Australia & New Zealand
Liver and Intestinal Transplant Registry

Report on liver and intestinal transplantation activity to 31/12/2023

35th
ANNUAL REPORT
ANZLITR

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1 Preface

We are pleased to present the 35th Annual Report of the Australia and New Zealand Liver and Intestinal Transplant Registry (ANZLITR). This report presents analyses of the cumulative liver and intestinal transplantation data since the establishment of the first liver transplant units in Australia and New Zealand in 1985 to 31st December 2023. The report can be downloaded from the ANZLITR website: https://www.anzlitr.org/. A limited number of hard copies are produced each year. Requests for hard copies may be made via the website or through your local liver or intestinal transplantation unit.

We thank the staff at all the transplantation units who contribute their data into the ANZLITR database. We are grateful to the Australian Government and the Organ and Tissue Authority (OTA) for the ongoing financial support of the Registry. We thank the Australia and New Zealand Organ Donation (ANZOD) Registry for their collaboration and provision of deceased donor data.

Our sincerest thank you to Pamela Dilworth, Cancer Registry Manager, and Mandy Byrne, Registry Manager for ANZLITR, who has since retired. We want to express our deepest gratitude for their many years of service and the impact they have had on the registry. Thank you to Damian Wildie, Number 9 Management Pty Ltd, for hosting the ANZLITR registry application used for data collection and for maintaining the public website as well as developing and maintaining all the complex code that goes into the making sure the Registry functions properly. Finally, thank you to Debra (Debbie) Cormack, Graphic Artist, Queensland Liver Transplant Service, Princess Alexandra Hospital, for doing all the graphic layout to make the annual report look fantastic.

We welcome any feedback or suggestions regarding the ANZLITR Annual Report.

Finally, we would like to acknowledge all the patients and their families that have been involved in the liver and intestinal transplantation program and organ donation over the years.

Dr Michael Fink, Registry Director
Dr Wing-Yee Lo, Registry Manager

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2 Executive Summary

2.1 Liver Transplantation

Annual waiting list mortality has decreased from a peak of 12.3% in 2007 to 3.8% in 2023. In 2023, two of 23 patients listed as category 1 died waiting.

There has been a progressive increase in liver transplantation from deceased donors since 2007 until the impact of COVID-19 resulted in a decrease in the number of deceased donors. Since the end of the COVID-19 pandemic, the number of transplants has slowly recovered. There have been 74 transplants using grafts that underwent normothermic machine perfusion and 17 using grafts that underwent hypothermic oxygenated perfusion. In 2023, 12.5% of deceased liver donors were donation after circulatory death (DCD) donors. Living donor liver transplantation accounted for 1.5% of all transplants performed since 1985.

In 2023, 344 liver transplants were performed in 336 patients. The number of liver transplants increased from 307 in 2021 but has not returned to the pre-COVID peak of 369 transplants in 2018. Between 1985 and 2023, 7,925 transplants were performed in 7,310 patients, including 1,331 transplants in 1,171 children and 6,594 transplants in 6,139 adults. Paediatric age at transplant has decreased progressively and adult recipient age has increased progressively over time. Split liver transplantation is a common form of liver transplantation in children (70.0% in 2023) and whole liver transplantation is the dominant form of liver transplantation in adults (92.8% in 2023).

The commonest indication for transplantation in children is biliary atresia and in adults was hepatitis C virus cirrhosis until 2014, after which hepatocellular carcinoma (HCC) and alcohol-related cirrhosis have become the commonest indications. There has also been a recent increase in patients transplanted for non-alcoholic fatty liver disease (NAFLD). The proportion of patients transplanted primarily for hepatitis C has decreased from 33.8% in 2012 to only 1.4% in 2023.

The 1-, 3-, 5- and 10-year patient survival in recent years for paediatric patients was 97%, 97%, 96% and 89%, respectively. Children transplanted with a split or living donor graft had slightly superior patient survival to those transplanted with a whole graft and those transplanted with a reduced graft had inferior survival ($P < 0.001$).

The 1-, 3-, 5- and 10-year patient survival in recent years for adult patients was 93%, 87%, 86% and 74%, respectively. Patient survival in adults reduced progressively with increasing recipient age ($P < 0.001$) and varied significantly by primary disease ($P < 0.001$), with poorer outcomes for hepatitis C virus and alcohol-related cirrhosis. Patient survival has improved over time for hepatitis B ($P < 0.001$).

The 1-, 3-, 5- and 10-year graft survival in recent years for paediatric patients was 94%, 93%, 86% and 79%, respectively. The 1-, 3-, 5- and 10-year graft survival in recent years for adult patients was 89%, 82%, 81% and 70%, respectively. Graft survival varied significantly by era of transplant (better outcomes since 2000 – 04 era ($P < 0.001$), age group (better outcome in children, $P < 0.001$), graft number ($P < 0.001$), graft type in children (poorer outcome with reduced grafts, $P < 0.001$), deceased donor age (better outcome with younger donors, $P < 0.001$), donor cause of death (poorer outcome from donors who died of stroke, $P < 0.001$), shipping of grafts (better outcome with livers that were not shipped from another unit, $P = 0.003$), cold ischaemia time (better outcome with cold ischaemia time < 431 mins, $P < 0.001$) and recipient urgency category at transplant (poorer outcome for category 1 recipients to 20 years post-transplant, $P < 0.001$).

