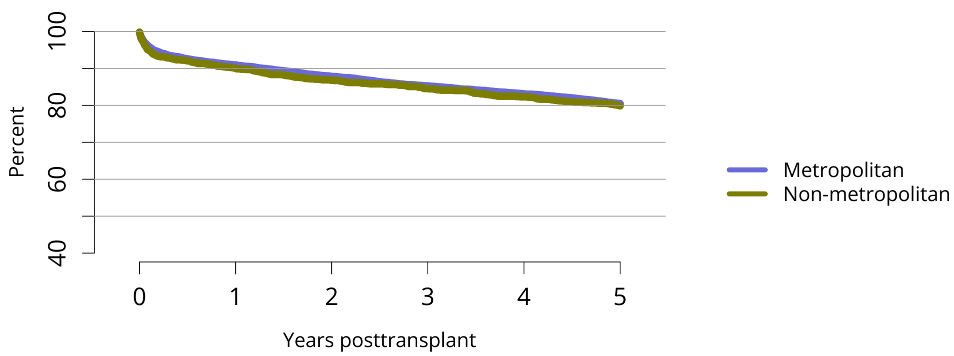

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Figure HR 66: Patient survival among adult heart transplant recipients, 2014-2016, by metropolitan vs. non-metropolitan recipient residence. Patient survival estimated using unadjusted Kaplan-Meier methods.

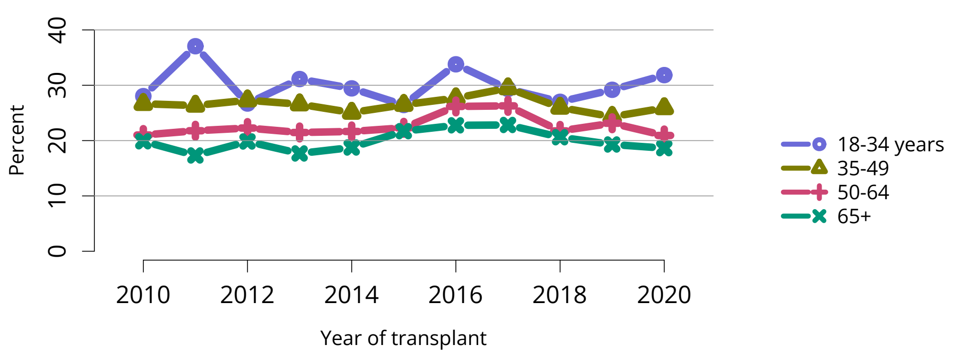

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Figure HR 67: Incidence of acute rejection by 1 year posttransplant among adult heart transplant recipients by age. Only the first reported rejection event is counted. Cumulative incidence is estimated using the Kaplan-Meier method.

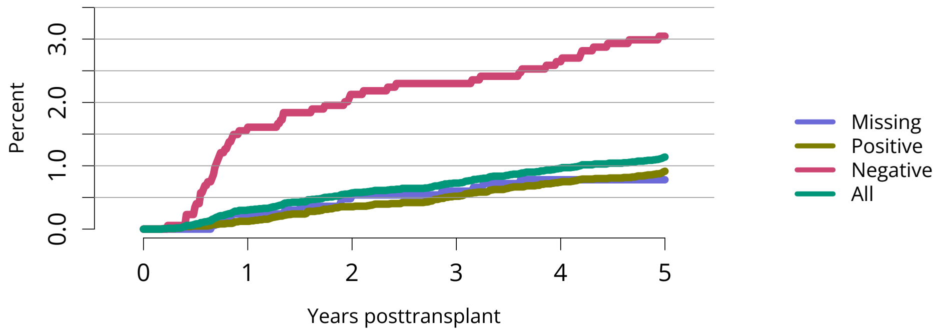

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Figure HR 68: Incidence of PTLD among adult heart transplant recipients by recipient EBV status at transplant, 2010-2016. Cumulative incidence is estimated using the Kaplan-Meier method. PTLD is identified as a reported complication or cause of death on the OPTN Transplant Recipient Follow-up Form or the Posttransplant Malignancy Form as polymorphic PTLD, monomorphic PTLD, or Hodgkin's disease. Only the earliest date of PTLD diagnosis is considered. EBV, Epstein-Barr virus; PTLD, posttransplant lymphoproliferative disorder.

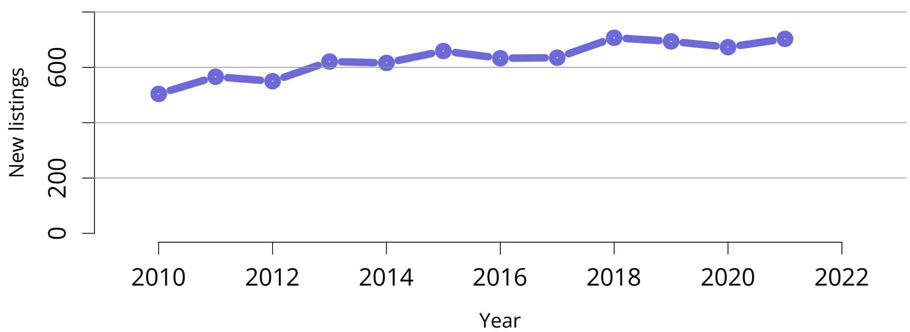

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Figure HR 69: New pediatric candidates added to the heart transplant waiting list. A new candidate is one who first joined the list during the given year, without having been listed in a previous year. Previously listed candidates who underwent transplant and subsequently relisted are considered new. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

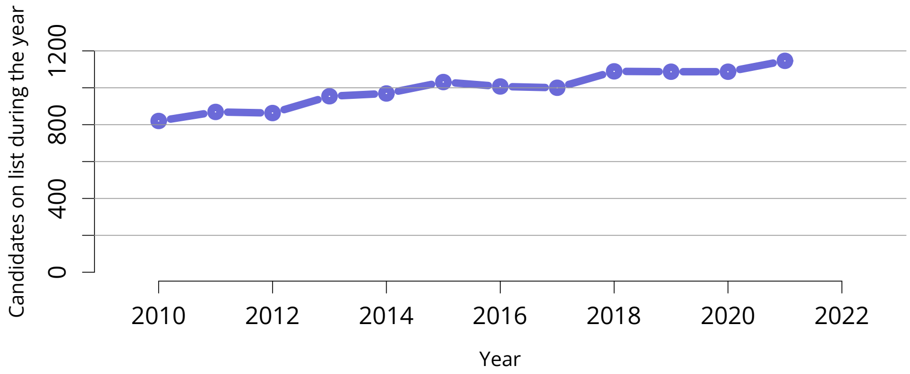

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Figure HR 70: All pediatric candidates on the heart transplant waiting list. Pediatric candidates listed at any time during the year. Candidates listed at more than one center are counted once per listing.

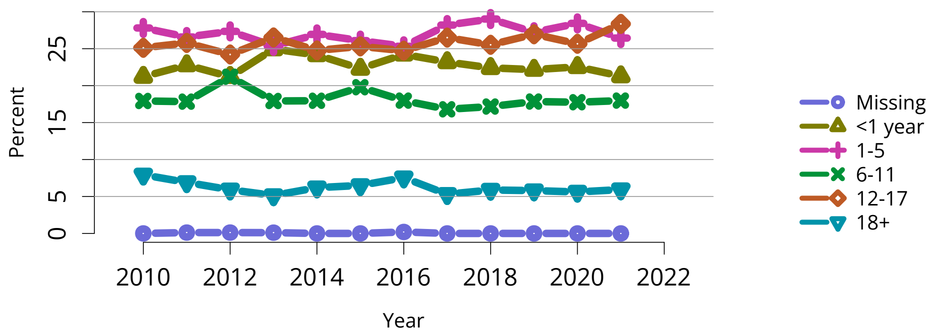

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Figure HR 71: Distribution of pediatric candidates waiting for heart transplant by age. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive candidates are included. Age is determined at the earliest of transplant, death, removal, or December 31 of the year.

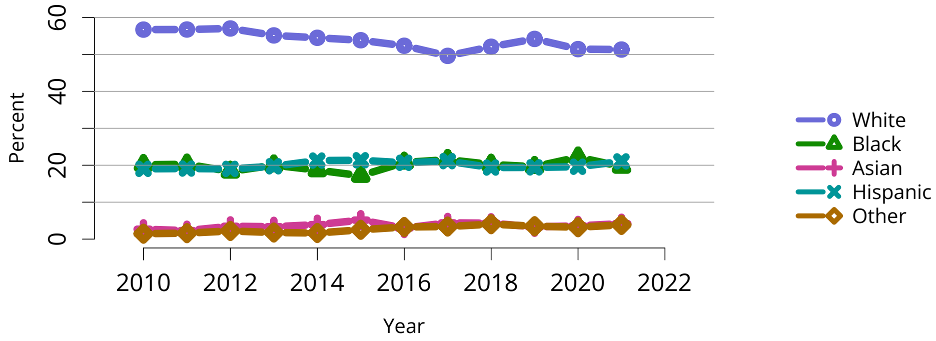

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Figure HR 72: Distribution of pediatric candidates waiting for heart transplant by race. Candidates waiting for transplant any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive candidates are included.

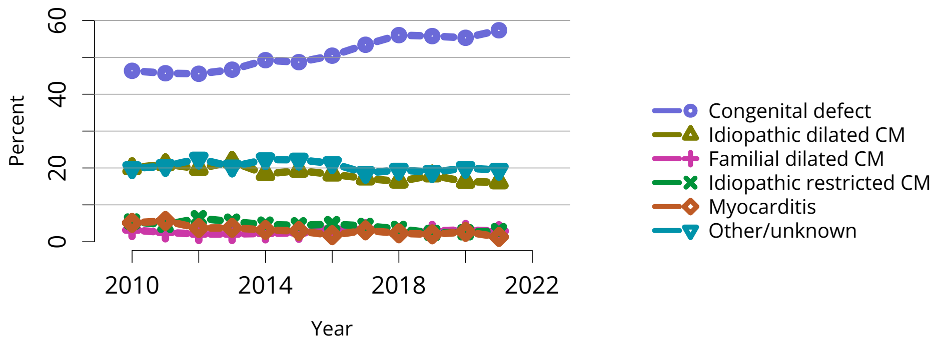

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Figure HR 73: Distribution of pediatric candidates waiting for heart transplant by diagnosis. Candidates waiting for transplant any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive candidates are included. CM, cardiomyopathy.

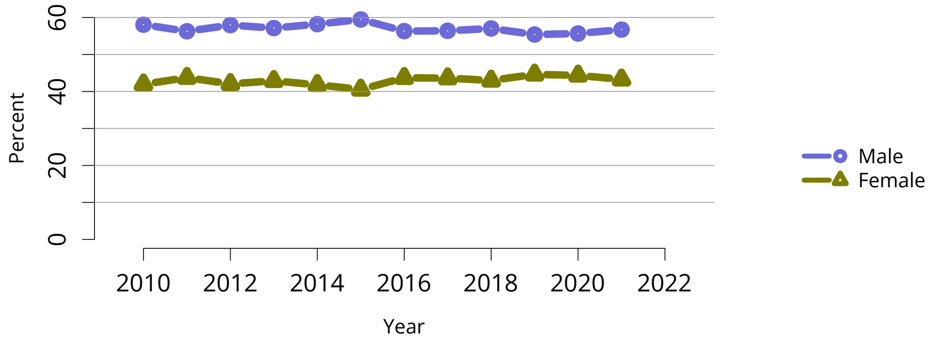

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Figure HR 74: Distribution of pediatric candidates waiting for heart transplant by sex. Candidates waiting for transplant any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

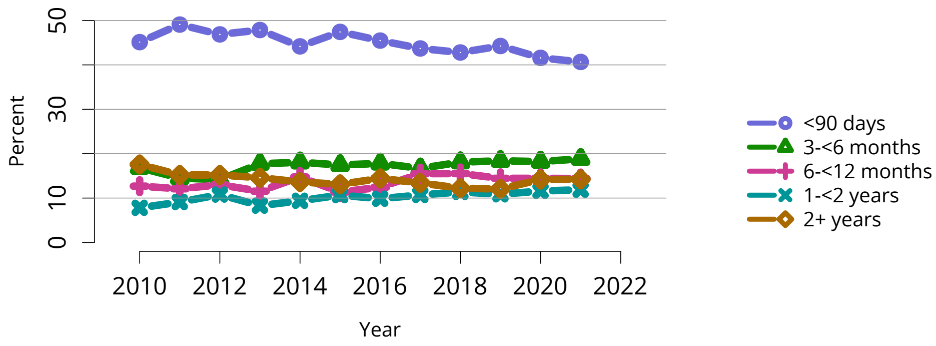

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Figure HR 75: Distribution of pediatric candidates waiting for heart transplant by waiting time. Candidates waiting for transplant any time in the given year. Candidates listed at more than one center are counted once per listing. Time on the waiting list is determined at the earliest of transplant, death, removal, or December 31 of the year. Active and inactive candidates are included.

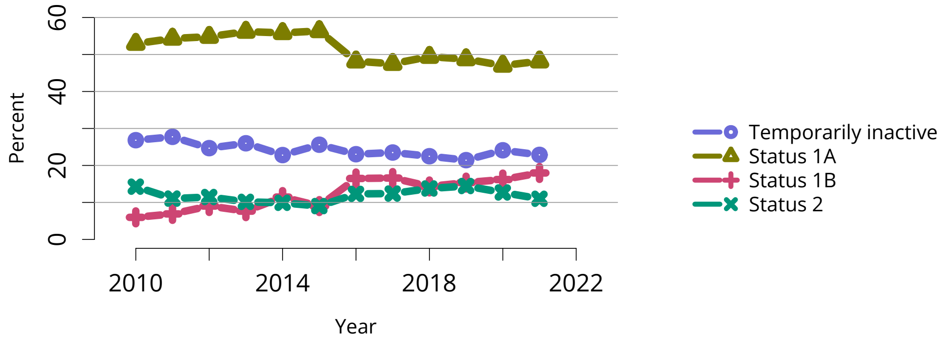

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Figure HR 76: Distribution of pediatric candidates waiting for heart transplant by medical urgency. Candidates waiting for transplant any time in the given year. Candidates listed at more than one center are counted once per listing. Medical urgency is determined at the earliest of transplant, death, removal, or December 31 of the year. Active and inactive patients are included.

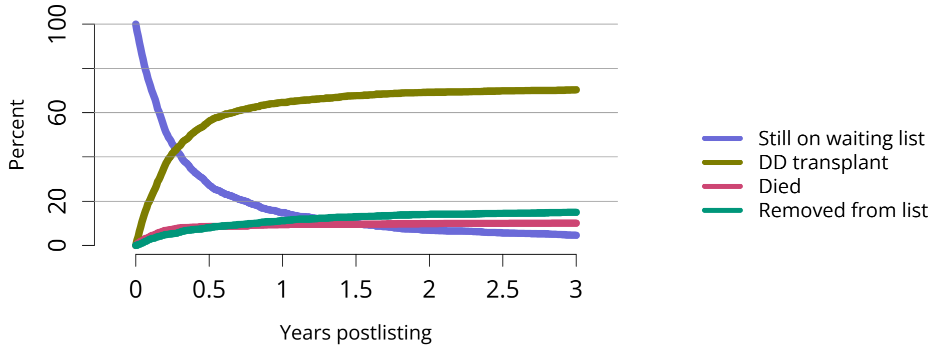

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Figure HR 77: Three-year outcomes for newly listed pediatric candidates waiting for heart transplant, 2016-2018. Pediatric candidates who joined the waiting list in 2016-2018. Pediatric candidates listed at more than one center are counted once per listing. Removed from list includes all reasons except transplant and death. DD, deceased donor.

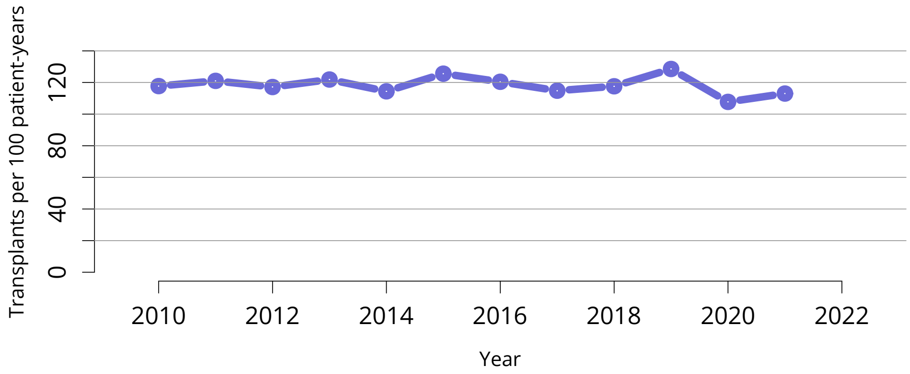

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Figure HR 78: Overall deceased donor heart transplant rates among pediatric waitlist candidates. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given year. Individual listings are counted separately.

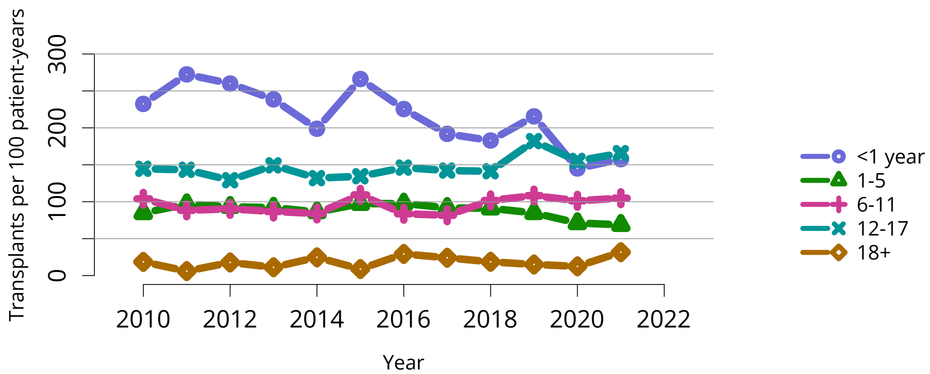

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Figure HR 79: Deceased donor heart transplant rates among pediatric waitlist candidates by age. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given year. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.

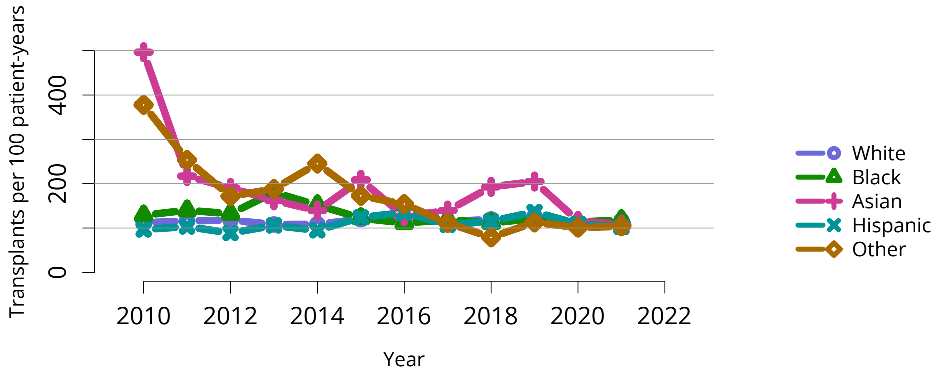

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Figure HR 80: Deceased donor heart transplant rates among pediatric waitlist candidates by race. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given year. Individual listings are counted separately.

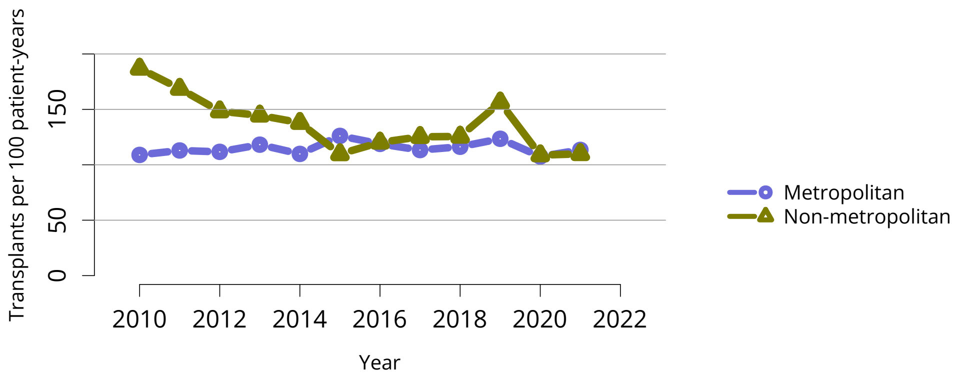

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Figure HR 81: Deceased donor heart transplant rates among pediatric waitlist candidates by metropolitan vs. non-metropolitan residence. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given year. Individual listings are counted separately.

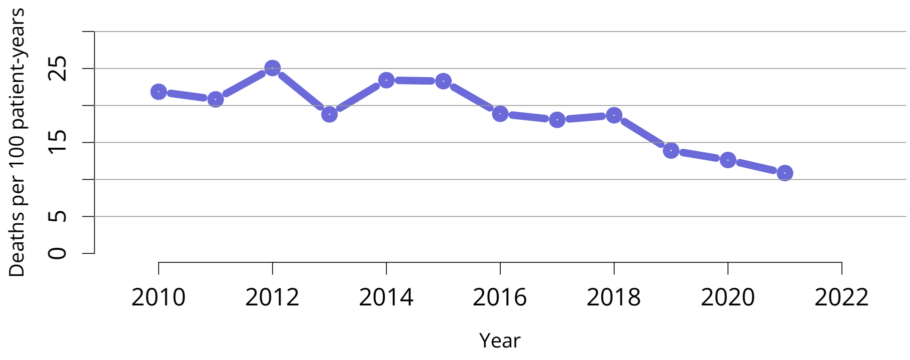

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Figure HR 82: Overall pretransplant mortality rates among pediatric candidates waitlisted for heart. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

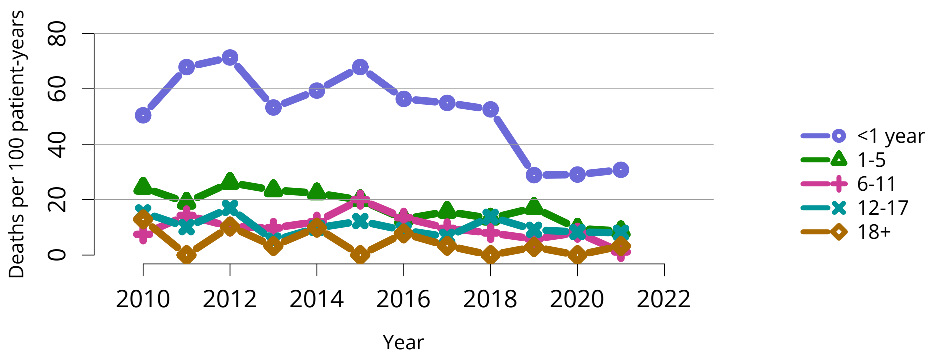

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Figure HR 83: Pretransplant mortality rates among pediatric candidates waitlisted for heart transplant by age. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.

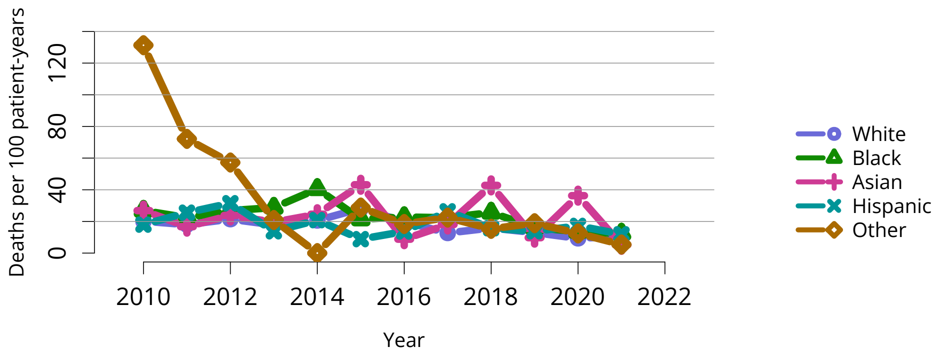

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Figure HR 84: Pretransplant mortality rates among pediatric candidates waitlisted for heart transplant by race. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

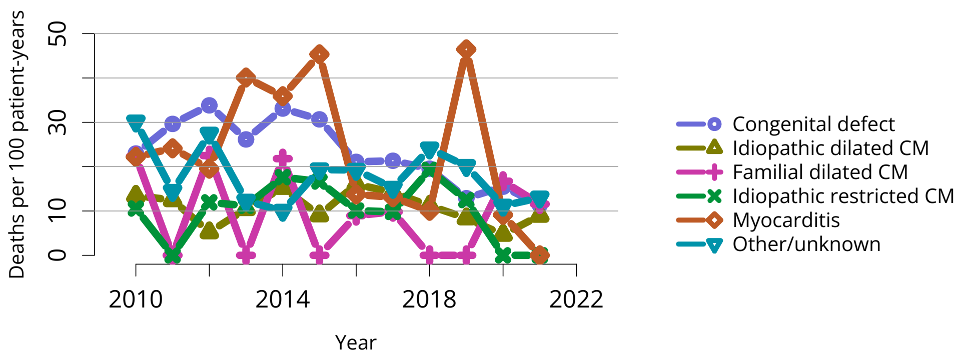

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Figure HR 85: Pretransplant mortality rates among pediatrics waitlisted for heart transplant by diagnosis. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. CM, cardiomyopathy.

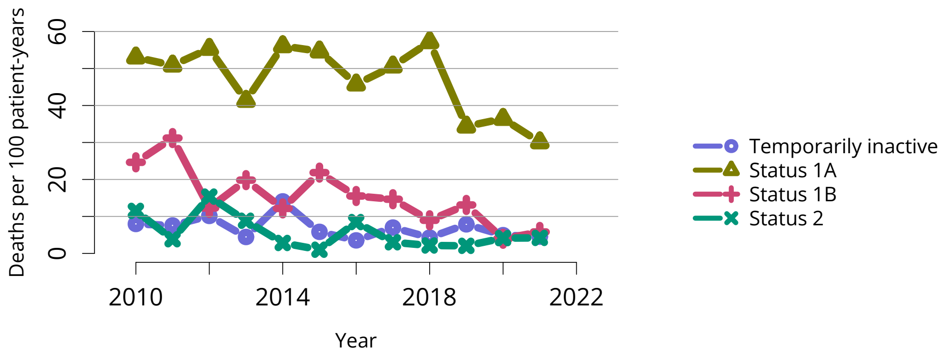

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Figure HR 86: Pretransplant mortality rates among pediatrics waitlisted for heart transplant by medical urgency. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Medical urgency is determined at the later of listing date or January 1 of the given year.

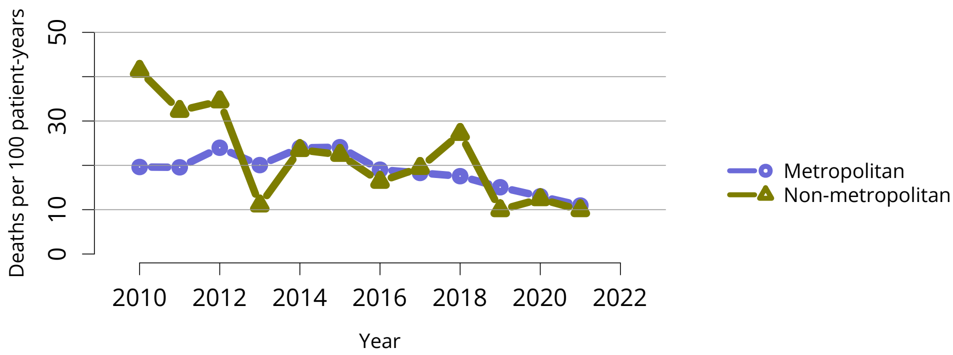

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Figure HR 87: Pretransplant mortality rates among pediatric candidates waitlisted for heart transplant by metropolitan vs. non-metropolitan residence. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Urban/rural determination is made using the RUCA (rural-urban commuting area) designation of the candidate's permanent zip code.

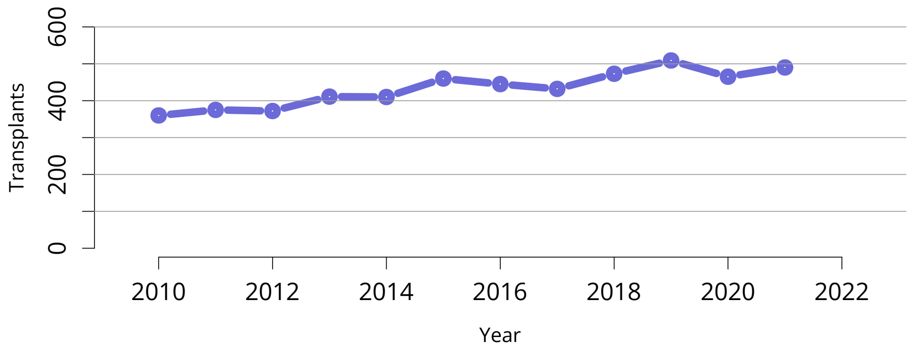

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Figure HR 88: Overall pediatric heart transplants. All pediatric heart transplant recipients, including retransplant, and multiorgan recipients.

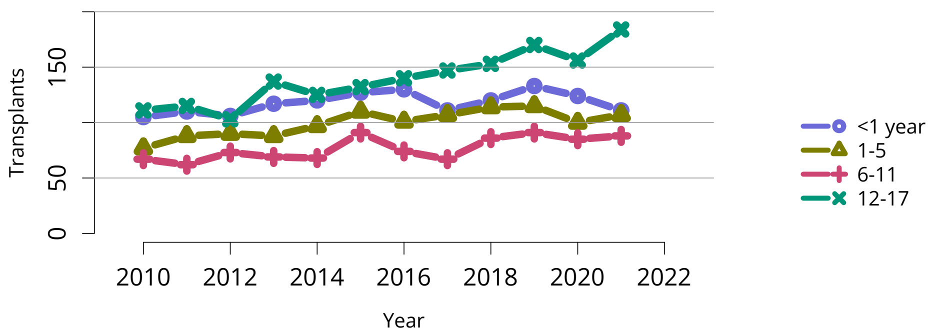

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Figure HR 89: Pediatric heart transplants by recipient age. All pediatric heart transplant recipients, including retransplant, and multiorgan recipients.

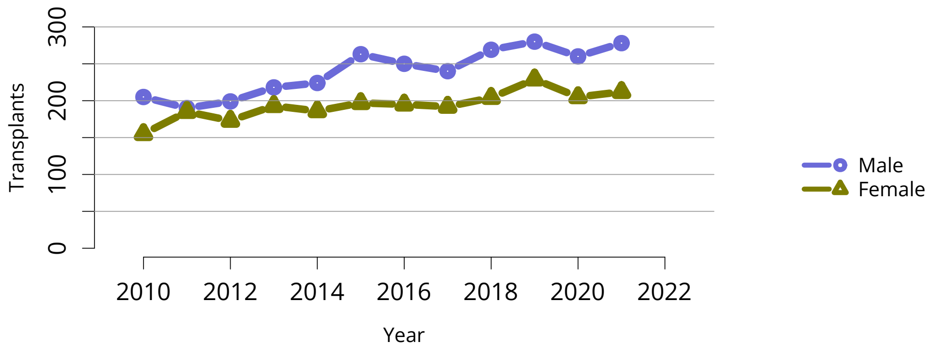

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Figure HR 90: Pediatric heart transplants by sex. All pediatric heart transplant recipients, including retransplant, and multiorgan recipients.

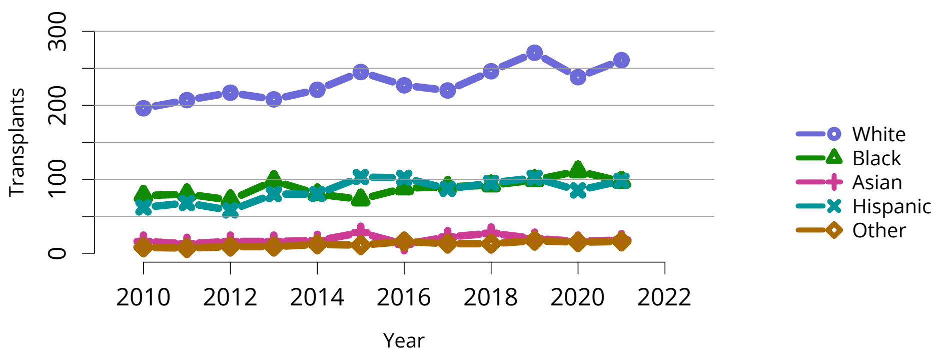

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Figure HR 91: Pediatric heart transplants by race. All pediatric heart transplant recipients, including retransplant, and multiorgan recipients.

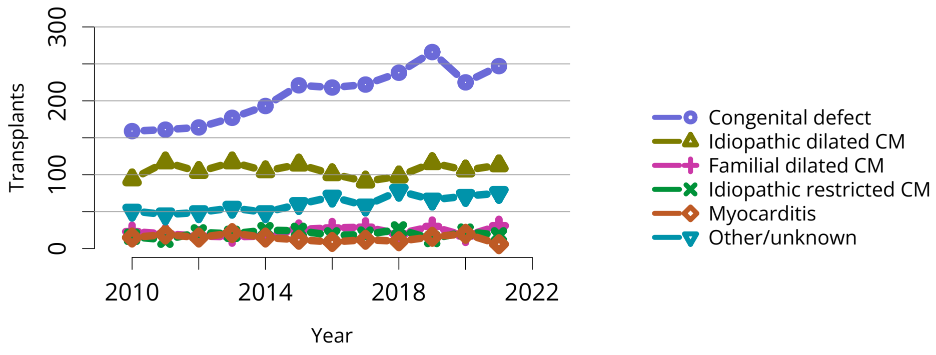

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Figure HR 92: Pediatric heart transplants by diagnosis. All pediatric heart transplant recipients, including retransplant, and multiorgan recipients. CM, cardiomyopathy.

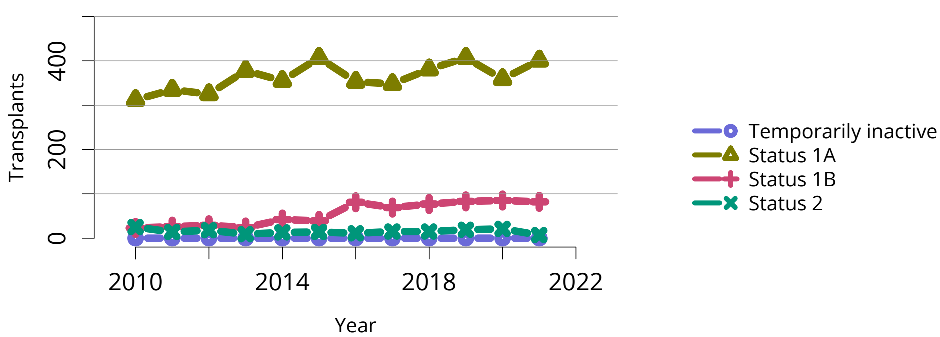

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Figure HR 93: Pediatric heart transplants by medical urgency. All pediatric heart transplant recipients, including retransplant, and multiorgan recipients. The OPTN heart allocation policy changed the status groups in October 2018.

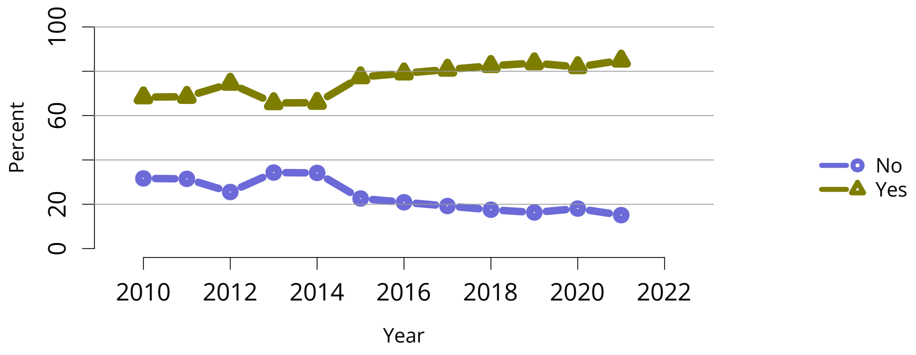

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Figure HR 94: Induction agent use in pediatric heart transplant recipients. Immunosuppression at transplant reported to the OPTN.

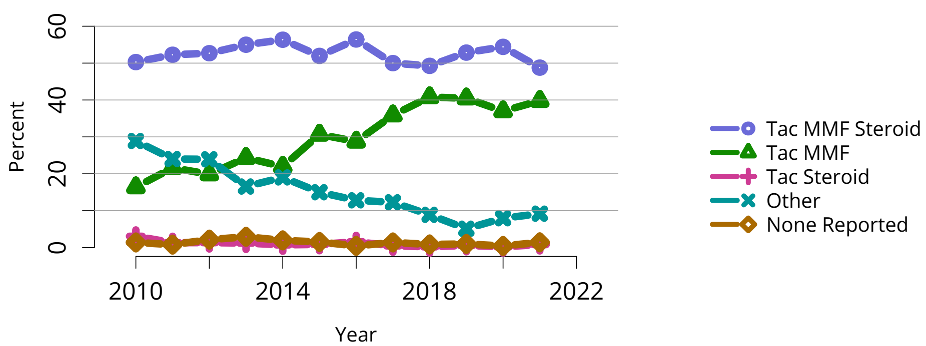

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Figure HR 95: Immunosuppression regimen use in pediatric heart transplant recipients. Immunosuppression regimen at transplant reported to the OPTN. Tac, tacrolimus. MMF, all mycophenolate agents.

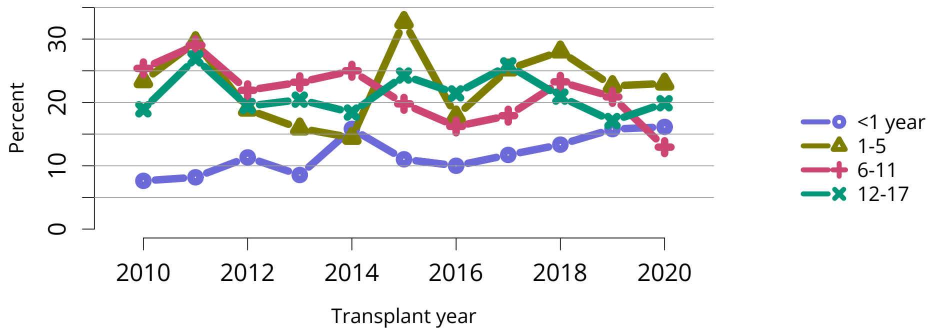

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Figure HR 96: Incidence of acute rejection by 1 year posttransplant among pediatric heart transplant recipients by age. Only the first reported rejection event is counted. Cumulative incidence is estimated using the Kaplan-Meier method.

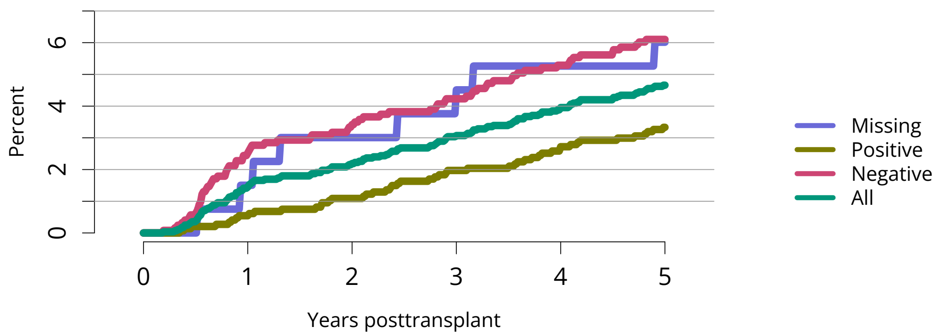

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Figure HR 97: Incidence of PTLD among pediatric heart transplant recipients by recipient EBV status at transplant, 2010-2016. Cumulative incidence is estimated using the Kaplan-Meier method. PTLD is identified as a reported complication or cause of death on the OPTN Transplant Recipient Follow-up Form or on the Posttransplant Malignancy Form as polymorphic PTLD, monomorphic PTLD, or Hodgkin's disease. Only the earliest date of PTLD diagnosis is considered. EBV, Epstein-Barr virus. PTLD, posttransplant lymphoproliferative disorder.

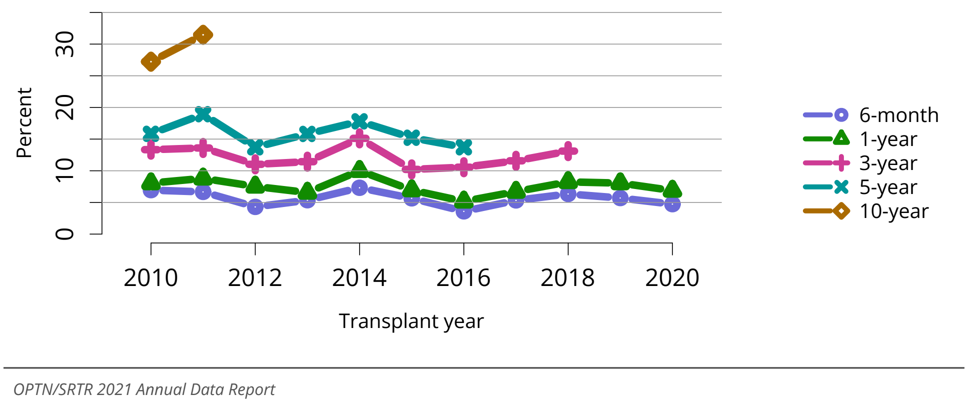

Figure HR 98: Patient death among pediatric heart transplant recipients. All pediatric recipients of deceased donor hearts, including multiorgan transplants. Estimates are unadjusted, computed using unadjusted Kaplan-Meier methods.

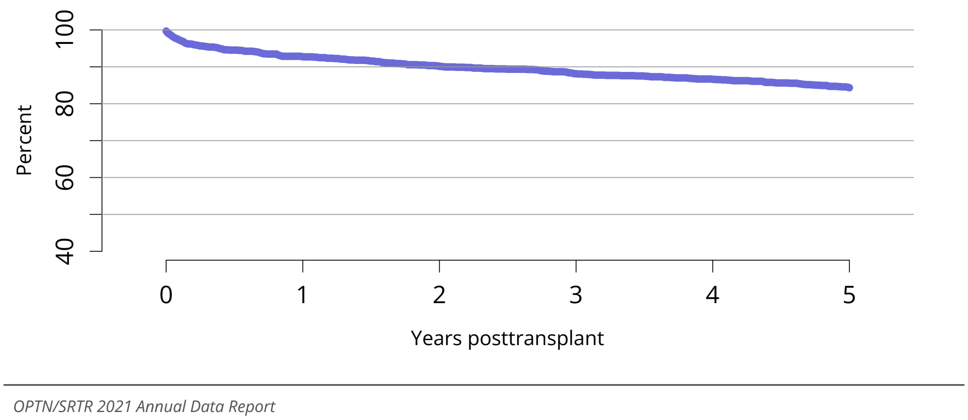

Figure HR 99: Overall patient survival among pediatric deceased donor heart transplant recipients, 2014-2016. Recipient survival estimated using unadjusted Kaplan-Meier methods.

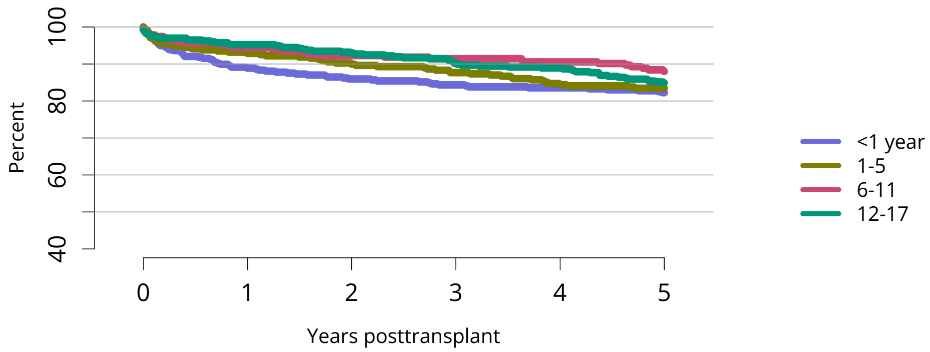

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Figure HR 100: Patient survival among pediatric deceased donor heart transplant recipients, 2014-2016, by recipient age. Recipient survival estimated using unadjusted Kaplan-Meier methods.

Table HR 1: Demographic characteristics of adults on the heart transplant waiting list on December 31, 2011, and December 31, 2021. Candidates waiting for transplant on December 31 of the given year, regardless of first listing date. Distance is computed from candidate's home zip code to the transplant center. Age is determined on December 31 of the year.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Age (years)				
18-34 years	320	11.1	365	11.9
35-49	651	22.6	680	22.1
50-64	1427	49.5	1465	47.7
65+	487	16.9	563	18.3
Sex				
Male	2146	74.4	2340	76.1
Female	739	25.6	733	23.9
Race				
White	1996	69.2	1732	56.4
Black	612	21.2	906	29.5
Asian	62	2.1	93	3
Hispanic	187	6.5	313	10.2
Other	28	1	29	0.9
Geography				
Metropolitan	2395	83	2613	85
Non-metropolitan	469	16.3	430	14
Missing	21	0.7	30	1
Miles between candidate to center				
<50 miles	1676	58.1	1867	60.8
50-<100	477	16.5	479	15.6
100-<150	269	9.3	296	9.6
150-<250	247	8.6	216	7
250+	198	6.9	191	6.2
Missing	18	0.6	24	0.8
All candidates				
All candidates	2885	100	3073	100

Table HR 2: Clinical characteristics of adults on the heart transplant waiting list on December 31, 2011, and December 31, 2021. Candidates waiting for transplant on December 31 of the given year, regardless of first listing date. VAD, ventricular assist device.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Diagnosis				
Coronary artery disease	1088	37.7	855	27.8
Cardiomyopathy	1429	49.5	1826	59.4
Congenital disease	151	5.2	167	5.4
Valvular disease	54	1.9	31	1
Other/unknown	157	5.4	194	6.3
NA	6	0.2	0	0
Blood Type				
A	923	32	821	26.7
AB	61	2.1	43	1.4
B	305	10.6	311	10.1
O	1596	55.3	1898	61.8
VAD status at listing				
No VAD	2318	80.3	1964	63.9
VAD	535	18.5	1096	35.7
Missing	32	1.1	13	0.4
Urgency status for heart candidates				
Status 1A	202	7	0	0
Status 1B	907	31.4	0	0
Status 2	963	33.4	0	0
Temporarily inactive	813	28.2	669	21.8
Adult Status 1	0	0	16	0.5
Adult Status 2	0	0	118	3.8
Adult Status 3	0	0	156	5.1
Adult Status 4	0	0	1419	46.2
Adult Status 5	0	0	134	4.4
Adult Status 6	0	0	560	18.2
Adults listed under pediatric status	0	0	1	0
All candidates				
All candidates	2885	100	3073	100

Table HR 3: Listing characteristics of adults on the heart transplant waiting list on December 31, 2011, and December 31, 2021. Candidates waiting for transplant on December 31 of the given year, regardless of first listing date.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Previous transplant				
No prior transplant	2770	96	2982	97
Prior transplant	115	4	91	3
Waiting time				
<90 days	541	18.8	594	19.3
3-<6 months	384	13.3	340	11.1
6-<12 months	518	18	581	18.9
1-<2 years	628	21.8	604	19.7
2+ years	814	28.2	954	31
All candidates				
All candidates	2885	100	3073	100

Table HR 4: Heart transplant waitlist activity among adults. Candidates listed at more than one center are counted once per listing. Candidates who are listed, undergo transplant, and are relisted are counted more than once. Candidates are not considered to be on the list on the day they are removed; counts on January 1 may differ from counts on December 31 of the prior year. Candidates listed for multiorgan transplants are included.

Waiting list state	2019	2020	2021
Waiting list state			
Patients at start of year	3476	3386	3146
Patients added during year	4087	4000	4373
Patients removed during year	4177	4240	4446
Patients at end of year	3386	3146	3073

Table HR 5: Removal reason among adult heart transplant candidates. Removal reason as reported to the OPTN. Candidates with death dates that precede removal dates are assumed to have died waiting.

Removal reason	2019	2020	2021
Removal reason			
Deceased donor transplant	3075	3240	3354
Patient died	177	191	210
Patient refused transplant	25	19	23
Improved, transplant not needed	163	147	198
Too sick for transplant	280	243	252
Other	457	400	409

Table HR 6: Adult heart recipients on life support before transplant. Patients may have more than one type of life support. Circulatory support: left ventricular assist device, right ventricular assist device, total artificial heart, extracorporeal membrane oxygenation, and intra-aortic balloon pump.