The commonest indications for retransplantation were vascular problems (27.3%), biliary complications (19.3%), rejection (17.9%), primary non-function or initial poor function (14.4%) and recurrent disease (13.5%). The commonest causes of death were malignancy (25.5%), graft-related causes (16.3%), sepsis (13.7%), cardiovascular disease (8.8%) and multi-organ failure (8.6%).

2.2 Intestinal Transplantation

Twenty-two patients have been listed for intestinal transplantation with one patient relisted in 2019, six years after initial delisting without transplant. Thirteen patients were transplanted, three died waiting, four were delisted without relisting and two were still waiting at the end of 2023.

The 1- and 3-year intestinal patient survival are 92.3% and the 5- and 10-year survival are 76.9%. The 1- and 3-year intestinal graft survival are 84.6% and the 5- and 10-year survival are 70.5%.

Two patients died with a functioning graft, one from respiratory infection at 3 months and one from complications of cardiac surgery at 3.5 years post-transplant. One intestinal graft has failed with the patient supported by total parenteral nutrition (liver and pancreas grafts functioning).

3 Australia and New Zealand Liver and Intestinal Transplant Registry Information

3.1 Australia and New Zealand Liver and Intestinal Transplant Registry Overview

The Australia and New Zealand Liver and Intestinal Transplant Registry (ANZLITR) is a collaborative effort of the liver transplantation units in Australia (Adelaide, Brisbane, Melbourne, Perth, Sydney) and New Zealand (Auckland). The Australian Intestinal Transplant Service, co-located with the Victorian Liver Transplant Unit, offers an intestinal transplant service to Australian and New Zealand paediatric and adult patients. The ANZLITR Management Committee is comprised of the Registry Director, the Registry Manager and the director of each liver transplant unit. The Management Committee oversees all activities associated with the Registry, including database design, data collection, analysis, reporting and approval of research utilising Registry data.

The Registry contains de-identified data on all liver and intestinal transplantation activity across Australia and New Zealand since the first liver transplant in the modern era in 1985. Following formal Human Research Ethics Committee (HREC) approval of the Registry in 2019, collection of identifying data on patients who sign the new consent forms commenced. Data are collected and entered into the Registry by a data manager/transplant nurse employed by each Liver Transplant Unit. Data include:

- demographics on patients placed on the liver and intestinal transplant waiting lists
- identifying data such as recipient name only if new consent form signed
- information at time of listing for transplant such as diagnoses, medical and laboratory information and urgency category
- date patient listed on transplant waiting list (full collection from 2004, partial collection prior to 2004)
- information about the transplant such as date, graft number, type of graft, donor source, serology and operative information
- information about the outcome of the transplant such as the status of the graft, patient status, cause of death
- information about patients delisted without transplantation, including reason for delisting
- donor information – deceased (from 1989 onwards) and living donors
- cancer after transplantation

3.2 History of the Australia and New Zealand Liver and Intestinal Transplant Registry

Data have been collected on all liver transplants in Australia and New Zealand since 1985. The first liver transplant in Australia performed in New South Wales in 1968 (patient died 5 days post-transplant) is not included in the registry. Queensland performed their first liver transplant in 1985. The second transplant by NSW occurred in 1986. Victoria performed their first liver transplant in 1988, South Australia and Western Australia, in 1992 and New Zealand, in 1998. The first intestinal transplant in Australia and New Zealand was performed by the Australian Intestinal Transplant Service in Melbourne in 2010.

In 1988, the three established liver transplants units in Australia (New South Wales, Queensland and Victoria) agreed to combine their liver transplant data into a central database to provide an overall report on liver transplantation and outcomes. In 1999, all Australian and New Zealand units agreed to collaborate and contribute their data to a combined registry and this was named the Australia and New Zealand Liver Transplant Registry (ANZLTR). In 2018, the registry name was changed to Australia and New Zealand Liver and Intestinal Transplant Registry (ANZLITR), to reflect that the Registry contains both liver and intestinal listing and transplant data.

The initial liver transplantation data reporting was undertaken by Professor A.G.R. Sheil at Royal Prince Alfred Hospital in Sydney in the late eighties. In the 1990s, reporting of liver transplantation activity alternated between Professor Sheil at Royal Prince Alfred Hospital in Sydney and Professor Russell Strong at Princess Alexandra Hospital in Brisbane.

Initial funding for the data collection from 1988 to 2000 was by the liver transplant units. In May 2001, at the Australian Health Ministers' Advisory Council meeting, the Registry was formalised and funding from the Commonwealth

Government was provided for the first time. This included funding for a part-time data manager (Ms. Glenda Balderson) and production costs of the Annual Report. An ANZLTR Management Committee was formed, comprising the head or a senior consultant from each of the liver transplant units and the ANZLTR data manager.

In 2003, the Management Committee decided to move to a web-based format and the liver transplant units provided the funds for the development of a web-based database. The electronic Registry was established and managed by Ms. Glenda Balderson (Registry Manager) and Professor Stephen Lynch (Registry Director) at Princess Alexandra Hospital in Brisbane. After importation of historical data, near real time data collection began in January 2004. Collection of all new listings and listing outcome data commenced at this time.

In 2007-08, the Commonwealth Funding Agreement was extended to include the costs of the web-based program hosting, software development and maintenance, and funds for each unit to assist with data entry services. Currently the ANZLITR is fully funded by the Organ and Tissue Authority, Australian Government.

In August 2018, the coordinating centre moved to Austin Health in Melbourne. Dr. Michael Fink commenced as the Registry Director and Ms. Mandy Byrne as the Registry Manager. Formal Human Research Ethics Committee approval for the Registry was obtained in 2019 under the National Mutual Acceptance scheme. Units obtained site specific ethics approval during 2020/2021 and began using the new consent forms that informed patients about identified data collection. Collection of identified patient data commenced only on patients who signed the new consent forms. Strict safeguards and security measures have been established to protect and control access to identified data. Identified data will be used to ensure integrity of data matching with external databases and will not be disclosed in research data releases or publications.

In 2021, the design of the HCC module in the Registry was updated to provide a clearer view and process for entering data and to include a more comprehensive data collection.

The Liver Transplantation Cancer Registry was established alongside the liver transplantation data collection by Professor A.G.R. Sheil at Royal Prince Alfred Hospital in Sydney in the mid-eighties. The Liver Cancer Registry was hosted and managed at Royal Prince Alfred Hospital and they undertake the cancer reporting for the ANZLITR Annual Report. Since the retirement of Ms. Pamela Dilworth, the cancer registry manager, the Liver Cancer Registry is now being incorporated into the main liver and intestinal transplant registry with Dr. Wing-Yee Lo as the new Registry Manager following the retirement of Ms. Mandy Byrne in 2023.

3.3 Australia and New Zealand Liver and Intestinal Transplant Registry Application

The ANZLITR database consists of an on-line data registry application which is hosted on an Australian based server cloud platform (Digital Pacific), with a Linux operating system and a web-based application using a Postgres database repository. High level security is maintained including high level user authentication, firewall protection and an intrusion prevention software framework. Two factor authentication was activated in 2021.

Access to this system is strictly controlled and only authenticated users are allowed access to the application. Users from each liver transplant unit only have full access to data relevant to their own patients.

3.4 Australia and New Zealand Liver and Intestinal Transplant Registry Website

The ANZLITR website is accessible to the public via the following address: https://www.anzlitr.org/
The website provides:

- an overview and history of the Registry
- a list of participating centres
- copies of Annual Reports
- links to international liver transplant registries, organ donation website in ANZ and other useful sites
- contact information

3.5 Funding of the Registry

The ANZLITR is funded by the Australian Government Organ and Tissue Authority.

3.6 Registry Secretariat

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3.7 Registry Management Committee

Director	Dr Michael Fink, Austin Health
Manager	Dr Wing-Yee Lo, Austin Health
New South Wales	Professor Simone Strasser, Royal Prince Alfred Hospital and Westmead Children's Hospital
Queensland	Dr Peter Hodgkinson, Princess Alexandra Hospital and Queensland Children's Hospital
South Australia	Dr John Chen, Flinders Medical Centre
Vicoria	Professor Robert Jones, Austin Health and The Royal Children's Hospital
Western Australia	Professor Luc Delriviere, Sir Charles Gairdner Hospital
New Zealand	Professor Ed Gane, Auckland City Hospital and Starship Children's Hospital

3.8 Participating Centres

Australian National Liver Transplant Unit (NSW)

Royal Prince Alfred Hospital
Missenden Road
Camperdown NSW 2050

The Children's Hospital at Westmead
Hawkesbury Road
Westmead NSW 2145

Queensland Liver Transplant Service

Princess Alexandra Hospital
Ipswich Road
Woolloongabba QLD 4102

Queensland Children's Hospital
Stanley Street
South Brisbane QLD 4101

South Australian Liver Transplant Unit

Flinders Medical Centre
Flinders Drive
Bedford Park SA 5042

Victorian Liver Transplant Unit
Australian Intestinal Transplant Service

Austin Health
Studley Road
Heidelberg VIC 3084

The Royal Children's Hospital Melbourne
Flemington Road
Parkville VIC 3052

WA Liver Transplantation Service

Sir Charles Gairdner Hospital
Verdun Street
Nedlands WA 6009

New Zealand Liver Transplant Unit

Auckland City Hospital
Park Road
Auckland New Zealand

Starship Children's Hospital
Park Road
Auckland New Zealand

4 Methodology

4.1 Data Collection and Preparation

Data are entered into the web-based Registry by data managers / transplant nurses at each Liver Transplant Unit in near real time. The Registry Manager undertakes regular data validation and cleaning steps to ensure data are accurate. Data are downloaded from the Registry to construct the analysis dataset after all validation and cleaning have been undertaken.