	2018		2021	
Life support type	**N**	**Percent**	**N**	**Percent**
Life support type				
Any life support	2431	81.9	2574	76.3
Left ventricular assist device	1307	44.1	1060	31.4
Intravenous inotropes	1015	34.2	1268	37.6
Intra-aortic balloon pump	278	9.4	930	27.6
Right ventricular assist device	46	1.6	57	1.7
Extra corporeal membrane oxygenation	58	2	229	6.8
Total artificial heart	32	1.1	13	0.4
Ventilator	34	1.1	78	2.3
Inhaled NO	5	0.2	14	0.4
Prostaglandins	5	0.2	5	0.1

Table HR 7: Demographic characteristics of adult heart transplant recipients, 2011 and 2021. Heart transplant recipients, including retransplants. Distance is computed from recipient's home zip code to the transplant center.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Recipient age (years)				
18-34 years	224	11.3	385	11.4
35-49	391	19.8	620	18.4
50-64	1024	51.9	1636	48.5
65+	335	17	731	21.7
Sex				
Male	1420	71.9	2484	73.7
Female	554	28.1	888	26.3
Race				
White	1340	67.9	1986	58.9
Black	409	20.7	842	25
Asian	59	3	158	4.7
Hispanic	157	8	354	10.5
Other	9	0.5	32	0.9
Insurance				
Private	971	49.2	1504	44.6
Medicare	731	37	1187	35.2
Medicaid	194	9.8	485	14.4
Other/unknown	78	4	196	5.8
Geography				
Metropolitan	1675	84.9	2824	83.7
Non-metropolitan	273	13.8	446	13.2
Missing	26	1.3	102	3
Miles between recipient to center				
<50 miles	1219	61.8	1999	59.3
50-<100	313	15.9	545	16.2
100-<150	182	9.2	275	8.2
150-<250	144	7.3	261	7.7
250+	98	5	199	5.9
Missing	18	0.9	93	2.8
All recipients				
All recipients	1974	100	3372	100

Table HR 8: Clinical characteristics of adult heart transplant recipients, 2011 and 2021. Heart transplant recipients, including retransplants. Ventricular assist device (VAD) information is from the OPTN Transplant Recipient Registration Form and includes left VAD, right VAD, total artificial heart, and left + right VAD. Collection of calculated panel-reactive antibody (cPRA) began March 31, 2015. Prior to that, PRA class I and II values were used. Missing/temporarily inactive urgency statuses are regarded as listing errors since they should not have received a transplant.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Diagnosis				
Coronary artery disease	750	38	995	29.5
Cardiomyopathy	1080	54.7	2051	60.8
Congenital disease	75	3.8	145	4.3
Valvular disease	28	1.4	22	0.7
Other/unknown	22	1.1	132	3.9
NA	19	1	27	0.8
Blood Type				
A	803	40.7	1279	37.9
AB	108	5.5	158	4.7
B	279	14.1	523	15.5
O	784	39.7	1412	41.9
VAD at transplant				
VAD	823	41.7	1141	33.8
No VAD	1151	58.3	2175	64.5
Missing	0	0	56	1.7
CPRA				
<1%	1035	52.4	1693	50.2
1-<20%	419	21.2	296	8.8
20-<80%	361	18.3	350	10.4
80-<98%	67	3.4	59	1.7
98-100%	27	1.4	22	0.7
Missing	65	3.3	952	28.2
Urgency status for heart recipients				
Status 1A	1113	56.4	11	0.3
Status 1B	731	37	5	0.1
Status 2	130	6.6	1	0
Adult Status 1	0	0	364	10.8
Adult Status 2	0	0	1692	50.2
Adult Status 3	0	0	449	13.3
Adult Status 4	0	0	635	18.8
Adult Status 5	0	0	34	1
Adult Status 6	0	0	181	5.4
All recipients				
All recipients	1974	100	3372	100

Table HR 9: Transplant characteristics of adult heart transplant recipients, 2011 and 2021. Heart transplant recipients, including retransplants.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Waiting time				
None	57	2.9	176	5.2
<90 days	919	46.6	2140	63.5
3-<6 months	316	16	361	10.7
6-<12 months	324	16.4	261	7.7
1-<2 years	235	11.9	188	5.6
2+	123	6.2	246	7.3
Previous transplant for recipients				
Prior transplant	80	4.1	98	2.9
No Prior transplant	1894	95.9	3274	97.1
All recipients				
All recipients	1974	100	3372	100

Table HR 10: Demographic characteristics of pediatric candidates on the heart transplant waiting list on December 31, 2011 and December 31, 2021. Candidates younger than 18 years at listing waiting for transplant on December 31 of the given year, regardless of first listing date. Age is determined on December 31 of the year. Distance is computed from candidate's home zip code to the transplant center.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Age (years)				
<1 year	33	10.5	74	15.3
1-5	94	30	142	29.3
6-11	69	22	105	21.6
12-17	82	26.2	121	24.9
18+	35	11.2	43	8.9
Sex				
Male	188	60.1	276	56.9
Female	125	39.9	209	43.1
Race				
White	183	58.5	239	49.3
Black	57	18.2	92	19
Asian	6	1.9	24	4.9
Hispanic	64	20.4	114	23.5
Other	3	1	16	3.3
Geography				
Metropolitan	270	86.3	407	83.9
Non-metropolitan	36	11.5	73	15.1
Missing	7	2.2	5	1
Miles between candidate to center				
<50 miles	160	51.1	239	49.3
50-<100	58	18.5	97	20
100-<150	27	8.6	62	12.8
150-<250	32	10.2	48	9.9
250+	29	9.3	34	7
Missing	7	2.2	5	1
All candidates				
All candidates	313	100	485	100

Table HR 11: Clinical characteristics of pediatric candidates on the heart transplant waiting list on December 31, 2011, and December 31, 2021. CM, cardiomyopathy; VAD, ventricular assist device.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Pediatric diagnosis				
Congenital defect	145	46.3	311	64.1
Idiopathic dilated CM	55	17.6	64	13.2
Familial dilated CM	4	1.3	5	1
Idiopathic restricted CM	23	7.3	12	2.5
Myocarditis	9	2.9	5	1
Other/unknown	77	24.6	88	18.1
Blood Type				
A	104	33.2	146	30.1
AB	9	2.9	8	1.6
B	24	7.7	52	10.7
O	176	56.2	279	57.5
VAD status at listing				
No VAD	289	92.3	443	91.3
VAD	12	3.8	41	8.5
Missing	12	3.8	1	0.2
Urgency status for heart candidates				
Status 1A	76	24.3	114	23.5
Status 1B	30	9.6	115	23.7
Status 2	72	23	111	22.9
Temporarily inactive	135	43.1	145	29.9
All candidates				
All candidates	313	100	485	100

Table HR 12: Listing characteristics of pediatric candidates on the heart transplant waiting list on December 31, 2011, and December 31, 2021. Candidates younger than 18 years at listing waiting for transplant on December 31 of the given year, regardless of first listing date.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Previous transplant				
No prior transplant	279	89.1	464	95.7
Prior transplant	34	10.9	21	4.3
Waiting time				
<90 days	75	24	137	28.2
3-<6 months	38	12.1	72	14.8
6-<12 months	56	17.9	78	16.1
1-<2 years	50	16	77	15.9
2+ years	94	30	121	24.9
All candidates				
All candidates	313	100	485	100

Table HR 13: Heart transplant waitlist activity among pediatric candidates. Candidates who are listed, undergo transplant, and are relisted are counted more than once. Candidates are not considered to be on the list on the day they are removed; counts on January 1 may differ from counts on December 31 of the prior year. Candidates listed for multiorgan transplants are included.

Waiting list state	2019	2020	2021
Waiting list state			
Patients at start of year	393	414	443
Patients added during year	694	673	703
Patients removed during year	673	644	661
Patients at end of year	414	443	485

Table HR 14: Removal reason among pediatric heart transplant candidates. Removal reason as reported to the OPTN. Candidates with death dates that precede removal dates are assumed to have died waiting.

Removal reason	2019	2020	2021
Removal reason			
Deceased donor transplant	520	475	505
Patient died	54	57	46
Patient refused transplant	3	2	3
Improved, transplant not needed	43	48	40
Too sick for transplant	29	33	33
Other	24	29	34

Table HR 15: Pediatric heart recipients on life support before transplant. Patients may have more than one type of life support. Circulatory support: left ventricular assist device, right ventricular assist device, total artificial heart, extracorporeal membrane oxygenation, and intra-aortic balloon pump.

	2016		2021	
Life support type	**N**	**Percent**	**N**	**Percent**
Life support type				
Any life support	341	76.6	332	67.8
Left ventricular assist device	102	22.9	168	34.3
Intravenous inotropes	236	53	195	39.8
Intra-aortic balloon pump	1	0.2	4	0.8
Right ventricular assist device	14	3.1	28	5.7
Extra corporeal membrane oxygenation	18	4	20	4.1
Total artificial heart	0	0	1	0.2
Ventilator	78	17.5	36	7.3
Inhaled NO	6	1.3	6	1.2
Prostaglandins	18	4	8	1.6

Table HR 16: Demographic characteristics of pediatric heart transplant recipients, 2011 and 2021. Pediatric heart transplant recipients, including retransplants. Distance is computed from recipient's home zip code to the transplant center.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Recipient age (years)				
<1 year	110	29.3	111	22.7
1-5	88	23.5	107	21.8
6-11	62	16.5	88	18
12-17	115	30.7	184	37.6
Sex				
Male	190	50.7	278	56.7
Female	185	49.3	212	43.3
Race				
White	207	55.2	261	53.3
Black	80	21.3	97	19.8
Asian	13	3.5	18	3.7
Hispanic	68	18.1	98	20
Other	7	1.9	16	3.3
Insurance				
Private	163	43.5	188	38.4
Medicare	2	0.5	1	0.2
Medicaid	178	47.5	250	51
Other/unknown	32	8.5	51	10.4
Geography				
Metropolitan	301	80.3	415	84.7
Non-metropolitan	67	17.9	64	13.1
Missing	7	1.9	11	2.2
Miles between recipient to center				
<50 miles	179	47.7	269	54.9
50-<100	62	16.5	86	17.6
100-<150	45	12	35	7.1
150-<250	51	13.6	47	9.6
250+	32	8.5	44	9
Missing	6	1.6	9	1.8
All recipients				
All recipients	375	100	490	100

Table HR 17: Clinical characteristics of pediatric heart transplant recipients, 2011 and 2021. Pediatric heart transplant recipients, including retransplants. Collection of calculated PRA (cPRA) began March 31, 2015. Prior to that, measured PRA values were used. CM, cardiomyopathy; VAD, ventricular assist device.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Diagnosis				
Congenital defect	161	42.9	247	50.4
Idiopathic dilated CM	117	31.2	113	23.1
Familial dilated CM	20	5.3	31	6.3
Idiopathic restricted CM	12	3.2	18	3.7
Myocarditis	19	5.1	6	1.2
Other/unknown	46	12.3	75	15.3
Blood Type				
A	148	39.5	175	35.7
AB	19	5.1	23	4.7
B	48	12.8	66	13.5
O	160	42.7	226	46.1
VAD at transplant				
VAD	71	18.9	176	35.9
No VAD	304	81.1	312	63.7
Missing	0	0	2	0.4
CPRA				
<1%	170	45.3	249	50.8
1-<20%	61	16.3	42	8.6
20-<80%	77	20.5	53	10.8
80-<98%	16	4.3	18	3.7
98-100%	7	1.9	5	1
Missing	44	11.7	123	25.1
Urgency status for heart recipients				
Status 1A	335	89.3	401	81.8
Status 1B	26	6.9	82	16.7
Status 2	14	3.7	7	1.4
All recipients				
All recipients	375	100	490	100

Table HR 18: Transplant characteristics of pediatric heart transplant recipients, 2011 and 2021.
Pediatric transplant recipients, including retransplants.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Waiting time				
None	10	2.7	10	2
<90 days	256	68.3	255	52
3-<6 months	62	16.5	113	23.1
6-<12 months	32	8.5	65	13.3
1-<2 years	13	3.5	29	5.9
2+	2	0.5	18	3.7
ABO-Incompatible transplant				
Compatible/Identical	361	96.3	448	91.4
Incompatible	14	3.7	42	8.6
Previous transplant for recipients				
Prior transplant	26	6.9	23	4.7
No Prior transplant	349	93.1	467	95.3
All recipients				
All recipients	375	100	490	100

OPTN/SRTR 2021 Annual Data Report: Lung

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Abstract

The number of lung transplants has continued to decline since 2020, a period that coincides with the onset of the COVID-19 pandemic. Lung allocation policy continues to undergo considerable change in preparation for adoption of the Composite Allocation Score system in 2023, beginning with multiple adaptations to the calculation of the Lung Allocation Score that occurred in 2021. The number of candidates added to the waiting list increased after a decline in 2020, while waitlist mortality has increased slightly with a decreased number of transplants. Time to transplant continues to improve, with 38.0% of candidates waiting fewer than 90 days for a transplant. Posttransplant survival remains stable, with 85.3% of transplant recipients surviving to 1 year; 67%, to 3 years; and 54.3%, to 5 years.

Keywords: End-stage lung disease, Lung Allocation Score, lung transplant, organ allocation, revised Lung Allocation Score, transplant outcomes

1 INTRODUCTION

The number of lung transplants has been declining since the peak noted in 2019, with 2,569 transplants occurring in 2021. This is a decrease of 28 transplants compared with 2020 and 190 transplants compared with 2019. New candidates added to the waiting list began to increase in 2021, with 415 more candidates added to the waiting list compared with 2020; but this still falls short of the number in 2019. COVID-19, and its complications, has emerged as a major indication for lung transplant, with 261 transplants performed for this indication in 2021. There have been only three cases of donor-derived transmission of COVID-19 to date (November 3, 2022), as a result of rigorous testing protocols used by the transplant community.

Major lung allocation policy changes occurred in 2021 in preparation for the implementation of the Composite Allocation Score (CAS) system, which is planned to go into effect in 2023. Changes to the Lung Allocation Score (LAS) were implemented on September 30, 2021, to reflect a more recent candidate and recipient cohort and improve the prediction of calculated waitlist and posttransplant survival models that are currently used in the LAS and will be used in the forthcoming CAS. This resulted in the removal of several previously significant variables from the survival models and parameter updates for multiple additional variables. Multiple variables were removed from the waitlist survival models, including diagnosis (obliterative bronchiolitis, lymphangioleiomyomatosis, and Eisenmenger syndrome), bilirubin increase of 50% or greater, diabetes, forced vital capacity, cardiac index, and central venous pressure. Variables removed from the posttransplant survival models include diagnosis (lymphangioleiomyomatosis, Eisenmenger syndrome, pulmonary fibrosis, and other), functional status, and serum creatinine increase of 150% or greater. Parameterizations on the remaining variables were updated to reflect the new cohort. The effect of these changes on the group LASs for the population has not yet been well studied, but readers should be cautioned that these changes make direct comparisons between LAS values pre- and post-policy difficult. Notably, the updated LAS still uses a 2:1 ratio of 1-year waitlist and 1-year posttransplant survival. The CAS will use a 1:1 ratio of 1-year waitlist and 5-year posttransplant survival.

The US lung allocation system will be the first to adopt a CAS system, with the goal of improving equity in organ allocation. The new CAS system will use the continuous distribution framework, whereby strict geographic cut points in concentric circles from the donor are no longer used to guide allocation. Work to develop the CAS system began with the Organ Procurement and Transplantation Network (OPTN) Lung Transplantation Committee in 2019, was open to public comment in 2019-2021, and was approved by the OPTN Board of Directors at the end of 2021. The CAS system includes five attributes:

medical urgency, posttransplant survival, candidate biology, patient access, and placement efficiency. In this system, medical urgency (1 year) and posttransplant survival (5 years) will receive equal weighting. In the LAS system, the allocation process differs for those aged 12 years or younger and is governed by illness-based priority status, age, geography, blood-type compatibility, and waiting time. With adoption of the CAS system, persons aged 12 years or younger will receive a 20% weighting for pediatric status within the system, eliminating the need for separate adult and pediatric allocation systems.

With the LAS, transplant benefit is estimated by calculating a measure of waitlist and posttransplant mortality. Waitlist mortality receives twice the weight of posttransplant survival. Pulmonary diseases are characterized into four main diagnosis groups: group A, obstructive lung disease; group B, pulmonary vascular disease; group C, cystic fibrosis and immunodeficiency disorders; and group D, restrictive lung diseases. These groupings were derived to aggregate individuals based on disease pathophysiology and survival probability. Notable changes to the allocation system that might affect longitudinal results reported in this chapter include (1) the 2015 update including a more contemporary cohort and new variables for candidates in diagnosis group B; (2) the 2017 update replacing the donation service area with a 250–nautical-mile radius from the donor hospital as the first unit of allocation; and (3) the 2021 update including a more contemporary cohort, removed variables, and updated parameterizations.

In this report, results for the Adult Lung Transplantation section include all lung transplant candidates and recipients 18 years or older at the time of listing; those younger than 18 years are reported in the Pediatric Lung Transplantation section. Reports prior to 2020 separate pediatric and adult candidates at an age of 12 years because the LAS is calculated for candidates aged 12 years and older. This change in reporting was made to align with international reporting. This chapter includes information about both heart-lung and lung candidates and recipients.

2 ADULT LUNG TRANSPLANTATION IN THE UNITED STATES

2.1 Waiting List

2.1.1 Characteristics of adult candidates listed for lung transplant

In 2021, there were 3,111 candidates added to the lung transplant waiting list. This represents a 27.7% increase compared with the past decade beginning in 2010 (Figure LU 1). The prevalent number of candidates on the waiting list remains stable at 4,117 (Figure LU 2). In 2021, 6.2% of candidates were aged 18-34 years, 13.5% were 35-49 years, 46.0% were 50-64 years, and 34.3% were 65 years or older. The candidates are older now compared with 2010. The proportion of individuals aged 18-34 years decreased by 49.2% and those aged 65 years or older increased by 67.0% compared with 2010 (Figure LU 3). The waiting list comprises a higher proportion of males at 55.7%, a 15% increase since 2010 (Figure LU 4). The proportion of candidates identifying as White race has declined to 68.6%, a 15.4% decline since 2010, whereas the proportion of candidates identifying as Black race has increased to 11.3% and Hispanic ethnicity to 14.7%, increases of 13.6% and 137.4%, respectively, over the same period (Figure LU 5). The proportion of individuals in group D continues to increase (67.7% of the waiting list), whereas those in group A have decreased to 22% and those in group C have decreased to 2.3%; the proportion of group B candidates on the list has remained stable (Figure LU 6). Distributions of LAS values changed slightly during the past 2 years, with a notable increase in individuals with an LAS of 60 or greater, who now make up 25.3% of the waitlist population. The proportion of candidates assigned an LAS less than 35 is converging to similar proportions for those assigned LAS values of 35-<40 and 40-<50 (Figure LU 8). Trends in height, blood type, and prior transplant status have remained stable over time (Figures LU 9, 10, and 11). Geographic proximity to transplant centers is varied, with 52.2% of candidates living within 50 miles of the nearest transplant center and 8.8% of candidates living more than 250 miles from the nearest transplant center. The vast majority of candidates (83.7%) live in a designated metropolitan region (Table LU 1). Lung transplant candidates, as a whole, have not received a prior transplant, with only 3.5% listed for a retransplant (Table LU 3).

With more attention being focused on addressing disparities in access to transplant, it is important to note that waitlist trends described herein can only be interpreted among candidates who are already listed. The US lung transplant registry only captures patients after listing and beyond; therefore, this report is unable to provide trends in the broader populations of individuals with end-stage lung disease. Research to evaluate disparities in access to transplant, an essential area of inquiry to promote equity in transplantation, is ongoing.

2.1.2 Outcomes of adult candidates listed for lung transplant

In 2021, 63.0% of candidates waited fewer than 90 days for a lung transplant, with only 24.6% of candidates waiting 6 months or more and 14.2% waiting 1 year or more (Figure LU 7). Transplant rates continue to increase annually, with 2021 having the highest transplant rate of 244.8 transplants per 100 patient-years (Figure LU 12). Deceased donor transplant rates were highest for individuals aged 65 years or older, followed by those aged 50-64, 35-49, and 18-34 years (Figure LU 13). Transplant rates varied slightly by race, with an outlier for "other" race due to small group numbers (Figure LU 14). Transplant rates were highest for individuals in group D, with clustering of transplant rates for diagnosis groups A, B, and C (129.5-150.3 transplants per 100 patient-years) (Figure LU 15). Transplant rates differed across blood type, most likely resulting from variability in numbers of candidates within each group (Figure LU 16). Transplant rates were highest for the tallest individuals (180 cm or greater), with decreasing transplant rates by height (Figure LU 17). Transplant candidates are accessing transplants faster, with 64% of individuals undergoing transplant within 3 months, a 56% increase from 2010 (Figures LU 19 and 20).

The waitlist mortality rate is 17.6 deaths per 100 patient-years, ranging from 14.8 to 21.2 since 2010 (Figure LU 21). Waitlist mortality has decreased markedly for individuals aged 18-34 years, a finding that may be subject to variability given small group numbers. Even with comparatively higher transplant rates, candidates aged 65 years or older have pretransplant mortality rates nearly two-fold those of persons aged 35-64 years and more than four-fold those of persons aged 18-34 years (Figure LU 22). Waitlist mortality rates vary by sex, with males having greater risk, and by race, blood type, and height, although these findings are influenced by small group numbers (Figures LU 23, 24, 27, and 28). Individuals in diagnosis group D have the highest mortality rate, followed by those in groups B, A, and C, respectively (Figure LU 25). Individuals with the highest LAS values have the highest waitlist mortality, and mortality rates increase by approximately two-fold moving from an LAS of 35-<40 to 40-<50, 40-<50 to 50-<60, and 50-<60 to 60 or greater (Figure LU 26). There is variability in waitlist mortality by geographic region (Figure LU 30). For individuals removed from the waiting list for reasons other than transplant or death, 23.3% died within 6 months of waitlist removal, with variability by diagnosis group and age (Figures LU 31, 32, and 33). In 2021, there were 52 candidates who improved and were removed from the waiting list, 154 who became too sick for transplant, 132 who died, and 165 who were removed for other reasons (Table LU 5).

2.2 Donors

In 2021, there were 2,631 deceased lung donors, with 60.7% of donors male and 7.6% younger than 18 years, 29.5% aged 18-29 years, 26.1% aged 30-39 years, 25.6% aged 40-54 years, and 11.2% aged 55 years or older (Figures LU 34, 36, and 37). Fifty-eight percent of donors were White; 19.1%, Hispanic; 18.7%, Black; and 2.9%, Asian (Figure LU 38). The overall rate of lungs recovered for transplant but not transplanted was 8.1%, with the highest rates for donors aged 55 years or older (Figures LU 39 and 40). The nonuse rates of recovered organs varied by donor cause of death but notably were similar among standard-risk and increased-risk donors (Figures LU 41 and 42). Head trauma was the leading cause of death at 37.1%, followed by anoxia (35.8%), cerebrovascular accident/stroke (25%), and other/unknown (2%) (Figure LU 43). Donation after circulatory death is becoming more common, accounting for 7.8% of transplants compared with 4% 5 years earlier (Table LU 8).

2.3 Transplant

2.3.1 Characteristics of adult lung transplant recipients

In 2021, there were 2,569 lung transplants, of which 2,063 were bilateral and 506 were single (Figures LU 44 and 45). The largest number of transplants (1,171) occurred in recipients aged 50-64 years, followed by 933 in those aged 65 years or older, with 440 transplants in recipients aged 18-49 years (Figure LU 46). More transplants occurred in males compared with females, in the context of a higher proportion of male candidates listed for transplant and a higher waitlist mortality compared with females (Figure LU 47). Fewer transplants occurred in White recipients, with small increases in transplants for Black, Hispanic, and Asian recipients (Figure LU 48). White recipients accounted for 70.6% of transplants; Hispanic, 13.9%; Black, 10.1%; and Asian, 4% (Table LU 6). Forty-four percent of recipients had Medicare insurance, followed by 41.6% with private insurance, 9.3% with Medicaid, and 5% unknown (Table LU 6). The number of transplants for recipients in group D continues to increase, with a 92% increase since 2010, while trends for groups A and B are relatively stable; transplants for group C have decreased by 75.1%, with most of that change occurring after approval of highly effective cystic fibrosis transmembrane conductance regulator modulator therapy (Figure LU 49). Trends by LAS have changed over time, with more transplants occurring for individuals with higher LAS values compared with 2010. There was a large increase in transplants for individuals with an LAS value of 60 or greater, a 36% increase compared with 2020 (Figure LU 50).

2.3.2 Outcomes of adult lung transplant recipients

Most adult lung transplant recipients receive induction therapy, with only 17.8% not receiving it (Figure LU 51). The mainstay of posttransplant immunosuppression continues to be tacrolimus, mycophenolate mofetil, and prednisone, and this regimen is used for 81.6% of US adult lung transplant recipients (Figure LU 52). Short- and long-term posttransplant survival has not meaningfully changed since 2010 (Figure LU 53). In 2021, 85.3% of transplant recipients survive to 1 year; 67.0%, to 3 years; 54.3%, to 5 years; and 32.8%, to 10 years (Figure LU 53). Posttransplant survival varies by age, and this trend is accentuated with increased time from transplant. Persons aged 35-49 years have the best survival, followed by those aged 50-64 years, 18-34 years, and 65 years or older (Figure LU 54). Posttransplant survival differs by race, although trends vary with time from transplant (Figure LU 55). Individuals with LAS values of 50 or greater have lower posttransplant survival at all time points (Figure LU 56). Survival is equivalent between single and bilateral transplant recipients until approximately 2 years posttransplant, when survival for bilateral transplants is higher, possibly reflecting patient characteristics that drove the initial decision to perform the less surgically complex procedure of single lung transplant (Figure LU 57). Recipients in group B have the lowest early posttransplant survival but converge with other groups by 3 years posttransplant (Figure LU 58). Recipients in groups A and C have the highest posttransplant survival and group D the lowest after approximately 2.5 years (Figure LU 58). These posttransplant trends are unadjusted analyses, and trends may be confounded by additional recipient factors. Survival is similar between sexes and metropolitan and non-metropolitan inhabitants (Figures LU 59 and 60).

3 PEDIATRIC LUNG TRANSPLANTATION IN THE UNITED STATES

3.1 Waiting List

3.1.1 Characteristics of pediatric candidates listed for lung transplant

In 2021, 47 new pediatric candidates (younger than 18 years) were added to the lung transplant waiting list, a 47% decrease from 88 new listings in 2010 (Figure LU 64). The total number of pediatric waitlist candidates decreased by 72.3%, from 249 in 2010 to 69 in 2021 (Figure LU 65, Table LU 10). The largest age group of pediatric candidates on the waiting list in 2021 was 12-17 years (30.3%), followed by other age groups: 6-11 years, younger than 1 year, 1-5 years, and 18 years or older (Figure LU 66). Most pediatric lung transplant candidates were White (52.2%), followed by Hispanic (23.2%), Black (13.0%), and Asian (5.8%) (Figure LU 67). Most (50.7%) pediatric candidates on the waiting list in 2021 had been on the list fewer than 90 days (Figure LU 69).

3.1.2 Outcomes of pediatric candidates listed for lung transplant

Of 43 candidates removed from the waiting list in 2021, 25 (58.1%) were removed after undergoing transplant, 6 (14.0%) due to becoming too sick to undergo transplant, 5 (11.6%) due to improved condition, and 3 (7.0%) due to patient death (Table LU 13).

Among pediatric lung transplant candidates listed in 2016-2018, 62.4% underwent deceased donor transplant within 3 years, 18.8% were removed from the list for reasons other than transplant or death, 17.3% died waiting, and 1.5% were still waiting (Figure LU 70). The overall pediatric lung transplant rate has generally increased since 2010, but it has decreased in the past 3 years from 150.3 transplants per 100 patient-years in 2019 to 108.7 transplants per 100 patient-years in 2021 (Figure LU 71). Transplant rates varied with age and were highest for candidates aged 12-17 years (211.2 per 100 patient-years), followed by candidates younger than 1 year (207.4 per 100 patient-years), 6-11 years (61.1 per 100 patient-years), and 1-5 years (59.6 per 100 patient-years) (Figure LU 72). Transplant rates also varied by race, with the highest rates among those who reported their race as "other," likely due to the small size of the group (471.0 per 100 patient-years), followed by Hispanic candidates (234.5 per 100 patient-years), Black candidates (117.6 per 100 patient-years), White candidates (83.9 per 100 patient-years), and Asian candidates (49.3 per 100 patient-years) (Figure LU 73). Pretransplant mortality decreased from a peak of 42.9 deaths per 100 patient-years in 2015 to 17.5 per 100 patient-years in 2021 (Figure LU 74). Pretransplant mortality varied by age, ranging from 31.7 deaths per 100 patient-years among candidates aged 12-17 years to 0 among candidates aged 1-5 years and 18 years or older (Figure LU 75).

3.2 Transplant

3.2.1 Characteristics of pediatric lung transplant recipients

In 2021, 25 lung transplants were performed in pediatric recipients aged 0-17 years, a decrease of 56% since 2010 (Figure LU 76): five in those younger than 1 year, three in those aged 1-5 years, five in those aged 6-11 years, and twelve in those aged 11-17 years (Figure LU 77). An increasing proportion of candidates was bridged to transplant; 16.0% required mechanical ventilation and extracorporeal membrane oxygenation (ECMO), 16.0% mechanical ventilation only, and 8.0% ECMO only (Table LU 15). Time to transplant has changed over time, with 76% of recipients in 2021 with waiting times shorter than 90 days, compared with 53.8% in 2016 (Table LU 16). Induction therapy was reported in 84.0% of pediatric lung transplant recipients in 2021 (Figure LU 78). The most common initial immunosuppression regimen was tacrolimus, mycophenolate, and steroids, reported in 92.0% of pediatric lung recipients (Figure LU 79).

3.2.2 Outcomes of pediatric lung transplant recipients

Across all pediatric recipients who underwent lung transplant in 2014-2016, 1-, 3-, and 5-year patient survival was 83.6%, 62.7%, and 56.7%, respectively (Figure LU 82). Incidence of death was 13.9% at 6 months and 22.2% at 1 year for transplants in 2020, 37.5% at 3 years for transplants in 2018, 33.3% at 5 years for transplants in 2016, and 64.4% at 10 years for transplants in 2011 (Figure LU 81). The incidence of posttransplant lymphoproliferative disorder among Epstein-Barr–negative recipients who underwent transplant in 2010-2016 was 8.8% at 5 years posttransplant, compared with 1.2% among Epstein-Barr–positive recipients (Figure LU 80).

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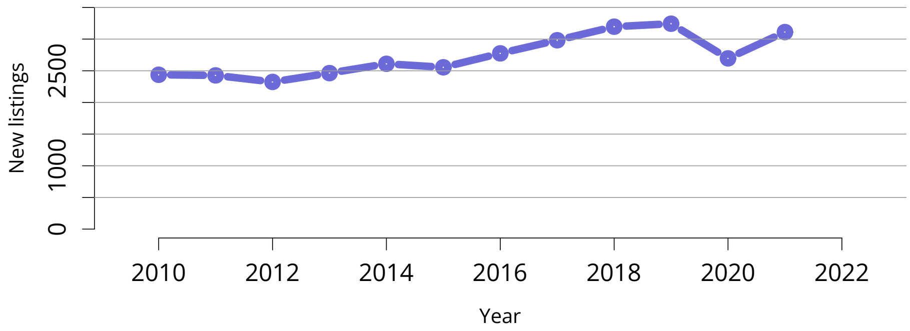

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Figure LU 1: New adult candidates added to the lung transplant waiting list. A new adult candidate is one who first joined the list during the given year, without having been listed in a previous year. Previously listed candidates who underwent transplant and subsequently relisted are considered new. Active and inactive patients are included.

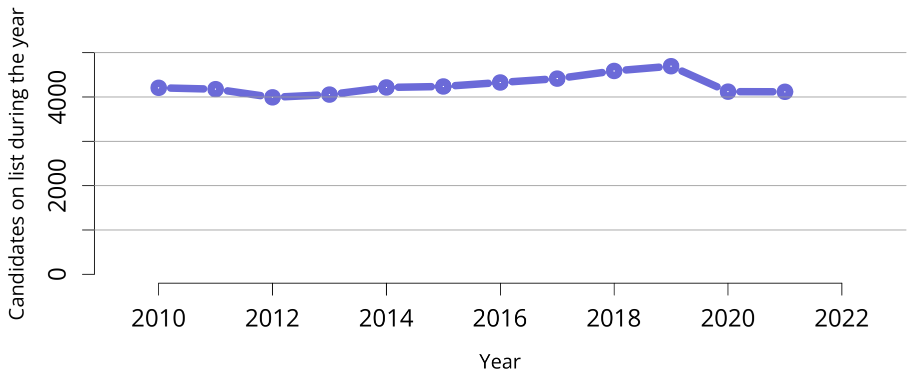

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Figure LU 2: All adult candidates on the lung transplant waiting list. Adult candidates on the list at any time during the year. Candidates listed at more than one center are counted once per listing.

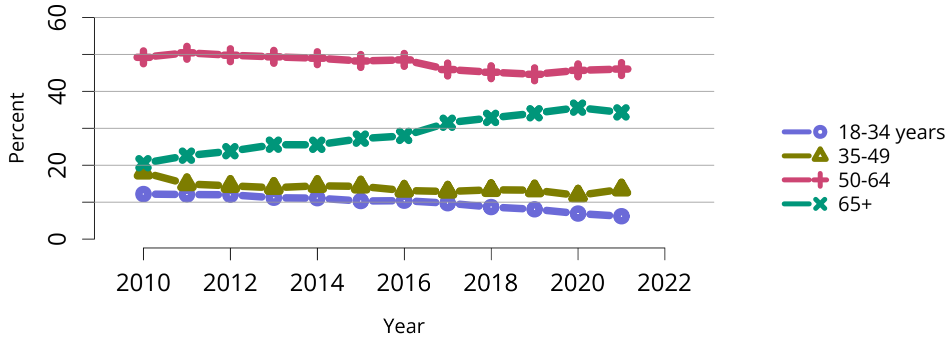

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Figure LU 3: Distribution of adults waiting for lung transplant by age. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive candidates are included. Age is determined at the earliest of transplant, death, removal, or December 31 of the year.

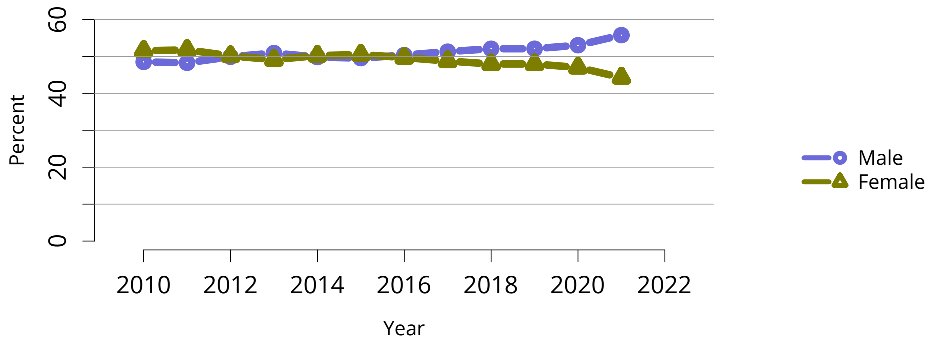

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Figure LU 4: Distribution of adults waiting for lung transplant by sex. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

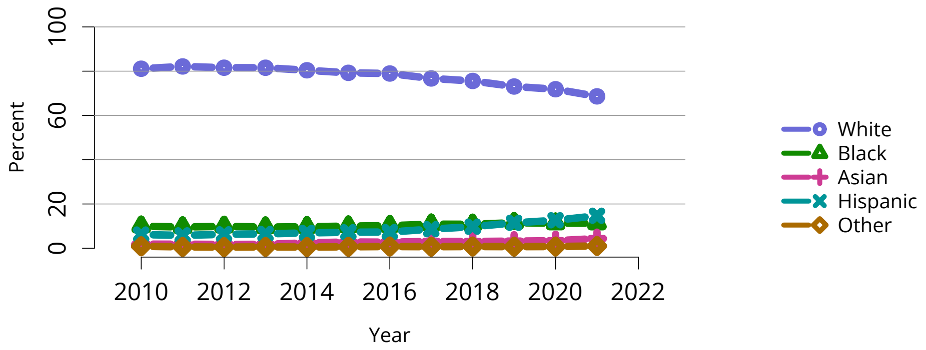

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Figure LU 5: Distribution of adults waiting for lung transplant by race. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

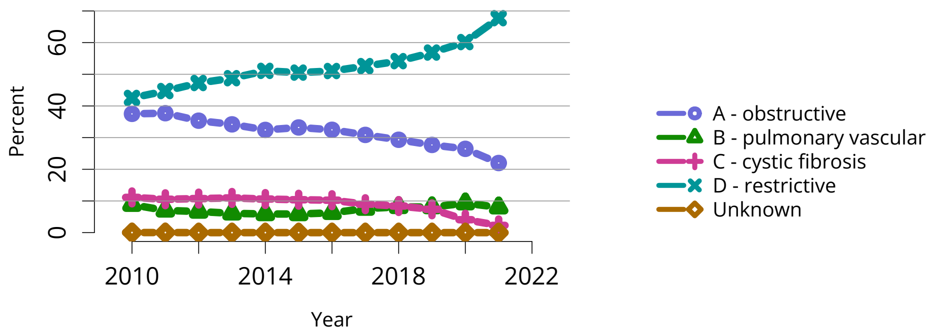

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Figure LU 6: Distribution of adults waiting for lung transplant by diagnosis group. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included. The Other/unknown group includes a small number of heart-lung candidates prior to 2015 who did not have an A/B/C/D diagnosis group specified.

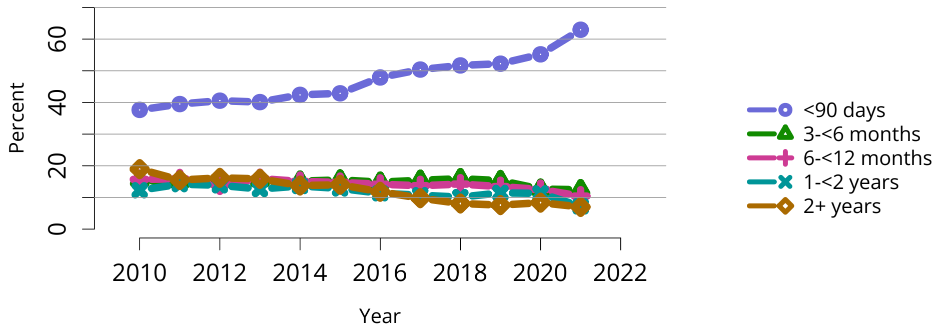

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Figure LU 7: Distribution of adults waiting for lung transplant by waiting time. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Time on the waiting list is determined at the earliest of transplant, death, removal, or December 31 of the year. Active and inactive candidates are included.

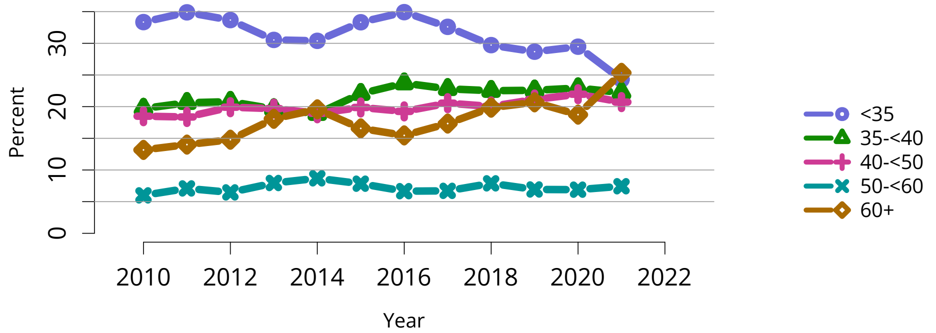

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Figure LU 8: Distribution of adult candidates waiting for lung transplant by LAS. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. LAS, lung allocation score. LAS is determined at the earliest of transplant, death, removal, or December 31 of the year.

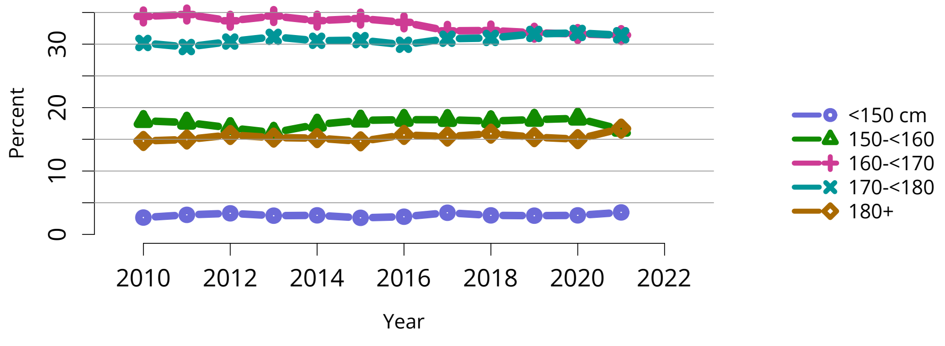

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Figure LU 9: Distribution of adult candidates waiting for lung transplant by height. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

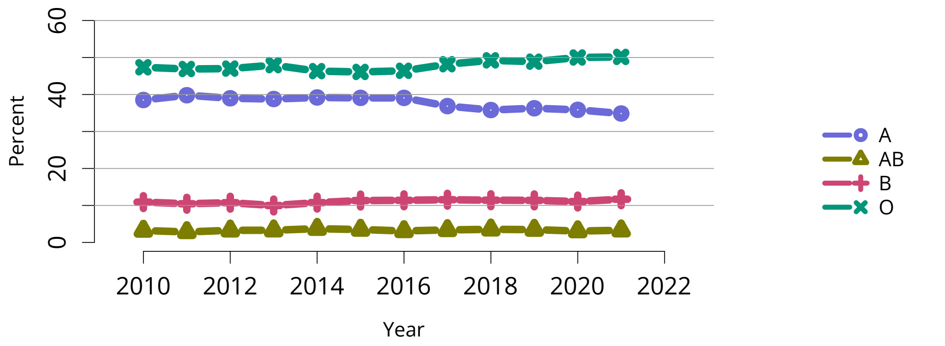

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Figure LU 10: Distribution of adults waiting for lung transplant by blood type. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

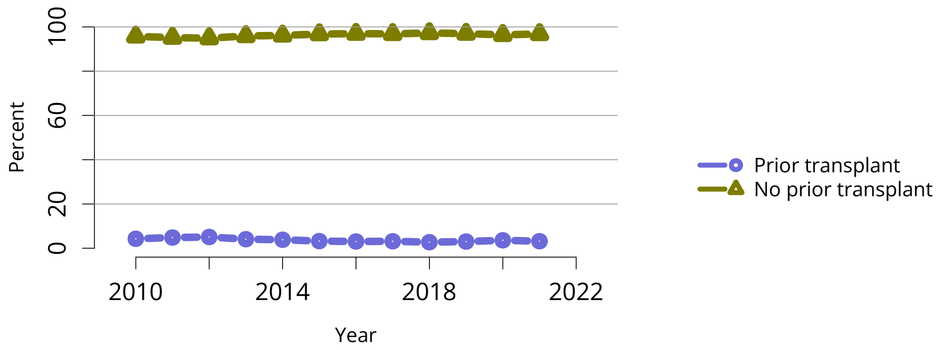

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Figure LU 11: Distribution of adults waiting for lung transplant by prior transplant status. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

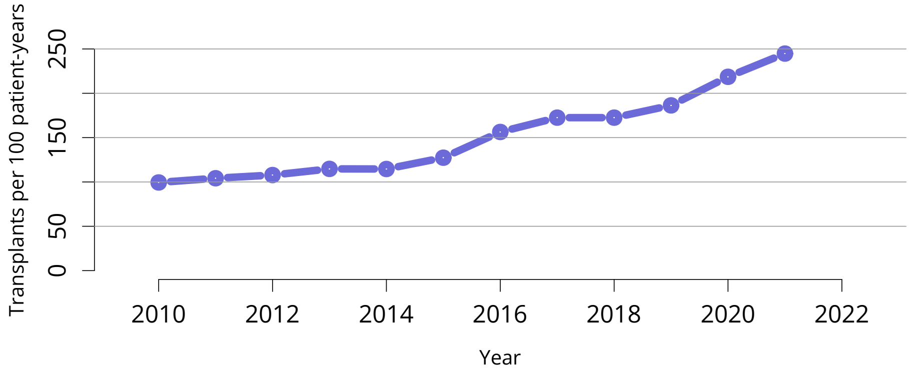

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Figure LU 12: Overall deceased donor lung transplant rates among adult waitlist candidates. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

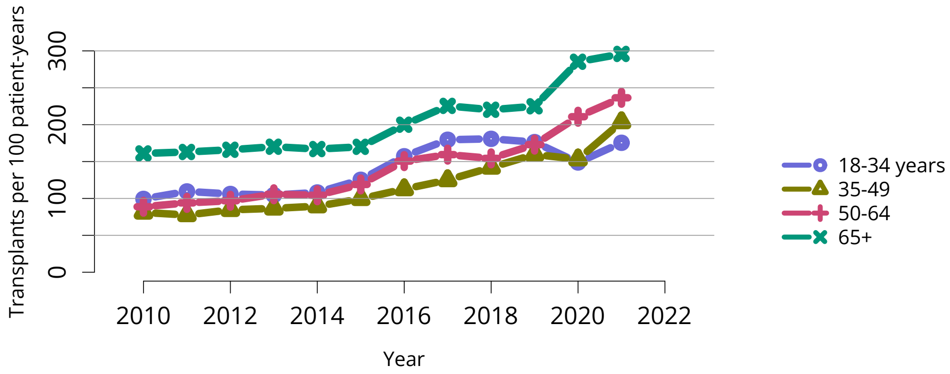

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Figure LU 13: Deceased donor lung transplant rates among adult waitlist candidates by age. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.

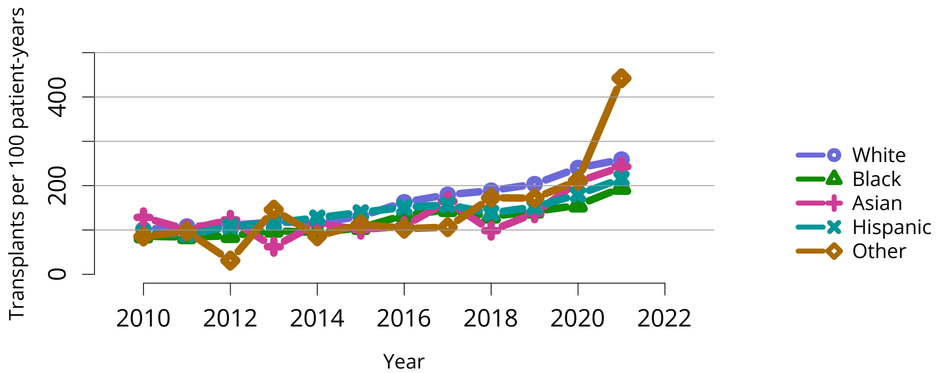

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Figure LU 14: Deceased donor lung transplant rates among adult waitlist candidates by race. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

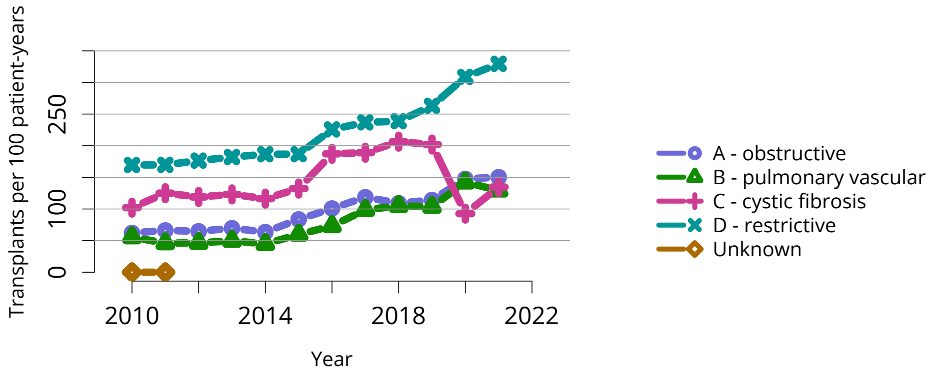

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Figure LU 15: Deceased donor lung transplant rates among adult waitlist candidates by diagnosis group. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately. The Other/unknown group includes a small number of heart-lung candidates prior to 2015 who did not have an A/B/C/D diagnosis group specified.

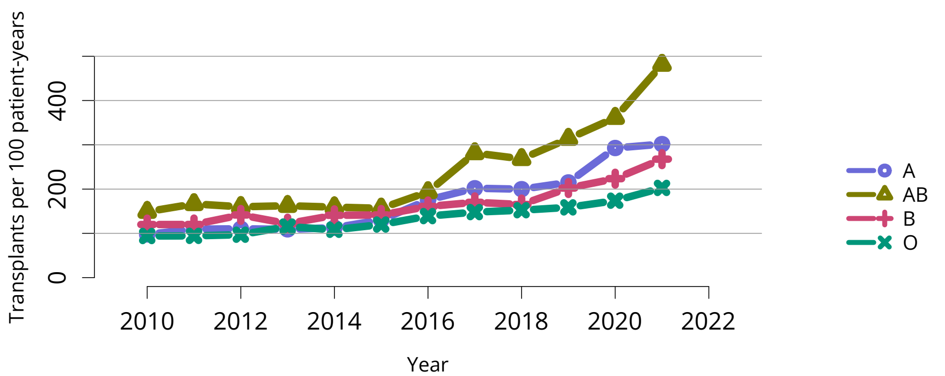

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Figure LU 16: Deceased donor lung transplant rates among adult waitlist candidates by blood type. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

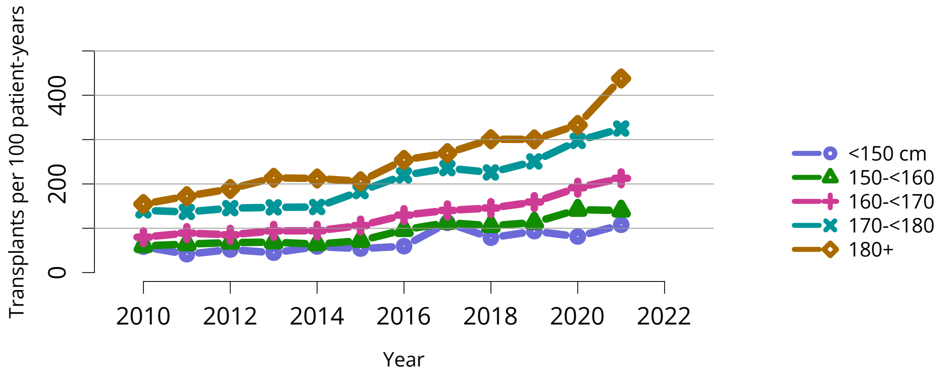

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Figure LU 17: Deceased donor lung transplant rates among adult waitlist candidates by height. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately.

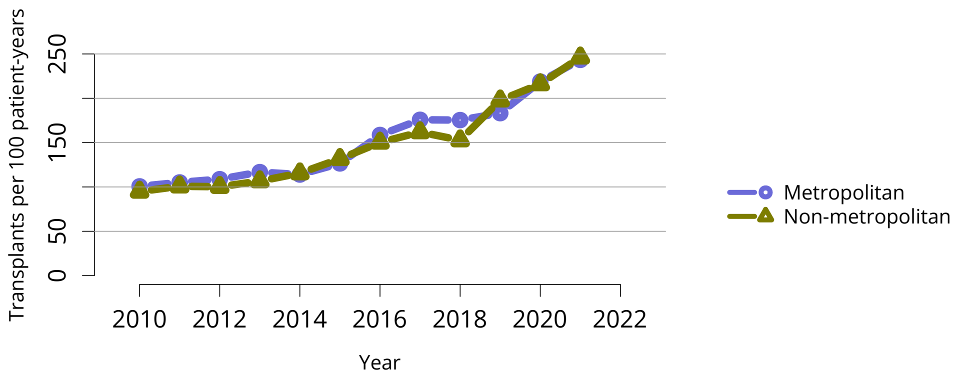

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Figure LU 18: Deceased donor lung transplant rates among adult waitlist candidates by metropolitan vs. non-metropolitan residence. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of wait time in a given year. Individual listings are counted separately. Urban/rural determination is made using the RUCA (rural-urban commuting area) designation of the candidate's permanent zip code.