4.2 Waiting Lists

Comprehensive waiting list data are available from 1 January 2004. The waiting list dataset contains all patients who have been added to the waiting list for a liver or intestinal transplant. Listing can occur in patients who have or have not had a prior liver transplant.

At the end of each year, the outcome of each listing is categorised as transplanted, waiting list mortality (patient died while on the waiting list or within one year of delisting for reasons other than transplantation), delisted without transplant (patient condition improved; patient too sick for transplant but still alive one year after delisting, other reasons) or listed at end of year. Waiting list mortality rate is calculated by dividing waiting list mortality by number of patients on the waiting list during the year (patients active at start of the year plus new patients listed during the year).

4.2.1 Liver Transplant Waiting List Dataset (7,184 listings)

Comprehensive waiting list data including listing and delisting date and delisting outcome are available from 1 January 2004. There are data on 7,184 active listings from this date.

A benchmarking analysis to compare 90-day and 1-year waiting list mortality between the six Australian and New Zealand liver transplant units was undertaken for patients listed from 1/1/2018 to 31/12/2022 who were ≥ 18 years old at listing, who were not listed as urgent (category 1 or 2) patients, who were listed for liver only transplantation and who had not undergone previous liver transplantation (n = 1,439 patients).

4.2.2 Intestinal Transplant Waiting List Dataset (23 listings)

Comprehensive waiting list data including listing and delisting date and delisting outcome are available from the first listing in 2007. There are 23 listings for 22 patients.

4.3 Liver Transplant Recipient Datasets

To ensure a consistent process for analysis, three datasets have been constructed from the transplant recipient data, as listed below.

4.3.1 Demographics Dataset (7,310 patients)

The demographic analysis dataset is based on the first liver transplant in Australia or New Zealand for each patient. Six patients had their first liver transplant overseas prior to undergoing retransplantation in Australia and New Zealand, including one patient who had two liver transplants overseas. Their first liver transplant in Australia or New Zealand has been used for demographic data analysis.

4.3.2 Patient Survival and Initial Diagnosis Dataset (7,304 patients)

The patient survival analysis dataset only includes patients who had their first transplant in Australia or New Zealand. The six patients who had prior liver transplants overseas are excluded from this dataset.

A benchmarking analysis to compare post-transplant mortality between the six Australian and New Zealand liver transplant units was undertaken for patients transplanted from 1/1/2018 to 31/12/2022 (1-year post-transplant mortality, n = 1,203 patients) and from 1/1/2014 to 31/12/2018 (5-year post-transplant mortality, n = 1,180 patients) who were ≥ 18 years old at transplantation, who were not transplanted as urgent (category 1 or 2) patients, who underwent liver only transplantation and who had not undergone previous liver transplantation.

4.3.3 Graft Survival Dataset (7,925 transplants)

All Australian and New Zealand transplants are included in this dataset. Patients who have had one or two prior transplants overseas have their first graft number in Australia or New Zealand recorded as graft two or three, respectively. Both deceased and living donor grafts are included in this analysis, unless otherwise specified.

A benchmarking analysis to compare graft loss between the six Australian and New Zealand liver transplant units was undertaken for patients transplanted from 1/1/2018 to 31/12/2022 (1-year graft loss, n = 1,203 grafts) and from 1/1/2014 to 31/12/2018 (5-year graft loss, n = 1,180 grafts) who were ≥ 18 years old at transplantation, who were not transplanted as urgent (category 1 or 2) patients, who underwent liver only transplantation and who had not undergone previous liver transplantation.

4.4 Deceased and Living Liver Donor Datasets

4.4.1 Deceased Liver Donor Dataset (7,202 deceased donors; 7,677 grafts)

The Australia and New Zealand Organ Donation (ANZOD) Registry provides the ANZLITR with deceased donor data for analysis. A total of 7,803 grafts were sourced from 7,328 deceased donors. Collection of deceased donor information commenced in 1989. There is no deceased donor information on 126 grafts from 1985 to 1988.

Deceased donor data are available on 7,202 donors. A total of 6,726 donated livers were allocated to a single recipient and 476 donated livers were split (one graft was not utilised as recipient found to be unsuitable at time of transplant), resulting in a total of 7,677 grafts with deceased donor data.

4.4.2 Living Liver Donor Dataset (122 living donors)

Data on 122 living liver donors (including five domino living donors) are collected in ANZLITR.

4.5 Intestinal Dataset (13 transplants)

The intestinal dataset includes data on all 22 wait-listed patients (the first listing was in 2007) and all 13 transplanted patients (the first intestinal transplant was performed in 2010). Patients requiring both liver and intestinal transplants are included in both the liver and intestinal datasets.

4.6 Patient Age Groups

Paediatric patients are defined as less than 16 years old and adults are 16 years and older.

4.7 Survival Curves

4.7.1 Patient Survival

Patient survival is based on patients who had their first liver transplant in Australia or New Zealand (i.e. Graft 1). Patients are classified as either alive (censored at the earlier of date of last contact or 31 December 2023) or dead. Patients may have undergone retransplantation in the time period. Retransplantation is not considered an event and the patient is not censored at retransplantation for patient survival analysis.

4.7.2 Graft Survival

Graft survival is based on patients who had a liver transplant in Australia or New Zealand (i.e. any graft number). Grafts are classified as either functioning (censored at the earlier of date of last contact or 31 December 2023) or failed (due to death, re-transplantation or for intestinal transplants, intestinal graft loss where the patient is supported by total parenteral nutrition).

4.8 Statistical Analysis

Statistical analyses were undertaken using IBM SPSS Statistics 29.

The log-rank (Mantel-Cox) test was used to compare the survival distributions of samples in Kaplan-Meier survival curve analysis.

For the benchmarking analysis, hierarchical regression models were generated. This method uses risk adjustment to account for variations in donor and recipient factors that might impact outcome and enables the estimation of the effect of the transplant units on outcomes. Variables used for risk adjustment were those that could plausibly have an effect on the outcomes of interest based on previous literature, previous analysis of the Registry data and expert opinion. Variables were recorded at the time of listing or transplantation. Risk standardised outcome rates were calculated for each unit using the estimated unit-specific parameters from the respective hierarchical models. For this analysis, the log-odds of outcomes within 90 days/1 year of listing or 1 year/5 years post-transplant were modelled as a function of patient age and clinical characteristics and a random unit specific effect. This strategy accounts for within-unit correlation of the observed outcomes and models the assumption that there are underlying differences in quality among units. These rates are obtained as the ratio of predicted to expected outcomes, multiplied by the global unadjusted rate. The ratio is the predicted outcome in each unit, given its patient mix and unit-specific effect divided by the expected outcome in that unit given the same patient mix and the average unit-specific effect. One of the results of the analysis is the intraclass coefficient (rho), which gives an estimate of the contribution of the transplant units (as opposed to donor or recipient factors) to the outcome, and is therefore an indicator of quality. These benchmarking analyses were undertaken by Prof Leonid Churilov, the University of Melbourne.

Receiver operating characteristic analysis of cold ischaemia time in relation to graft loss within 1 year was performed and the Youden-J statistic was calculated to determine the optimal cut off for the categories of cold ischaemia time.

The Nelson-Aalen estimator was used to estimate the cumulative expected events to determine the cumulative risk of diagnosis of skin or non-skin cancer following liver transplant.

P values < 0.05 were considered significant.

5 Liver Transplant Waiting List

5.1 Waiting List Activity

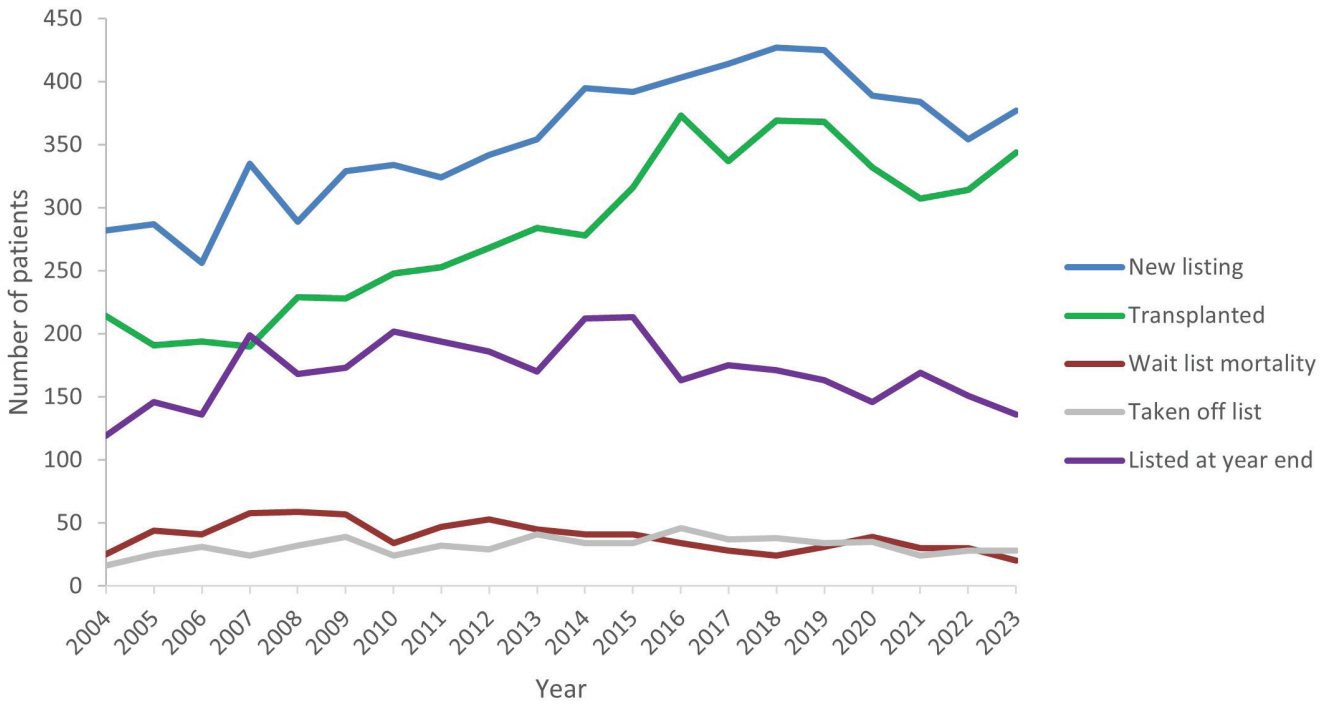
Up to 2019, there had been a steady increase in the number of new listings on the liver transplant waiting list per year, increasing 50.7% from 2004 to 2019 (282 to 425, Figure 1). However, from 2019 to 2022, the number of patients listed for liver transplantation fell by 16.7% (425 to 354). Since then, the number has slightly improved by 6.5% in 2023 (354 to 377).