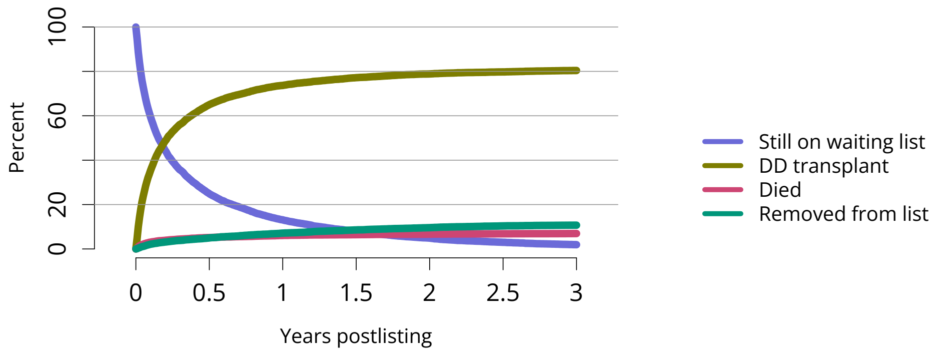

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Figure LU 19: Three-year outcomes for adults waiting for lung transplant, new listings in 2016-2018. Candidates listed at more than one center are counted once per listing. Removed from list includes all reasons except transplant and death. DD, deceased donor.

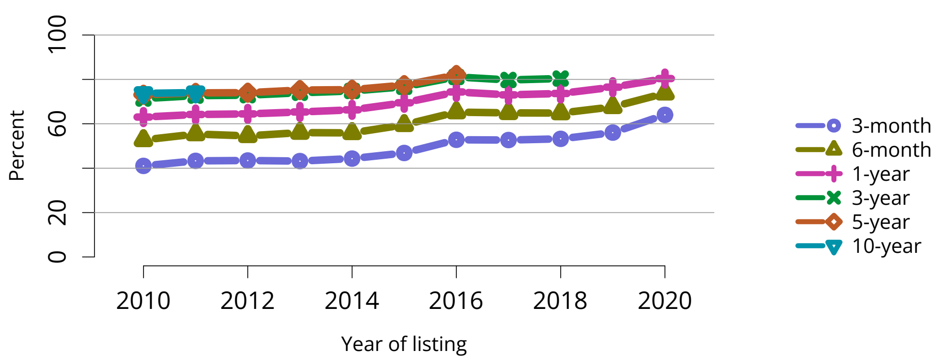

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Figure LU 20: Percentage of adults who underwent deceased donor lung transplant within a given period of listing. Candidates listed at more than one center are counted once per listing.

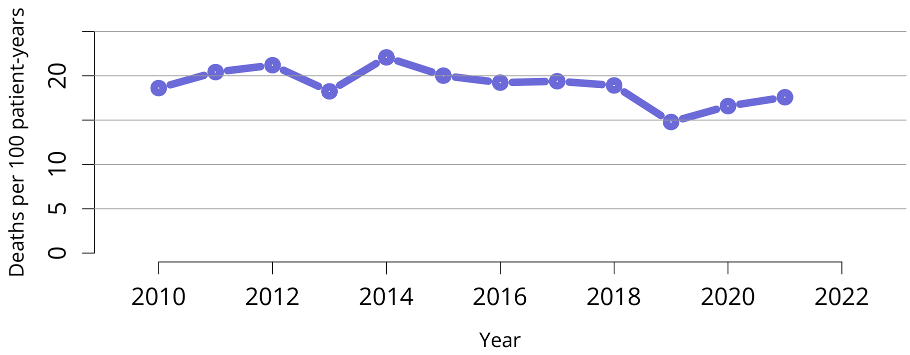

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Figure LU 21: Overall pretransplant mortality rates among adults waitlisted for lung transplant. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

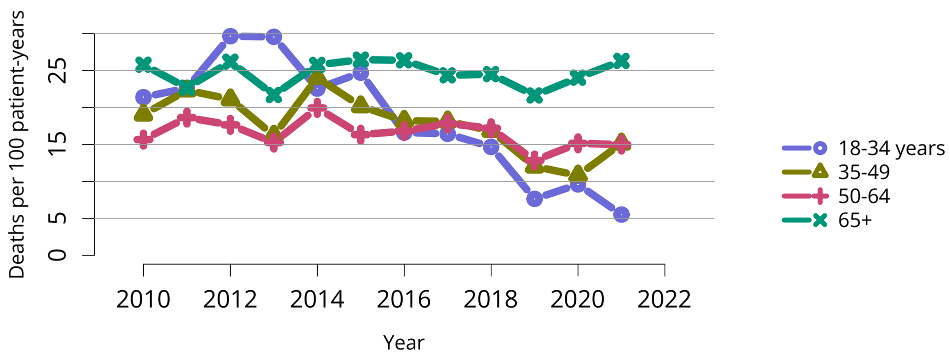

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Figure LU 22: Pretransplant mortality rates among adults waitlisted for lung transplant by age. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.

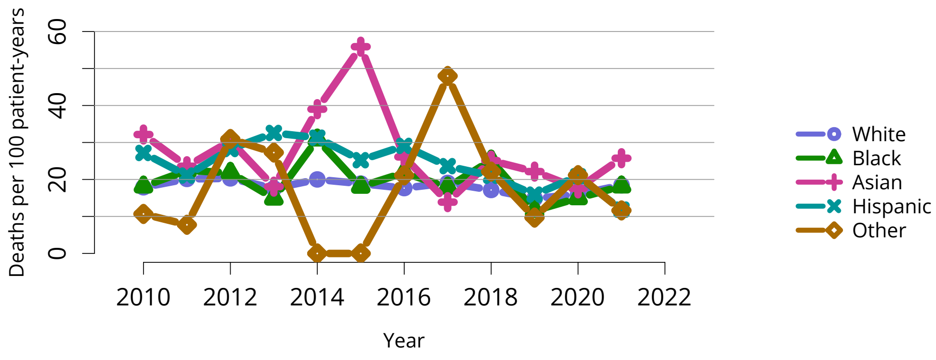

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Figure LU 23: Pretransplant mortality rates among adults waitlisted for lung transplant by race. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

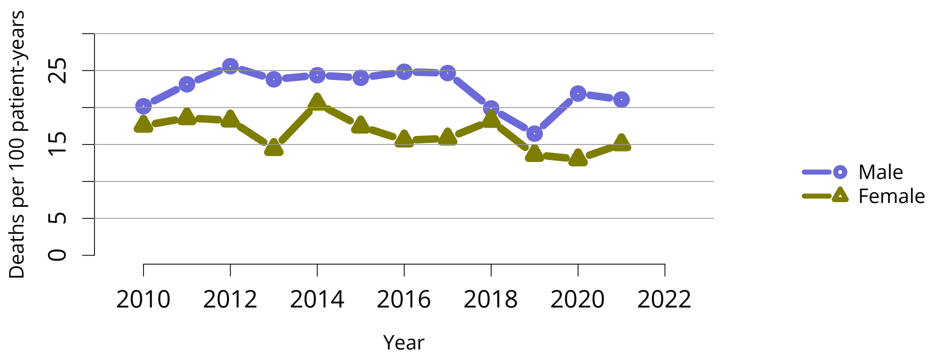

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Figure LU 24: Pretransplant mortality rates among adults waitlisted for lung transplant by sex. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

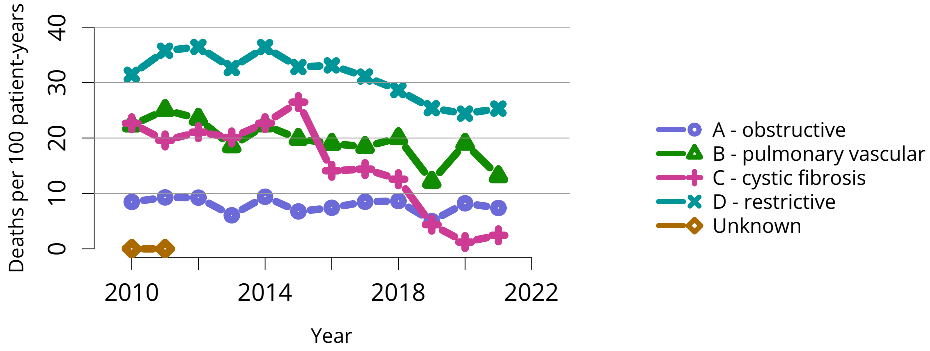

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Figure LU 25: Pretransplant mortality rates among adults waitlisted for lung transplant by diagnosis. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. The Other/unknown group includes a small number of heart-lung candidates prior to 2015 who did not have an A/B/C/D diagnosis group specified.

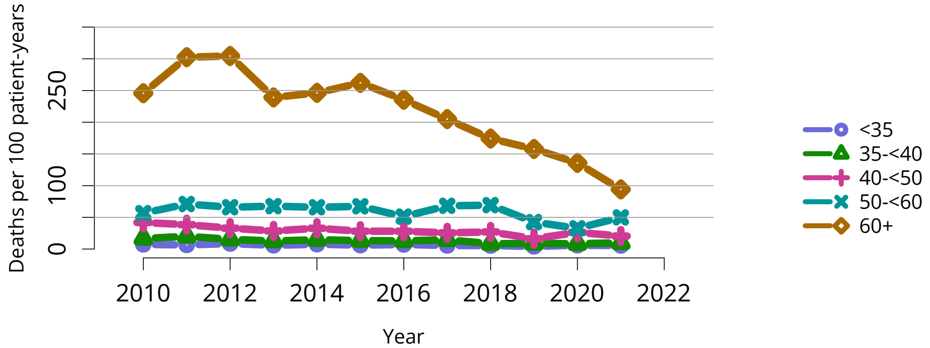

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Figure LU 26: Pretransplant mortality rates among adults waitlisted for lung transplant by LAS. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. LAS is determined at the later of listing date or January 1 of the given year.

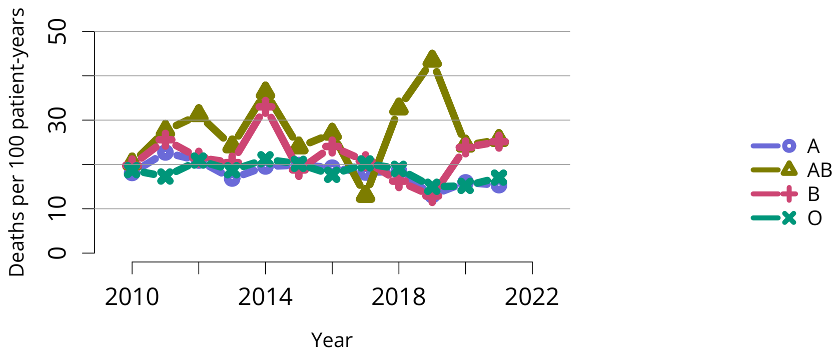

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Figure LU 27: Pretransplant mortality rates among adults waitlisted for lung transplant by blood type. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

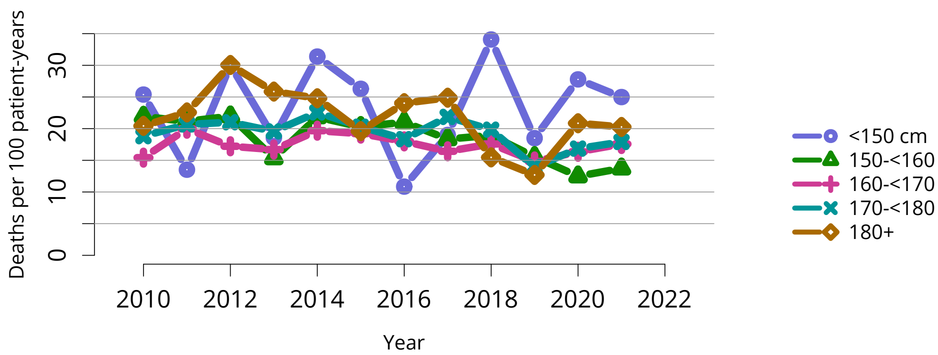

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Figure LU 28: Pretransplant mortality rates among adults waitlisted for lung transplant by height. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

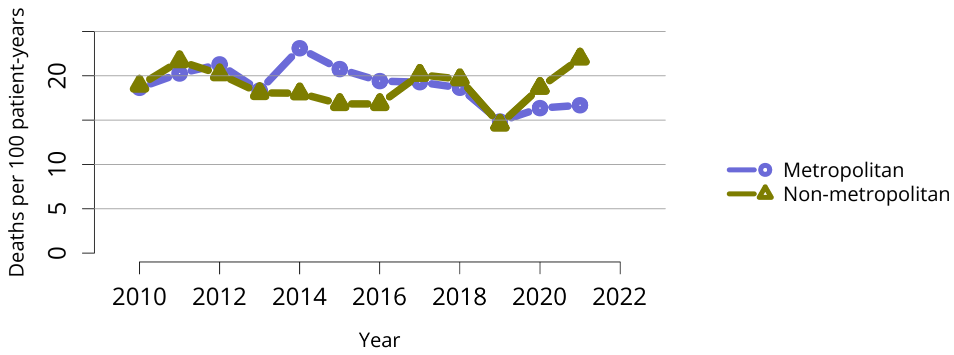

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Figure LU 29: Pretransplant mortality rates among adults waitlisted for lung transplant by metropolitan vs. non-metropolitan residence. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Urban/rural determination is made using the RUCA (rural-urban commuting area) designation of the candidate's permanent zip code.

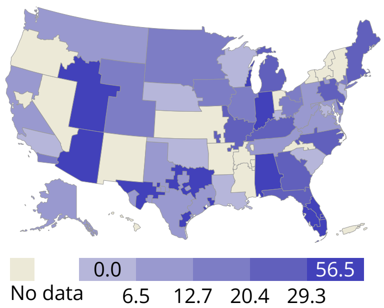

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Figure LU 30: Pretransplant mortality rates among adults waitlisted for lung transplant in 2021 by DSA. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

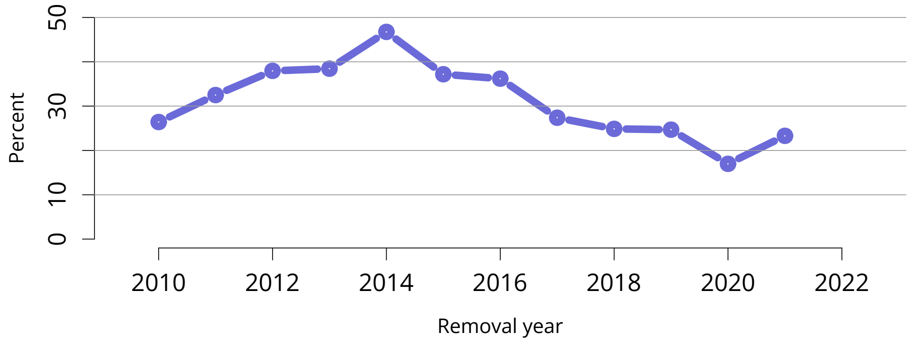

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Figure LU 31: Deaths within six months after removal among adult lung waitlist candidates, overall. Denominator includes only candidates removed from the waiting list for reasons other than transplant or death while on the list.

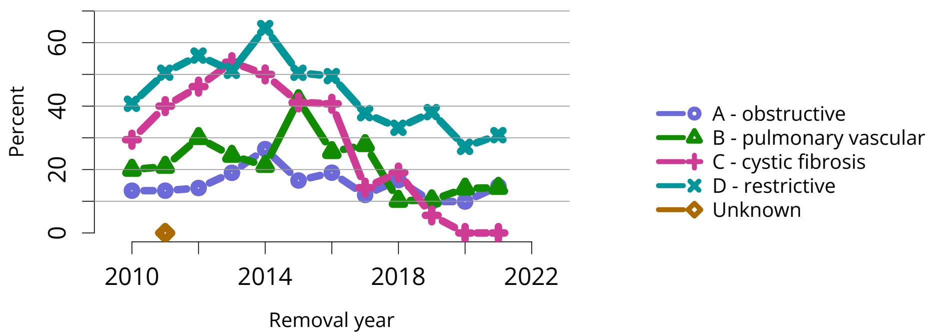

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Figure LU 32: Deaths within six months after removal among adult lung waitlist candidates, by diagnosis. Denominator includes only candidates removed from the waiting list for reasons other than transplant or death while on the list. The Other/unknown group includes a small number of heart-lung candidates prior to 2015 who did not have an A/B/C/D diagnosis group specified.

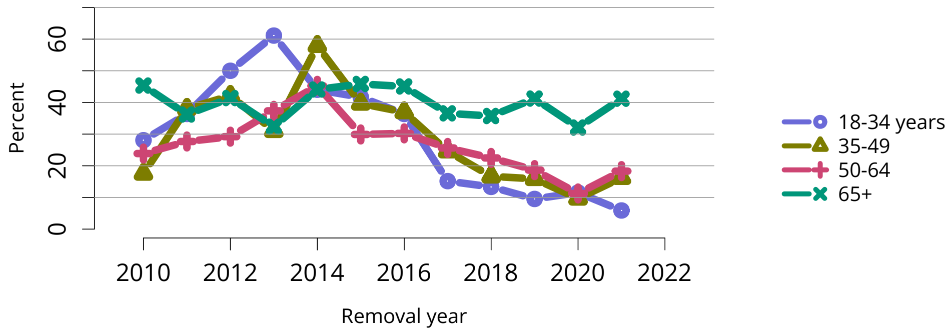

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Figure LU 33: Deaths within six months after removal among adult lung waitlist candidates, by age. Denominator includes only candidates removed from the waiting list for reasons other than transplant or death while on the list. Age is determined at removal.

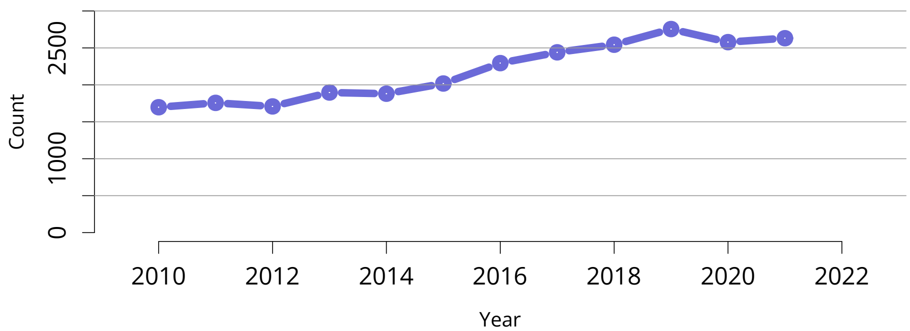

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Figure LU 34: Overall deceased lung donor count. Count of deceased donors with at least one lung recovered. Donors are counted once, regardless of the number of lungs recovered.

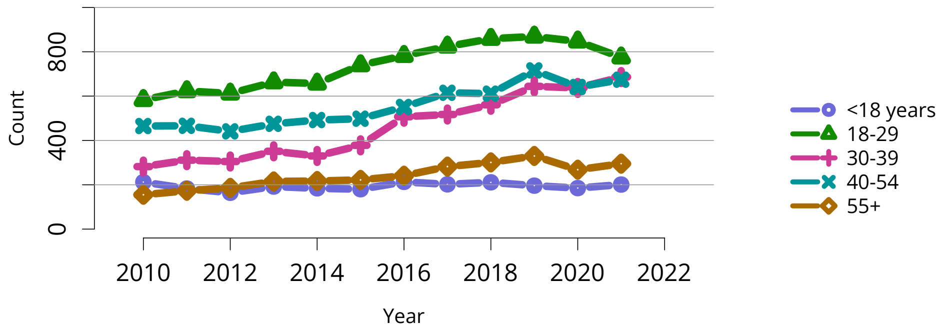

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Figure LU 35: Deceased lung donor count by age. Count of deceased donors with at least one lung recovered. Donors are counted once, regardless of the number of lungs recovered.

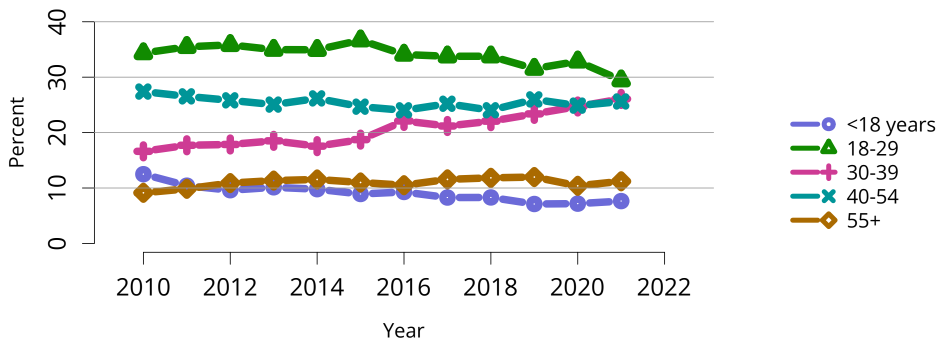

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Figure LU 36: Distribution of deceased lung donors by age. Deceased donors whose lungs were recovered for transplant. Donors are counted once, regardless of the number of lungs recovered.

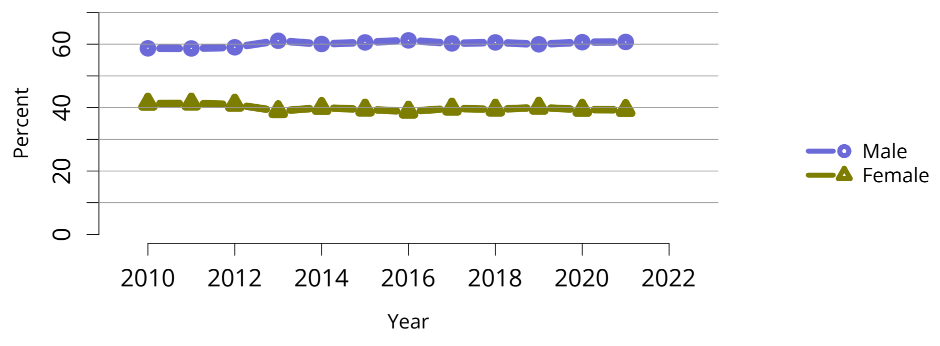

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Figure LU 37: Distribution of deceased lung donors by sex. Deceased donors whose lungs were recovered for transplant. Donors are counted once, regardless of the number of lungs recovered.

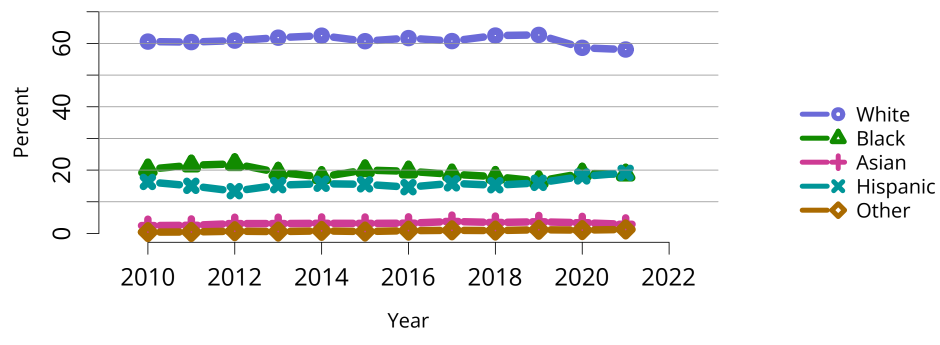

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Figure LU 38: Distribution of deceased lung donors by race. Deceased donors whose lungs were recovered for transplant. Donors are counted once, regardless of the number of lungs recovered.

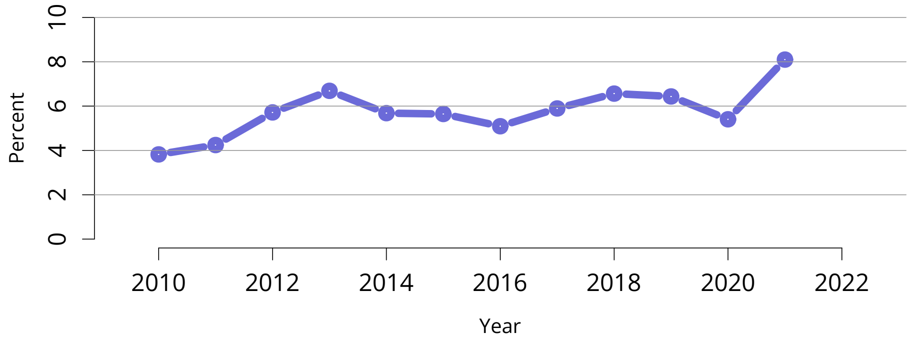

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Figure LU 39: Overall percent of lungs recovered for transplant and not transplanted. Percentages of lungs not transplanted out of all lungs recovered for transplant.

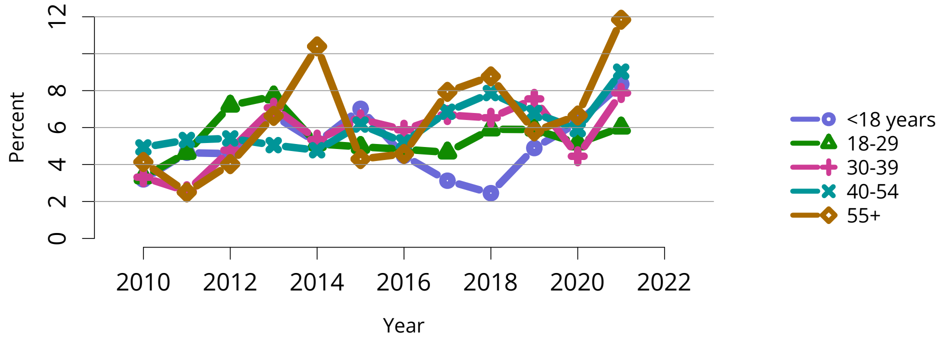

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Figure LU 40: Percent of lungs recovered for transplant and not transplanted by donor age. Percentages of lungs not transplanted out of all lungs recovered for transplant.

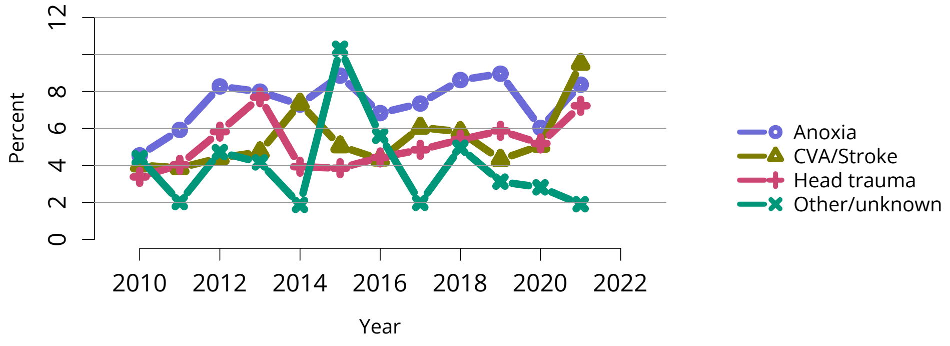

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Figure LU 41: Percent of lungs recovered for transplant and not transplanted by donor cause of death. Percentages of lungs not transplanted out of all lungs recovered for transplant. CVA, cerebrovascular accident.

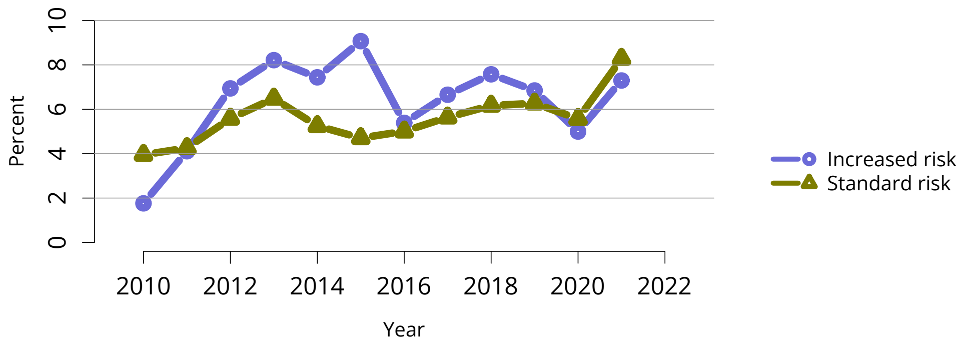

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Figure LU 42: Percent of lungs recovered for transplant and not transplanted, by donor risk of disease transmission. Percentages of lungs not transplanted out of all lungs recovered for transplant. “Increased risk” is defined by criteria from the US Public Health Service Guidelines for increased risk for HIV, hepatitis B, and hepatitis C transmission.

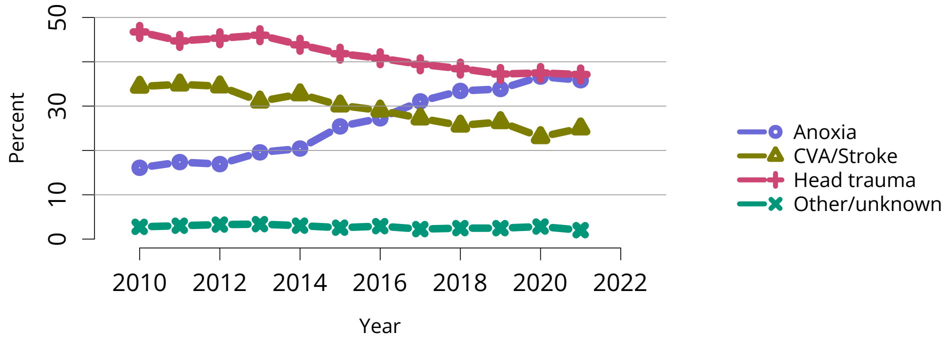

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Figure LU 43: Cause of death among deceased lung donors. Deceased donors with a lung recovered for the purposes of transplant. CVA, cerebrovascular accident.

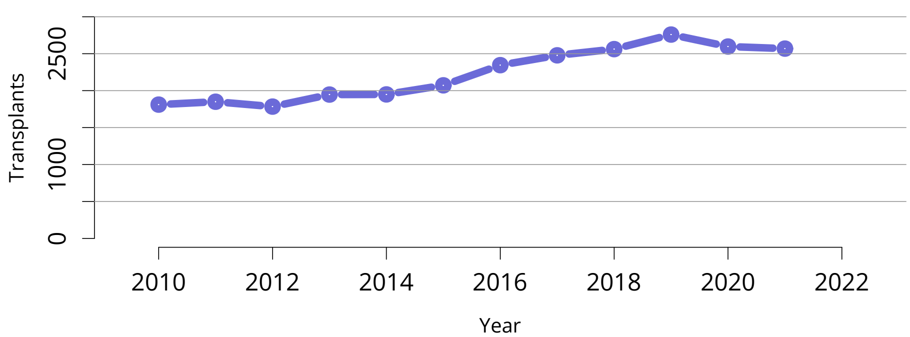

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Figure LU 44: Overall lung transplants. All lung transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

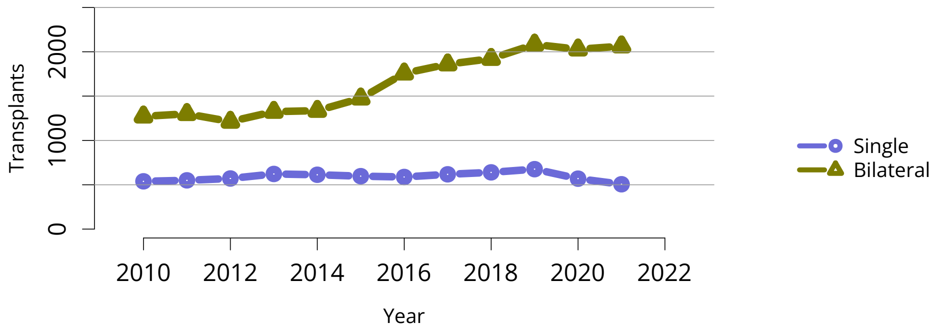

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Figure LU 45: Total lung transplants by procedure type. All lung transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

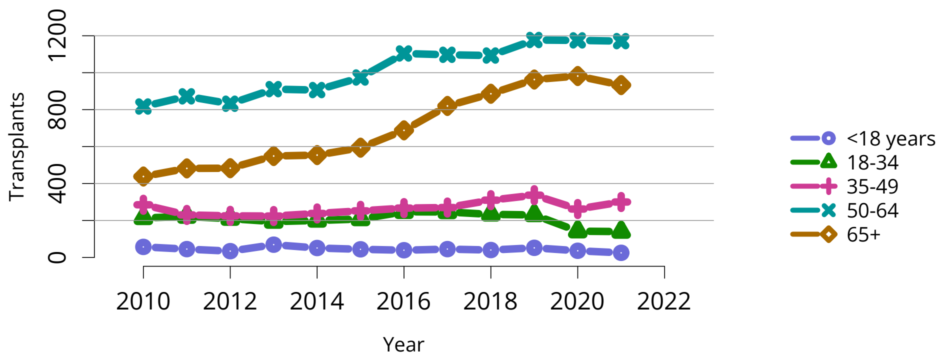

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Figure LU 46: Total lung transplants by age. All lung transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

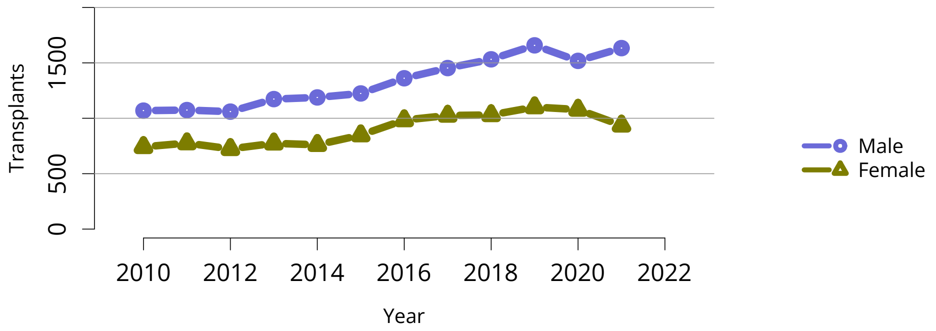

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Figure LU 47: Total lung transplants by sex. All lung transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

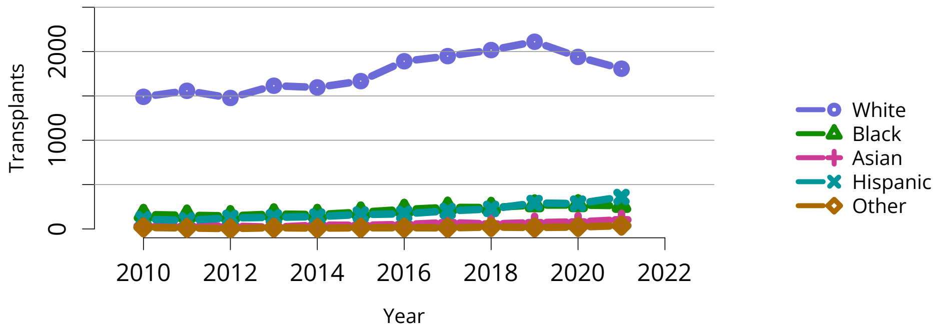

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Figure LU 48: Total lung transplants by race. All lung transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

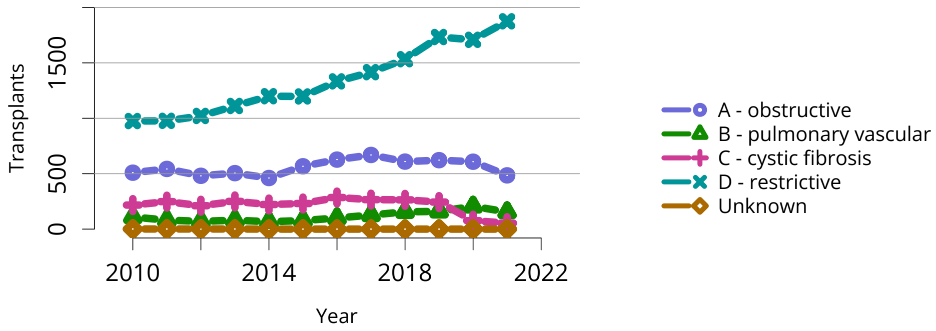

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Figure LU 49: Total lung transplants by diagnosis. All lung transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients. The Other/unknown group includes a small number of heart-lung recipients prior to 2015 who did not have an A/B/C/D diagnosis group specified.

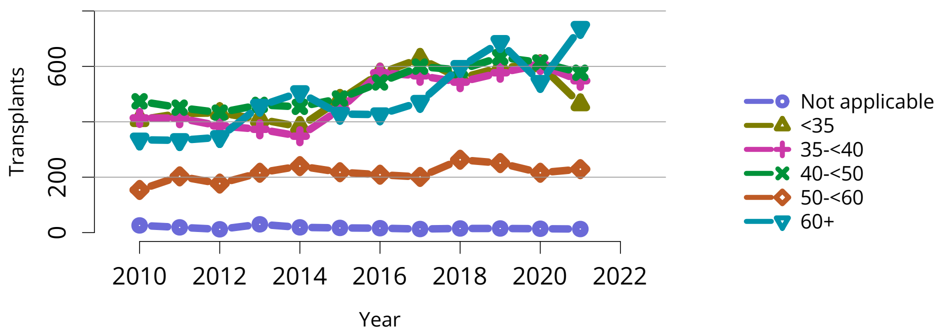

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Figure LU 50: Total lung transplants by LAS. All lung transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

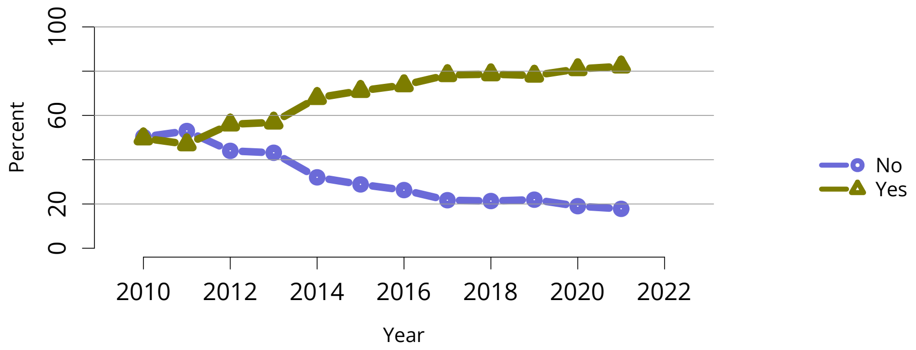

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Figure LU 51: Induction agent use in adult lung transplant recipients. Immunosuppression at transplant reported to the OPTN.

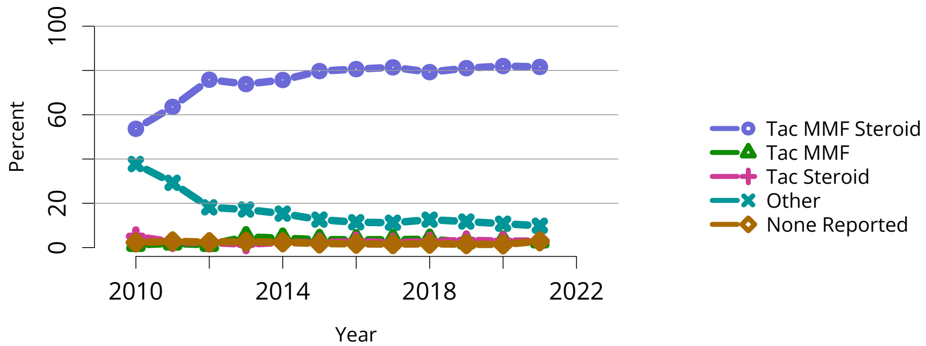

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Figure LU 52: Immunosuppression regimen use in adult lung transplant recipients. Immunosuppression regimen at transplant reported to the OPTN. Tac, tacrolimus. MMF, all mycophenolate agents.

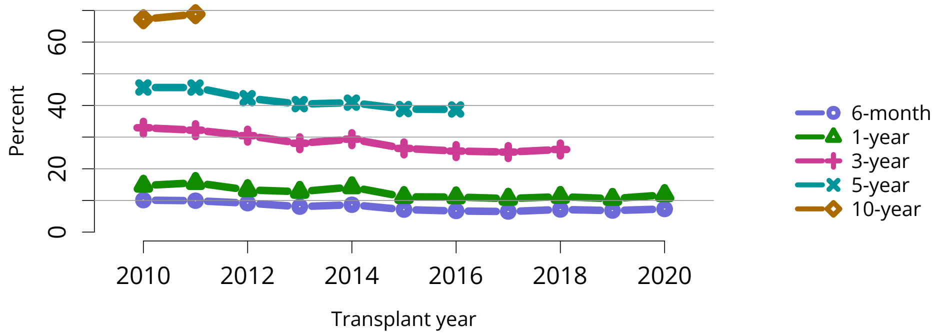

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Figure LU 53: Patient death among adult lung transplant recipients. All adult recipients of deceased donor lungs, including multiorgan transplants.

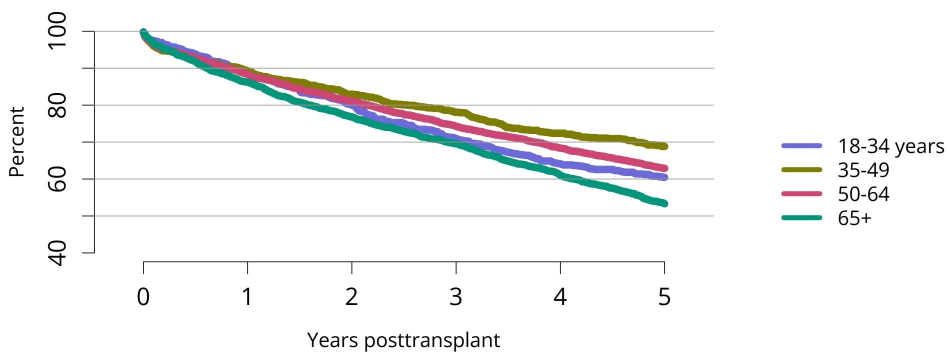

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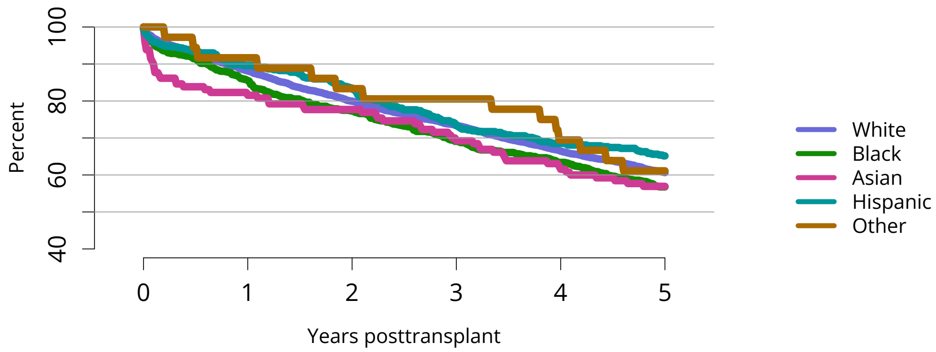
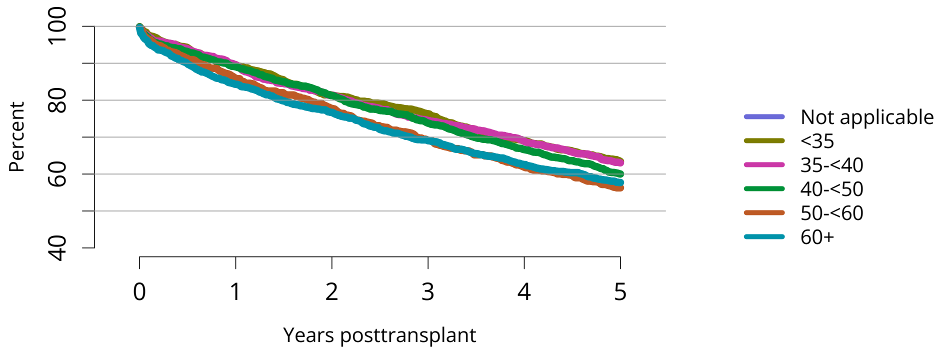
Figure LU 54: Patient survival among adult lung transplant recipients, 2014-2016, by age. Patient survival estimated using unadjusted Kaplan-Meier methods.



OPTN/SRTR 2021 Annual Data Report

Figure LU 55: Patient survival among adult lung transplant recipients, 2014-2016, by race. Patient survival estimated using unadjusted Kaplan-Meier methods.



OPTN/SRTR 2021 Annual Data Report

Figure LU 56: Patient survival among adult lung transplant recipients, 2014-2016, by LAS. Patient survival estimated using unadjusted Kaplan-Meier methods.

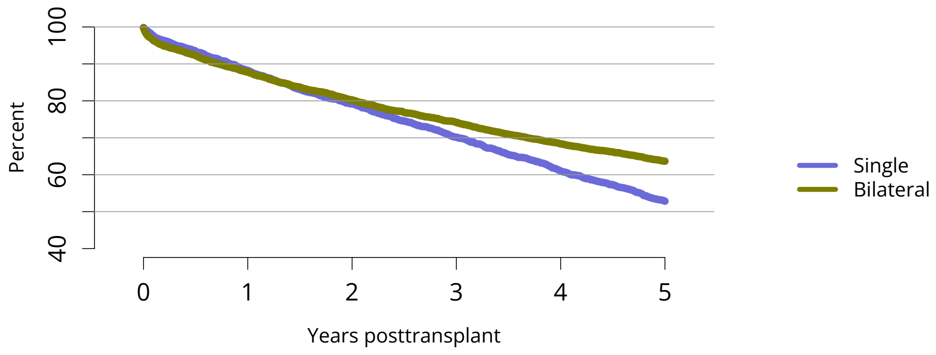


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Figure LU 57: Patient survival among adult lung transplant recipients, 2014-2016, by transplant type. Patient survival estimated using unadjusted Kaplan-Meier methods.

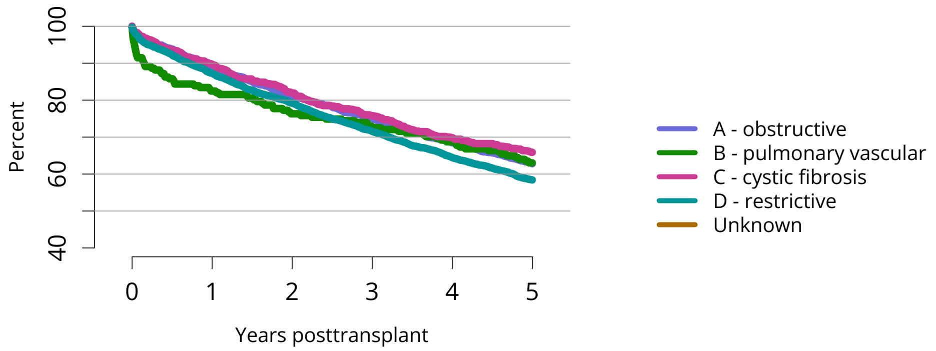

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Figure LU 58: Patient survival among adult lung transplant recipients, 2014-2016, by diagnosis group. Patient survival estimated using unadjusted Kaplan-Meier methods. The Other/unknown group includes a small number of heart-lung recipients prior to 2015 who did not have an A/B/C/D diagnosis group specified.

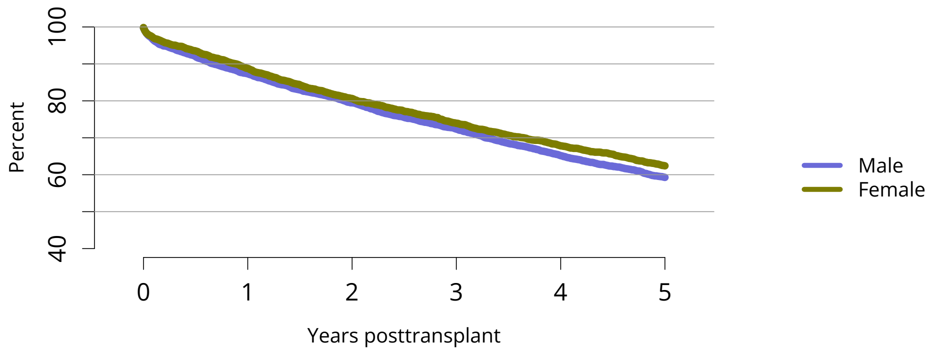

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Figure LU 59: Patient survival among adult lung transplant recipients, 2014-2016, by sex. Patient survival estimated using unadjusted Kaplan-Meier methods.

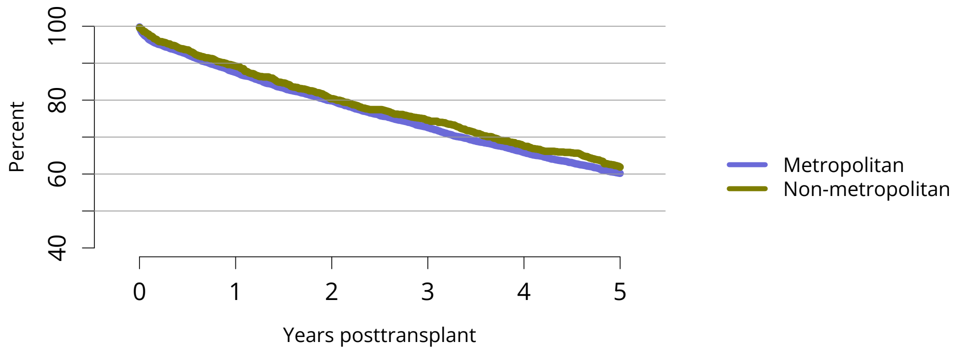

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Figure LU 60: Patient survival among adult lung transplant recipients, 2014-2016, by metropolitan vs. non-metropolitan recipient residence. Patient survival estimated using unadjusted Kaplan-Meier methods.