Between 2004 and 2019, there was a 72.0% increase in the number of liver transplants performed per year (214 to 368). However, there was a 9.8% decrease (to 332) in 2020 and another 7.5% decrease in 2021 to 307 liver transplants. In 2022, there was a 2.3% increase to 314 liver transplants and a 9.6% increase to 344 transplants in 2023 performed in Australia and New Zealand. It is likely that the reduction in transplant activity over the last few years is related to the COVID-19 pandemic.

There were 136 people on the waiting list for a liver transplant at the end of 2023.

The annual waiting list mortality rate progressively decreased from a peak of 12.3% in 2007 to 4.0% in 2018 and has remained between 5% and 7% since this time. The annual waiting list mortality was 5.7% in 2022 and has decreased to 3.8% in 2023.

Figure 1. Liver transplant waiting list activity – all patients



5.2 Paediatric Waiting List Activity

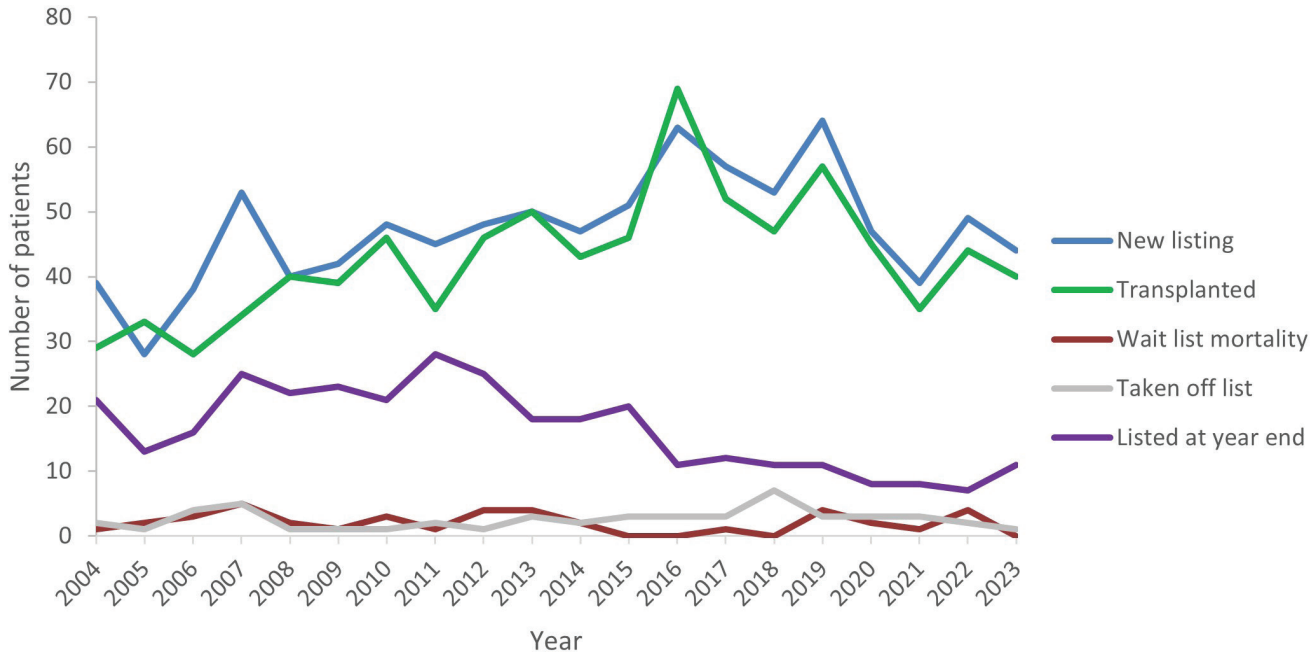
The number of new paediatric listings on the liver transplant waiting list showed a gradual increase over time, increasing 64.1% from 2004 to 2019 (39 to 64, Figure 2). However, from 2019 to 2020, the number of children listed for liver transplantation fell by 26.6% (64 to 47), then another 17.0% decrease to 39 in 2021. In 2022, there was a 25.6% increase to 49 listings. However, there has been a slight reduction of 10.2% in paediatric listings in 2023 from 49 to 44.

Between 2004 and 2019, there was a 96.6% increase in the number of paediatric liver transplants performed per year (29 to 57). However, there was a 21.1% decrease (to 45) in 2020 and another 22.2% decrease (to 35) in 2021. In 2022, there was a 25.7% increase to 44 paediatric liver transplants performed in Australia and New Zealand, but this has again decreased by 9.1% to 40 transplants in 2023. It is likely that the reduction in transplant activity over the last few years is at least partly related to the COVID-19 pandemic.

The number of children on the liver transplant waiting list at the end of the year peaked at 28 in 2011 and has fallen to 11 at the end of 2023.

The paediatric annual waiting list mortality rate has progressively decreased from a peak of 7.2% in 2007 to 2.1% in 2021. However, the paediatric mortality rate rose to 7.0% in 2022 but has now decreased to 0% mortality in 2023.

Figure 2. Paediatric liver transplant waiting list activity



5.3 Adult Waiting List Activity

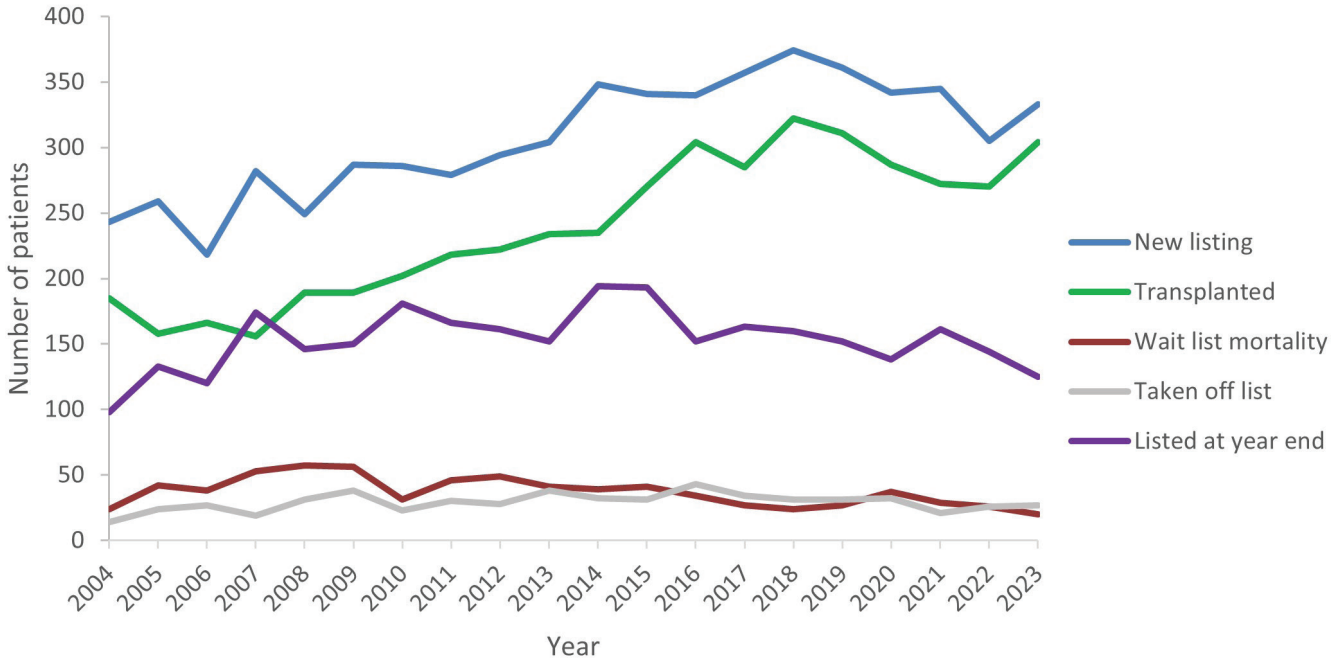
Up to 2019, there had been a steady increase in the number of new adult listings on the liver transplant waiting list per year, increasing 48.6% from 2004 to 2019 (243 to 361, Figure 3). However, from 2019 to 2020, the number of adults listed for liver transplantation fell by 5.3% (361 to 342), then there was a small 0.9% increase to 345 in 2021. In 2022, there was an 11.6% decrease to 305 listings, however, the number of listings has increased by 9.2% to 333 in 2023.

Between 2004 and 2019, there was a 68.1% increase in the number of adult liver transplants performed per year (185 to 311). However, there was an 7.7% decrease (to 287) in 2020, another 5.2% decrease in 2021 to 272 and another 0.7% decrease in 2022 to 270 liver transplants performed in Australia and New Zealand. The number of adult liver transplants has increased by 12.6% to 304 in 2023. It is likely that the reduction in transplant activity over the last few years is at least partly related to the COVID-19 pandemic and has now slowly recovered. It is also possible that reduction in demand for transplantation is related to a reduction in end-stage liver disease in hepatitis C virus cirrhosis related to the wide availability of direct acting antiviral therapy.

The number of adults on the waiting list for a liver transplant at the end of the year peaked at 194 in 2014 and has fallen to 125 in 2023.