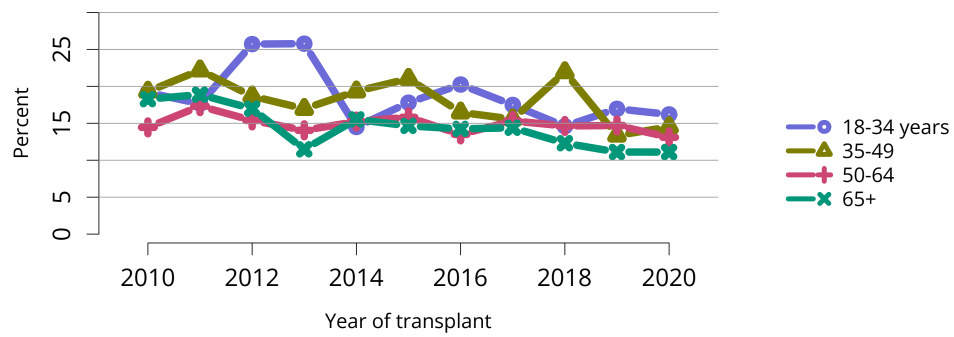

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Figure LU 61: Incidence of acute rejection by 1 year posttransplant among adult lung transplant recipients by age. Only the first reported rejection event is counted. Cumulative incidence is estimated using the Kaplan-Meier method.

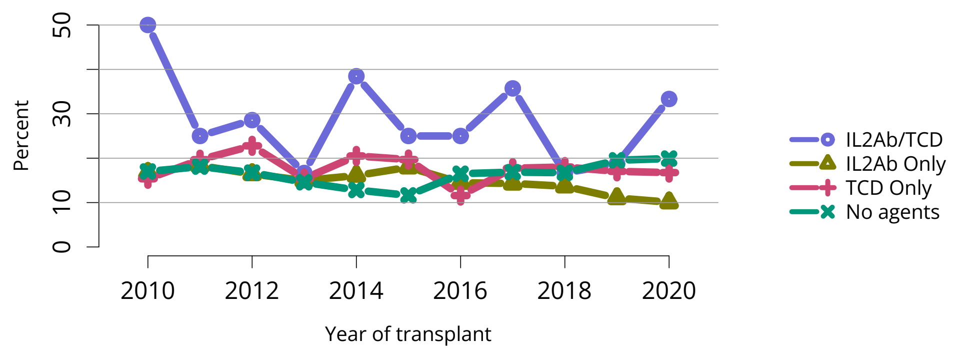

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Figure LU 62: Incidence of acute rejection by 1 year posttransplant among adult lung transplant recipients by induction agent. Only the first reported rejection event is counted. Cumulative incidence is estimated using the Kaplan-Meier method. IL2Ab, interleukin-2 receptor antibody; TCD, T-cell depleting.

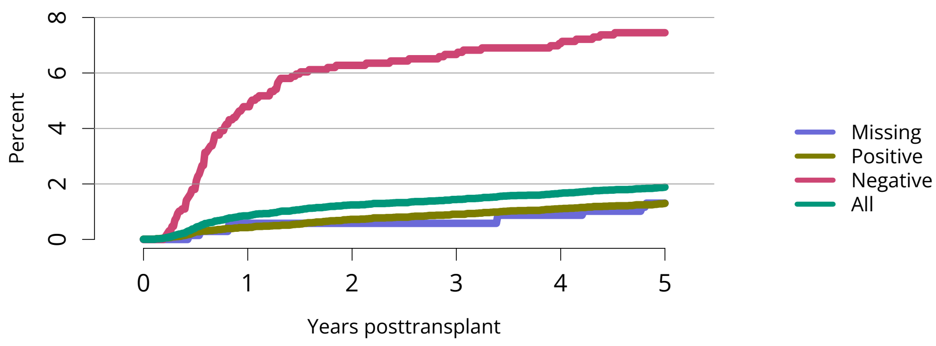

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Figure LU 63: Incidence of PTLD among adult lung transplant recipients by recipient EBV status at transplant, 2010-2016. Cumulative incidence is estimated using the Kaplan-Meier method. PTLD is identified as a reported complication or cause of death on the OPTN Transplant Recipient Follow-up Form or the Posttransplant Malignancy Form as polymorphic PTLD, monomorphic PTLD, or Hodgkin's disease. Only the earliest date of PTLD diagnosis is considered. EBV, Epstein-Barr virus; PTLD, posttransplant lymphoproliferative disorder.

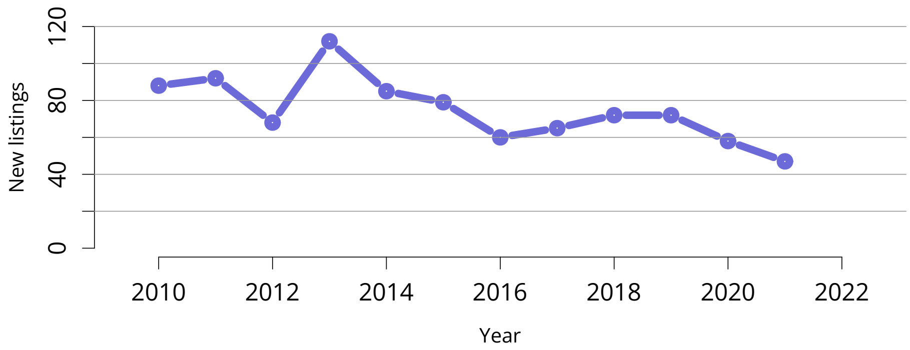

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Figure LU 64: New pediatric candidates added to the lung transplant waiting list. A new candidate is one who first joined the list during the given year, without having been listed in a previous year. Previously listed candidates who underwent transplant and subsequently relisted are considered new. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

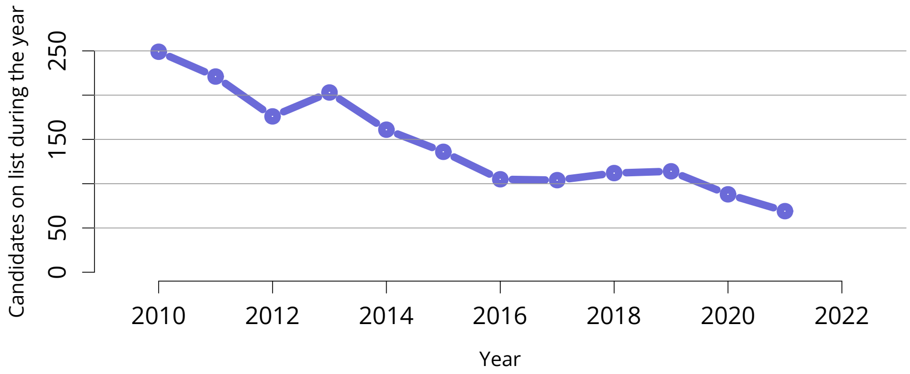

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Figure LU 65: All pediatric candidates on the lung transplant waiting list. Pediatric candidates listed at any time during the year. Candidates listed at more than one center are counted once per listing.

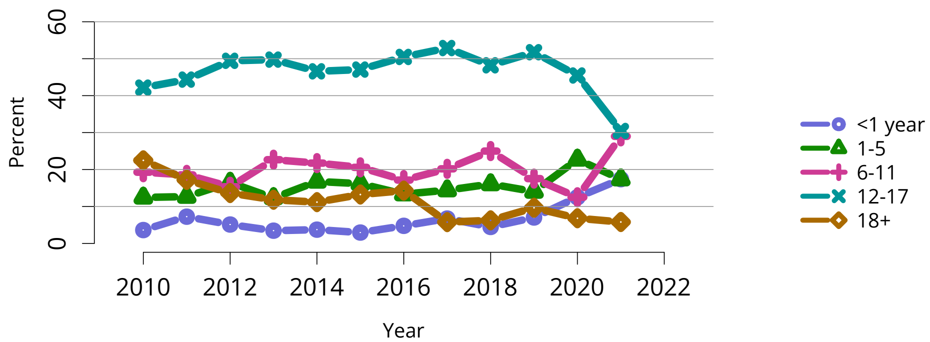

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Figure LU 66: Distribution of pediatric candidates waiting for lung transplant by age. Candidates waiting for transplant at any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive candidates are included. Age is determined at the earliest of transplant, death, removal, or December 31 of the year.

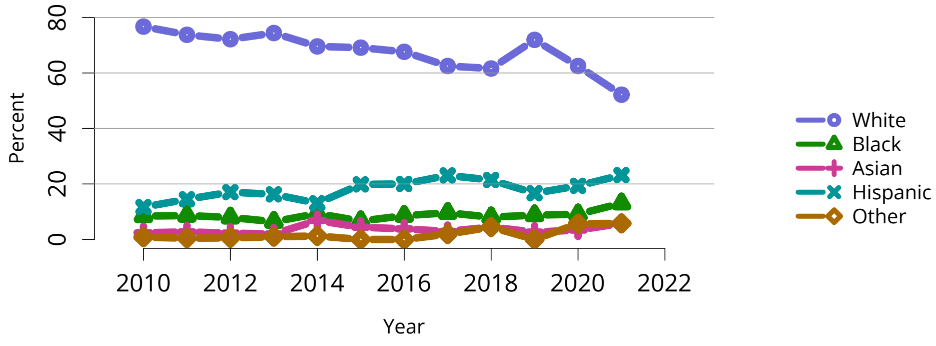

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Figure LU 67: Distribution of pediatric candidates waiting for lung transplant by race. Candidates waiting for transplant any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive candidates are included.

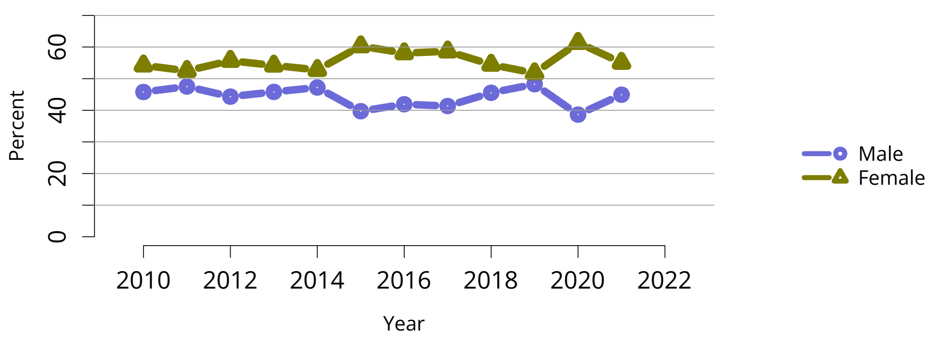

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Figure LU 68: Distribution of pediatric candidates waiting for lung transplant by sex. Candidates waiting for transplant any time in the given year. Candidates listed at more than one center are counted once per listing. Active and inactive patients are included.

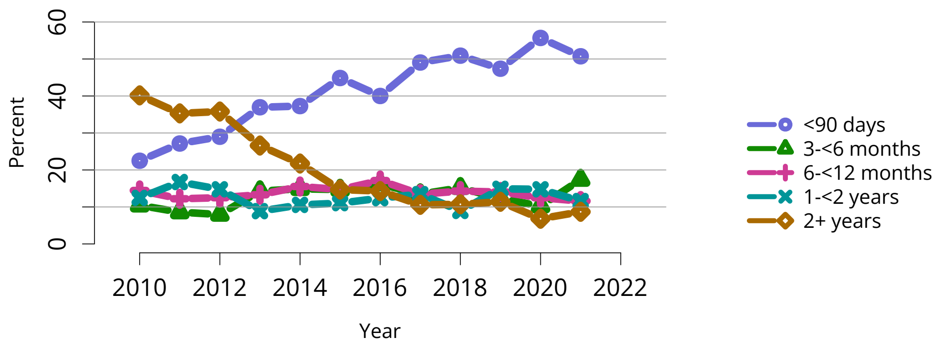

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Figure LU 69: Distribution of pediatric candidates waiting for lung transplant by waiting time. Candidates waiting for transplant any time in the given year. Candidates listed at more than one center are counted once per listing. Time on the waiting list is determined at the earliest of transplant, death, removal, or December 31 of the year. Active and inactive candidates are included.

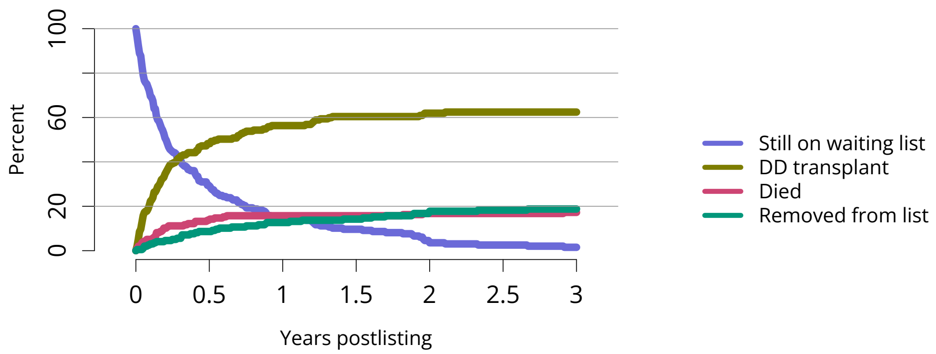

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Figure LU 70: Three-year outcomes for newly listed pediatric candidates waiting for lung transplant, 2016-2018. Pediatric candidates who joined the waiting list in 2016-2018. Pediatric candidates listed at more than one center are counted once per listing. Removed from list includes all reasons except transplant and death. DD, deceased donor.

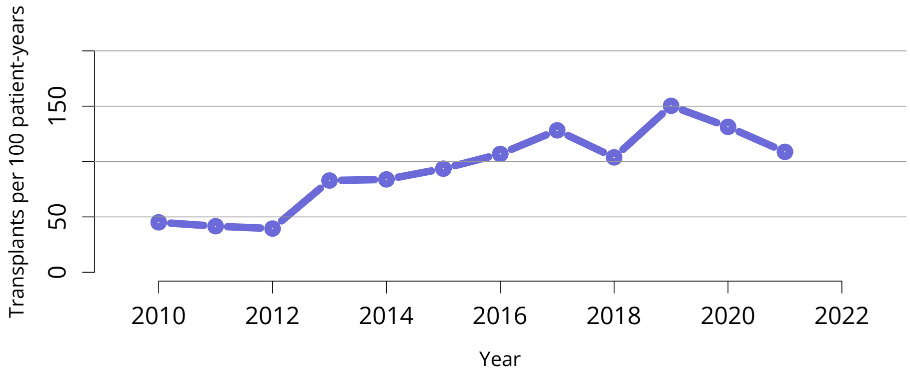

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Figure LU 71: Overall deceased donor lung transplant rates among pediatric waitlist candidates. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given year. Individual listings are counted separately.

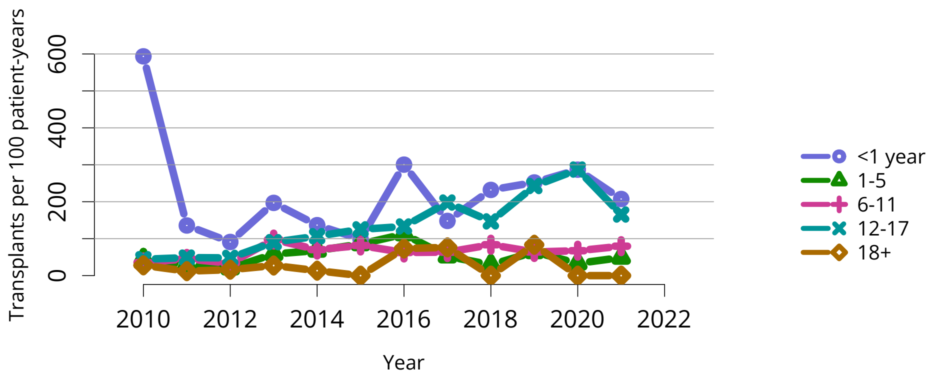

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Figure LU 72: Deceased donor lung transplant rates among pediatric waitlist candidates by age. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given year. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.

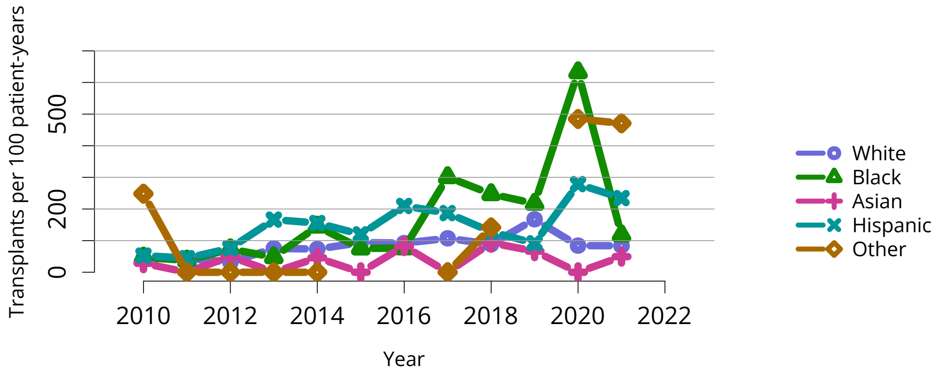

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Figure LU 73: Deceased donor lung transplant rates among pediatric waitlist candidates by race. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given year. Individual listings are counted separately.

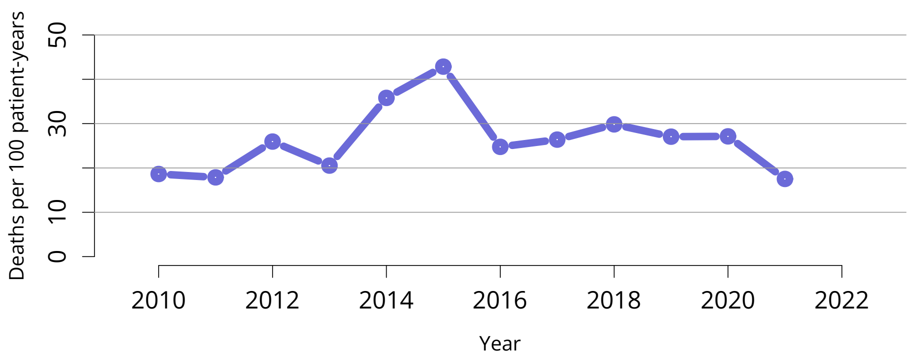

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Figure LU 74: Overall pretransplant mortality rates among pediatric candidates waitlisted for lung. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

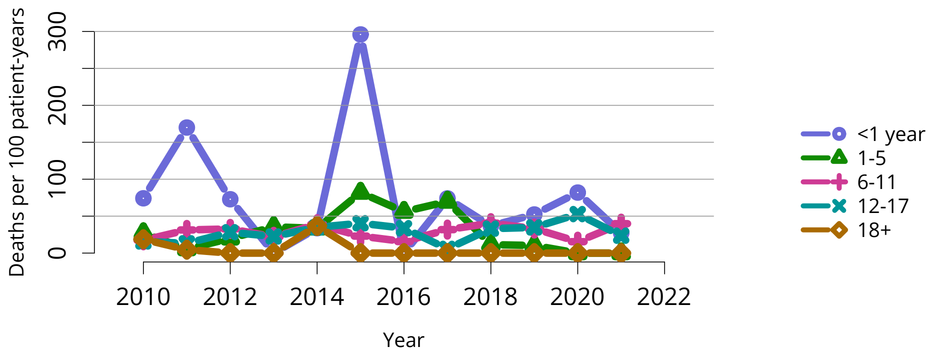

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Figure LU 75: Pretransplant mortality rates among pediatric candidates waitlisted for lung transplant by age. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Age is determined at the later of listing date or January 1 of the given year.

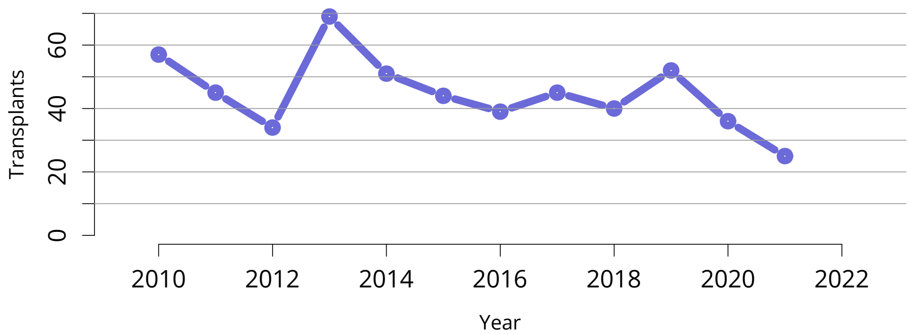

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Figure LU 76: Overall pediatric lung transplants. All pediatric lung transplant recipients, including retransplant, and multiorgan recipients.

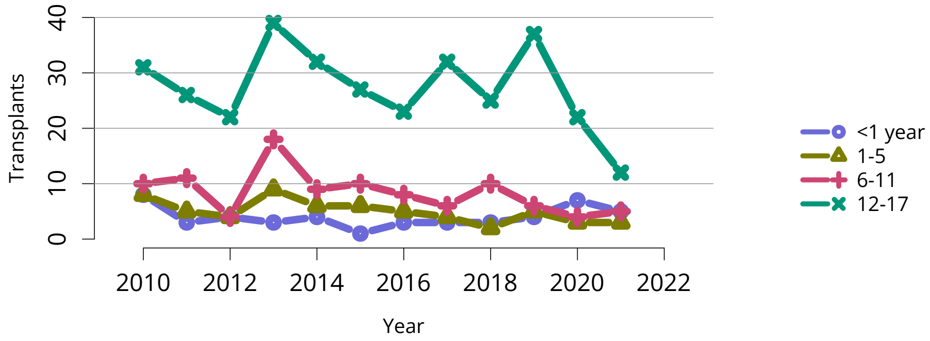

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Figure LU 77: Pediatric lung transplants by recipient age. All pediatric lung transplant recipients, including retransplant, and multiorgan recipients.

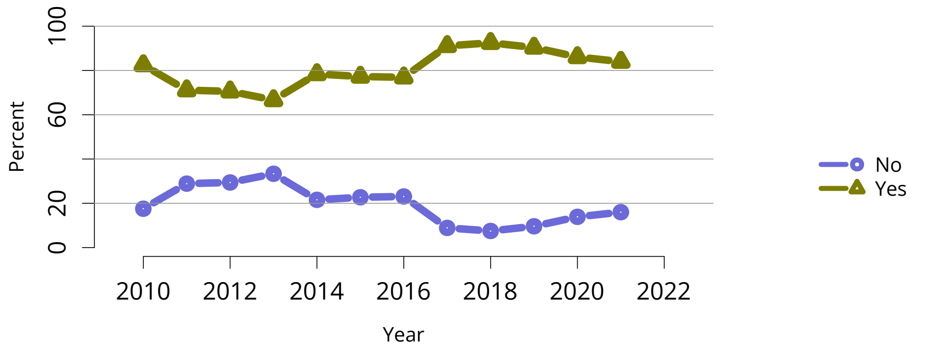

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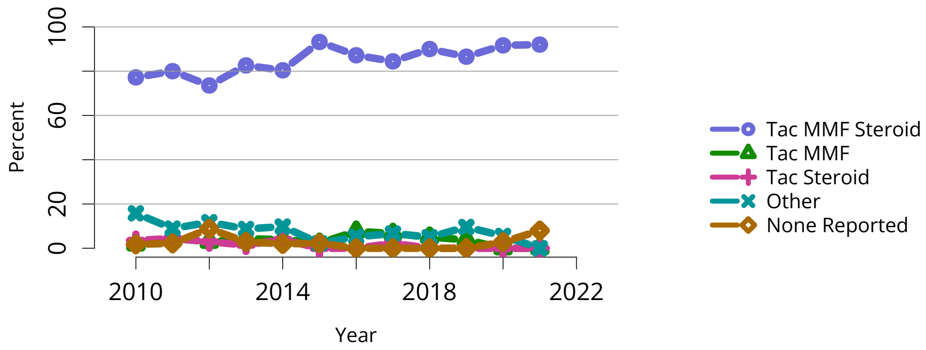
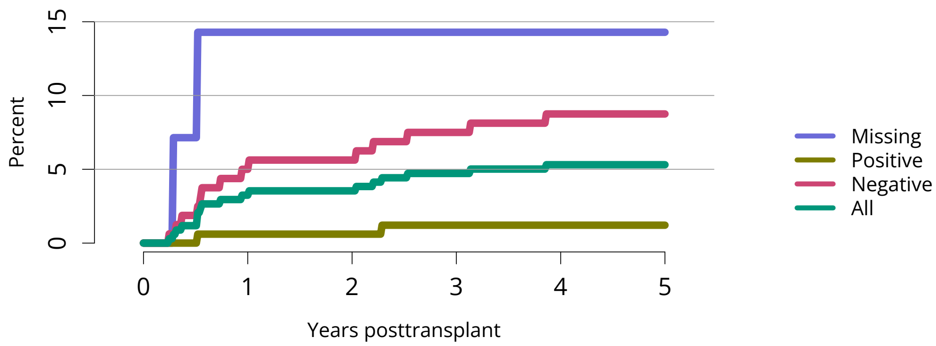
Figure LU 78: Induction agent use in pediatric lung transplant recipients. Immunosuppression at transplant reported to the OPTN.



OPTN/SRTR 2021 Annual Data Report

Figure LU 79: Immunosuppression regimen use in pediatric lung transplant recipients. Immunosuppression regimen at transplant reported to the OPTN. Tac, tacrolimus. MMF, all mycophenolate agents.



OPTN/SRTR 2021 Annual Data Report

Figure LU 80: Incidence of PTLD among pediatric lung transplant recipients by recipient EBV status at transplant, 2010-2016. Cumulative incidence is estimated using the Kaplan-Meier method. PTLD is identified as a reported complication or cause of death on the OPTN Transplant Recipient Follow-up Form or on the Posttransplant Malignancy Form as polymorphic PTLD, monomorphic PTLD, or Hodgkin's disease. Only the earliest date of PTLD diagnosis is considered. EBV, Epstein-Barr virus. PTLD, posttransplant lymphoproliferative disorder.

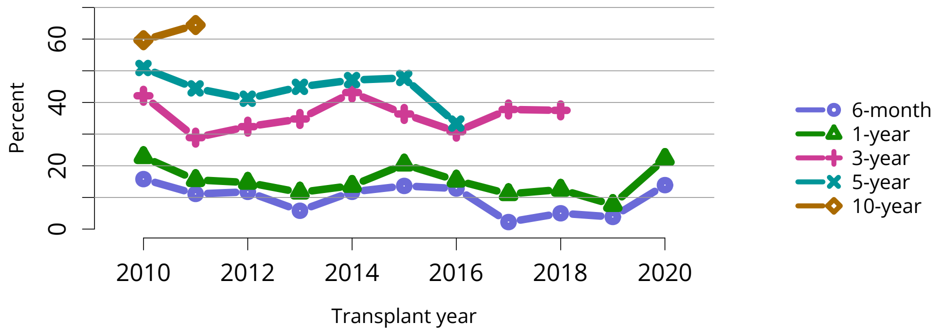


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Figure LU 81: Patient death among pediatric lung transplant recipients. All pediatric recipients of deceased donor lungs, including multiorgan transplants. Estimates are unadjusted, computed using unadjusted Kaplan-Meier methods.

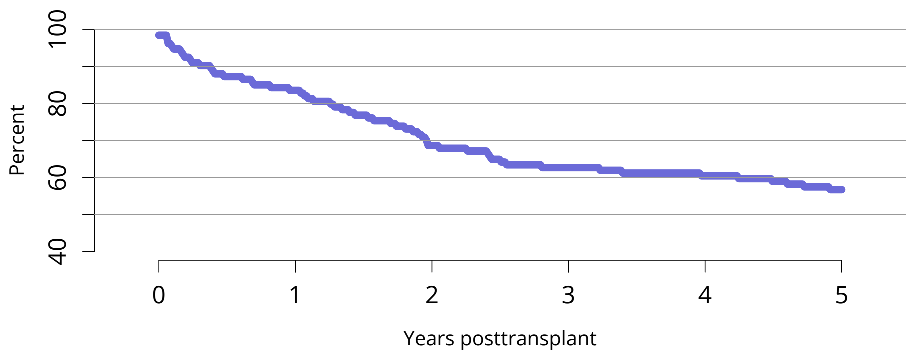

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Figure LU 82: Overall patient survival among pediatric deceased donor lung transplant recipients, 2014-2016. Recipient survival estimated using unadjusted Kaplan-Meier methods.

Table LU 1: Demographic characteristics of adults on the lung transplant waiting list on December 31, 2016, and December 31, 2021. Candidates waiting for transplant on December 31 of the given year, regardless of first listing date. Distance is computed from candidate's home zip code to the transplant center. Age is determined on December 31 of the year.

	2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Age (years)				
18-34 years	147	10.3	77	7.2
35-49	222	15.5	170	15.9
50-64	720	50.3	499	46.8
65+	343	24	321	30.1
Sex				
Male	564	39.4	442	41.4
Female	868	60.6	625	58.6
Race				
White	1106	77.2	694	65
Black	157	11	146	13.7
Asian	46	3.2	51	4.8
Hispanic	108	7.5	171	16
Other	15	1	5	0.5
Geography				
Metropolitan	1172	81.8	893	83.7
Non-metropolitan	246	17.2	166	15.6
Missing	14	1	8	0.7
Miles between candidate to center				
<50 miles	674	47.1	557	52.2
50-<100	270	18.9	194	18.2
100-<150	143	10	106	9.9
150-<250	172	12	108	10.1
250+	159	11.1	94	8.8
Missing	14	1	8	0.7
Height at listing (cm)				
<150 cm	65	4.5	54	5.1
150-<160	323	22.6	237	22.2
160-<170	532	37.2	363	34
170-<180	355	24.8	284	26.6
180+	157	11	123	11.5
Missing	0	0	6	0.6
All candidates				
All candidates	1432	100	1067	100

Table LU 2: Clinical characteristics of adults on the lung transplant waiting list on December 31, 2016, and December 31, 2021. Candidates waiting for transplant on December 31 of the given year, regardless of first listing date.

	2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Diagnosis group				
A - obstructive	618	43.2	322	30.2
B - pulmonary vascular	120	8.4	114	10.7
C - cystic fibrosis	136	9.5	23	2.2
D - restrictive	558	39	608	57
LAS at waiting				
<35	753	52.6	407	38.1
35-<40	377	26.3	311	29.1
40-<50	208	14.5	211	19.8
50-<60	46	3.2	52	4.9
60+	48	3.4	86	8.1
Blood Type				
A	524	36.6	350	32.8
AB	34	2.4	21	2
B	162	11.3	114	10.7
O	712	49.7	582	54.5
All candidates				
All candidates	1432	100	1067	100

Table LU 3: Listing characteristics of adults on the lung transplant waiting list on December 31, 2016, and December 31, 2021. Candidates waiting for transplant on December 31 of the given year, regardless of first listing date.

	2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Previous transplant				
No prior transplant	1400	97.8	1030	96.5
Prior transplant	32	2.2	37	3.5
Waiting time				
<90 days	411	28.7	405	38
3-<6 months	222	15.5	183	17.2
6-<12 months	268	18.7	198	18.6
1-<2 years	235	16.4	118	11.1
2+ years	296	20.7	163	15.3
All candidates				
All candidates	1432	100	1067	100

Table LU 4: Lung transplant waitlist activity among adults. Candidates listed at more than one center are counted once per listing. Candidates who are listed, undergo transplant, and are relisted are counted more than once. Candidates are not considered to be on the list on the day they are removed; counts on January 1 may differ from counts on December 31 of the prior year. Candidates listed for multiorgan transplants are included.

Waiting list state	2019	2020	2021
Waiting list state			
Patients at start of year	1451	1424	1006
Patients added during year	3243	2696	3111
Patients removed during year	3270	3114	3050
Patients at end of year	1424	1006	1067

Table LU 5: Removal reason among adult lung transplant candidates. Removal reason as reported to the OPTN. Candidates with death dates that precede removal dates are assumed to have died waiting.

Removal reason	2019	2020	2021
Removal reason			
Deceased donor transplant	2701	2560	2542
Patient died	143	151	132
Patient refused transplant	11	14	5
Improved, transplant not needed	41	65	52
Too sick for transplant	168	131	154
Other	206	193	165

Table LU 6: Demographic characteristics of adult lung transplant recipients, 2016 and 2021. Lung transplant recipients, including retransplants. Distance is computed from recipient's home zip code to the transplant center.

	2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Recipient age (years)				
18-34 years	247	10.7	140	5.5
35-49	267	11.6	300	11.8
50-64	1104	47.9	1171	46
65+	688	29.8	933	36.7
Sex				
Male	1344	58.3	1622	63.8
Female	962	41.7	922	36.2
Race				
White	1868	81	1795	70.6
Black	217	9.4	258	10.1
Asian	48	2.1	102	4
Hispanic	159	6.9	354	13.9
Other	14	0.6	35	1.4
Height at transplant (cm)				
<150 cm	38	1.6	61	2.4
150-<160	320	13.9	320	12.6
160-<170	716	31	759	29.8
170-<180	807	35	866	34
180+	425	18.4	521	20.5
Missing	0	0	17	0.7
Insurance				
Private	1035	44.9	1058	41.6
Medicare	1021	44.3	1124	44.2
Medicaid	165	7.2	236	9.3
Other/unknown	85	3.7	126	5
Geography				
Metropolitan	1926	83.5	2131	83.8
Non-metropolitan	357	15.5	370	14.5
Missing	23	1	43	1.7
Miles between recipient to center				
<50 miles	1138	49.3	1297	51
50-<100	405	17.6	481	18.9
100-<150	259	11.2	216	8.5
150-<250	245	10.6	239	9.4
250+	239	10.4	268	10.5
Missing	20	0.9	43	1.7
All recipients				
All recipients	2306	100	2544	100

Table LU 7: Clinical characteristics of adult lung transplant recipients, 2016 and 2021. Lung transplant recipients, including retransplants. ECMO, extracorporeal membrane oxygenation.

	2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Diagnosis group				
A - obstructive	625	27.1	482	18.9
B - pulmonary vascular	90	3.9	148	5.8
C - cystic fibrosis	266	11.5	50	2
D - restrictive	1325	57.5	1864	73.3
Blood Type				
A	961	41.7	941	37
AB	79	3.4	101	4
B	258	11.2	291	11.4
O	1008	43.7	1211	47.6
LAS at transplant				
<35	570	24.7	459	18
35-<40	568	24.6	544	21.4
40-<50	538	23.3	577	22.7
50-<60	209	9.1	229	9
60+	421	18.3	735	28.9
Vent/ECMO at transplant				
Vent+ECMO	73	3.2	173	6.8
Vent only	52	2.3	46	1.8
ECMO only	63	2.7	111	4.4
Neither	2118	91.8	2214	87
All recipients				
All recipients	2306	100	2544	100

Table LU 8: Transplant characteristics of adult lung transplant recipients, 2016 and 2021. Lung transplant recipients, including retransplants. DBD, donation after brain death; DCD, donation after circulatory death.

	2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Waiting time				
None	80	3.5	90	3.5
<90 days	1381	59.9	1867	73.4
3-<6 months	348	15.1	257	10.1
6-<12 months	252	10.9	163	6.4
1-<2 years	144	6.2	118	4.6
2+	101	4.4	49	1.9
Bilateral versus single lung transplant				
Bilateral	1720	74.6	2038	80.1
Single	586	25.4	506	19.9
Donation after circulatory death				
DBD	2214	96	2346	92.2
DCD	92	4	198	7.8
Previous transplant for recipients				
Prior transplant	76	3.3	76	3
No Prior transplant	2230	96.7	2468	97
All recipients				
All recipients	2306	100	2544	100

Table LU 9: Demographic characteristics of pediatric candidates on the lung transplant waiting list on December 31, 2016, and December 31, 2021. Candidates younger than 18 years at listing waiting for transplant on December 31 of the given year, regardless of first listing date. Age is determined on December 31 of the year. Distance is computed from candidate's home zip code to the transplant center.

	2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Age (years)				
<1 year	2	5.1	2	7.7
1-5	7	17.9	4	15.4
6-11	7	17.9	11	42.3
12-17	18	46.2	7	26.9
18+	5	12.8	2	7.7
Sex				
Male	15	38.5	15	57.7
Female	24	61.5	11	42.3
Race				
White	29	74.4	13	50
Black	4	10.3	4	15.4
Asian	1	2.6	2	7.7
Hispanic	5	12.8	7	26.9
Geography				
Metropolitan	31	79.5	23	88.5
Non-metropolitan	8	20.5	1	3.8
Missing	0	0	2	7.7
Miles between candidate to center				
<50 miles	9	23.1	5	19.2
50-<100	8	20.5	3	11.5
100-<150	8	20.5	3	11.5
150-<250	4	10.3	5	19.2
250+	10	25.6	8	30.8
Missing	0	0	2	7.7
Height at listing (cm)				
<70 cm	5	12.8	3	11.5
70-<90	1	2.6	4	15.4
90-<110	7	17.9	2	7.7
110-<130	5	12.8	8	30.8
130+	21	53.8	9	34.6
All candidates				
All candidates	39	100	26	100

Table LU 10: Clinical characteristics of pediatric candidates on the lung transplant waiting list on December 31, 2016, and December 31, 2021. Candidates younger than 18 years at listing waiting for transplant on December 31 of the given year, regardless of first listing date.

	2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Pediatric diagnosis group				
Cystic fibrosis	15	38.5	1	3.8
Pulmonary hypertension	9	23.1	5	19.2
Pulmonary fibrosis	3	7.7	2	7.7
Other vascular	1	2.6	3	11.5
Other/unknown	11	28.2	11	42.3
NA	0	0	4	15.4
Blood Type				
A	12	30.8	6	23.1
AB	5	12.8	1	3.8
B	2	5.1	2	7.7
O	20	51.3	17	65.4
All candidates				
All candidates	39	100	26	100

Table LU 11: Listing characteristics of pediatric candidates on the lung transplant waiting list on December 31, 2016, and December 31, 2021. Candidates younger than 18 years at listing waiting for transplant on December 31 of the given year, regardless of first listing date.

	2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Previous transplant				
No prior transplant	38	97.4	26	100
Prior transplant	1	2.6	0	0
Waiting time				
<90 days	13	33.3	8	30.8
3-<6 months	6	15.4	5	19.2
6-<12 months	6	15.4	4	15.4
1-<2 years	6	15.4	7	26.9
2+ years	8	20.5	2	7.7
All candidates				
All candidates	39	100	26	100

Table LU 12: Lung transplant waitlist activity among pediatric candidates. Candidates who are listed, undergo transplant, and are relisted are counted more than once. Candidates are not considered to be on the list on the day they are removed; counts on January 1 may differ from counts on December 31 of the prior year. Candidates listed for multiorgan transplants are included.

Waiting list state	2019	2020	2021
Waiting list state			
Patients at start of year	42	30	22
Patients added during year	72	58	47
Patients removed during year	84	66	43
Patients at end of year	30	22	26

Table LU 13: Removal reason among pediatric lung transplant candidates. Removal reason as reported to the OPTN. Candidates with death dates that precede removal dates are assumed to have died waiting.

Removal reason	2019	2020	2021
Removal reason			
Deceased donor transplant	56	36	25
Patient died	9	7	3
Improved, transplant not needed	5	8	5
Too sick for transplant	5	4	6
Other	9	11	4

Table LU 14: Demographic characteristics of pediatric lung transplant recipients, 2016 and 2021. Pediatric lung transplant recipients, including retransplants. Distance is computed from recipient's home zip code to the transplant center.

	2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Recipient age (years)				
<1 year	3	7.7	5	20
1-5	5	12.8	3	12
6-11	8	20.5	5	20
12-17	23	59	12	48
Sex				
Male	17	43.6	11	44
Female	22	56.4	14	56
Race				
White	23	59	12	48
Black	2	5.1	4	16
Asian	2	5.1	1	4
Hispanic	12	30.8	6	24
Other	0	0	2	8
Height at transplant (cm)				
<70 cm	3	7.7	4	16
70-<90	2	5.1	3	12
90-<110	2	5.1	2	8
110-<130	5	12.8	1	4
130+	26	66.7	15	60
Missing	1	2.6	0	0
Insurance				
Private	18	46.2	8	32
Medicaid	18	46.2	14	56
Other/unknown	3	7.7	3	12
Geography				
Metropolitan	35	89.7	19	76
Non-metropolitan	2	5.1	4	16
Missing	2	5.1	2	8
Miles between recipient to center				
<50 miles	16	41	10	40
50-<100	3	7.7	0	0
100-<150	2	5.1	0	0
150-<250	3	7.7	4	16
250+	13	33.3	9	36
Missing	2	5.1	2	8
All recipients				
All recipients	39	100	25	100

Table LU 15: Clinical characteristics of pediatric lung transplant recipients, 2016 and 2021. Pediatric lung transplant recipients, including retransplants. Pediatric priority was reported in 2010 and later. ECMO, extracorporeal membrane oxygenation.

	2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Diagnosis group				
Cystic fibrosis	19	48.7	4	16
Pulmonary hypertension	7	17.9	4	16
Pulmonary fibrosis	5	12.8	1	4
Other vascular	1	2.6	0	0
Other/unknown	7	17.9	14	56
NA	0	0	2	8
Blood Type				
A	13	33.3	8	32
AB	2	5.1	1	4
B	4	10.3	2	8
O	20	51.3	14	56
LAS at transplant				
<35	5	12.8	5	20
35-<40	9	23.1	4	16
40-<50	4	10.3	0	0
60+	5	12.8	3	12
Not applicable	16	41	13	52
Vent/ECMO at transplant				
Vent+ECMO	2	5.1	4	16
Vent only	4	10.3	4	16
Neither	33	84.6	15	60
ECMO only	0	0	2	8
All recipients				
All recipients	39	100	25	100

Table LU 16: Transplant characteristics of pediatric lung transplant recipients, 2016 and 2021. Pediatric lung transplant recipients, including retransplants.

	2016		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
Waiting time				
None	2	5.1	2	8
<90 days	19	48.7	17	68
3-<6 months	8	20.5	3	12
6-<12 months	6	15.4	2	8
1-<2 years	3	7.7	0	0
2+	1	2.6	1	4
Bilateral versus single lung transplant				
Bilateral	37	94.9	25	100
Single	2	5.1	0	0
Previous transplant for recipients				
No Prior transplant	39	100	25	100
All recipients				
All recipients	39	100	25	100

OPTN/SRTR 2021 Annual Data Report: Deceased Organ Donation

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Abstract

The Scientific Registry of Transplant Recipients uses data collected by the Organ Procurement and Transplantation Network to calculate metrics such as donation rate, organ yield, and rate of organs recovered for transplant but not transplanted (ie, nonuse). In 2021, there were 13,862 deceased donors, a 10.1% increase from 12,588 in 2020, and an increase from 11,870 in 2019; this number has been increasing since 2010. The number of deceased donor transplants increased to 41,346 transplants in 2021, a 5.9% increase from 39,028 in 2020; this number has been increasing since 2012. The increase may be due in part to the rising number of deaths of young people amid the ongoing opioid epidemic. The number of organs transplanted included 9,702 left kidneys, 9,509 right kidneys, 551 en bloc kidneys, 964 pancreata, 8,595 livers, 96 intestines, 3,861 hearts, and 2,443 lungs. Compared with 2019, transplants of all organs except lungs increased in 2021, which is remarkable as this occurred despite the COVID-19 pandemic. In 2021, 2,951 left kidneys, 3,149 right kidneys, 184 en bloc kidneys, 343 pancreata, 945 liver, 1 intestine, 39 hearts, and 188 lungs were not used. These numbers suggest an opportunity to increase numbers of transplants by reducing nonused organs. Despite the pandemic, there was no dramatic increase in number of nonused organs and there was an increase in total numbers of donors and

transplants. The new Centers for Medicare & Medicaid Services metrics for donation rate and transplant rate have also been described and vary across organ procurement organizations; the donation rate metric varied from 5.82 to 19.14 and the transplant rate metric varied from 18.7 to 60.0.
Keywords: Donation rate, eligible death, organ nonuse, organ yield

1 INTRODUCTION

This chapter reports data collected by the Organ Procurement and Transplantation Network (OPTN) to describe changes in deceased donor characteristics over the past decade and deceased organ donor metrics such as donation rate, organ yield, and rate of organs recovered for transplant but not transplanted (ie, nonuse). These metrics are currently produced by the Scientific Registry of Transplant Recipients (SRTR), and some, such as organ yield, are used for organ procurement organization (OPO) quality assessment by OPTN. Some data described in this chapter are also used by the Centers for Medicare & Medicaid Services (CMS) to develop its own quality assessment of OPOs. The chapter also describes the Centers for Disease Control and Prevention's (CDC's) national data on deaths that will be used by CMS as part of its metrics to assess OPO quality. In 2019, the federal government ordered the revision of OPO quality metrics "to establish more transparent, reliable, and enforceable objective metrics for evaluating an OPO's performance."[1] This federal order also aims to reduce organ nonuse nationally. CMS has approved new metrics to assess OPO quality.[2] The impact of new metrics to assess OPO quality will be seen after they are implemented in 2022.

Definitions of Terms Related to Deceased Organ Donation

- **DBD:** Donation after brain death.
- **DCD:** Donation after circulatory death.
- **Donation rate:** Number of eligible donors per 100 eligible deaths.
- **Donor:** A person from whom at least one organ was recovered for transplant, regardless of whether the organ was transplanted.
- **Eligible death:** As per OPTN policy 1.2, in place before 2017, death of a person aged 70 years or younger who is legally declared brain dead according to hospital policy and does not exhibit any of the following indications: tuberculosis, HIV with specified conditions, Creutzfeldt-Jacob disease, herpetic septicemia, rabies, reactive hepatitis B surface antigen, any retrovirus infection, active malignant neoplasms (except primary central nervous system tumors and skin cancers), Hodgkin disease, multiple myeloma,

leukemia, miscellaneous carcinomas, aplastic anemia, agranulocytosis, fungal and viral encephalitis, gangrene of bowel, extreme immaturity, or positive serologic or viral culture findings for HIV. On January 1, 2017, a new eligible death definition was enacted. Per this definition, eligible death is death of a person aged 75 years or younger who is legally declared brain dead according to state or local law, and has a body weight of 5 kg or more, a body mass index of 50 kg/m^2 or lower, and at least one kidney, liver, heart, or lung deemed to meet the eligible data definitions, per the new OPTN policy 1.2.

- **Eligible donor:** A donor whose death met the definition of eligible death.
- **Nonuse:** Organs recovered for transplant but not transplanted.
- **Nonuse rate:** Number of organs not used divided by number of organs recovered for transplant.
- **Organs authorized for recovery:** Authorization requested and given for recovery of specific organs from a donor. Recovery of organs for transplant must be authorized by the individual(s) authorizing the donation (donor or surrogate decision maker), consistent with applicable state law.
- **Organs recovered per donor (ORPD):** Total number of organs recovered for transplant, divided by the number of donors, not limited to eligible deaths.
- **Organs transplanted per donor (OTPD):** Total number of organs transplanted, divided by the number of donors, not limited to eligible deaths (eg, OTPD for kidneys is the total number of kidneys transplanted, divided by the total number of all donors).
- **Referrals:** All deaths and imminent deaths reported to an OPO.

2 DONORS

There were 41,346 transplants in the United States from organs recovered in 2021, a 5.9% increase from 39,028 in 2020; this number has been increasing since 2012. The number of deceased donor transplants increased to 34,807, a 4.5% increase from 33,303 in 2020; this number has also been increasing since 2012. There were 13,862 deceased donors in 2021, a 10.1% increase from 12,588 in 2020, and an increase from 11,870 deceased donors in 2019, 10,721 in 2018, and 10,286 in 2017; this number has been increasing since 2010. The increase may be explained in part by the rising number of deaths of young people due to the ongoing opioid epidemic. In 2021, 6,539 living donor transplants (ie, difference between overall transplants and deceased donor transplants) were performed, an increase from 5,725 in 2020 and a decrease from 7,391 in 2019 and 6,843 in 2018; this number increased from 2016 to 2019. Thus, living donor transplants are recovering from the negative impact of the COVID-19 pandemic. In 2021, 13,102 individuals met the definition of eligible death according to OPTN policy, a slight increase from 12,696 in 2020. In 2021, 22,359 imminent neurologic and eligible deaths were reported, a slight increase from 21,446 in 2020, 20,934 in 2019, 21,259 in 2018, and 22,258 in 2017, and a decline from 23,441 in 2016. The decline was anticipated due to changes in the OPTN definition of imminent neurologic and eligible deaths (Figure DD 1) (eg, changing the absence of three brainstem reflexes to the absence of spontaneous breathing and two other brainstem reflexes).

Donations after brain death (DBDs) increased to 9,673 in 2021, a 3.2% increase from 9,364 in 2020, and from 9,152 in 2019, 8,589 in 2018, and 8,403 in 2017; this number has been increasing since 2012. Donations after circulatory death (DCDs) increased to 4,189 in 2021, a 29.9% increase from 3,224 in 2020, and from 2,718 in 2019, 2,132 in 2018, and 1,883 in 2017; this number has been increasing since 2009 (Figure DD 2). Potential reasons for the increases in DBD and DCD donors include rising numbers of deaths of young people due to the opioid epidemic, new innovations in perfusion methods, and increasing use of organs from DBD donors.

Consistent with the increasing number of DBD and DCD donations, 99,714 organs were authorized in 2021, a 10.4% increase from 90,310 organs in 2020; this number has been increasing since 2010. In 2021, 49,100 organs were recovered, a 10.5% increase from 44,426 in 2020 and an increase from 43,717 in 2019; this number has been increasing since 2012. In 2021, 35,700 organs were transplanted, an increase of 4.3% from 34,220 in 2020 and an increase from 33,302 in 2019; this number has been increasing since 2012 (Figure DD 3).

3 DONATION RATE

Any metric based solely on eligible deaths uses only a subset of potential donors, because successful donations can come from donors not meeting the eligible death definition (eg, DCD or donors older than 75 years). Recognizing this limitation, SRTR's current donation rate measures how often a person with an eligible death becomes a donor. Unadjusted donation rates varied by donation service area (DSA), ranging from 54.1 to 88.4 eligible donors per 100 eligible deaths (Figure DD 4). Risk-adjusted donation rates are presented for each OPO semiannually in OPO reports on the SRTR website.

The overall donation rate was 70.1 eligible donors per 100 eligible deaths in 2021. As expected, donation rates varied by organ (Figure DD 5). In 2021, the highest rate was for kidney, followed by liver, heart, lung, and pancreas. The kidney donation rate was 66.2 eligible donors per 100 eligible deaths in 2021. The next highest donation rate after kidney in 2021 was liver, at 60.3 donors per 100 eligible deaths (Figure DD 5). The donation rates for heart, lung, and pancreas were 27.6, 17.9, and 9.4 donors per 100 eligible deaths, respectively.

4 ORGANS RECOVERED PER DONOR

In 2021, 3.33 organs were recovered per donor, slightly lower than the 3.41 in 2020, 3.51 in 2019, 3.53 in 2018, and 3.54 in 2017 (Figure DD 6). Given that each donor can potentially donate two kidneys, the ORPD was highest for kidney, at 1.90 in 2021, a slight increase from 1.89 in 2020 and from 1.87 in 2019 (Figure DD 6). The ORPD for liver was 0.69, a slight decrease from 0.73 in 2020 and 0.77 in 2019 (Figure DD 7). Over the past decade, ORPDs have remained stable for kidney and slightly decreased for liver. The ORPD for heart was 0.28 in 2021, a slight decrease from 0.29 in 2020 and 0.30 in 2019. The ORPD for lung was 0.37 in 2021, a slight decrease from 0.39 in 2020 and 0.44 in 2019. These declines in ORPD may have been due to the COVID-19 pandemic; whether they will reverse in subsequent years remains to be seen (Figure DD 7). The ORPD for pancreas was 0.09 in 2021, the same as in 2020 and a decrease from 0.11 in 2019, but this decline has been ongoing for the past decade. In 2020, the ORPD varied substantially by DSA, ranging from 2.56 to 3.66 (Figure DD 8). The ORPD is an unadjusted number representing a mix of donor types, including young, old, DBDs, and DCDs, which explains some differences observed.

5 ORGANS TRANSPLANTED PER DONOR

The number of OTPDs was 2.75 in 2021, a decrease from 2.90 in 2020, 3.01 in 2019, 3.06 in 2018, and 3.07 in 2017 (Figure DD 9). Given that each donor can potentially donate two kidneys, the OTPD was highest for kidney, followed by liver (Figures DD 9 and 10). The OTPD for kidney was 1.43 in 2021, a decrease from 1.48 in 2020, and 1.50 in 2019 (Figure DD 10). In 2021, the OTPD for other individual organs was 0.62 for liver, 0.34 for lung, 0.28 for heart, 0.07 for pancreas, and 0.007 for intestine. The OTPD for all organs varied by DSAs and ranged from 1.87 to 3.27 (Figure DD 11).

The OTPD varies depending on whether the donation was DBD or DCD. Accounting for all organs, the OTPD was 3.18 for DBD donors and 1.75 for DCD donors (Figure DD 12). For kidney, the OTPD was 1.45 and 1.38 for DBD and DCD donors, respectively. This was the first year in a decade that the OTPD for kidney was lower for DCD compared with DBD (Figure DD 13). The difference was wider for all other organs, with a higher OTPD for DBD than DCD donors (Figures DD 14, 15, 16, 17, and 18). No intestines were transplanted from DCD donors. A few hearts were transplanted from DCD donors starting in 2019.

Numbers of deceased donor organs transplanted in 2021 were 19,762 kidneys (9,702 left kidneys, 9,509 right kidneys, and 551 en bloc kidneys), 964 pancreata, 8,595 livers, 96 intestines, 3,861 hearts, and 2,443 lungs (Figures DD 23, 24, 25, 26, 27, 28, 29, and 30). Numbers of deceased donor organs transplanted in 2020 included 18,410 kidneys (9,113 left kidneys, 9,021 right kidneys, and 276 en bloc kidneys), 962 pancreata, 8,350 livers, 91 intestines, 3,722 hearts, and 2,463 lungs. Therefore, in 2021, the number of deceased donor organs transplanted increased for all organs except for lung. The number of deceased donor lungs transplanted in 2020 may have decreased because of the COVID-19 pandemic and then increased in 2021 as the transplant community adjusted to the pandemic. In a 2021 unadjusted analysis, not accounting for the mix of DBD and DCD donor types, OTPD varied substantially by DSA, ranging from 1.87 to 3.27, a range similar to the 1.92 to 3.41 in 2020 (Figure DD 11).

The OTPD from DBD donors was 3.17 in 2021, down from 3.25 in 2020, 3.33 in 2019, and 3.34 in 2018. The OTPD from DCD donors was 1.74 in 2021, down from 1.89 in 2020 and from 1.94 in 2019 and 2018 (Figure DD 12).

In 2021, among kidney donors, OTPD varied by kidney donor profile index (KDPI), at 1.91, 1.82, 1.45, and 0.54 for KDPI <20%, 21%-34%, 35%-85%, and >85%, respectively (Figure DD 19). The trends seem relatively stable over the past decade (Figure DD 19).

6 ORGANS RECOVERED FOR TRANSPLANT BUT NOT TRANSPLANTED

The number of nonused organs is calculated by subtracting the number of organs transplanted from the number of organs recovered for transplant. The nonuse rate is then calculated by dividing nonused organs by the number of organs recovered for transplant. The nonuse rate in 2021 for all organs combined was 17.6 per recovered organ, higher than the 15.0 per recovered organ in 2020, 14.3 per recovered organ in 2019, and 13.2 per recovered organ in 2018 and 2017 (Figure DD 20). This trend in increasing annual nonuse has persisted since 2017. In 2021, the percentages for kidney, pancreas, liver, intestine, heart, and lung were 24.6, 26.2, 9.90, 1.03, 1.00, and 8.1 per recovered organ, respectively, and slightly increased from 21.3, 23.2, 9.3, 5.4 per recovered donor for kidney, pancreas, liver, and lung in 2020. In contrast, the percentages were higher in 2020 for intestine, at 3.2 per recovered donor. The percentages for heart were similar in 2021 and 2020. The number for kidney nonuse increased the most in 2021 (Figures DD 23, 24, 25, 26, 27, 28, 29, and 30). In 2021, 2,951 left kidneys, 3,149 right kidneys, 184 en bloc kidneys, 343 pancreata, 945 livers, 1 intestine, 39 hearts, and 188 lungs were recovered for transplant but not transplanted. In 2020, 2,290 left kidneys, 2,399 right kidneys, 181 en bloc kidneys, 294 pancreata, 861 livers, 3 intestines, 39 hearts, and 115 lungs were recovered for transplant but not transplanted. Thus, the absolute nonuse number for all organs increased from 2020 to 2021, except for intestine and heart.

7 USE OF DCD ORGANS AND HIGH-KDPI KIDNEYS ACROSS OPOs

Use of DCD organs varied across OPOs, from 0% to 53% of all deceased donors, in 2021 (Figure DD 21). In 2021, the percentage of DCD donor organs among deceased donor transplant recipients varied across DSAs, from 0% to 44.4%, a narrower range than in 2020. In 2021, the percentage of kidney donors with KDPI higher than 85% also varied across DSAs, from 1.14 to 17.5, a wider range than 0.70 to 15.18 in 2020 and 0 to 16.8 in 2019 (Figure DD 22).

8 DISPOSITION OF ORGANS

The disposition of each organ from actual donors is described in Figures DD 23, 24, 25, 26, 27, 28, 29, and 30. For left, right, and en bloc kidneys, the most common reason for recovered for transplant but not transplanted was "no recipient located, list exhausted," followed by "biopsy findings." For pancreata, the most common reasons were "other" and "anatomical abnormalities." For livers, the most common reason was by "other, specify" followed by "biopsy findings." The reasons for the one intestine nonused was "recipient determined to be unsuitable for transplantation in the operating room." For hearts, the most common reason was "other, specify." For lungs, the most common reason was "other, specify" and "poor organ function." These reasons are similar to those in 2020. Donor characteristics from 2021 are compared with those in 2011 in Table DD 1. The most remarkable difference was the increase in HIV-positive donors to 30 in 2021, from none in 2011. This increase is due to the 2013 HIV Organ Policy Equity (HOPE) Act, which modified rules about organ donation between HIV-positive individuals and authorized use of these organs as part of clinical research. Other remarkable differences were an increase in anoxia as cause of donor death, from 28% in 2011 to 47.3% in 2021, and decreases in stroke (36.1% to 25%) and head trauma (33% to 24.1%). The percentage of DCD donors increased from 13% in 2011 to 30.2% in 2021. The increase in numbers of donors from 2011 to 2021 (8,126 to 13,862) and those with anoxia as cause of death may be due to the opioid epidemic.

New CMS metrics were finalized and published in December 2021 for the OPO public performance report. This new metric is being used in 2022. The new metrics determine the CMS potential donors, which is the denominator for both the donation rate and transplant rate metrics. In Table DD 2, the CMS potential donors were identified using data obtained from the CDC's National Center for Health Statistics Detailed Multiple Cause of Death (MCOD) file. The *International Classification of Diseases, Tenth Revision*, codes used to identify potential donor deaths include 120-125 for ischemic heart disease, 160-169 for cerebrovascular disease, and V-1-Y89 for external causes of morbidity and mortality, which includes blunt trauma, gunshot wound, drug overdose, suicide, drowning, and asphyxiation. Thus, the definition of potential donors is based on the cause of death, age younger than 75 years, and the location of death being consistent with organ donation, mainly inpatient deaths. The number of donors is the numerator for the donation rate and is defined as the number of deceased individuals from whom at least one organ, such as heart, liver, lung, kidney, pancreas, or intestine, was transplanted. The number of donors also includes donors with pancreata or islet cells that were either recovered for research or recovered for transplant but submitted for research. Figure DD 31 and Table DD 2 show that the donation rate metric varied across OPOs from 5.82 to 19.14 in 2020.

The second CMS metric, for transplant rate, uses number of organs transplanted from deceased donors as shown in Table DD 2. This numerator also includes pancreata and islet cells that are either recovered for research or recovered for transplant but submitted for research. The CMS transplant rate varied across OPOs from 18.7 to 60.0 in 2020 (Figure DD 32). The CMS transplant rate was lowest for the Hawaii OPO, and the metric for this OPO only includes transplanted kidneys in its numerator.

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[1] Executive Office of the President. Executive Order 13879 of July 10, 2019: Advancing American Kidney Health. 2019. Accessed October 27, 2022. https://www.federalregister.gov/documents/2019/07/15/2019-15159/advancing-american-kidney-health

[2] US Department of Health and Human Services. Centers for Medicare and Medicaid Services. 42 CFR Part 486 [CMS-3380-F], RIN 0938-AU02. Medicare and Medicaid Programs; Organ Procurement Organizations Conditions for Coverage: Revisions to the Outcome Measure Requirements for Organ Procurement Organizations; Final rule. 2022. Accessed October 27, 2022. https://www.cms.gov/files/document/112020-opo-final-rule-cms-3380-f.pdf

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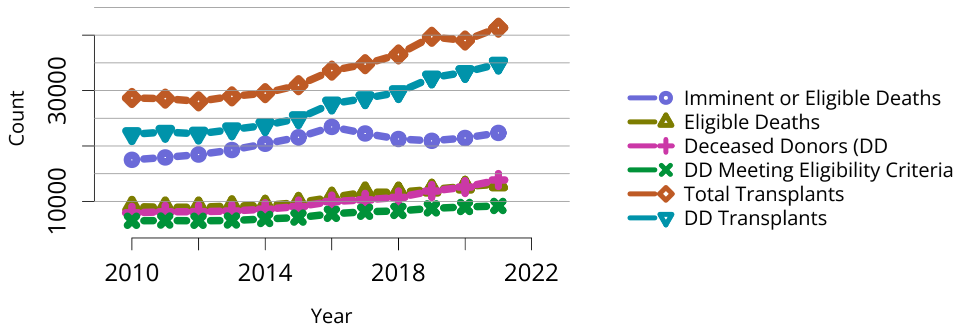

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Figure DD 1: Overall counts of eligible deaths, donors, and transplants, 2010-2021. The number and source of donors with the number of transplants.

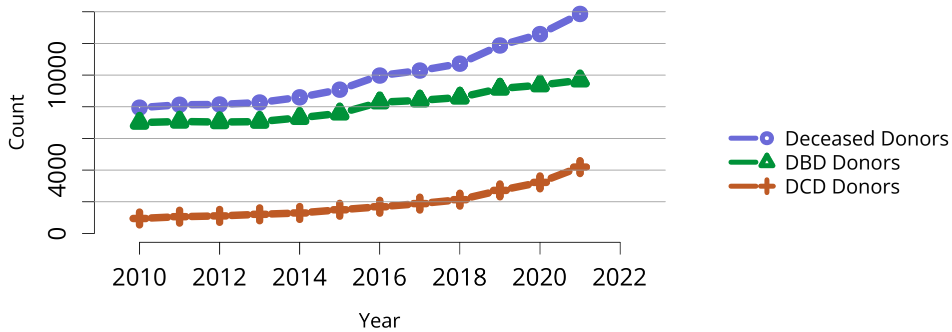

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Figure DD 2: Overall counts of deceased donors, DBD donors, and DCD donors, 2010-2021. The number of deceased donors, DBD donors, and DCD donors. Deceased donor counts include all donors for whom at least one organ was recovered for transplant. DBD, donation after brain death; DCD, donation after circulatory death.

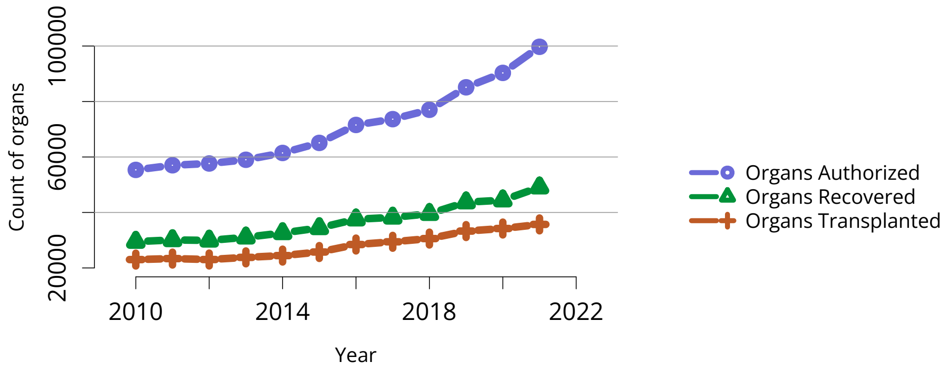

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Figure DD 3: Overall counts of authorized, recovered, and transplanted organs, 2010-2021. The number of authorized , recovered, and transplanted organs.

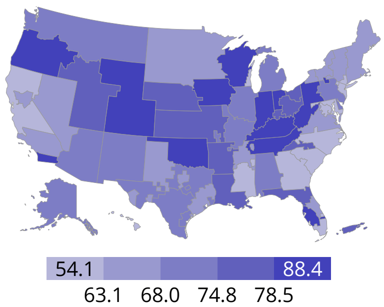

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Figure DD 4: Eligible Donors per 100 eligible deaths by DSA, 1/1/2021-12/31/2021. Donation rate is the number of deceased donors meeting eligibility criteria per 100 eligible deaths. An eligible death is any hospital-reported death that is evaluated and meets organ donor eligibility requirements, with none of the exclusions listed in OPTN policy.

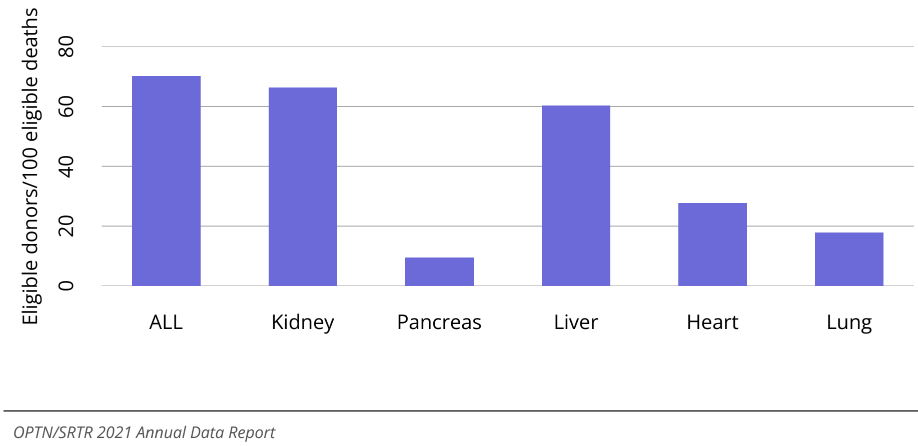

Figure DD 5: Overall and organ-specific eligible donors per 100 eligible deaths, 1/1/2021-12/31/2021. Organ-specific rates represent the number of donors of each organ type meeting eligibility criteria per 100 eligible deaths.

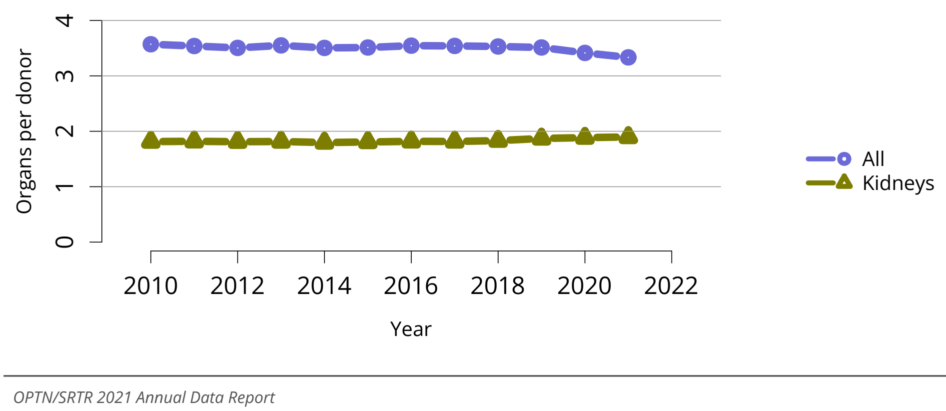

Figure DD 6: Organs recovered per donor, all organs and kidney. Average number of overall organs and kidneys recovered per donor, calculated as the sum of recovered organs and by organ type; e.g., up to two kidneys can be recovered from each donor, but only one heart.

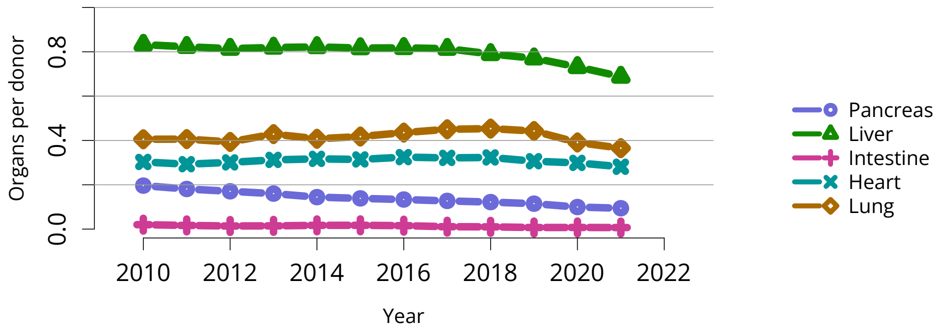

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Figure DD 7: Organs recovered per donor, pancreas, liver, intestine, heart, and lung. Average number of organs other than kidneys recovered per donor, calculated as the sum of recovered organs and by organ type. Pancreata recovered for islet transplant are excluded.

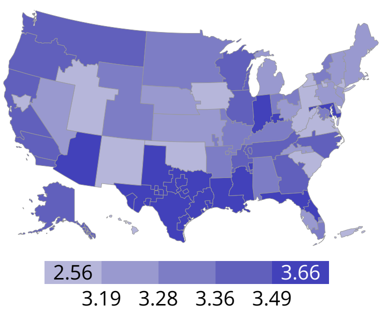

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Figure DD 8: Organs recovered per donor by DSA, 2021. Average number of organs recovered per donor, calculated as the sum of recovered organs and by organ type; i.e., up to two kidneys can be recovered from each donor, but only one heart. Pancreata recovered for islet transplant are excluded.

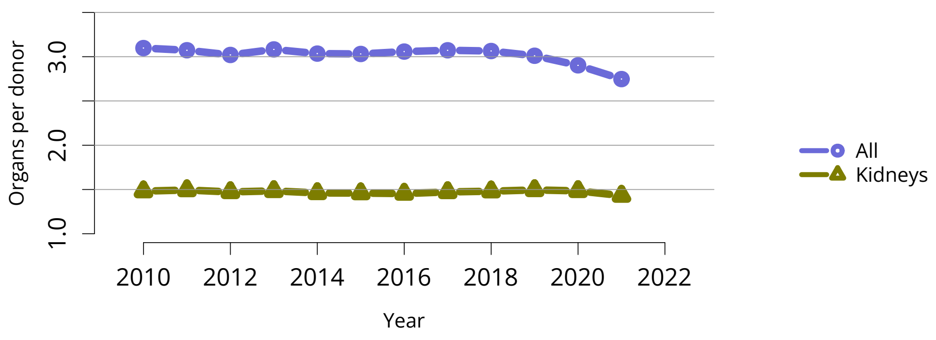

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Figure DD 9: Organs transplanted per donor, all organs and kidney. Average number of overall organs and kidneys transplanted per donor. As organs divided into segments (liver, lung, pancreas, intestine) may account for more than one transplant, the number or organs transplanted may exceed the number recovered. Based on a count of recovered organs that are transplanted, which differs from number of transplant operations. Pancreata recovered for islet transplant are excluded.

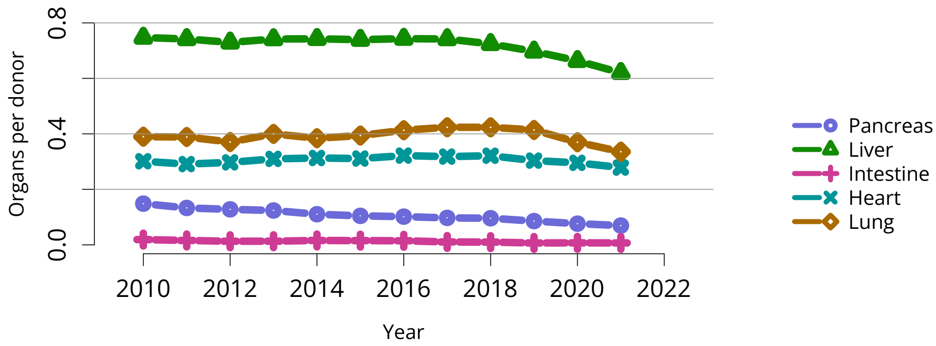

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Figure DD 10: Organs transplanted per donor, pancreas, liver, intestine, heart, and lung. Average number of organs other than kidneys transplanted per donor. As organs divided into segments (liver, lung, pancreas, intestine) may account for more than one transplant, the number or organs transplanted may exceed the number recovered. Based on a count of recovered organs that are transplanted, which differs from number of transplant operations. Pancreata recovered for islet transplant are excluded.

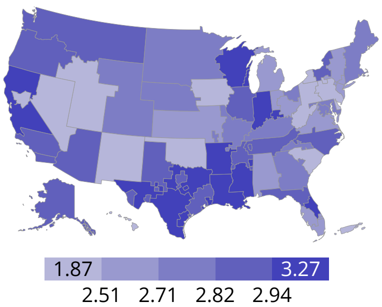

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Figure DD 11: Organs transplanted per donor, by DSA, 2021. Average number of organs transplanted per donor. As organs divided into segments (liver, lung, pancreas, intestine) may account for more than one transplant, the number or organs transplanted may exceed the number recovered. Based on a count of recovered organs that are transplanted, which differs from number of transplant operations. DSA-level means are shown. Pancreata recovered for islet transplant are excluded.

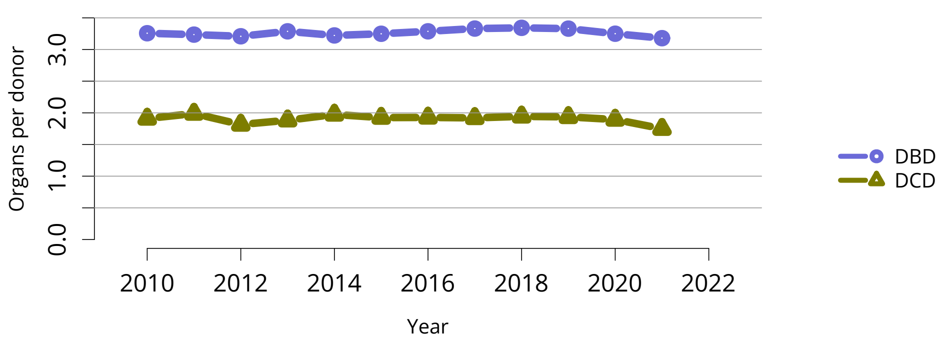

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Figure DD 12: Organs transplanted per donor, by DBD and DCD status. Average number of organs transplanted per donor. As organs divided into segments (liver, lung, pancreas, intestine) may account for more than one transplant, the number of organs transplanted may exceed the number recovered. Based on a count of recovered organs that are transplanted, which differs from number of transplant operations. Pancreata recovered for islet transplant are excluded. DBD, donation after brain death; DCD, donation after circulatory death.

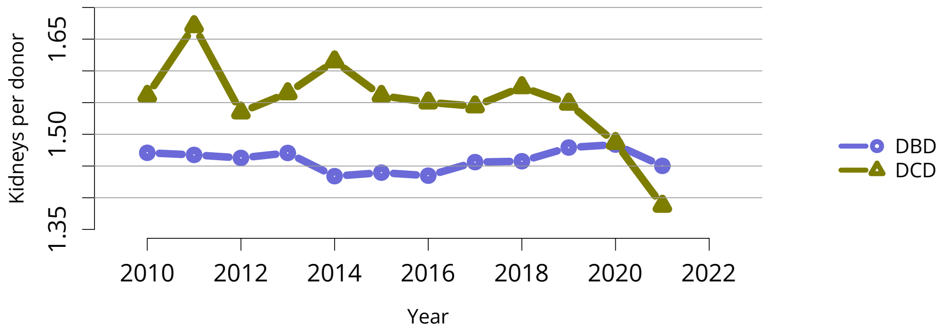

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Figure DD 13: Kidneys transplanted per donor, by DBD and DCD status. Average number of kidneys transplanted per donor. Based on a count of recovered kidneys that are transplanted, which differs from number of transplant operations. DBD, donation after brain death; DCD, donation after circulatory death.

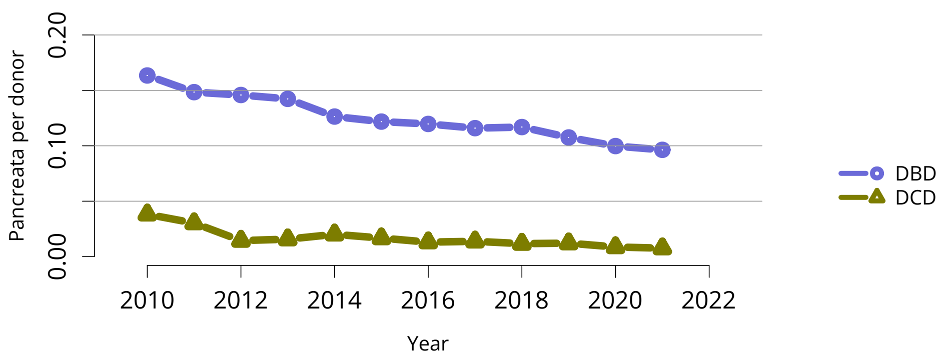

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Figure DD 14: Pancreata transplanted per donor, by DBD and DCD status. Average number of pancreata transplanted per donor. Pancreata divided into segments may account for more than one transplant, thus the number of pancreata transplanted may exceed the number recovered. Based on a count of recovered pancreata that are transplanted, which differs from number of transplant operations. Pancreata recovered for islet transplant are excluded. DBD, donation after brain death; DCD, donation after circulatory death.

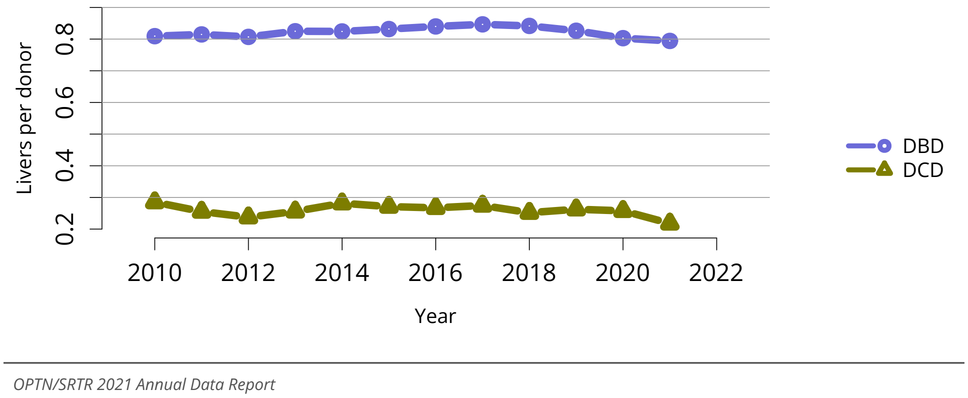

Figure DD 15: Livers transplanted per donor, by DBD and DCD status. Average number of livers transplanted per donor. Livers divided into segments may account for more than one transplant, thus the number of livers transplanted may exceed the number recovered. Based on a count of recovered livers that are transplanted, which differs from number of transplant operations. DBD, donation after brain death; DCD, donation after circulatory death.

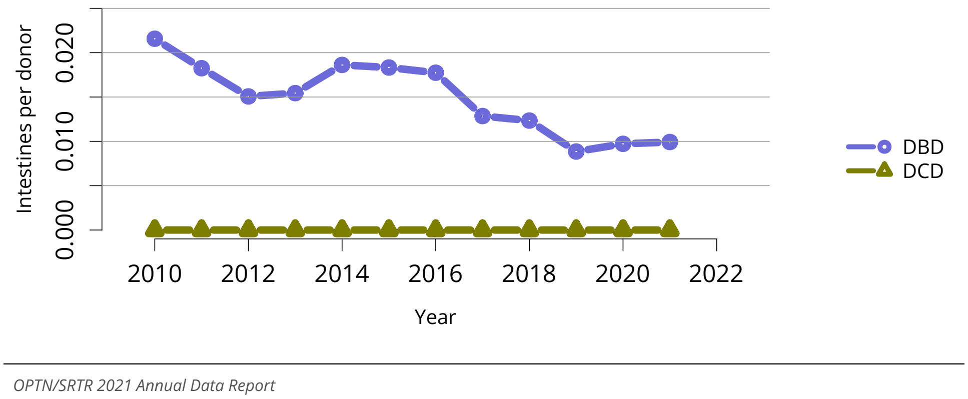

Figure DD 16: Intestines transplanted per donor, by DBD and DCD status. Average number of intestines transplanted per donor. Intestines divided into segments may account for more than one transplant, thus the number of intestines transplanted may exceed the number recovered. Based on a count of recovered intestines that are transplanted, which differs from number of transplant operations. DBD, donation after brain death; DCD, donation after circulatory death.

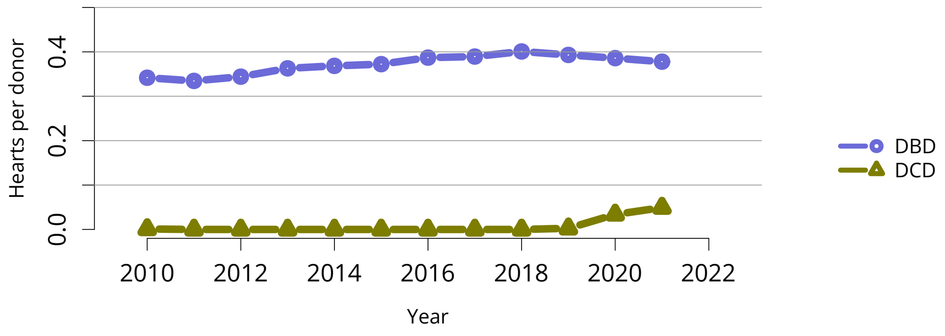

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Figure DD 17: Hearts transplanted per donor, by DBD and DCD status. Average number of hearts transplanted per donor. Based on a count of recovered hearts that are transplanted, which differs from number of transplant operations. DBD, donation after brain death; DCD, donation after circulatory death.

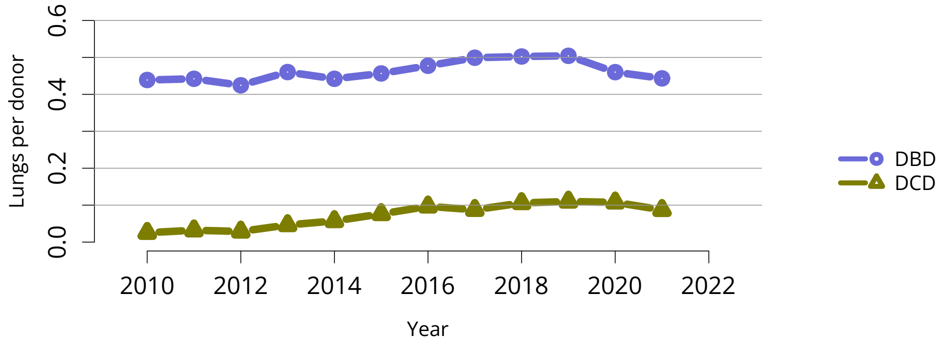

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Figure DD 18: Lungs transplanted per donor, by DBD and DCD status. Average number of lungs transplanted per donor. Lungs divided into segments may account for more than one transplant, thus the number of lungs transplanted may exceed the number recovered. Based on a count of recovered lungs that are transplanted, which differs from number of transplant operations. DBD, donation after brain death; DCD, donation after circulatory death.

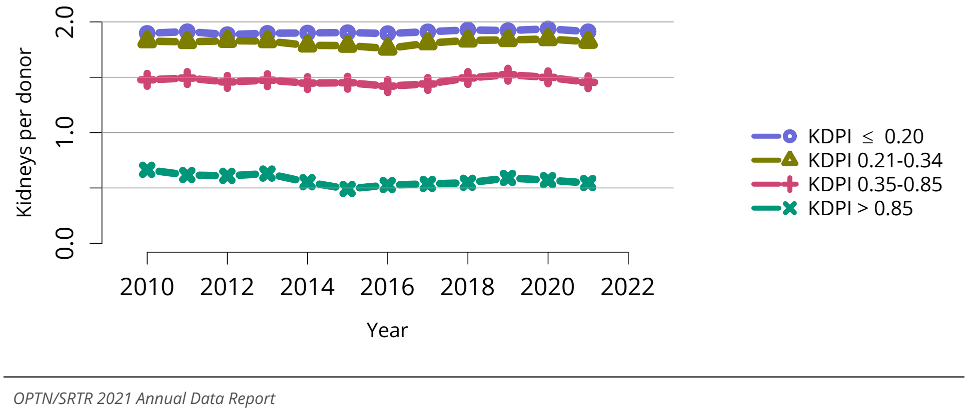

Figure DD 19: Kidneys transplanted per donor, by KDPI. Average number of kidneys transplanted per donor. Based on a count of recovered kidneys that are transplanted, which differs from number of transplant operations. KDPI, kidney donor profile index.

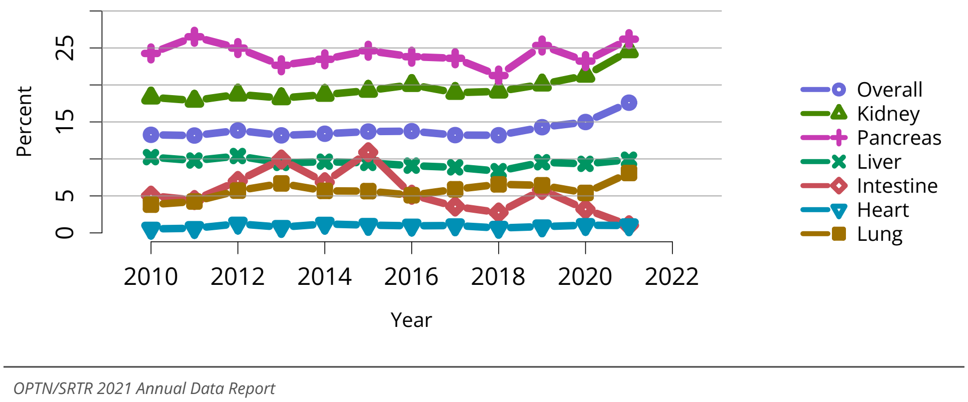

Figure DD 20: Organs recovered for transplant and not transplanted. Percents are calculated as the difference between the number of organs recovered and the number of organs transplanted, divided by the number of organs recovered. Pancreata recovered for islet transplant are excluded.

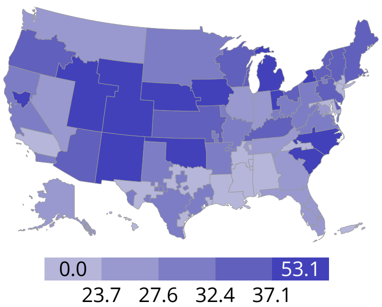

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Figure DD 21: The percentage of DCD donors across DSAs from all donors, 2021. Percentage of DCD donors within a DSA.

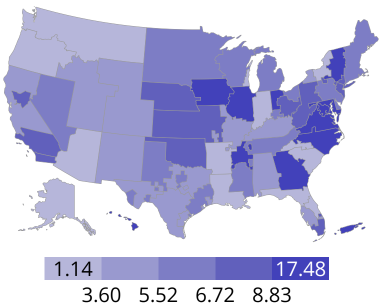

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Figure DD 22: The percentage of kidney donors with KDPI greater than 85% among deceased donor kidney transplant recipients across DSAs, 2021. Percentage of kidney donors within a DSA with a donor KDPI greater than 85%.

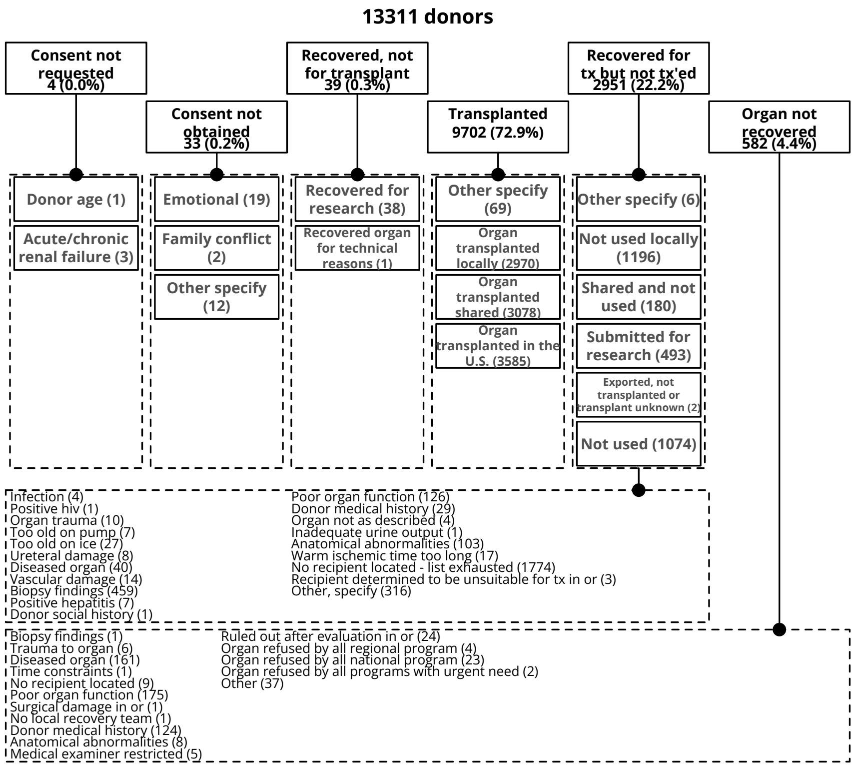

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Figure DD 23: Organ use chart for reported left kidneys, 2021. A summary of the consent, recovered, transplanted, or nonuse status for donated left kidneys. The number of left and right kidneys may not equal the total number of donors. "Local" transplant or nonuse occurred within the donation service area (DSA) of the donor organ, and "shared" occurred outside the DSA. Tx, transplant.

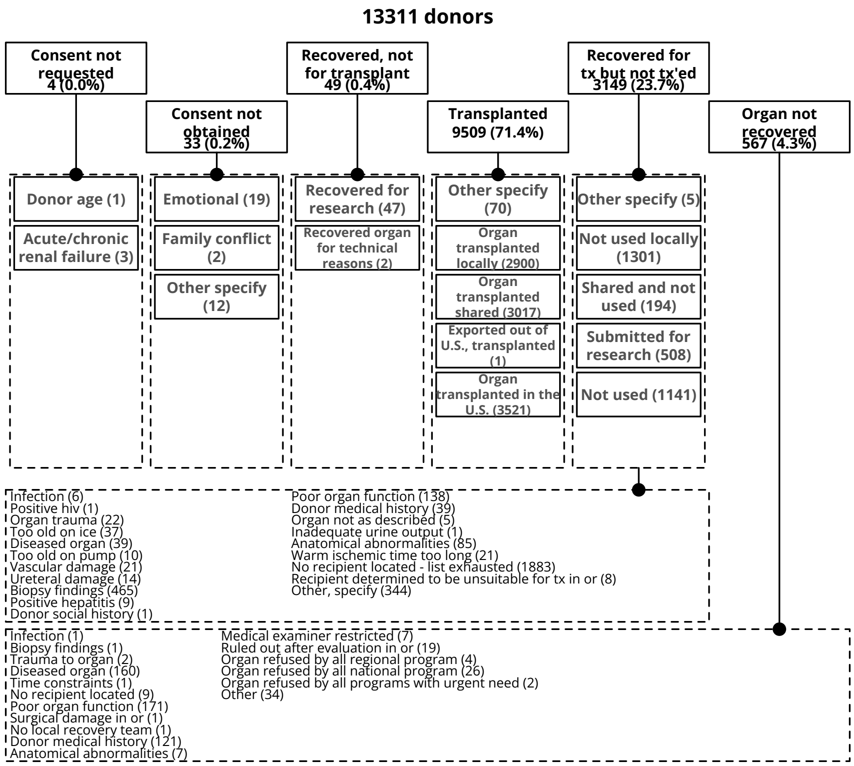

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Figure DD 24: Organ use chart for reported right kidneys, 2021. A summary of the consent, recovered, transplanted, or nonuse status for donated right kidneys. The number of left and right kidneys may not equal the total number of donors. "Local" transplant or nonuse occurred within the donation service area (DSA) of the donor organ, and "shared" occurred outside the DSA. Tx, transplant.

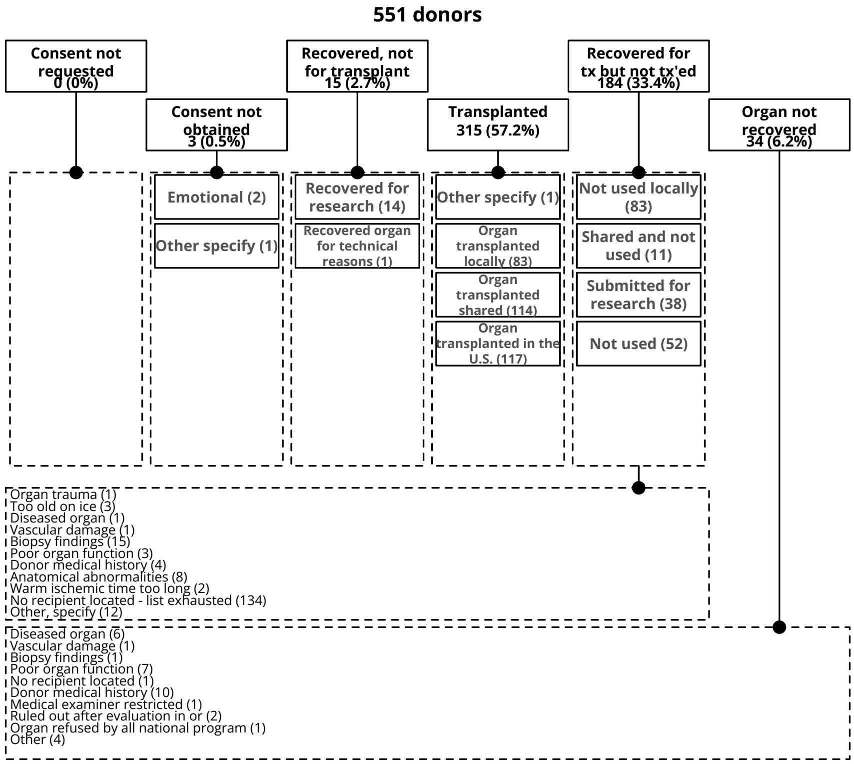

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Figure DD 25: Organ use chart for reported en bloc kidneys, 2021. A summary of the consent, recovered, transplanted, or nonuse status for donated en bloc kidneys. The number of en bloc kidneys may not equal the total number of donors. “Local” transplant or nonuse occurred within the donation service area (DSA) of the donor organ, and “shared” occurred outside the DSA. Tx, transplant.

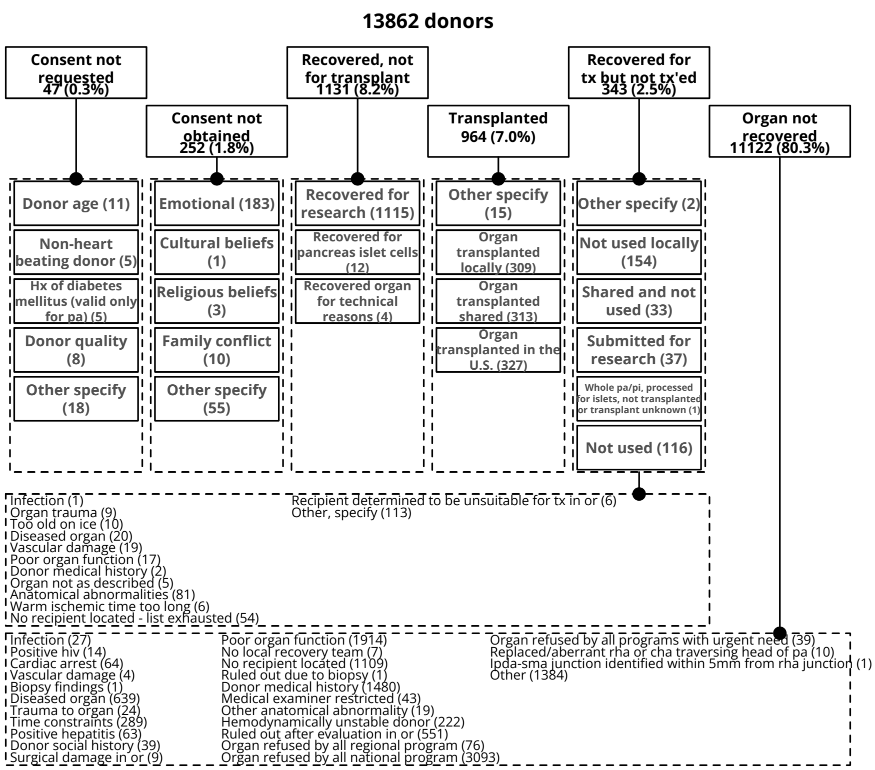

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Figure DD 26: Organ use chart for pancreas, 2021. A summary of the consent, recovered, transplanted, or nonuse status for donated pancreas. "Local" transplant or nonuse occurred within the donation service area (DSA) of the donor organ, and "shared" occurred outside the DSA. cha, common hepatic artery; hx, history; ipda-sma, inferior pancreaticoduodenal artery-superior mesenteric artery; pa, pancreas; rha, right hepatic artery; tx, transplant.

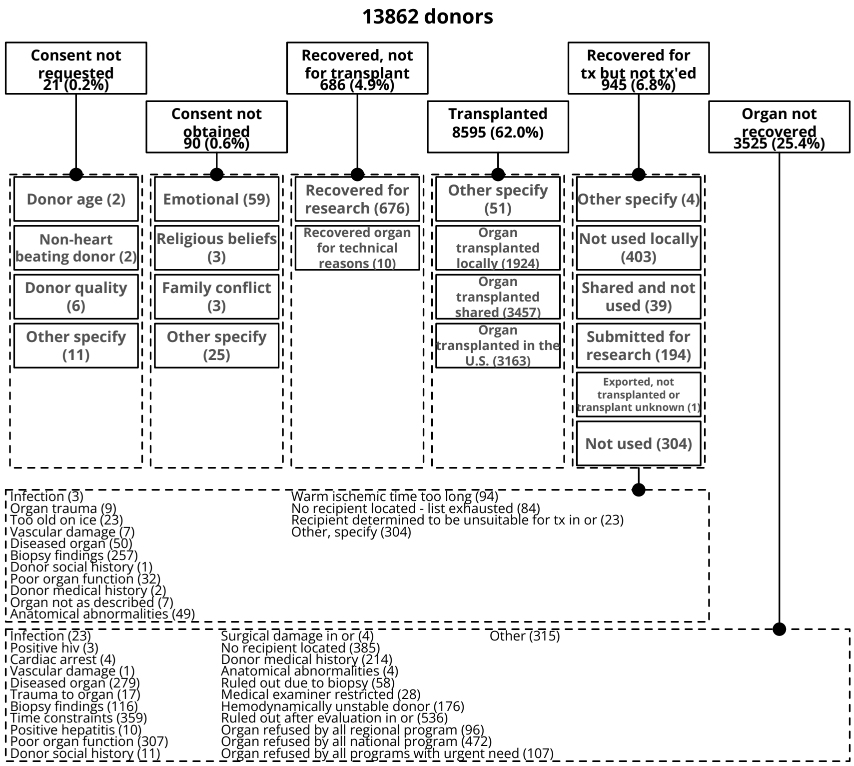

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Figure DD 27: Organ use chart for liver, 2021. A summary of the consent, recovered, transplanted, or nonuse status for donated livers. “Local” transplant or nonuse occurred within the donation service area (DSA) of the donor organ, and “shared” occurred outside the DSA. Tx, transplant.

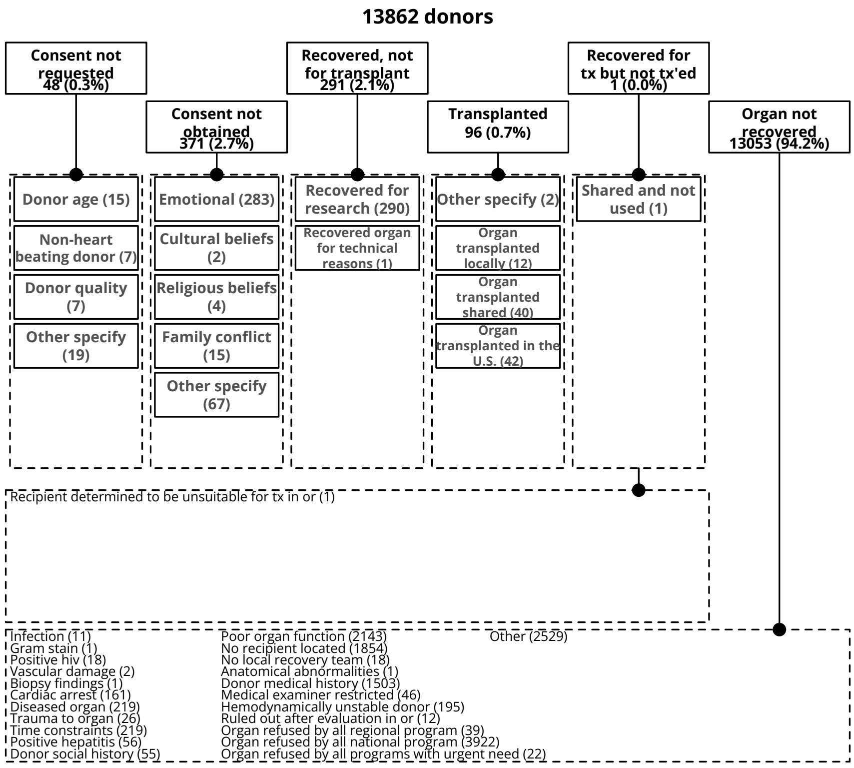

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Figure DD 28: Organ use chart for intestine, 2021. A summary of the consent, recovered, transplanted, or nonuse status for donated intestines. "Local" transplant or nonuse occurred within the donation service area (DSA) of the donor organ, and "shared" occurred outside the DSA. Tx, transplant.

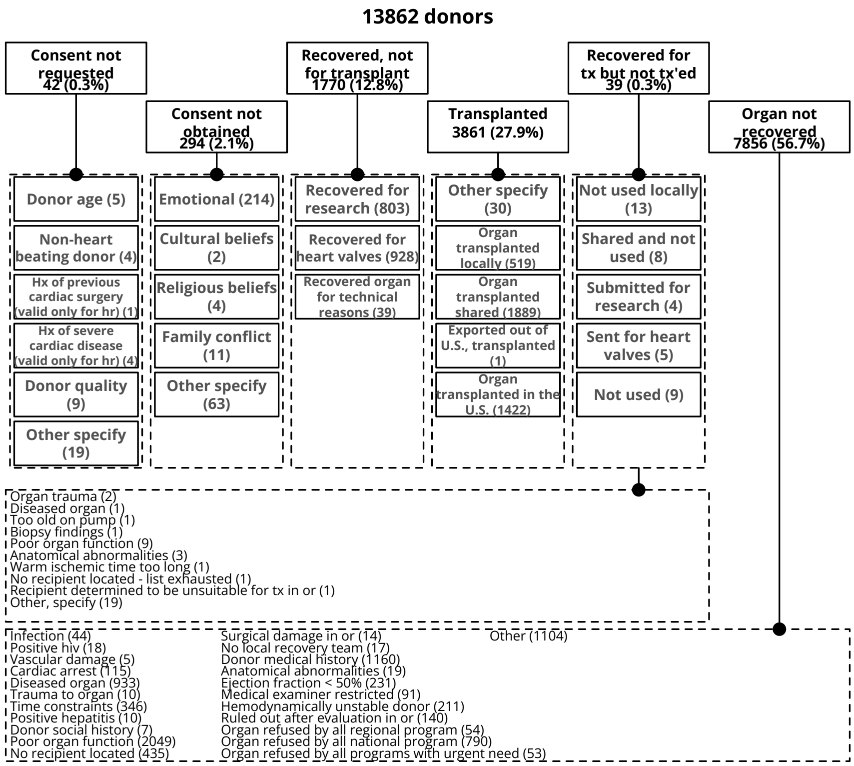

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Figure DD 29: Organ use chart for heart, 2021. A summary of the consent, recovered, transplanted, or nonuse status for donated hearts. “Local” transplant or nonuse occurred within the donation service area (DSA) of the donor organ, and “shared” occurred outside the DSA. Hx, history; tx, transplant.

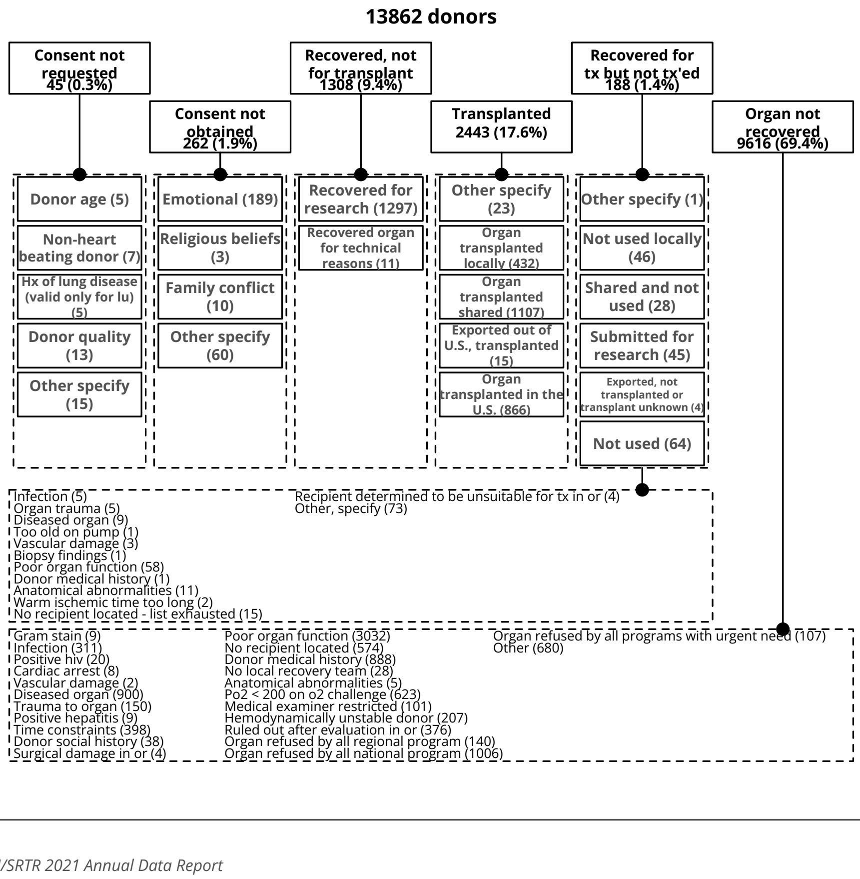

Figure DD 30: Organ use chart for lung, 2021. A summary of the consent, recovered, transplanted, or nonuse status for donated lungs. "Local" transplant or nonuse occurred within the donation service area (DSA) of the donor organ, and "shared" occurred outside the DSA. Hx, history; tx, transplant.

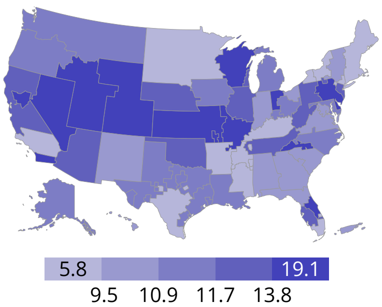

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Figure DD 31: CMS Defined Donor Rate across DSAs, 2020. Donation rate as defined by new Centers for Medicare & Medicaid Services criteria.

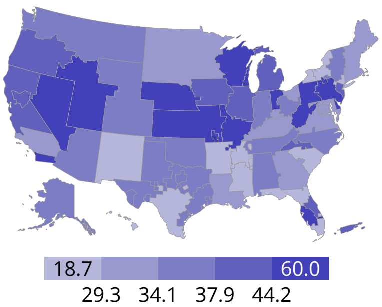

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Figure DD 32: CMS Defined Transplant Rate across DSAs, 2020. Transplant rate as defined by new Centers for Medicare & Medicaid Services criteria.

Table DD 1: Characteristics of deceased donors, 2011 and 2021. Note: The way citizenship data are collected changed in 2012, so differences may be misleading.

	2011		2021	
Characteristic	**N**	**Percent**	**N**	**Percent**
KDPI				
<20%	1908	23.5	2614	18.9
21-34%	1042	12.8	1840	13.3
35-85%	3884	47.8	6996	50.5
>85%	1292	15.9	2412	17.4
HIV				
Not Positive	0	100	13832	0
Positive	0	0	30	0
HCV				
Not Positive	7806	96.1	13057	94.2
Positive	320	3.9	805	5.8
Citizenship				
US	7930	97.6	12474	90
Non-US	15	0.2	353	2.5
Other/unkown	181	2.2	1035	7.5
COD				
Anoxia	2278	28	6551	47.3
Stroke	2932	36.1	3459	25
Head Trauma	2685	33	3336	24.1
CNS Tumor	41	0.5	42	0.3
Other/unkown	190	2.3	474	3.4
Sex				
Female	3362	41.4	5202	37.5
Male	4764	58.6	8660	62.5
Age				
<18 years	881	10.8	922	6.7
18-34 years	2241	27.6	3572	25.8
35-49 years	2167	26.7	4114	29.7
50-64 years	2242	27.6	4271	30.8
>=65 years	595	7.3	983	7.1
Ethnicity				
Non-Latino/unkown	6954	85.6	11778	85
Latino	1172	14.4	2084	15
Race				
White	6475	79.7	11203	80.8
Black	1384	17	2114	15.3
Asian	191	2.4	340	2.5
Other/unkown	76	0.9	205	1.5
DCD status				
DBD	7069	87	9673	69.8
DCD	1057	13	4189	30.2

Table DD 2: CMS Eligible Donor Funnel. Patient deaths determined from CDC county- level mortality datafiles used to determine eligible donors. Organ procurement organization abbreviation expansions can be found online here: https://www.srtr.org/reports/opo-specific-reports/

OPO	CDC Total Deaths	Total Referrals	CDC Inpatient Deaths LE 75	CMS Potential Donors	CMS Donors	CMS Donation Rate	CMS Transplant Rate
OPO							
ALOB	63387	26039	11963	1798	184	10.23	35.42
AROR	32830	12418	5806	1032	63	6.11	24.12
AZOB	77090	27109	12449	2269	290	12.78	36.77
CADN	107121	38466	17869	3147	378	12	38.29
CAGS	28747	10175	4259	894	133	14.93	42.01
CAOP	165310	65724	32474	5543	476	8.59	33.24
CASD	27272	12116	4570	813	127	15.62	49.37
CORS	52461	14139	7407	1401	201	14.35	37.13
DCTC	39524	16090	7572	1206	120	9.95	33.92
FLFH	46318	16662	6605	1478	205	13.87	43.93
FLMP	70764	28776	11508	2274	184	8.09	26.44
FLUF	51388	20527	8898	1954	187	9.57	26.25
FLWC	74635	26449	10743	2260	286	12.65	46.75
GALL	104248	43355	19741	2959	322	10.87	33.06
HIOP	12070	4240	1697	385	40	10.39	18.7
IAOP	35387	11374	4681	839	94	11.19	39.48
ILIP	122666	50207	21540	3508	438	12.51	39.69
INOP	68437	27093	11288	2210	238	10.77	34.84
KYDA	57933	24348	11184	1927	171	8.87	31.76
LAOP	56828	21876	10707	1794	202	11.26	33.03
MAOB	150646	47579	21512	3332	324	9.45	31.26
MDPC	43497	13924	6109	1121	131	11.69	32.43
MIOP	113780	47178	18572	3048	338	11.09	39.7
MNOP	72248	22367	9983	1870	173	9.26	30.5
MOMA	60308	23068	10108	1670	263	15.74	53.26
MSOP	32102	13841	6541	1109	97	8.75	27.47
MWOB	62718	21962	9197	1608	305	18.97	54.31
NCCM	29547	11303	4905	882	140	15.87	43.34
NCNC	81678	30202	13361	2533	284	11.21	34.28
NEOR	19577	7022	2991	529	70	13.06	49.24
NJTO	77027	30791	14817	1740	205	11.84	38.81
NMOP	23095	7335	4036	603	64	10.61	26.36
NVLV	23451	8910	4685	925	177	19.14	57.09
NYAP	28828	9599	3723	664	72	10.83	36.49
NYFL	25754	9722	3736	650	54	8.29	26.52
NYRT	133103	55023	30175	3363	254	7.55	26.22
NYWN	18031	6686	2718	448	33	7.37	23.78
OHLB	56059	18890	8281	1551	154	9.93	33.6
OHLC	28613	9238	3868	737	109	14.73	44.22
OHLP	39935	14271	6936	1309	154	11.63	35.17
OHOV	24685	7774	3645	686	76	11.08	32.8
OKOP	46426	18786	8371	1569	187	11.92	36.77
ORUO	53443	13261	6873	1434	165	11.51	39.87
PADV	131591	44898	19727	3407	559	16.35	46.66
PATF	74090	25097	10937	2192	289	13.3	45.62
PRLL	33022	16983	6686	949	103	10.85	38.4
SCOP	58217	20626	10494	1767	188	10.64	28.95
TNDS	77544	33178	14046	2957	356	12.05	37.89
TNMS	24284	11488	5269	911	53	5.82	20.16
TXGC	93643	41402	20522	3570	416	11.65	37.14
TXSA	63059	25319	13816	2218	178	8.03	27
TXSB	97338	30918	19836	3346	383	11.44	37.88
UTOP	28900	7614	3807	787	140	17.79	45.16
VATB	60862	23790	10765	2106	207	9.82	30.65
WALC	77592	28469	12593	2510	286	11.39	35.25
WIDN	26466	8798	3940	798	107	13.38	44.96
WIUW	37715	11321	4833	978	170	17.38	60

OPTN/SRTR 2021 Annual Data Report: COVID-19

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Abstract

This chapter updates the COVID-19 chapter from the 2020 Annual Data Report with trends through February 12, 2022, and introduces trends in COVID-19–specific cause of death on the waiting list and posttransplant. Transplant rates remain at or above prepandemic levels for all organs, indicating a sustained transplantation system recovery following the initial 3-month disruption due to the onset of the pandemic. Posttransplant mortality and graft failure remain a concern in all organs, with rates surging corresponding to waves of the pandemic. Waitlist mortality due to COVID-19 is also a concern, particularly among kidney candidates. While the recovery of the transplantation system has been sustained in the second year of the pandemic, ongoing efforts should focus on reducing posttransplant and waitlist mortality due to COVID-19, and graft failure.

Keywords: COVID-19, solid organ transplant, transplant outcomes, waitlist mortality

1 INTRODUCTION

The COVID-19 pandemic has now continued for more than 2 years. While the most dramatic disruptions to transplant activity happened in the first months of the pandemic,[1,2,3,4] the effects of COVID-19 on the US transplantation system are ongoing. This chapter updates the COVID-19 chapter from the Organ Procurement and Transplantation Network (OPTN)/Scientific Registry of Transplant Recipients (SRTR) 2020 Annual Data Report[5] with trends through February 12, 2022 (the most recent available complete data) and includes figures on COVID-19–specific pretransplant and posttransplant mortality that were not available in that previous Annual Data Report. SRTR continues to maintain an online app that is now updated quarterly and tracks these metrics, as well as more detailed subgroup and adjusted analyses, at www.srtr.org/tools/covid-19-evaluation.

The previous (2020) Annual Data Report presented monthly trends before and after the March 13, 2020, declaration of a national emergency through March 12, 2021. Since that previous report, vaccines and vaccine boosters have become widely available for all age groups except children younger than 5 years. In the fall and winter of 2021 to 2022, variants of COVID-19 that demonstrated more immune evasiveness to the early iterations of the vaccines arose: the Delta variant corresponding to months 17 and 18 after the national emergency declaration (August 13, 2021, through October 12, 2021) and the Omicron variant corresponding to months 21 and 22 after the national emergency declaration (December 13, 2021, through February 12, 2022). These led to two COVID-19 waves in the fall and winter of 2021 to 2022, which are detailed in this chapter. In many cases we note where increases in mortality correspond to waves of COVID-19 that were linked to the Delta variant or the Omicron variant. It is not possible to fully attribute mortality to these variants, and, for example, some mortality that occurred during the wave dominated by the Omicron variant may have been attributable to the Delta variant due to the lag between infection and mortality; there may have also been geographic variability in the timing of waves of the different variants.

2 KIDNEY

The number of prevalent kidney listings, which fell by almost 5,000 in the first year of the pandemic, remained low. There were 104,648 adult kidney transplant listings in the month before the onset of the pandemic (February 13, 2020, through March 12, 2020), and there were 99,414 adult kidney transplant listings in the most recent month for which data are available (January 13, 2022, through February 12, 2022) (Figure COV 1).

The numbers of new adult kidney candidates added to the waiting list each month in the second year of the pandemic were similar to numbers added each month before the pandemic (Figure COV 2).

Living donor transplant rates in the second year of the pandemic were similar to monthly rates before the pandemic (Figure COV 4), and deceased donor transplant rates in the second year of the pandemic were slightly higher than those before the pandemic (Figure COV 3). The number of kidney offers made increased substantially (Figure COV 5) and the unadjusted offer acceptance rate decreased substantially (Figure COV 6) in the second year of the pandemic. However, these changes also correspond with the implementation of the 250–nautical-mile circle kidney allocation policy on March 15, 2021, which replaced organ procurement organization (OPO) donation service area (DSA) with a 250–nautical-mile circle around the donor hospital as the unit for local allocation.

Adult waitlist mortality rates showed spikes that correlated to the Delta variant wave and Omicron variant wave (Figure COV 7). Corresponding to the overall spikes in waitlist mortality are spikes in mortality with COVID-19 listed as the cause of death (Figure COV 8). The spikes during the Delta and Omicron variant waves in COVID-19–specific cause of death are notably smaller than the spike during the winter 2020-2021 wave. Concerningly, there was a substantial increase in overall waitlist mortality rates for pediatric candidates during the Delta variant wave, rising to 4.6 deaths per 100 person-years in the month from September 13, 2021, through October 12, 2021, although there did not seem to be a similar spike during the Omicron variant wave (Figure COV 7).

Adult all-cause kidney graft failure rates rose during the Delta variant wave and showed their biggest spike in the past 3 years during the Omicron variant wave, rising to 12.1 graft failures per 100 person-years from January 13, 2022, through February 12, 2022 (Figure COV 9). Corresponding to these graft failure spikes were spikes in posttransplant mortality with COVID-19 cause of death (Figure COV 10).

Geographically, differences in the adjusted rates of kidney waitlist mortality from before to after the start of the COVID-19 pandemic differed slightly by OPO DSA, with some increasing and some decreasing. Hazard ratios for waitlist mortality, the difference in the OPO's hazard ratio compared with the nation as a whole in the 12 months after the start of the COVID-19 pandemic as compared with the 12 months before, ranged from 0.86 to 1.11 (Figure COV 11). Similarly, differences in adjusted rates of adult kidney transplant from before to after the start of the COVID-19 pandemic by OPO DSA ranged from 0.60 to 2.02 (Figure COV 12). Differences in adjusted rates of kidney graft failure from before to after the start of the COVID-19 pandemic by OPO DSA ranged from 0.88 to 1.20 (Figure COV 13).

3 PANCREAS

The number of prevalent pancreas candidates has continued a gradual increase that started before the pandemic (Figure COV 14). The number of new pancreas candidates added each month remains similar to levels before the start of the pandemic (Figure COV 15), as does the pancreas waitlist mortality rate (Figure COV 17) and there have been very few recorded COVID-19–specific cause of death among pancreas waitlist candidates. The pancreas deceased donor transplant rate remains slightly lower than before the pandemic, although not as low as in the first months after the national emergency declaration (Figure COV 16). The only recorded COVID-19–specific cause of death among pancreas waitlist candidates occurred during month 22 after the national emergency declaration, but the rate was small (0.7 deaths per 100 person-years).

Pancreas all-cause graft failure shows slight peaks that correspond to waves of the pandemic, and reached a level of 8.9 graft failures per 100 person-years from January 13, 2022, through February 12, 2022, compared with a highest monthly level of 6.6 graft failures per 100 person-years in the year before the start of the pandemic (Figure COV 18). There are peaks in COVID-19–specific deaths among pancreas transplant recipients during waves of the pandemic, with the highest level observed during the Omicron variant wave from January 13, 2022, through February 12, 2022, at 2.9 deaths per 100 person-years (Figure COV 19).

Geographically, differences in the adjusted rates of pancreas waitlist mortality from before to after the start of the COVID-19 pandemic by OPO DSA ranged from 0.68 to 1.36 (Figure COV 20). Differences in adjusted rates of adult pancreas transplant from before to after the start of the COVID-19 pandemic by OPO DSA ranged from 0.77 to 1.45 (Figure COV 21). Differences in adjusted rates of pancreas graft failure from before to after the start of the COVID-19 pandemic by OPO DSA ranged from 0.93 to 1.05 (Figure COV 22).

4 LIVER

The ongoing downward trend in prevalent adult liver listings continued from March 2021 to February 2022 (Figure COV 23), and the monthly number of new listings remained similar to levels before the start of the pandemic (Figure COV 24). Deceased donor transplant rates (Figure COV 25) and living donor transplant rates (Figure COV 26) also remained similar to levels before the start of the pandemic. Numbers of liver offers continued their increase relative to levels before the pandemic (Figure COV 27), and unadjusted offer acceptance rates remained lower than levels before the pandemic (Figure COV 28); these trends are likely due to the implementation of the liver acuity circle allocation policy in

February 2020.

Liver waitlist mortality was higher during waves of the pandemic, although these peaks were no higher than levels seen in some months before the pandemic (Figure COV 29). COVID-19–specific cause of death was higher among liver candidates during waves of the pandemic, although the rates during the Delta and Omicron variant waves were lower than the rate during the winter 2020-2021 wave (Figure COV 30).

Liver all-cause graft failure was notably higher during waves of the pandemic and rose to 7.0 graft failures per 100 person-years from January 13, 2022, through February 12, 2022, during the Omicron variant wave, as compared with a highest monthly rate of 5.3 failures per 100 person-years in the year before the start of the pandemic (Figure COV 31). There were also notable increases in COVID-19–specific cause of death among liver recipients during waves of the pandemic (Figure COV 32).

Geographically, differences in the adjusted rates of liver waitlist mortality from before to after the start of the COVID-19 pandemic by OPO DSA ranged from 0.92 to 1.06 (Figure COV 33). Differences in adjusted rates of adult liver transplant from before to after the start of the COVID-19 pandemic by OPO DSA ranged from 0.49 to 1.84 (Figure COV 34). Differences in adjusted rates of liver graft failure before to after the start of the COVID-19 pandemic by OPO DSA ranged from 0.98 to 1.03 (Figure COV 35).

5 INTESTINE

Small numbers of patients receiving or waiting for an intestine transplant led to high month-to-month variability in metrics, making it difficult to detect any trends related to the pandemic (Figures COV 36, 37, 38, 39, 40, 41, and 42). The decrease in the number of prevalent pediatric candidates and increase in the number of prevalent adult candidates during the pandemic noted in the previous (2020) Annual Data Report continued from March 2021 to February 2022 (Figure COV 36).

6 HEART

The number of prevalent heart listings remained slightly lower than before the pandemic (Figure COV 43), although the number of new monthly heart listings was slightly higher than before the pandemic (Figure COV 44). As with other organs, heart allocation policy was changed recently, with the January 2020 removal of DSA from heart allocation, making it difficult to attribute any changes in listings solely to COVID-19. The heart transplant rate remained slightly higher after the start of the pandemic compared with before (Figure COV 45). There was no discernable trend in heart offer numbers (Figure COV 46) or unadjusted offer acceptance rates (Figure COV 47) before to after the start of the pandemic. While there were deaths due to COVID-19 among heart waitlist candidates (Figure COV 49), rates of overall heart waitlist mortality were not substantially higher after the start of the pandemic (Figure COV 48).

All-cause heart graft failure increased during the waves of the pandemic, and reached a rate of 9.6 graft failures per 100 person-years from January 13, 2022, through February 12, 2022, as compared with a highest monthly rate of 5.7 graft failures per 100 person-years in the year before the start of the pandemic (Figure COV 50). COVID-19–specific cause of death increased among heart transplant recipients during waves of the pandemic, with a highest monthly level of 2.5 deaths per 100 patient-years from January 13, 2022, through February 12, 2022, during the Omicron variant wave (Figure COV 51).

Geographically, differences in the adjusted rates of heart waitlist mortality from before to after the start of the COVID-19 pandemic by OPO DSA ranged from 0.93 to 1.07 (Figure COV 52). Differences in adjusted rates of adult heart transplant from before to after the start of the COVID-19 pandemic by OPO DSA ranged from 0.68 to 1.53 (Figure COV 53). Differences in adjusted rates of heart graft failure from before to after the start of the COVID-19 pandemic by OPO DSA ranged from 0.99 to 1.02 (Figure COV 54).

7 LUNG

The number of prevalent lung listings (Figure COV 55) and the number of monthly new lung listings (Figure COV 56) remained lower after the start of the pandemic as compared with before, while the lung transplant rate remained higher (Figure COV 57). Lung transplant has emerged as a treatment for severe COVID-19, so higher transplant rates are not surprising, although lower numbers of new and prevalent listings are somewhat unexpected. Offer numbers remained lower after the start of the pandemic (Figure COV 58), but there was no noticeable trend in unadjusted offer acceptance rates (Figure COV 59). Rates of overall lung waitlist mortality were not substantially higher after the start of the pandemic (Figure COV 60), although there were deaths due to COVID-19 among lung waitlist candidates (Figure COV 61).

All-cause lung graft failure increased during the waves of the pandemic and reached a rate of 20.5 graft failures per 100 person-years from January 13, 2022, through February 12, 2022, as compared with a highest monthly rate of 12.7 graft failures per 100 person-years in the year before the start of the pandemic (Figure COV 62). COVID-19–specific cause of death increased among lung transplant recipients during waves of the pandemic, with a highest monthly level of 6.5 deaths per 100 patient-years from January

13, 2022, through February 12, 2022, during the Omicron variant wave (Figure COV 63).

Geographically, differences in the adjusted rates of lung waitlist mortality from before to after the start of the COVID-19 pandemic by OPO DSA ranged from 0.87 to 1.13 (Figure COV 64). Differences in adjusted rates of adult lung transplant from before to after the start of the COVID-19 pandemic by OPO DSA ranged from 0.49 to 2.25 (Figure COV 65). Differences in adjusted rates of lung graft failure from before to after the start of the COVID-19 pandemic by OPO DSA ranged from 0.92 to 1.05 (Figure COV 66).

8 DISCUSSION

The previous (2020) Annual Data Report noted a decrease in transplants in the early months of the pandemic, followed by a return to prepandemic levels.[5] The return to, or even slight increase from, prepandemic transplant rates continued in the second year of the pandemic, indicating that the transplantation system has generally stayed at prepandemic functioning after the initial 3-month disruption.

Transplant recipient outcomes, however, remain a point of concern. While notable increases in waitlist mortality were only observed among kidney candidates, there were dramatic increases in posttransplant graft failure and COVID-19–specific mortality among recipients of all solid organs. For most organs, the increase in mortality and all-cause graft failure was highest during the Omicron variant wave of the pandemic. While there is evidence in the general population that Omicron is less virulent than the original COVID-19 strain,[6,7] this chapter shows that mortality remains high among transplant recipients.

Kidney candidates, many of whom have to undergo in-center dialysis where there may be risk for viral spread, and who have longer waiting times before transplant, showed higher levels of mortality during waves of the pandemic. Increases in pretransplant mortality were generally among adult kidney candidates, although there was a concerning rise in pediatric kidney candidate mortality during the Delta variant wave. Because the kidney allocation policies give priority based on waiting time, additional candidate information is available from the OPTN to assess waitlist mortality due to COVID-19. It is possible that potential candidates of other organs also had increased mortality, but they may have never been listed as a result of their COVID-19 infection. Thus, mortality for non-kidney patients in end-organ failure may not have been captured as well as it was for kidney candidates.

While transplant activity seems to have resumed as normal, transplant professionals need to seek continued improvements in protecting transplant recipients and kidney transplant candidates against COVID-19 infection.

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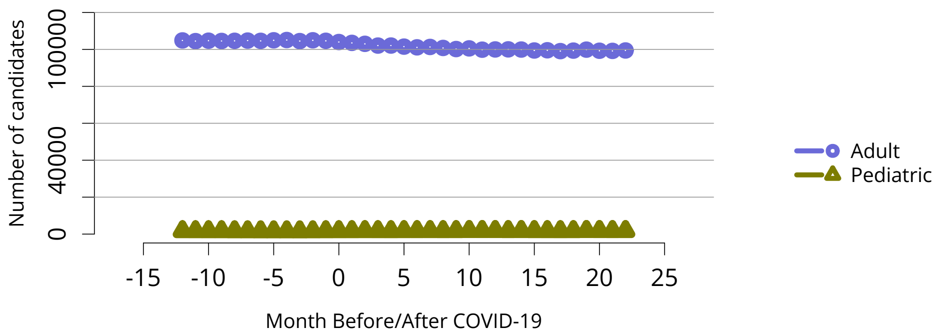

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Figure COV 1: Number of prevalent kidney candidates. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time during the month.

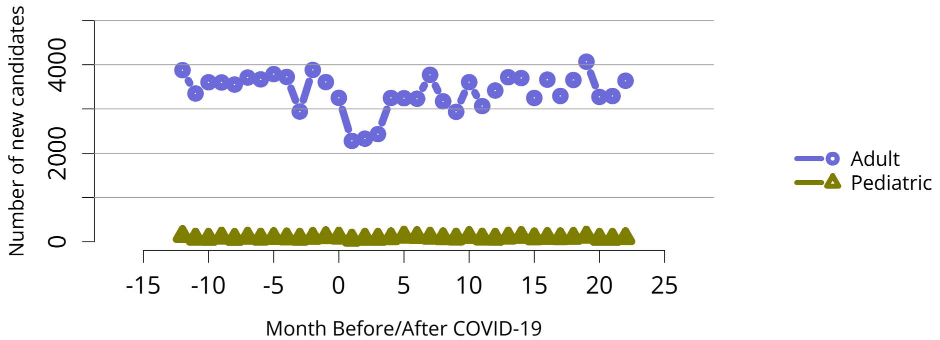

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Figure COV 2: Number of new kidney candidates. Month 0 begins March 13, 2020, the date of declaration of the national emergency. A new candidate is one who first joined the list during the given month, without having been listed in a previous month.

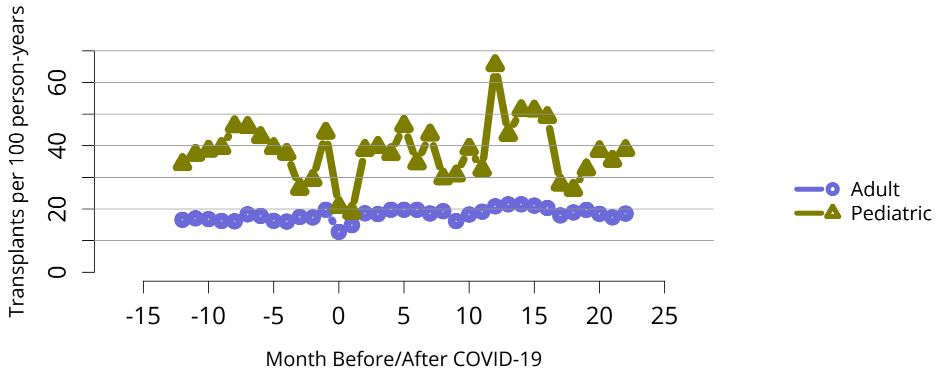

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Figure COV 3: Deceased donor kidney transplant rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given month. Individual listings are counted separately.

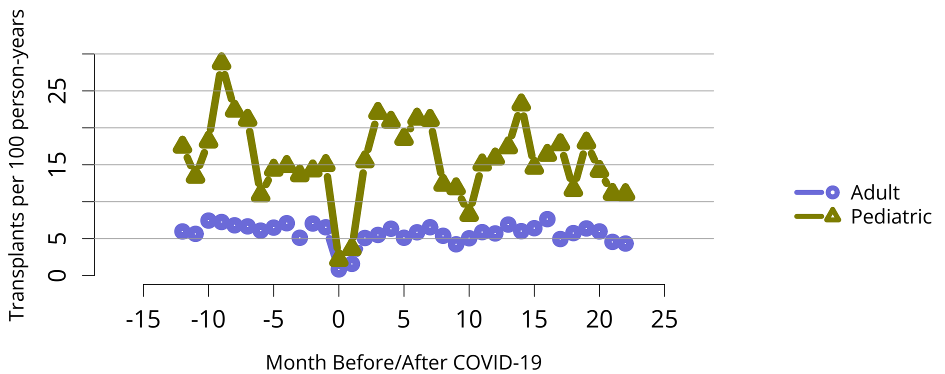

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Figure COV 4: Living donor kidney transplant rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Transplant rates are computed as the number of living donor transplants per 100 patient-years of waiting in a given month. Individual listings are counted separately.

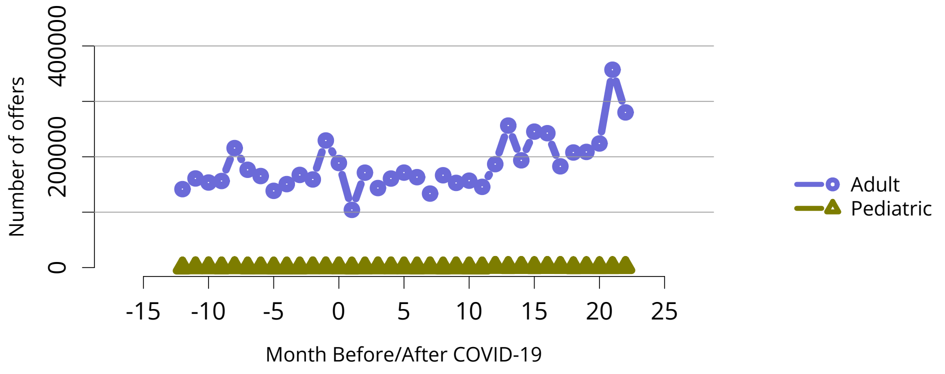

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Figure COV 5: Number of kidney offers. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

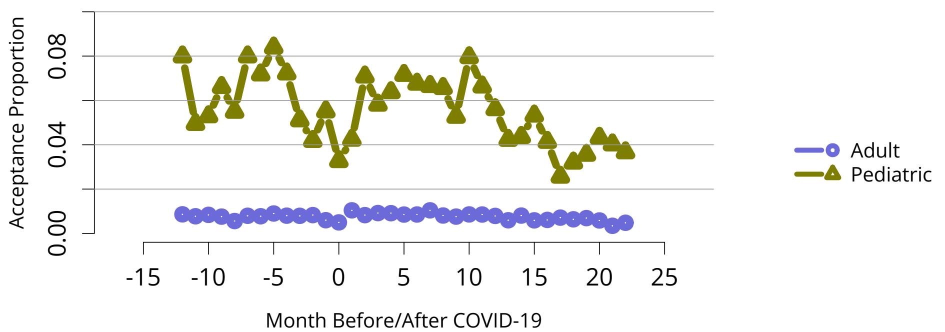

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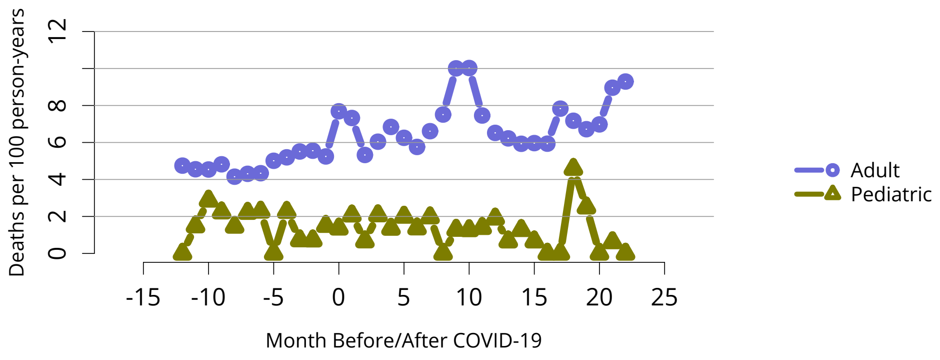
Figure COV 6: Kidney offer acceptance rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency.



OPTN/SRTR 2021 Annual Data Report

Figure COV 7: Kidney waitlist mortality rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

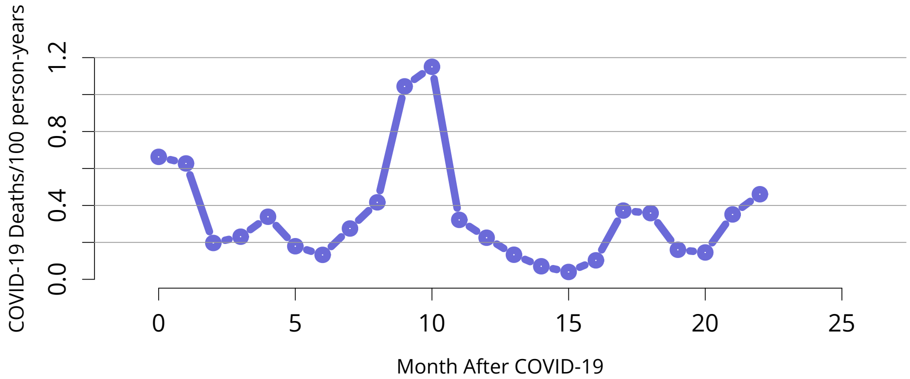


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Figure COV 8: Kidney waitlist COVID-19 mortality rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

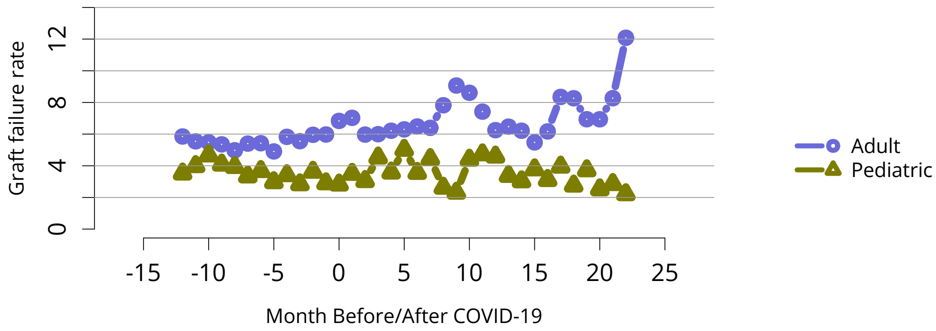

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Figure COV 9: Kidney all-cause graft failure. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

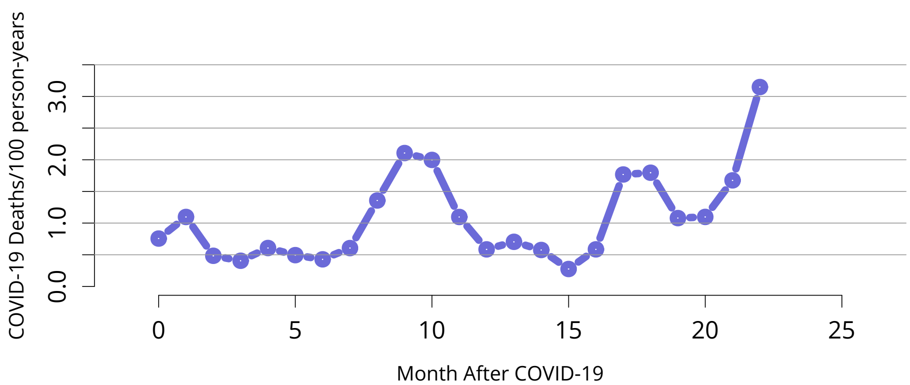

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Figure COV 10: Kidney post-transplant COVID-19 mortality rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

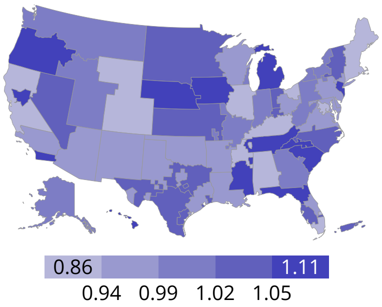

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Figure COV 11: Difference in risk adjusted kidney waitlist mortality hazard ratio before to after COVID-19 by OPO. Waitlist mortality hazard ratio is the difference in the organ procurement organization's (OPO's) hazard ratio compared to the nation as a whole in the 12 months after the onset of the COVID-19 pandemic as compared to the 12 months before the onset of the pandemic. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Model adjusted for blood type, age in years, body mass index, calculated panel reactive antibody, primary diagnosis, duration of dialysis, miles between candidate and program, ethnicity, sex, type of kidney transplant, candidate insurance type, race, previous transplant for candidates, candidate urbanicity, and waiting time (years).

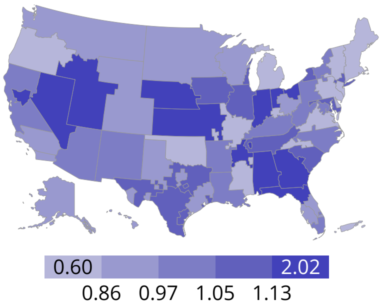

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Figure COV 12: Difference in risk adjusted kidney transplant rate before to after COVID-19 by OPO. Transplant rate ratio is the difference in the organ procurement organization's (OPO's) rate ratio compared to the nation as a whole in the 12 months after the onset of the COVID-19 pandemic as compared to the 12 months before the onset of the pandemic. Individual listings are counted separately. Model adjusted for blood type, age in years, body mass index, calculated panel reactive antibody, primary diagnosis, duration of dialysis, miles between candidate and program, ethnicity, sex, type of kidney transplant, candidate insurance type, race, previous transplant for candidates, candidate urbanicity, and waiting time (years).

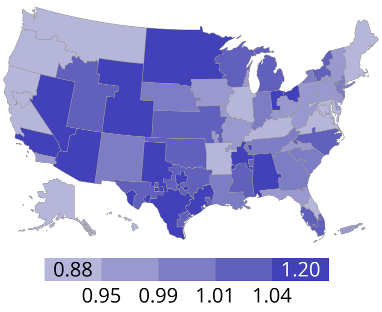

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Figure COV 13: Difference in risk adjusted kidney all-cause graft failure hazard ratio before to after COVID-19 by OPO. Graft failure hazard ratio is the difference in the organ procurement organization's (OPO's) hazard ratio compared to the nation as a whole in the 12 months after the onset of the COVID-19 pandemic as compared to the 12 months before the onset of the pandemic. Model adjusted for blood type, ethnicity, sex, candidate insurance type, race, donor age (years), donor ethnicity, donor hypertension status, donor race, donor sex, recipient age (years), body mass index, cold ischemia time (hours), primary diagnosis, diabetes status, years of dialysis, miles between recipient and program, donor diabetes status, donor serum creatinine, donor type, number of HLA mismatches, donor kidney donor profile index, multiorgan transplant, calculated panel reactive antibody, recipient had a previous transplant, recipient urbanicity, type of kidney transplant, and miles between donor and program.

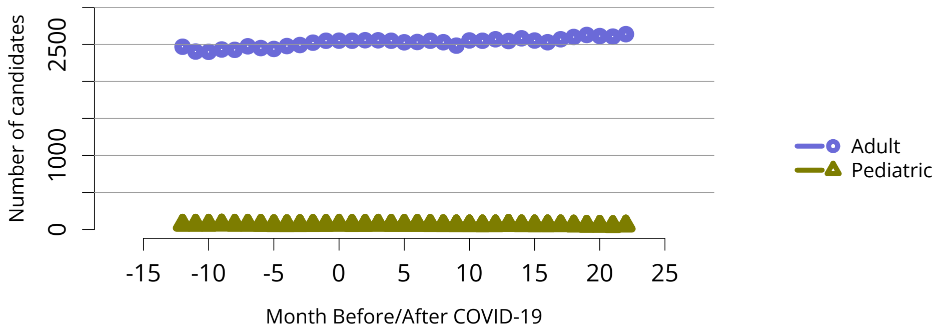

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Figure COV 14: Number of prevalent pancreas candidates. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time during the month.

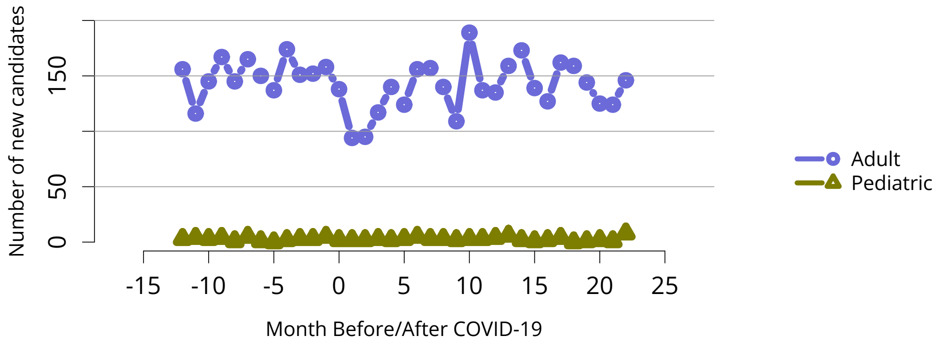

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Figure COV 15: Number of new pancreas candidates. Month 0 begins March 13, 2020, the date of declaration of the national emergency. A new candidate is one who first joined the list during the given month, without having been listed in a previous month.

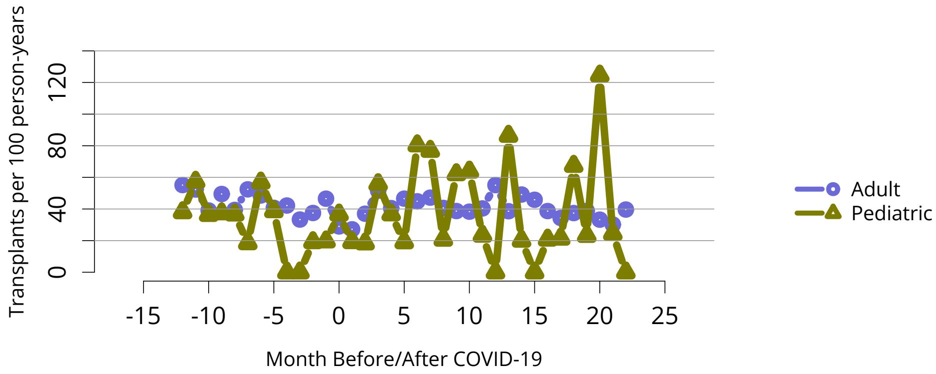

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Figure COV 16: Deceased donor pancreas transplant rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given month. Individual listings are counted separately.

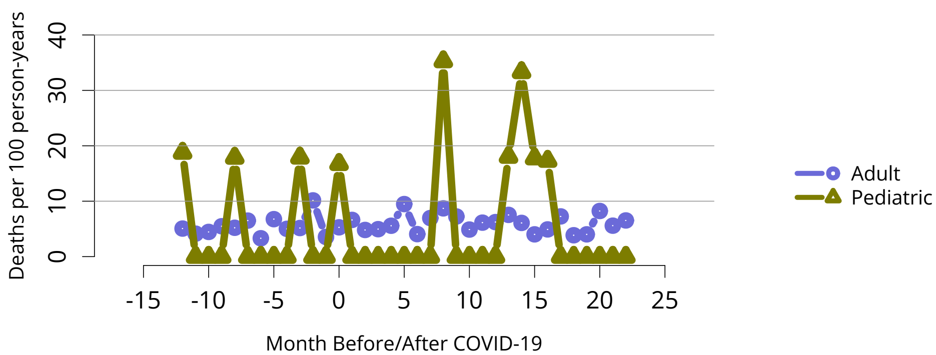

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Figure COV 17: Pancreas waitlist mortality rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

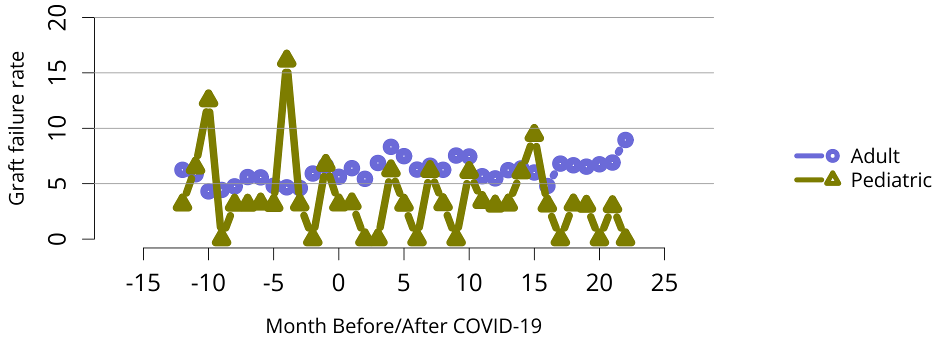

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Figure COV 18: Pancreas all-cause graft failure. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

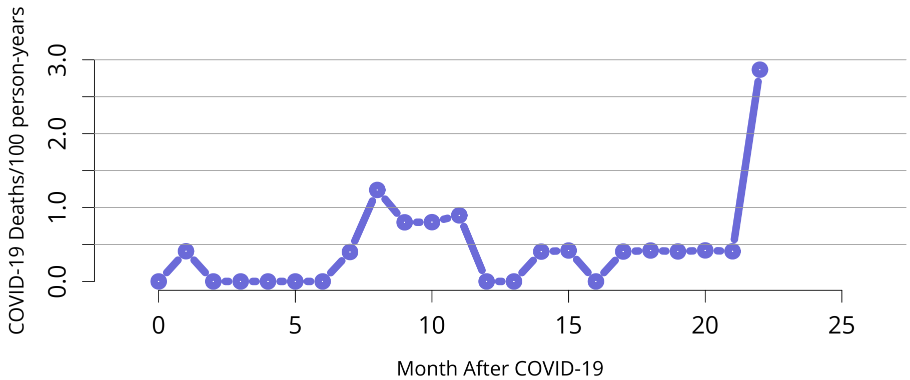

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Figure COV 19: Pancreas post-transplant COVID-19 mortality rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

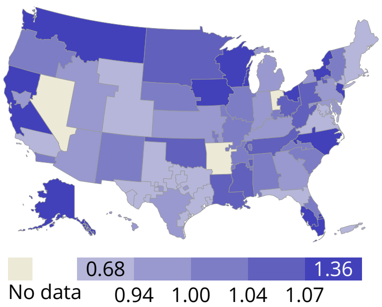

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Figure COV 20: Difference in risk adjusted pancreas waitlist mortality hazard ratio before to after COVID-19 by OPO. Waitlist mortality hazard ratio is the difference in the organ procurement organization (OPO's) hazard ratio compared to the nation as a whole in the 12 months after the onset of the COVID-19 pandemic as compared to the 12 months before the onset of the pandemic. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Model adjusted for blood type, age in years, body mass index, primary diagnosis, duration of dialysis, miles between candidate and program, ethnicity, sex, type of pancreas transplant, candidate insurance type, race, previous transplant for candidates, candidate urbanicity, and waiting time.

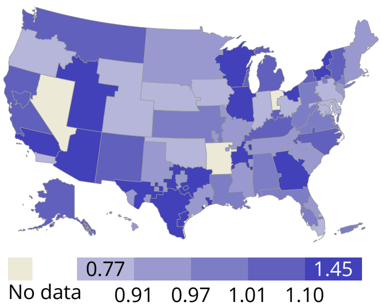

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Figure COV 21: Difference in risk adjusted pancreas transplant rate before to after COVID-19 by OPO. Transplant rate ratio is the difference in the organ procurement organization's (OPO's) rate ratio compared to the nation as a whole in the 12 months after the onset of the COVID-19 pandemic as compared to the 12 months before the onset of the pandemic. Individual listings are counted separately. Model adjusted for blood type, age in years, body mass index, primary diagnosis, duration of dialysis, miles between candidate and program, ethnicity, sex, type of pancreas transplant, candidate insurance type, race, previous transplant for candidates, candidate urbanicity, and waiting time.

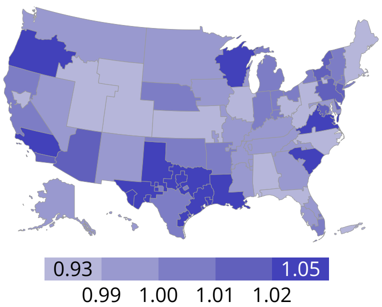

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Figure COV 22: Difference in risk adjusted pancreas all-cause graft failure hazard ratio before to after COVID-19 by OPO. Graft failure hazard ratio is the difference in the organ procurement organization's (OPO's) hazard ratio compared to the nation as a whole in the 12 months after the onset of the COVID-19 pandemic as compared to the 12 months before the onset of the pandemic. Model adjusted for blood type, ethnicity, sex, candidate insurance type, race, donor age (years), donor ethnicity, donor hypertension status, donor race, donor sex, recipient age (years), body mass index, primary diagnosis, years of dialysis, miles between recipient and program, donor type, recipient urbanicity, and miles between donor and program.

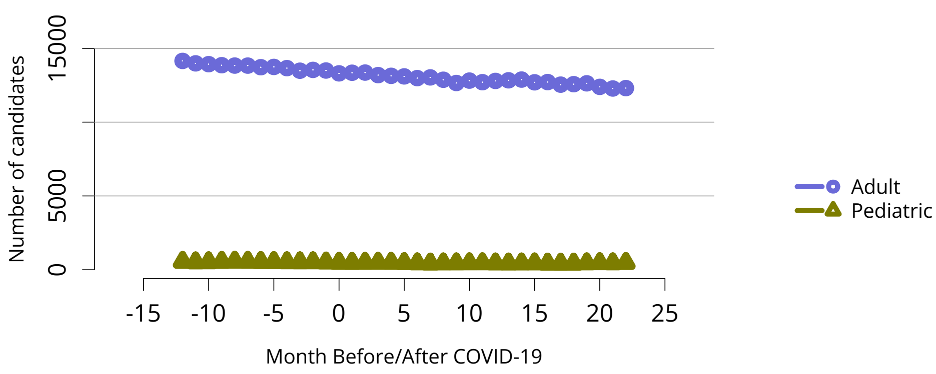

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Figure COV 23: Number of prevalent liver candidates. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time during the month.

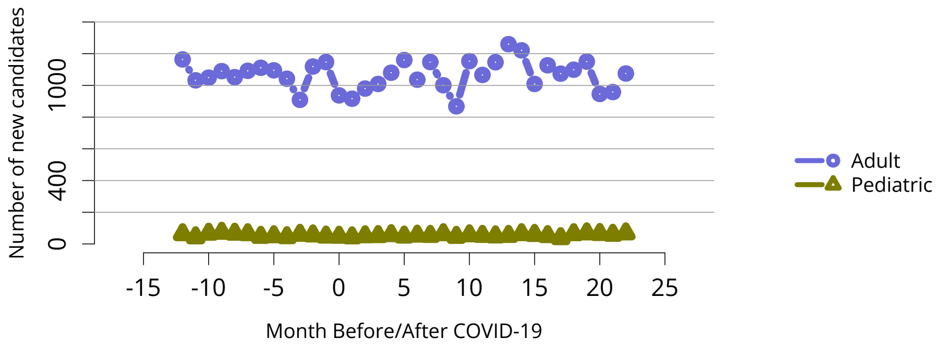

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Figure COV 24: Number of new liver candidates. Month 0 begins March 13, 2020, the date of declaration of the national emergency. A new candidate is one who first joined the list during the given month, without having been listed in a previous month.

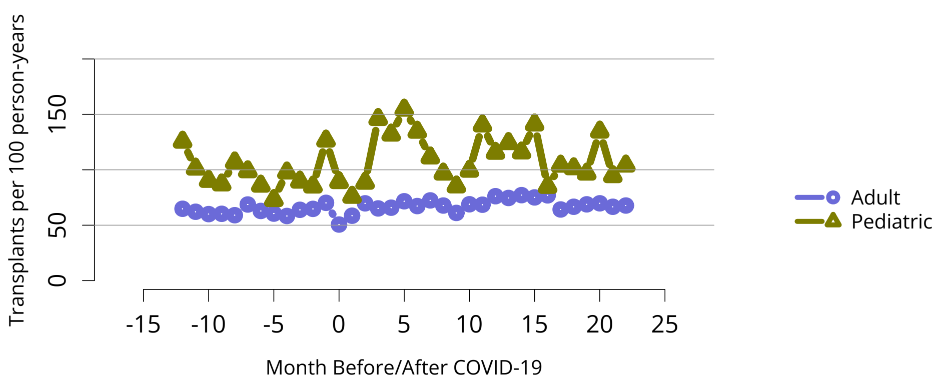

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Figure COV 25: Deceased donor liver transplant rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given month. Individual listings are counted separately.

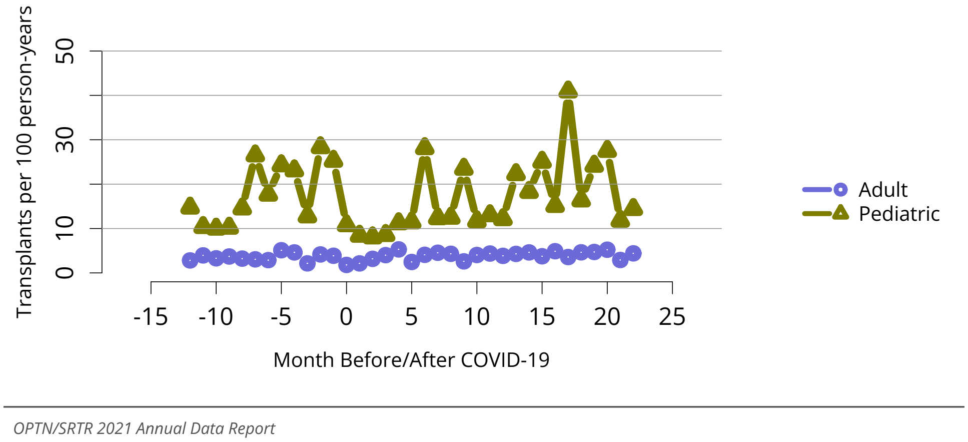

Figure COV 26: Living donor liver transplant rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Transplant rates are computed as the number of living donor transplants per 100 patient-years of waiting in a given month. Individual listings are counted separately.

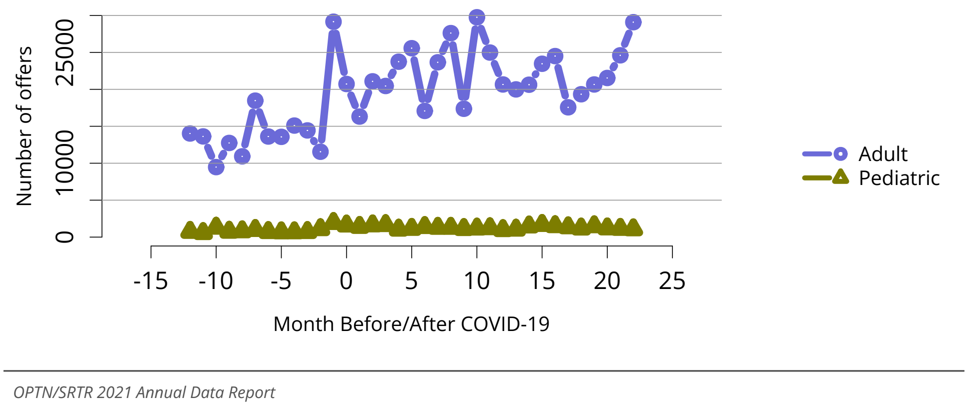

Figure COV 27: Number of liver offers. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

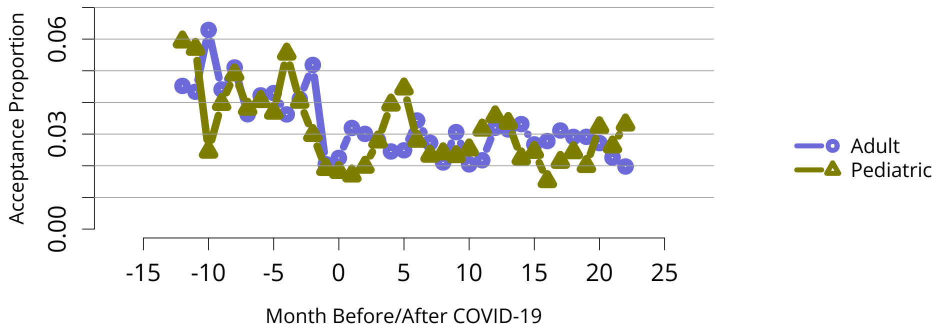

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Figure COV 28: Liver offer acceptance rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

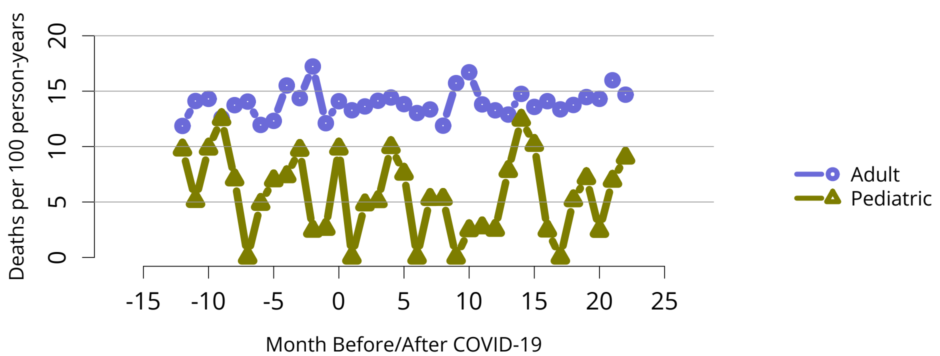

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Figure COV 29: Liver waitlist mortality rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

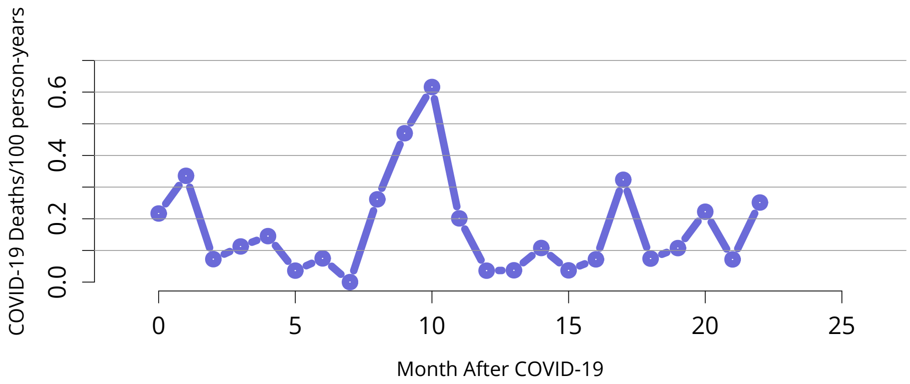

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Figure COV 30: Liver waitlist COVID-19 mortality rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

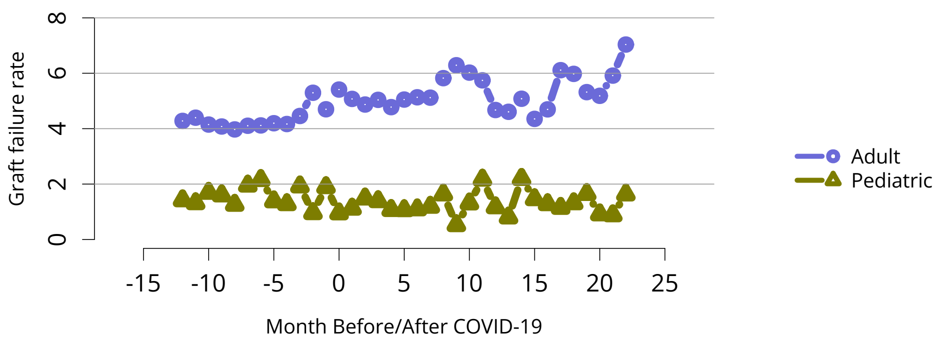

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Figure COV 31: Liver all-cause graft failure. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

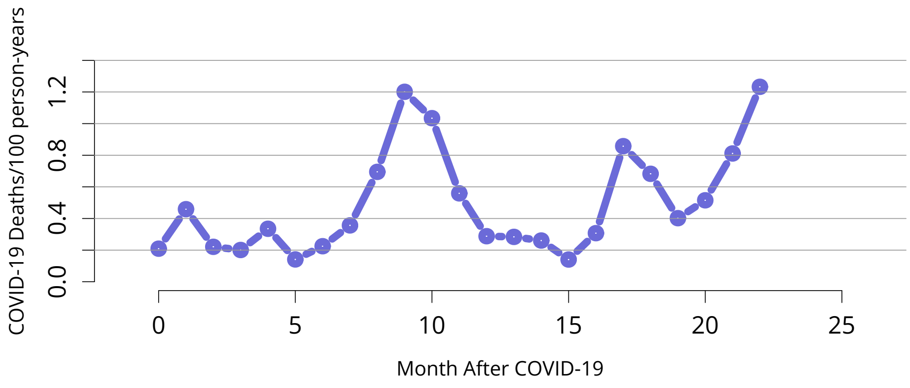

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Figure COV 32: Liver post-transplant COVID-19 mortality rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

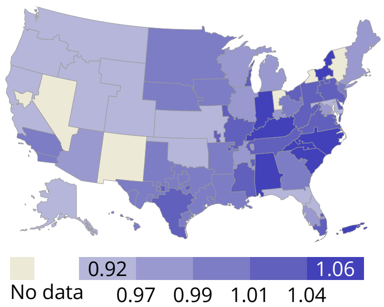

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Figure COV 33: Difference in risk adjusted liver waitlist mortality hazard ratio before to after COVID-19 by OPO. Waitlist mortality hazard ratio is the difference in the organ procurement organization's (OPO's) hazard ratio compared to the nation as a whole in the 12 months after the onset of the COVID-19 pandemic as compared to the 12 months before the onset of the pandemic. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Model adjusted for blood type, age in years, body mass index, primary diagnosis, miles between candidate and program, ethnicity, pediatric end-stage liver disease (PELD)/model for end-stage liver disease (MELD) score, sex, hepatocellular carcinoma status, candidate insurance type, race, previous transplant for candidates, candidate urbanicity, and waiting time.

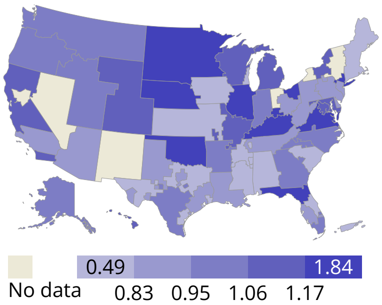

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Figure COV 34: Difference in risk adjusted liver transplant rate before to after COVID-19 by OPO. Transplant rate ratio is the difference in the organ procurement organization's (OPO's) rate ratio compared to the nation as a whole in the 12 months after the onset of the COVID-19 pandemic as compared to the 12 months before the onset of the pandemic. Individual listings are counted separately. Model adjusted for blood type, age in years, body mass index, primary diagnosis, miles between candidate and program, ethnicity, pediatric end-stage liver disease (PELD)/model for end-stage liver disease (MELD) score, sex, hepatocellular carcinoma status, candidate insurance type, race, previous transplant for candidates, candidate urbanicity, and waiting time.

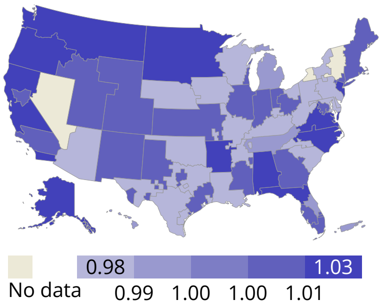

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Figure COV 35: Difference in risk adjusted liver all-cause graft failure hazard ratio before to after COVID-19 by OPO. Graft failure hazard ratio is the difference in the organ procurement organization's (OPO's) hazard ratio compared to the nation as a whole in the 12 months after the onset of the COVID-19 pandemic as compared to the 12 months before the onset of the pandemic. Model adjusted for blood type, ethnicity, sex, candidate insurance type, race, donor age (years), donor ethnicity, donor hypertension status, donor race, donor sex, recipient age (years), body mass index, cold ischemia time (hours), primary diagnosis, miles between recipient and program, donor diabetes status, donor type, recipient hepatocellular carcinoma status, number of HLA mismatches, laboratory model for end-stage liver disease (MELD) at transplant, multiorgan transplant, recipient had a previous transplant, recipient urbanicity, miles between donor and program, and type of liver transplant.

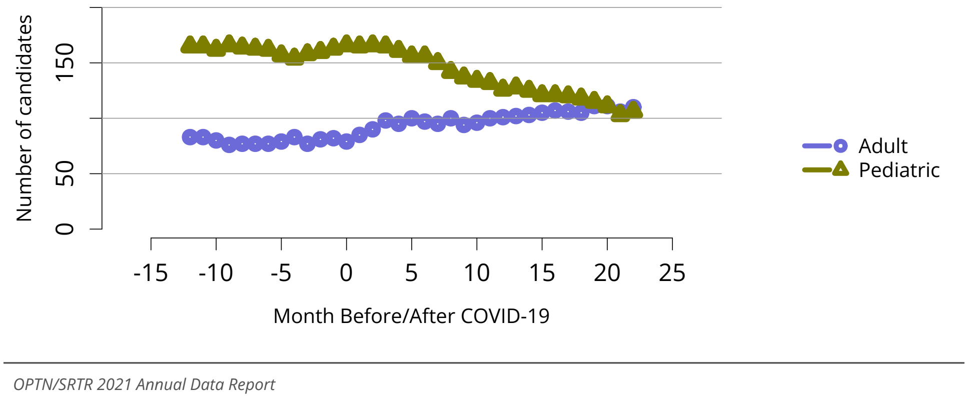

Figure COV 36: Number of prevalent intestine candidates. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time during the month.

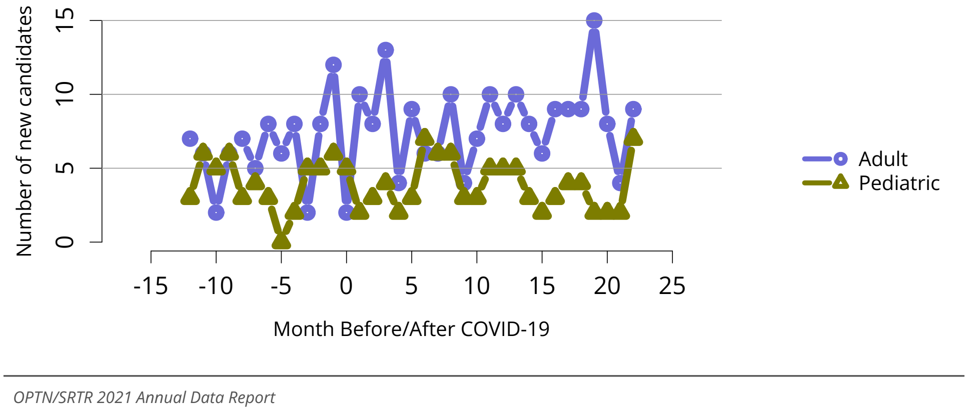

Figure COV 37: Number of new intestine candidates. Month 0 begins March 13, 2020, the date of declaration of the national emergency. A new candidate is one who first joined the list during the given month, without having been listed in a previous month.

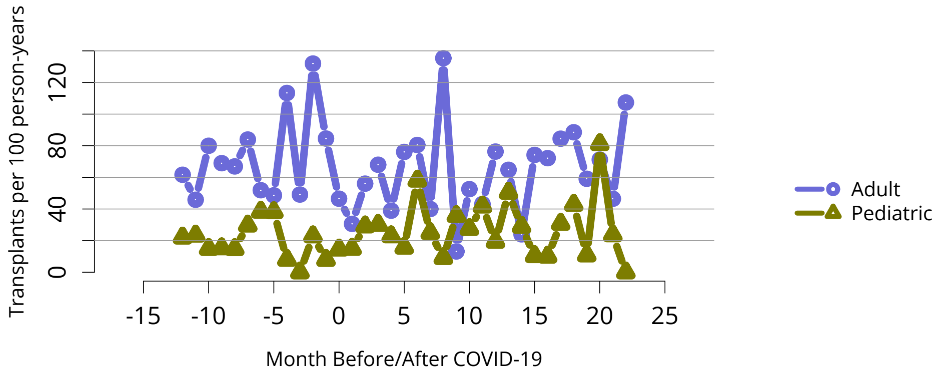

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Figure COV 38: Deceased donor intestine transplant rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given month. Individual listings are counted separately.

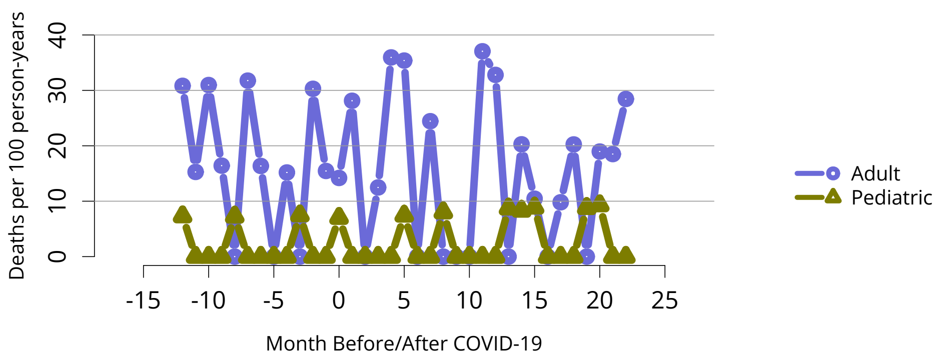

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Figure COV 39: Intestine waitlist mortality rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

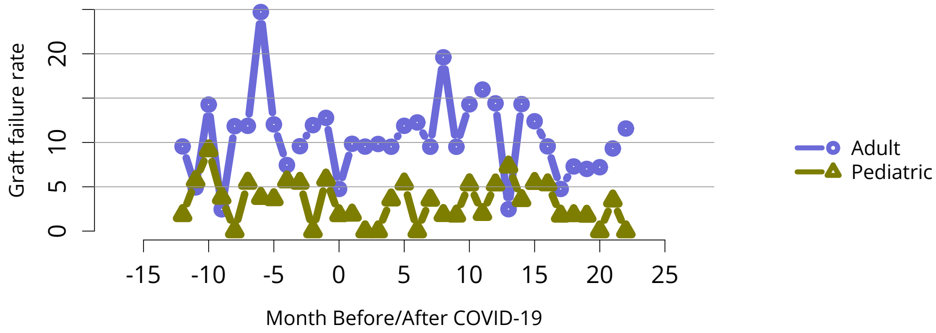

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Figure COV 40: Intestine all-cause graft failure. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

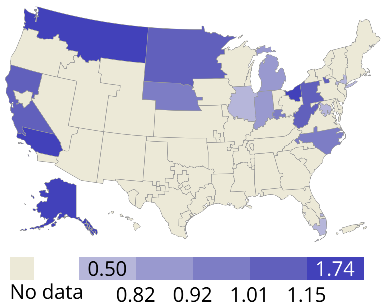

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Figure COV 41: Difference in risk adjusted intestine transplant rate before to after COVID-19 by OPO. Transplant rate ratio is the difference in the organ procurement organization's (OPO's) rate ratio compared to the nation as a whole in the 12 months after the onset of the COVID-19 pandemic as compared to the 12 months before the onset of the pandemic. Individual listings are counted separately. Model adjusted for blood type, age in years, body mass index, primary diagnosis, miles between candidate and program, ethnicity, sex, intestine listing type, candidate insurance type, race, previous transplant for candidates, candidate urbanicity, and waiting time.

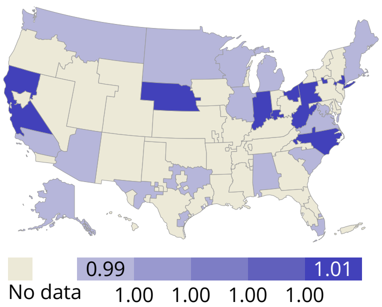

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Figure COV 42: Difference in risk adjusted intestine all-cause graft failure hazard ratio before to after COVID-19 by OPO. Graft failure hazard ratio is the difference in the organ procurement organization's (OPO's) hazard ratio compared to the nation as a whole in the 12 months after the onset of the COVID-19 pandemic as compared to the 12 months before the onset of the pandemic. Model adjusted for ethnicity, sex, candidate insurance type, race, donor age (years), donor diabetes status, donor hypertension status, recipient age (years), body mass index, primary diagnosis, miles between recipient and program, intestine transplant type, recipient had a previous transplant, recipient urbanicity, and miles between donor and program.

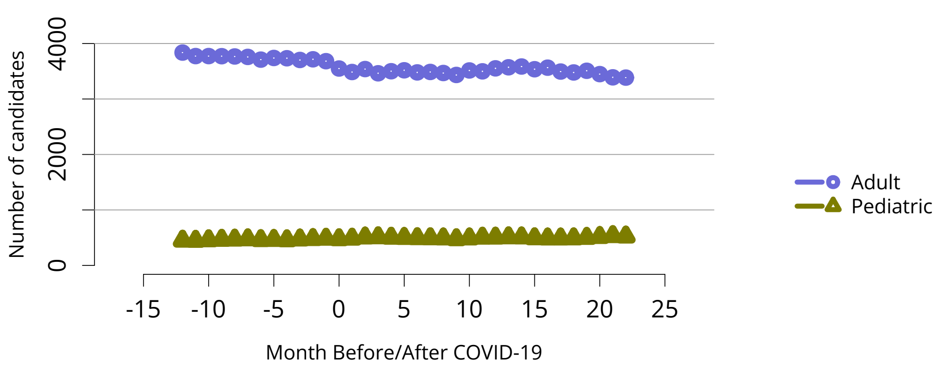

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Figure COV 43: Number of prevalent heart candidates. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time during the month.

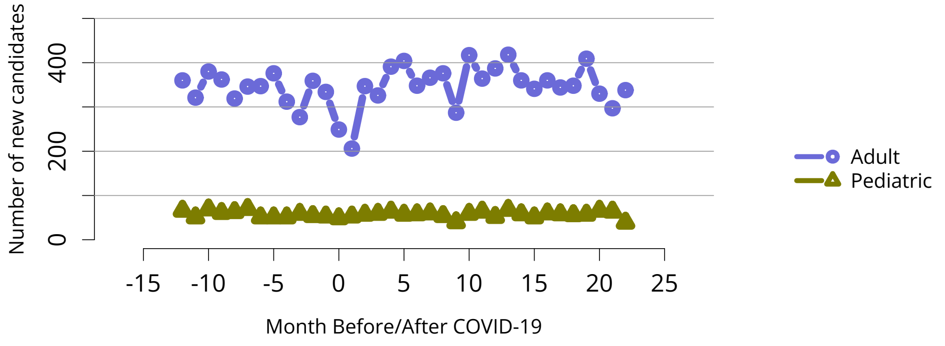

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Figure COV 44: Number of new heart candidates. Month 0 begins March 13, 2020, the date of declaration of the national emergency. A new candidate is one who first joined the list during the given month, without having been listed in a previous month.

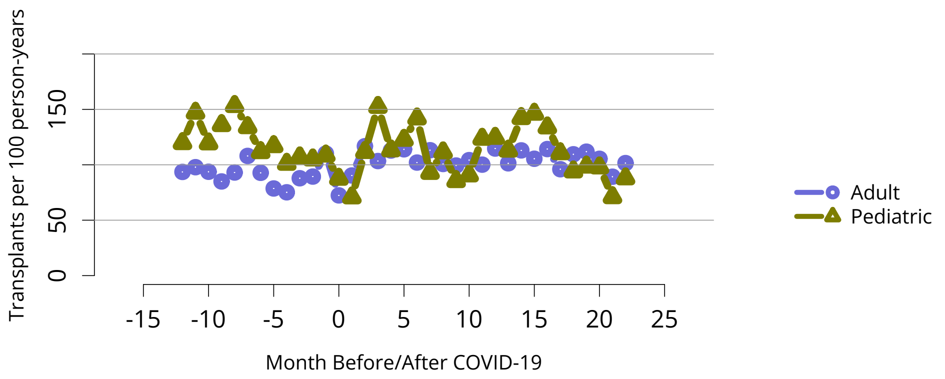

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Figure COV 45: Deceased donor heart transplant rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given month. Individual listings are counted separately.

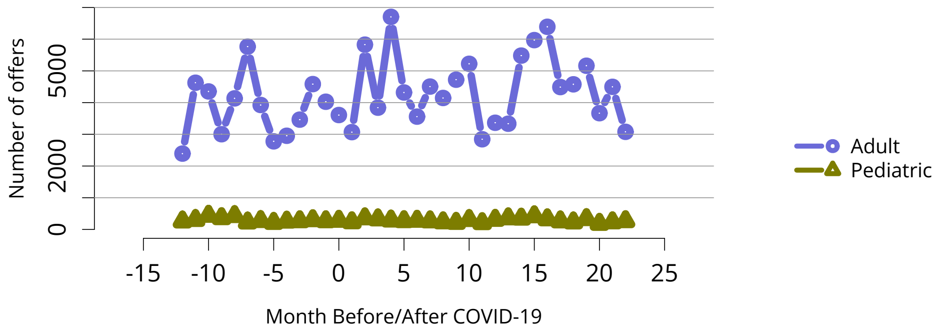

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Figure COV 46: Number of heart offers. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

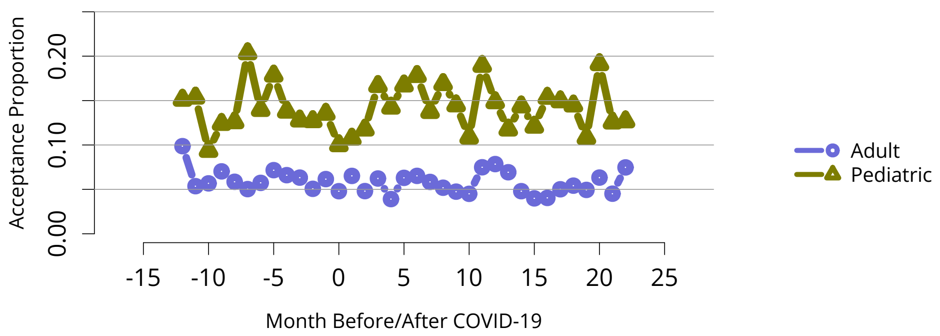

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Figure COV 47: Heart offer acceptance rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

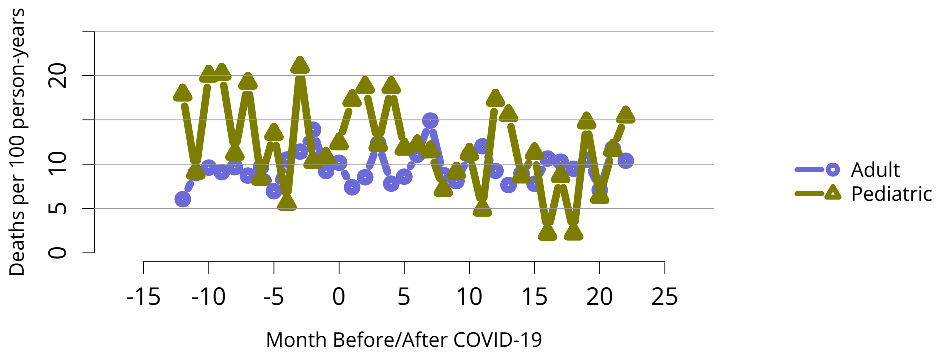

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Figure COV 48: Heart waitlist mortality rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

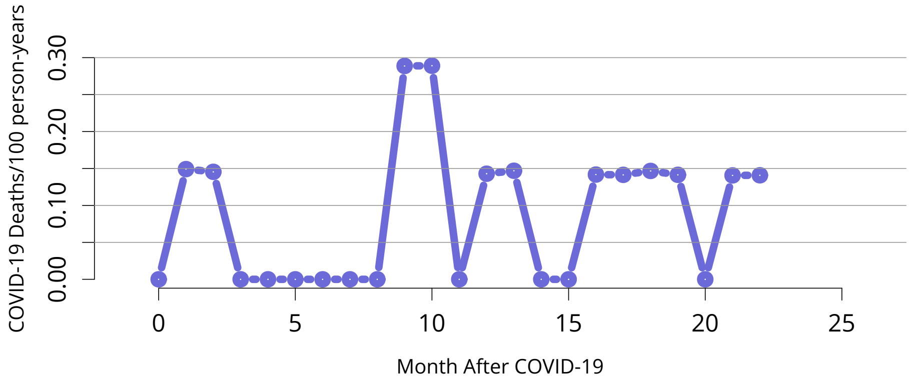

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Figure COV 49: Heart waitlist COVID-19 mortality rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

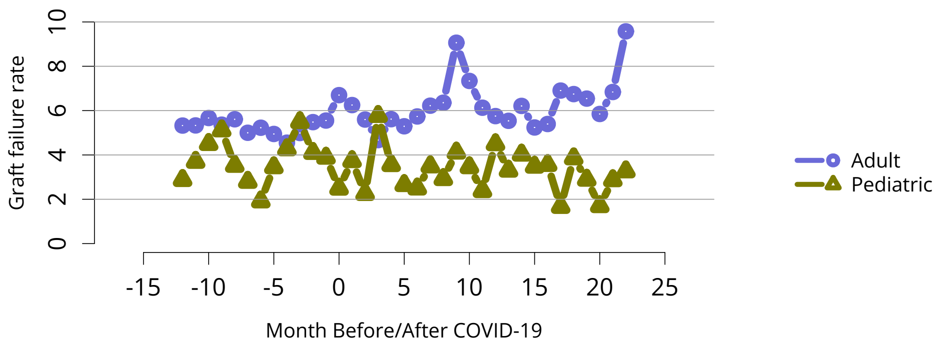

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Figure COV 50: Heart all-cause graft failure. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

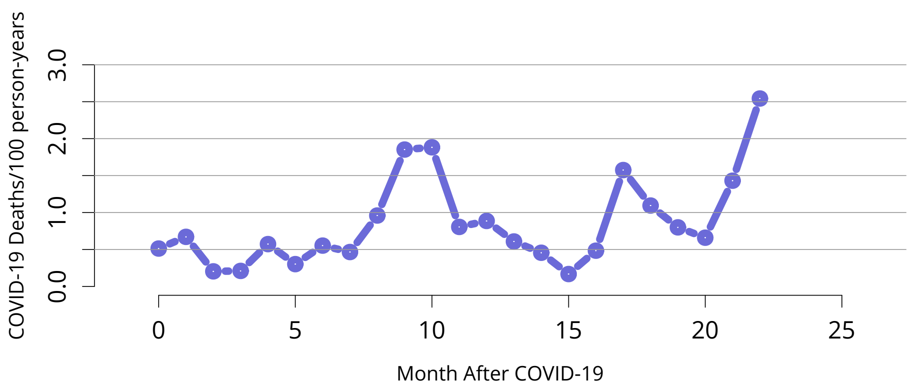

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Figure COV 51: Heart post-transplant COVID-19 mortality rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

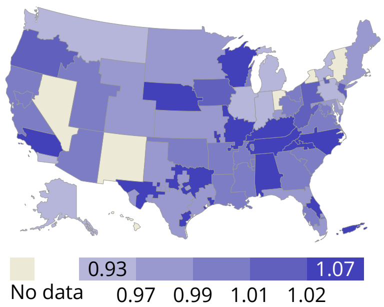

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Figure COV 52: Difference in risk adjusted heart waitlist mortality hazard ratio before to after COVID-19 by OPO. Waitlist mortality hazard ratio is the difference in the organ procurement organization's (OPO's) hazard ratio compared to the nation as a whole in the 12 months after the onset of the COVID-19 pandemic as compared to the 12 months before the onset of the pandemic. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Model adjusted for blood type, age in years, body mass index, primary diagnosis, miles between candidate and program, ethnicity, sex, height at listing (cm), candidate insurance type, race, previous transplant for candidates, candidate urbanicity, ventricular assist device status at listing, and waiting time.

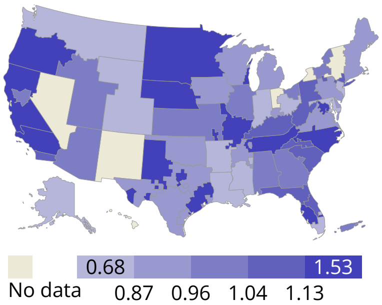

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Figure COV 53: Difference in risk adjusted heart transplant rate before to after COVID-19 by OPO. Transplant rate ratio is the difference in the organ procurement organization's (OPO's) rate ratio compared to the nation as a whole in the 12 months after the onset of the COVID-19 pandemic as compared to the 12 months before the onset of the pandemic. Individual listings are counted separately. Model adjusted for blood type, age in years, body mass index, primary diagnosis, miles between candidate and program, ethnicity, sex, height at listing (cm), candidate insurance type, race, previous transplant for candidates, candidate urbanicity, ventricular assist device status at listing, and waiting time.

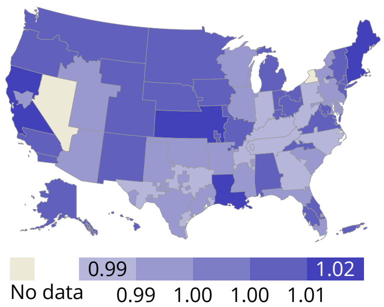

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Figure COV 54: Difference in risk adjusted heart all-cause graft failure hazard ratio before to after COVID-19 by OPO. Graft failure hazard ratio is the difference in the organ procurement organization's (OPO's) hazard ratio compared to the nation as a whole in the 12 months after the onset of the COVID-19 pandemic as compared to the 12 months before the onset of the pandemic. Model adjusted for blood type, ethnicity, sex, candidate insurance type, race, donor age (years), donor diabetes status, donor ethnicity, donor hypertension status, donor race, donor sex, recipient age (years), body mass index, primary diagnosis, miles between recipient and program, number of HLA mismatches, allocation tier, height at transplant (cm), multiorgan transplant, recipient had a previous transplant, recipient urbanicity, ventricular assist device at transplant, and miles between donor and program.

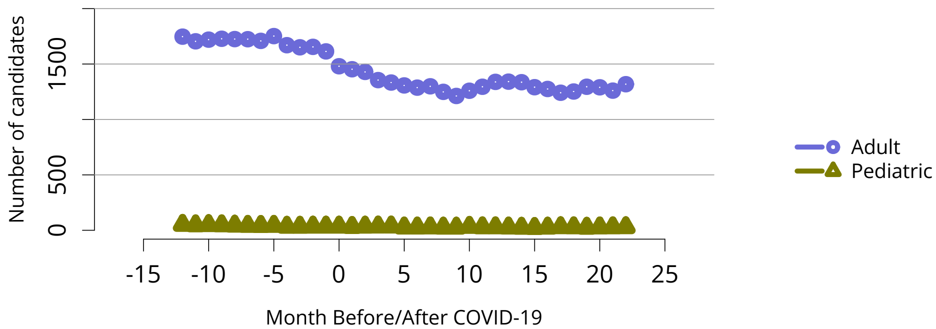

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Figure COV 55: Number of prevalent lung candidates. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time during the month.

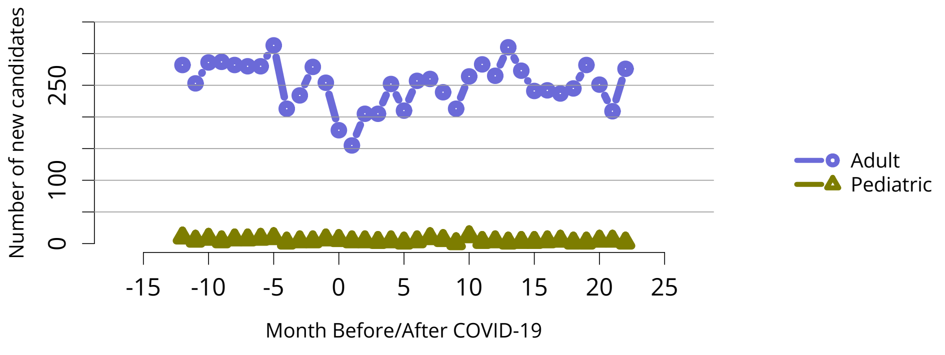

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Figure COV 56: Number of new lung candidates. Month 0 begins March 13, 2020, the date of declaration of the national emergency. A new candidate is one who first joined the list during the given month, without having been listed in a previous month.

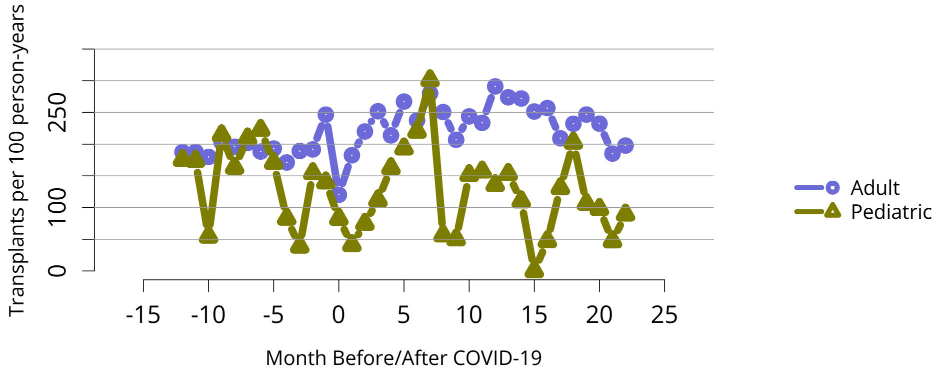

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Figure COV 57: Deceased donor lung transplant rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Transplant rates are computed as the number of deceased donor transplants per 100 patient-years of waiting in a given month. Individual listings are counted separately.

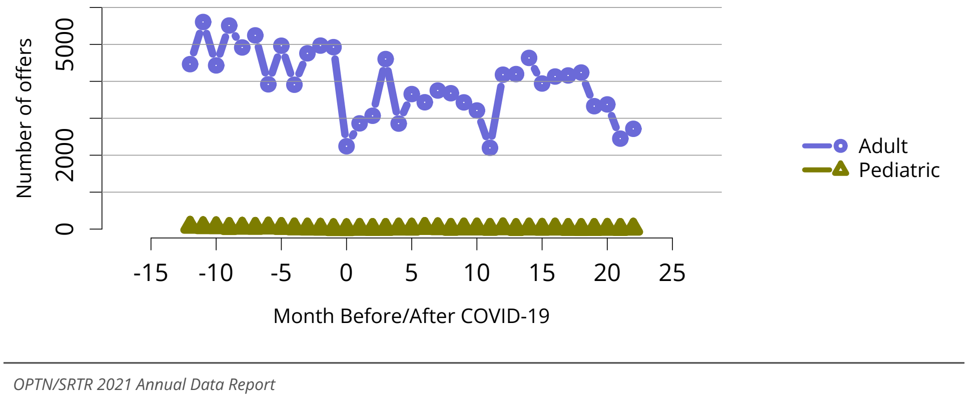

Figure COV 58: Number of lung offers. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

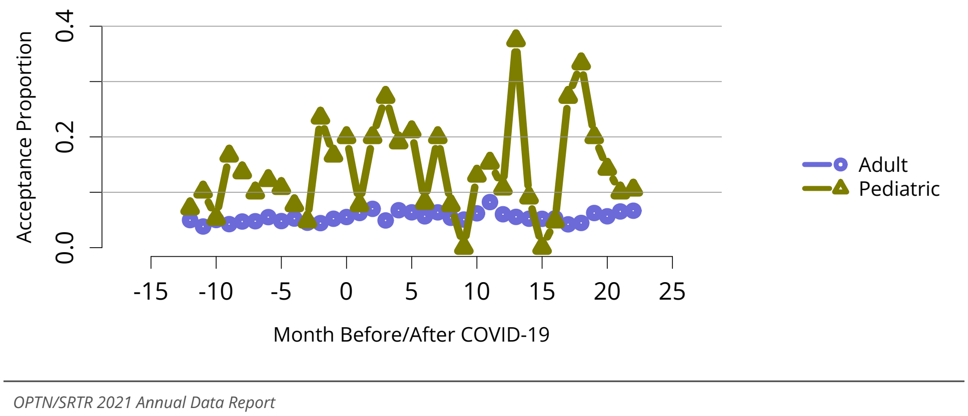

Figure COV 59: Lung offer acceptance rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

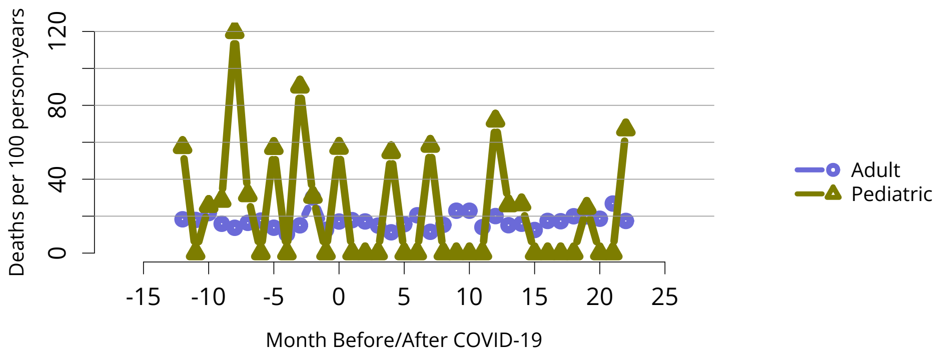

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Figure COV 60: Lung waitlist mortality rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

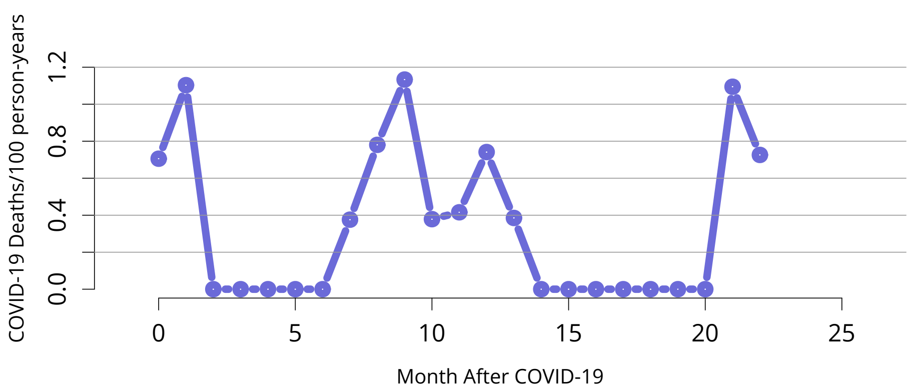

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Figure COV 61: Lung waitlist COVID-19 mortality rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency. Mortality rates are computed as the number of deaths per 100 patient-years of waiting in the given year. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately.

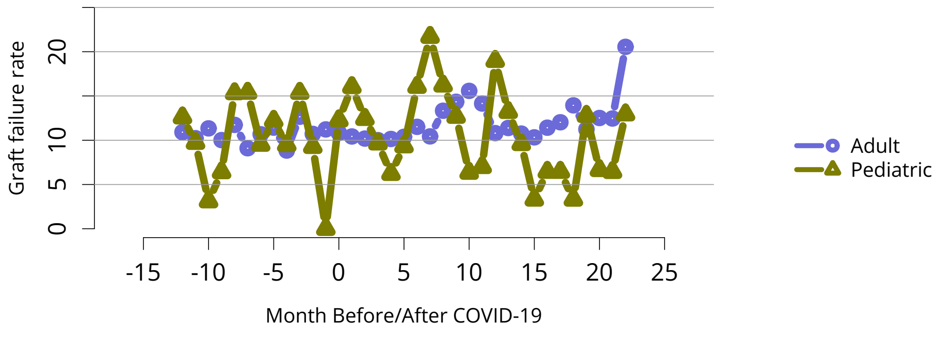

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Figure COV 62: Lung all-cause graft failure. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

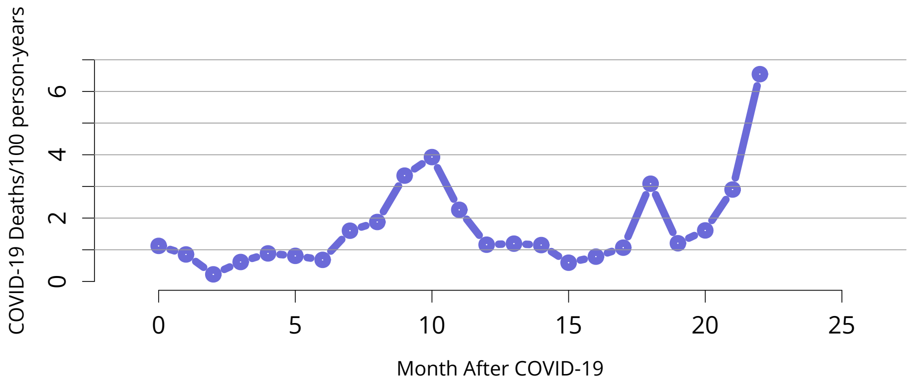

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Figure COV 63: Lung post-transplant COVID-19 mortality rate. Month 0 begins March 13, 2020, the date of declaration of the national emergency.

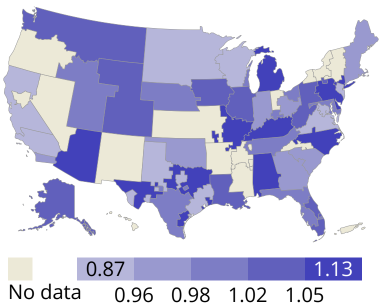

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Figure COV 64: Difference in risk adjusted lung waitlist mortality hazard ratio before to after COVID-19 by OPO. Waitlist mortality hazard ratio is the difference in the organ procurement organization's (OPO's) hazard ratio compared to the nation as a whole in the 12 months after the onset of the COVID-19 pandemic as compared to the 12 months before the onset of the pandemic. Waiting time is censored at transplant, death, transfer to another program, removal because of improved condition, or end of cohort. Individual listings are counted separately. Model adjusted for blood type, age in years, body mass index, diagnosis group, pediatric diagnosis group, miles between candidate and program, ethnicity, sex, height at listing (cm), lung allocation score category, candidate insurance type, race, previous transplant for candidates, candidate urbanicity, and waiting time.

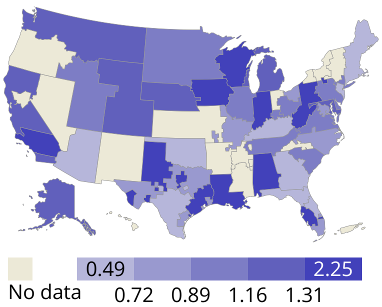

Figure COV 65: Difference in risk adjusted lung transplant rate before to after COVID-19 by OPO. Transplant rate ratio is the difference in the organ procurement organization's (OPO's) rate ratio compared to the nation as a whole in the 12 months after the onset of the COVID-19 pandemic as compared to the 12 months before the onset of the pandemic. Individual listings are counted separately. Model adjusted for blood type, age in years, body mass index, diagnosis group, pediatric diagnosis group, miles between candidate and program, ethnicity, sex, height at listing (cm), lung allocation score category, candidate insurance type, race, previous transplant for candidates, candidate urbanicity, and waiting time.

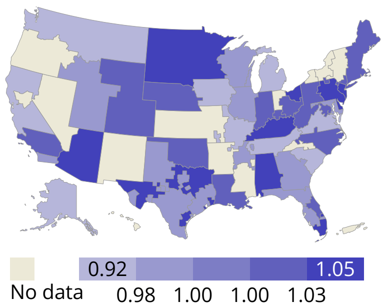

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Figure COV 66: Difference in risk adjusted lung all-cause graft failure hazard ratio before to after COVID-19 by OPO. Graft failure hazard ratio is the difference in the organ procurement organization's (OPO's) hazard ratio compared to the nation as a whole in the 12 months after the onset of the COVID-19 pandemic as compared to the 12 months before the onset of the pandemic. Model adjusted for blood type, ethnicity, sex, candidate insurance type, race, donor age (years), donor diabetes status, donor ethnicity, donor hypertension status, donor race, donor sex, donor smoked more than 20 packs per year, recipient age (years), body mass index, diagnosis group, miles between recipient and program, donor type, number of HLA mismatches, height at transplant (cm), lung allocation score at transplant, multiorgan transplant, recipient had a previous transplant, recipient urbanicity, and miles between donor and program.

OPTN/SRTR 2021 Annual Data Report: Vascularized Composite Allograft

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Abstract

Year 2020 marked the first OPTN/SRTR Annual Data Report that included a chapter on vascularized composite allograft (VCA), which encompassed reviews of data collected between 2014 (when VCA was included in the Final Rule) and 2020. The present Annual Data Report shows that the number of VCA recipients in the United States continues to be small and trended downward in 2021. While data continue to be limited by sample size, trends continue to show a predominance in White, young/middle-aged, male recipients. Similar to the 2020 report, eight uterus and one non-uterus VCA graft failures were reported from 2014 through 2021. Critical to advancement of VCA transplantation will be the standardization of definitions, protocols, and outcome measures for the different VCA types. Like intestinal transplants, it is likely that VCA transplants will be concentrated and performed at referral transplant centers.

Keywords: Abdominal wall transplant, face transplant, multiorgan transplant, upper limb transplant, vascularized composite allograft (VCA)

1 INTRODUCTION

In 2014, vascularized composite allograft (VCA) was included within the Final Rule, which established regulatory oversight by the Organ Procurement and Transplantation Network (OPTN).[1,2] The Final Rule defined VCA transplantation as the transplant of any body part that meets the following nine criteria:

1. Vascularized and requires blood flow by surgical connection of blood vessels to function after transplant
2. Contains multiple tissue types
3. Recovered from a human donor as an anatomical/structural unit
4. Transplanted into a human recipient as an anatomical/structural unit
5. Minimally manipulated (ie, processing that does not alter the original relevant characteristics of the organ relating to the organ's utility for reconstruction, repair, or replacement)
6. For homologous use (the replacement or supplementation of a recipient's organ with an organ that performs the same basic function or functions in the recipient as in the donor)
7. Not combined with another article such as a device
8. Susceptible to ischemia and, therefore, only stored temporarily and not cryopreserved
9. Susceptible to allograft rejection[3]

Last year, 2020, marked the first year of the OPTN/SRTR Annual Data Report including a chapter on VCA, which encompassed reviews of data collected between 2014 (when VCA was included in the Final Rule) and 2020.[4] To provide context, this year, the report will also include data beginning in 2014 with a focus on the year 2021. Due to the small number of recipients, subsequent reports will aim to provide a comparison to the previous year to describe and analyze trends within the VCA community. Detailed information on VCA candidates, donors, and recipients, as well as VCA access and patient outcomes, in the United States from July 2014 through 2021 is presented below.

2 UTERUS TRANSPLANT

2.1 Candidates

Ten candidates were on the waiting list for uterus transplant in 2021 (Figure VCA 1). Most uterus transplant candidates have been younger than 35 years (Figure VCA 2) and White (Figure VCA 3), with blood types A or O (Figure VCA 4).

2.2 Transplants

As of December 2021, 33 uterus transplants were performed (Figure VCA 5). Most uterus transplants were performed in White (29 of 33 recipients; Figure VCA 7) women younger than 35 years (28 of 33 recipients; Figure VCA 6). Uterus transplant recipients were predominantly blood types A or O (29 of 33 recipients; Figure VCA 8). Primary diagnosis of absolute uterine factor infertility due to congenital absence of the uterus was present in 25 of 33 recipients (Figure VCA 9).

2.3 Donors

Unlike transplants for other VCA organs that use only deceased donor organs, living donor uterus transplants are performed: 64% of uterus transplants (21/33) since 2016 used living donors (Figure VCA 10). All deceased donor uterus transplants were performed with donors younger than 50 years, with most using donors aged 18-34 years. All but one of the living donors were younger than 50 years (Figure VCA 11).

2.4 Posttransplant Outcomes

Unlike other organ transplants, uterus grafts are always removed after the recipient has finished having children. Data reported to the OPTN show 21 functioning grafts and 8 uterus grafts failed (24% of 33 transplants; Figure VCA 12). However, uterus transplantation is a small and growing field, and the authors are aware of 17 uterus grafts that have, in fact, been removed after successful child delivery. The essential outcome variable for a uterus transplant is a live birth. While number of births is not yet captured in the data, as of December 2021, the authors are aware of 21 children who have been born to 19 uterus transplant recipients.

2.5 Access

Uterus transplants through 2021 were performed at centers in three states: Ohio, Pennsylvania, and Texas. Of these, most transplants have been performed in Texas (67%, 22/33; Table VCA 1).

3 VCA TRANSPLANTS OTHER THAN UTERUS

3.1 Candidates

The total number of candidates listed for non-uterus VCA has remained stable since 2014 when the OPTN VCA waiting list was established, with 18 total candidates ever waiting in 2021 (Figure VCA 13). Since 2014, candidate listings by organ type show that the most common has been upper limb (43%, 23/53) and the least common has been "other/multiple" (13%, 7/53). Annual data are difficult to evaluate due to sample size; however, at the end of 2021, seven patients were waiting for abdominal wall transplant, three were waiting for face transplant, six were waiting for upper limb transplant, and two were waiting for other/multiple transplant (Figures VCA 13 and 14).

Similar to last year's report, most non-uterus VCA candidates listed since 2014 were aged 18-34 years (32%, 17/53), 35-49 years (26%, 14/53), and 50-64 years (30%, 16/53) (Figure VCA 15). By race and ethnicity, most non-uterus VCA transplant candidates identified as White (74%, 39/53), followed by Hispanic (13%, 7/53), Black (11%, 6/53), and other (2%, 1/53) (Figure VCA 16). Since 2014, non-uterus VCA transplant candidates have predominantly been male (70%, 37/53) (Figure VCA 17) with blood type O (45%, 24/53), followed by type A (34%, 18/53), type B (17%, 9/53), and type AB (4%, 2/53) (Figure VCA 18). In addition, when evaluating median days to transplant by organ type since 2014, the longest time to transplant was scalp (355 days). Median days to transplant for face, penis, other/multiple, upper limb, and abdominal wall were 342 days, 262 days, 238 days, 186 days, and 125 days, respectively (Figure VCA 19).

3.2 Donors

With respect to age, most donors from 2014 through 2021 were within the 18- to 34-year age group (52%, 16/31). Data for the remaining age groups are as follows: 13% (4/31) were younger than 18 years, 32% (10/31) were aged 35-49 years, and 3% (1/31) were aged 50-64 years (Figure VCA 27).

3.3 Recipients

Since July 3, 2014, of the 53 total non-uterus VCA transplant candidates listed, 31 (58%) have undergone transplants. While it continues to be difficult to evaluate data trends due to sample size limitations, no substantial change has been seen in VCA transplants performed annually from 2014 through 2021 (Figure VCA 20). The most commonly transplanted non-uterus VCA was upper limb (48%, 15/31), followed by face (35%, 11/31), other (including penis and scalp; 10%, 3/31), and abdominal wall (6%, 2/31) (Figures VCA 20 and 21).

Demographic data for patients who underwent non-uterus VCA transplant in 2014 through 2021 are as follows. The three most common causes of need for VCA transplant were trauma (45%, 14/31), infection (26%, 8/31), and burn/explosion (6%, 2/31). However, 10% (3/31) of data was missing (Figure VCA 26), which was similar to our previous (2020) report. The most common age group among non-uterus VCA transplant recipients was 18-34 years (39%, 12/31), followed by 50-64 years (29%, 9/31), 35-49 years (19%, 6/31), 65 years or older (10%, 3/31), and younger than 18 years (3%, 1/31) (Figure VCA 22). Due to small numbers of non-White recipients, race within the non-uterus VCA transplant recipient group has continued to be presented differently from that in the listed non-uterus VCA candidate group; for recipients, race is stratified as White and non-White. The proportions of White and non-White non-uterus VCA transplant recipients were 81% (25/31) and 19% (6/31), respectively (Figure VCA 23). Non-uterus VCA transplant recipients were mostly male (74%, 23/31) (Figure VCA 24) with blood type O (48%, 15/31), followed by type A (29%, 9/31) and type B (23%, 7/31). No transplants were performed in patients with type AB blood (Figure VCA 25).

3.4 Access and Outcomes

Nineteen centers in 11 US states have performed non-uterus VCA transplants since July 2014 (Table VCA 3). In terms of the number of centers performing VCA transplants by organ, upper limb is the most common (nine centers), followed by face (five centers), abdominal wall (two centers), penis (two centers), and scalp (one center) (Figure VCA 28). Compared with last year's report, centers performing upper limb and face VCA transplants since 2014 have slightly increased (8 to 9 and 4 to 5, respectively).[4]

Regarding patient outcomes for non-uterus VCA transplant, end points were broken into two groups per organ type: "functioning graft" and "failed graft." In the period being discussed (2014-2021), only 7% of upper limb VCAs (1/15) failed, and there was a 100% functioning graft rate in abdominal wall, face, penis, and scalp VCA transplants (Table VCA 2).

4 OBSERVATIONS

Vascularized composite allotransplantation continues to evolve with advances in techniques, immunomodulation, and patient selection. Nonetheless, the number of VCA recipients within the United States continues to be small and trended downward in 2021.

Although it is clear that the inclusion of VCA transplant within the Final Rule in 2014 was a milestone for the field, several factors may be contributing to this trend in 2021, including lack of funding and VCA programs' access to resources necessary to sustain programs and possibly continued impact of the COVID-19 pandemic. Other challenges that the VCA community faces include unstandardized definitions, non-validated VCA outcome-specific tools, chronic rejection, and missingness of data entries submitted to the OPTN database. To address some of these challenges, VCA will be integrated into the OPTN Computer System (UNet) in 2023, and will include implementation of several approved modifications to policy/data collection, including updates to the definition of VCA graft failure. Like intestinal transplants, it is likely that VCA transplants will be concentrated and performed at referral transplant centers.

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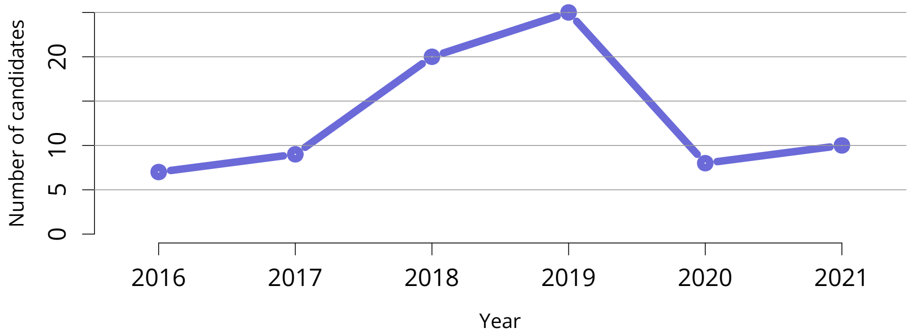

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Figure VCA 1: Number of prevalent uterus candidates. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time during the year.

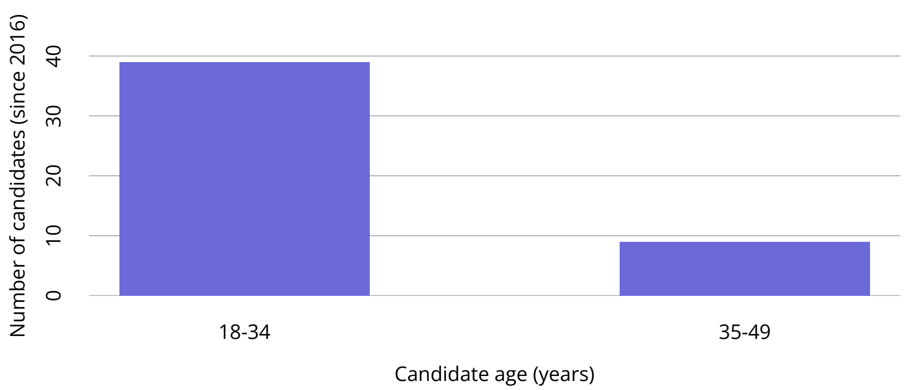

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Figure VCA 2: Number of uterus candidates by age since 2016. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time.

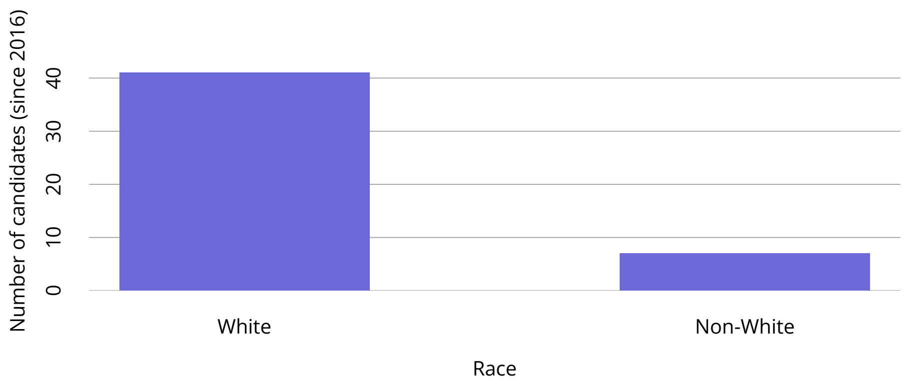

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Figure VCA 3: Number of uterus candidates by race since 2016. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time.

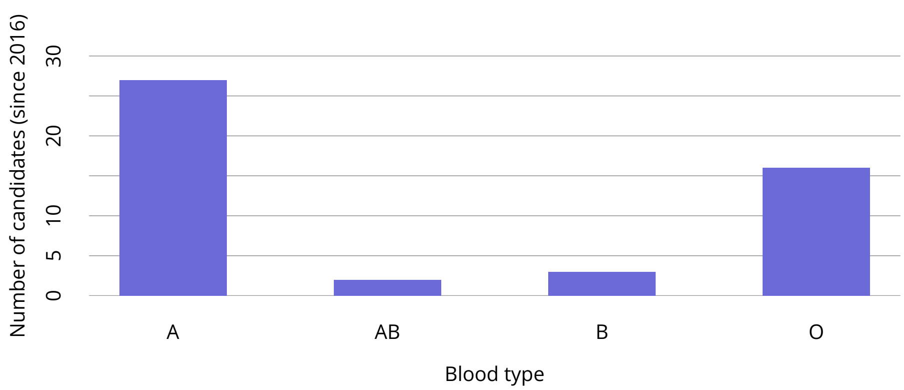

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Figure VCA 4: Number of uterus candidates by blood type since 2016. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time.

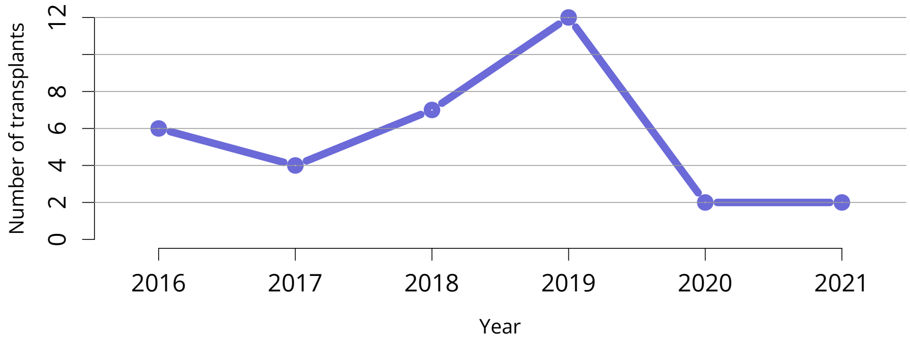

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Figure VCA 5: Number of uterus transplants. All uterus transplant recipients, including retransplant, and multiorgan recipients.

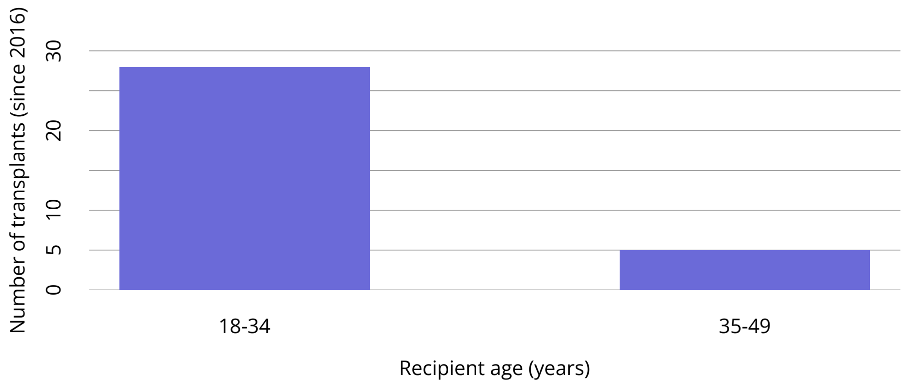

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Figure VCA 6: Number of uterus transplants by age since 2016. All uterus transplant recipients, including retransplant, and multiorgan recipients.

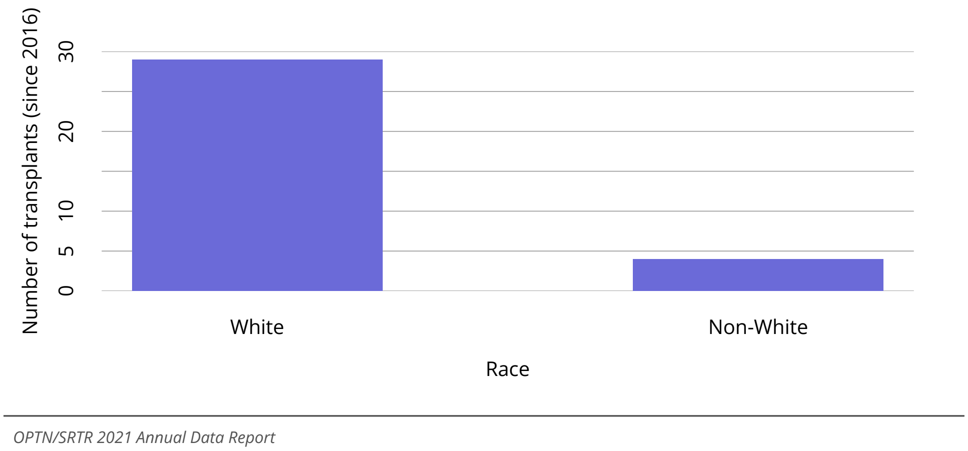

Figure VCA 7: Number of uterus transplants by race since 2016. All uterus transplant recipients, including retransplant, and multiorgan recipients.

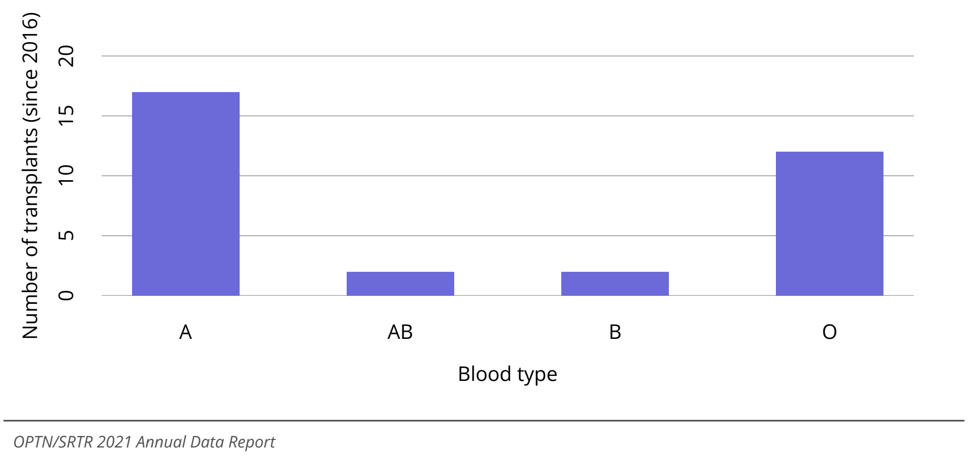

Figure VCA 8: Number of uterus transplants by blood type since 2016. All uterus transplant recipients, including retransplant and multiorgan recipients.

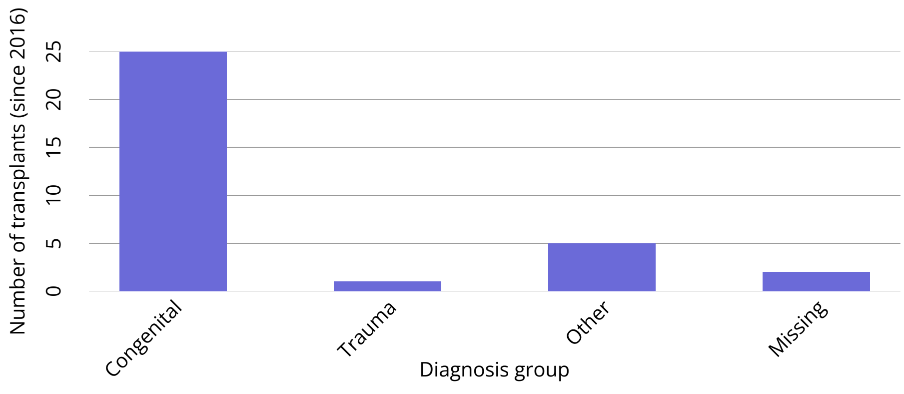

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Figure VCA 9: Number of uterus transplants by diagnosis since 2016. All uterus transplant recipients, including retransplant, and multiorgan recipients.

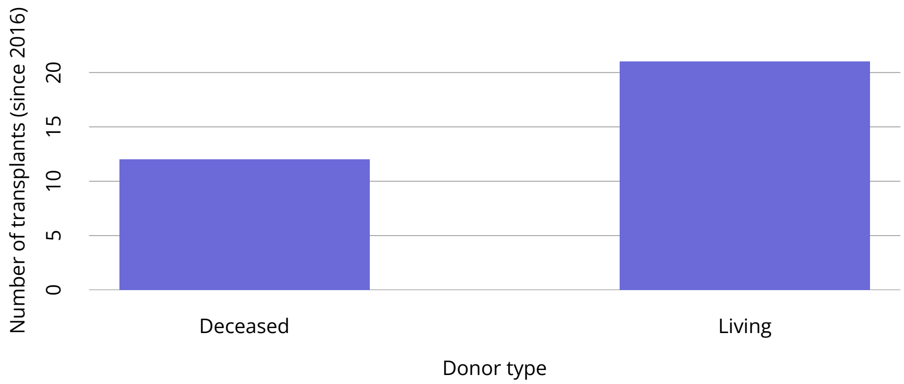

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Figure VCA 10: Number of uterus transplants by donor type since 2016. All uterus transplant recipients, including retransplant, and multiorgan recipients.

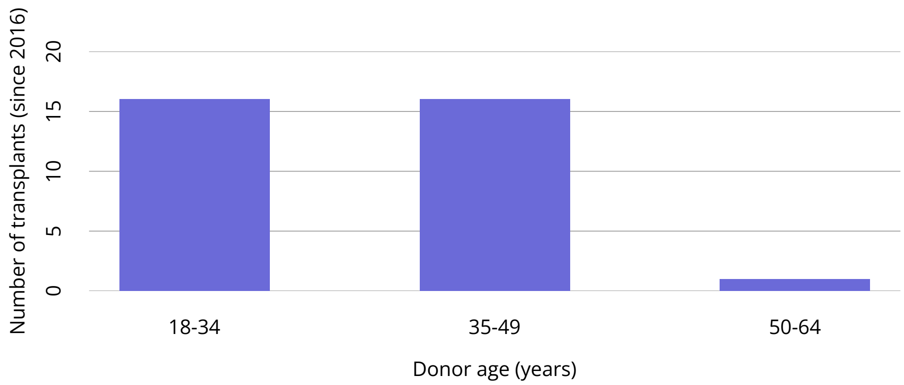

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Figure VCA 11: Number of uterus transplants by donor age since 2016. All uterus transplant recipients, including retransplant, and multiorgan recipients.

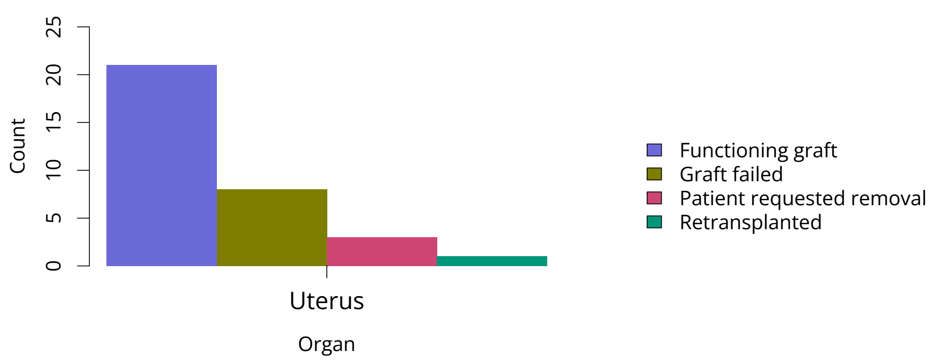

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Figure VCA 12: Posttransplant outcome counts among uterus transplant recipients since 2016. All uterus transplant recipients, including retransplant, and multiorgan recipients.

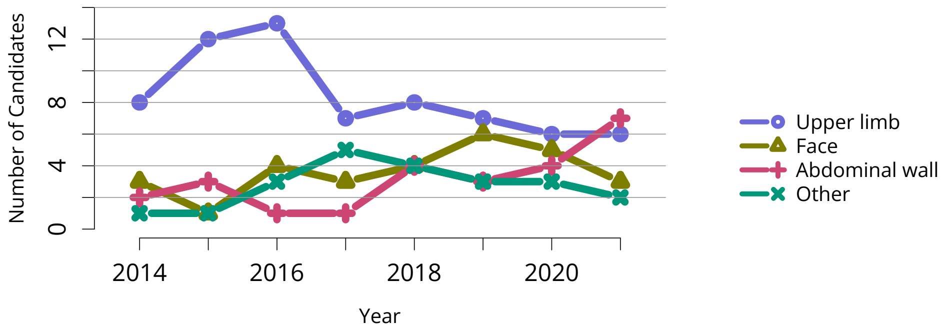

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Figure VCA 13: Number of prevalent non-uterus VCA candidates by organ. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time during the year.

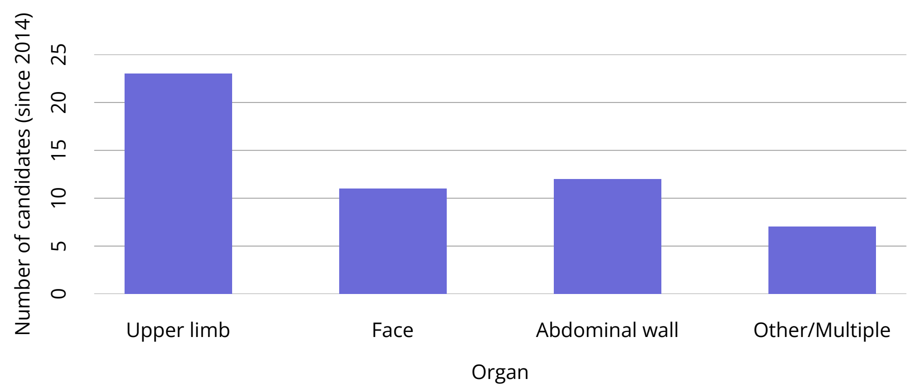

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Figure VCA 14: Number of non-uterus VCA candidates by organ type since 2014. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time.

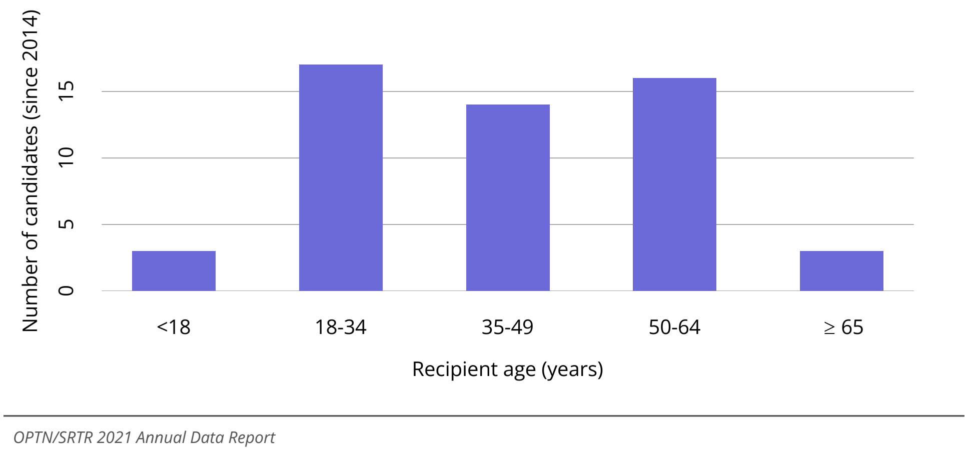

Figure VCA 15: Number of non-uterus VCA candidates by age since 2014. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time.

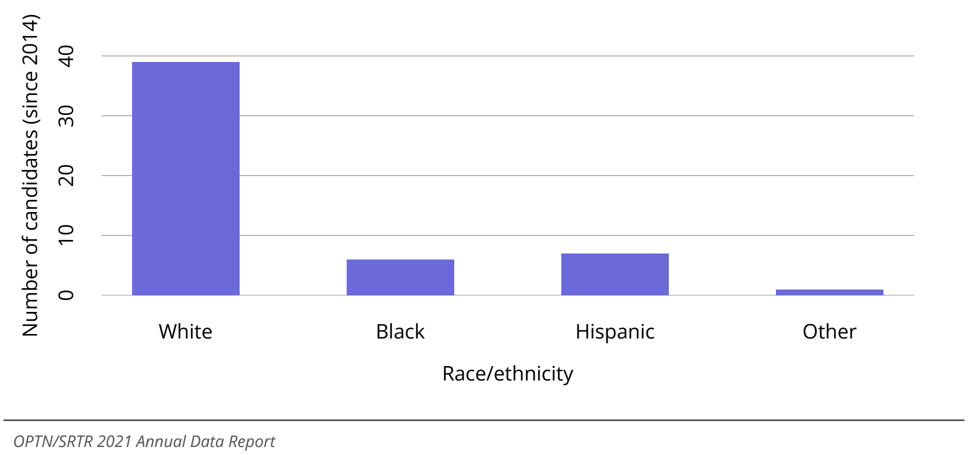

Figure VCA 16: Number of non-uterus VCA candidates by race/ethnicity since 2014. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time.

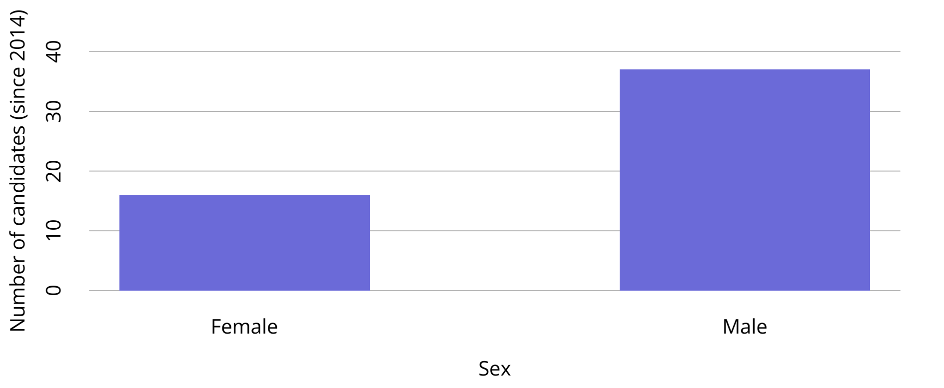

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Figure VCA 17: Number of non-uterus VCA candidates by sex since 2014. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time.

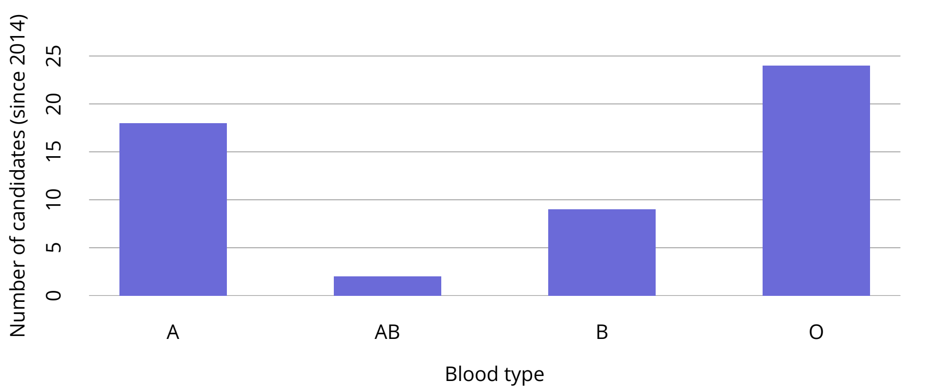

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Figure VCA 18: Number of non-uterus VCA candidates by blood type since 2014. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time.

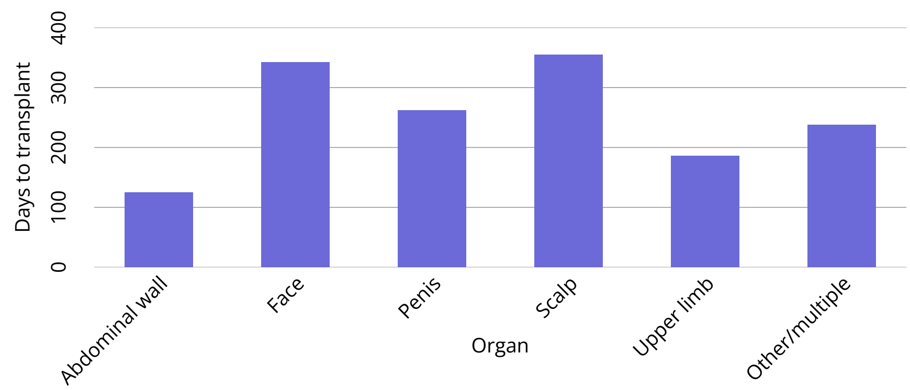

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Figure VCA 19: Median days to transplant among non-uterus VCA candidates by organ since 2014. Candidates listed at multiple centers are counted once per listing. Includes active and inactive candidates on the list any time. Organs with no visible bar in the graph have a median days to transplant of 0, meaning that more than 50% of candidates are added to the list on the same day that they are transplanted or do not have a recorded listing date, in which case their listing date is assumed to be their transplant date.

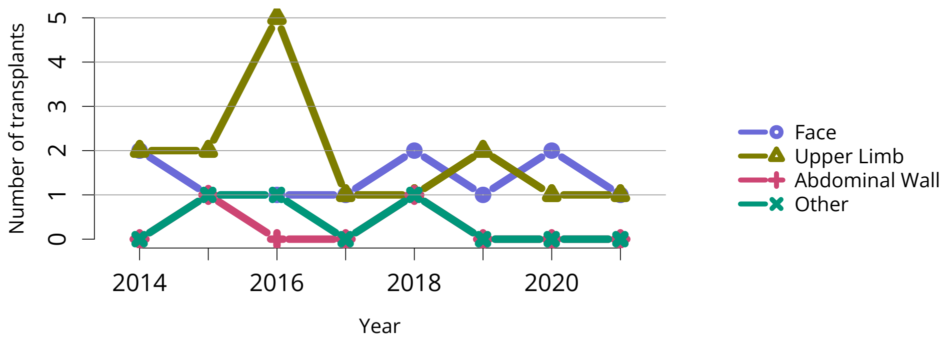

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Figure VCA 20: Number of non-uterus VCA transplants by organ. Non-uterus VCA transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

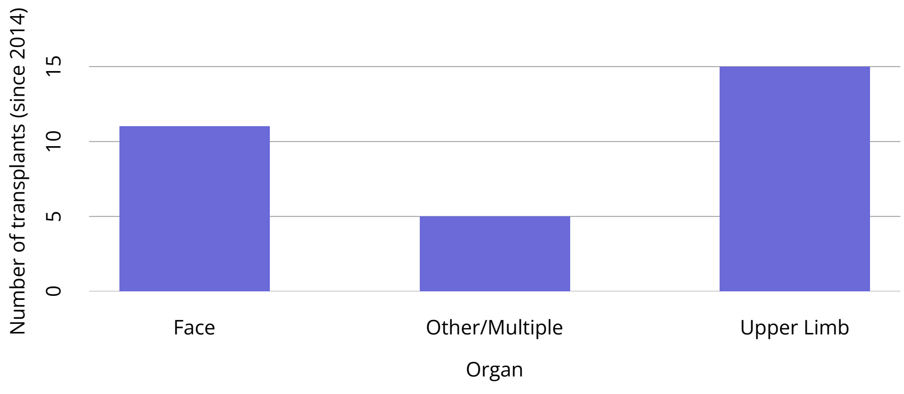

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Figure VCA 21: Number of non-uterus VCA transplants by organ type since 2014. Non-uterus VCA transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients. 'Other/Multiple' category includes penis, scalp and abdominal wall transplants.

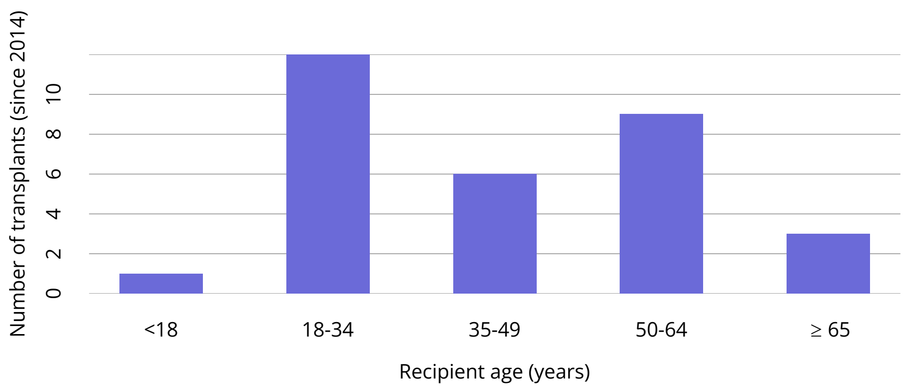

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Figure VCA 22: Number of non-uterus VCA transplants by age since 2014. Non-uterus VCA transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

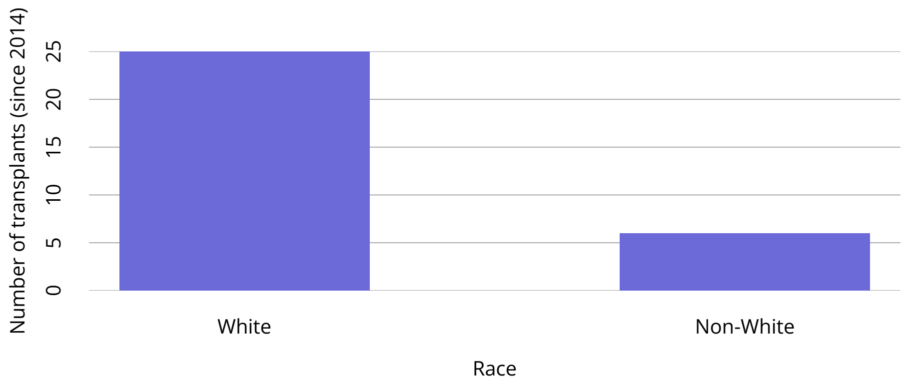

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Figure VCA 23: Number of non-uterus VCA transplants by race since 2014. Non-uterus VCA transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

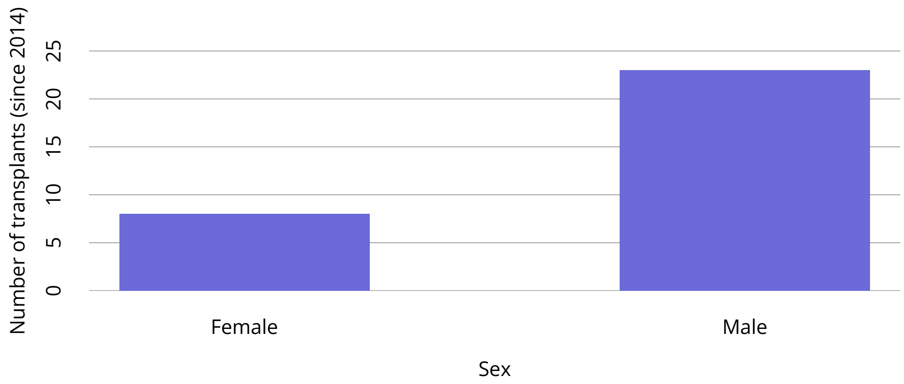

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Figure VCA 24: Number of non-uterus VCA transplants by sex since 2014. Non-uterus VCA transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

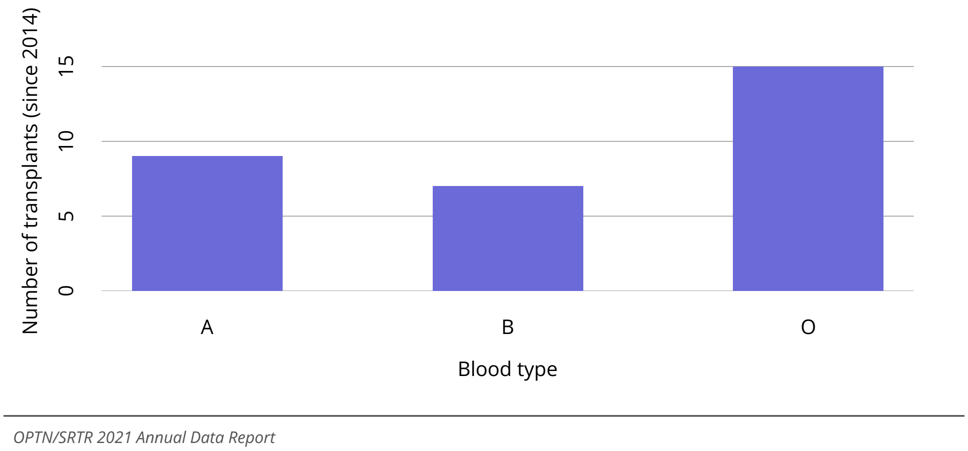

Figure VCA 25: Number of non-uterus VCA transplants by blood type since 2014. Non-uterus VCA transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

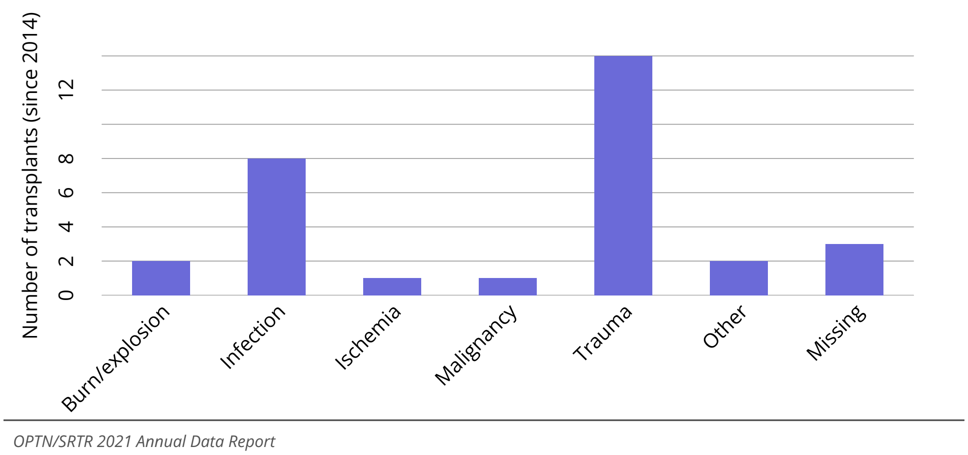

Figure VCA 26: Number of non-uterus VCA transplants by diagnosis since 2014. Non-uterus VCA transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

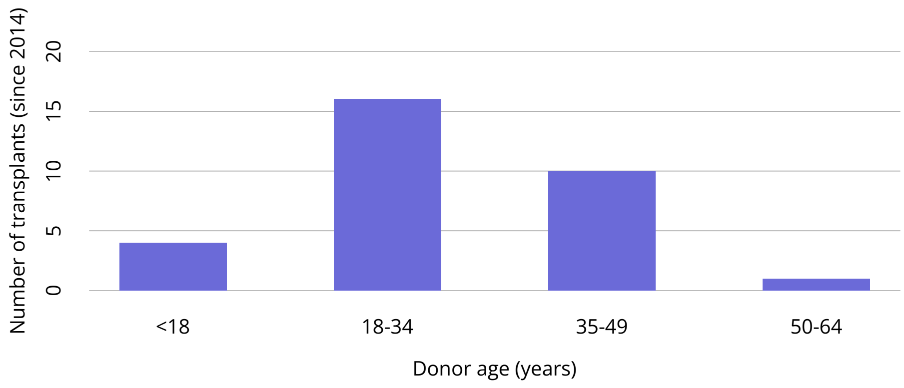

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Figure VCA 27: Number of non-uterus VCA transplants by donor age since 2014. Non-uterus VCA transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

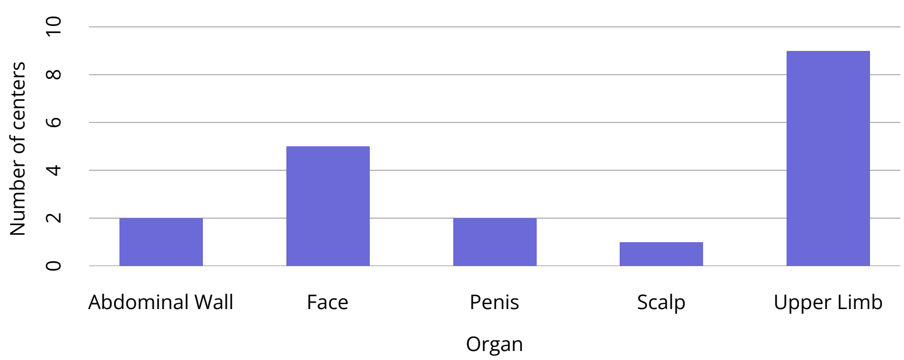

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Figure VCA 28: Number of transplant hospitals performing VCA transplants by non-uterus organ since 2014. All unique transplant hospitals performing non-uterus VCA transplants by organ type

Table VCA 1: Number of uterus transplants by state where transplant hospital is located. All uterus transplant recipients, including retransplant, and multiorgan recipients.

State	Transplant Count
State	
Ohio	8
Pennsylvania	3
Texas	22

Table VCA 2: Posttransplant outcome counts by non-uterus VCA organ type since 2014. Non-uterus VCA transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

Organ	Functioning graft	Graft failed
Organ		
Abdominal Wall	2	0
Face	11	0
Penis	2	0
Scalp	1	0
Upper Limb	14	1

Table VCA 3: Number of non-uterus VCA transplants by state where transplant hospital is located. Non-uterus VCA transplant recipients, including adult and pediatric, retransplant, and multiorgan recipients.

State	Transplant Count
State	
California	1
Florida	1
Kentucky	2
Massachusetts	6
Maryland	3
Minnesota	2
North Carolina	4
New York	2
Ohio	2
Pennsylvania	3
Texas	1