The adult annual waiting list mortality rate peaked at 13.5% in 2008 and has fallen to 4.2% in 2023

Figure 3. Adult liver transplant waiting list activity

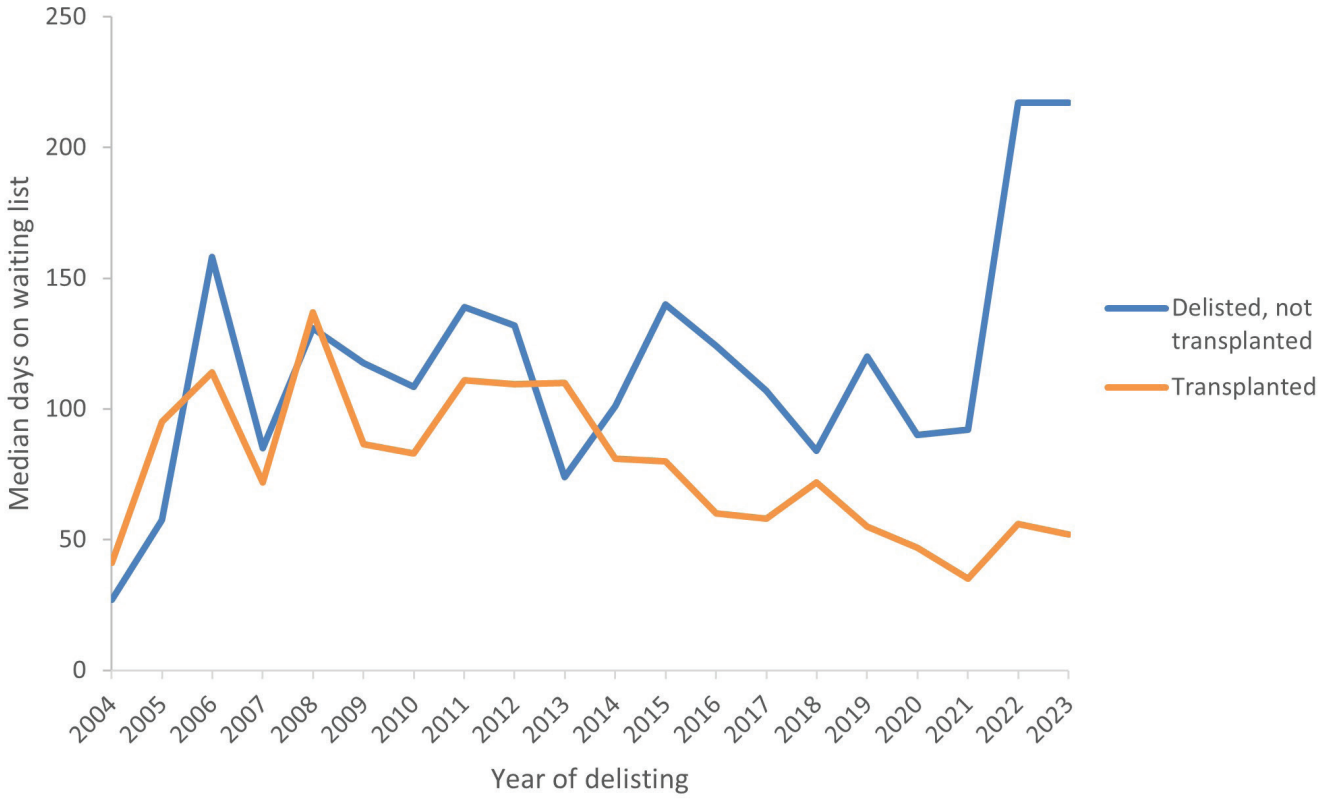


Benchmarking analysis using hierarchical regression models estimated that 5.2% of the variation in 90-day waiting list mortality and 2.2% of the variation in 1-year waiting list mortality was due to variation between liver transplant units. One transplant unit appears to be an outlier in this analysis. A consensus of the Liver and Intestinal Transplant Advisory Committee of the Transplantation Society of Australia and New Zealand is that wait list outcomes will be reviewed both by the unit involved and an independent expert panel, to determine factors involved in the variation and whether any action should be undertaken.

5.4 Time on the Waiting List

The median time from listing to transplantation by the year of transplantation was 137 days in 2008 and has decreased to 52 days in 2023 (Figure 4). The median time from listing to delisting without transplant was 140 days in 2015 and has increased to 217 days in 2023.

Figure 4. Time on waiting list by year of delisting



5.5 Urgent Waiting List Activity

Certain categories of patients have a high risk of dying waiting for liver transplantation and a short window of opportunity for transplantation. A system of organ sharing between units in Australia and New Zealand has been developed by the Liver and Intestinal Transplant Advisory Committee of the Transplantation Society of Australia and New Zealand. The guidelines can be viewed via the following address:
https://tsanz.com.au/guidelinesethics-documents/organallocationguidelines.htm

Urgent cases are flagged in the waiting list as Category 1 and Category 2.

Category 1 patients are defined as patients suitable for transplantation with acute liver failure who are ventilated and in an ICU at risk of imminent death. When such patients are listed, allocation to them is mandatory.

Category 2 patients are defined as listed below. When a donor liver becomes available, discussion occurs between the urgent listing unit and the local retrieving unit to determine optimal allocation.

- Category 2a. Patients suitable for transplantation with acute liver failure from whatever cause who are not yet ventilated but who meet the King's College criteria. This includes patients who have acute liver failure because of vascular thrombosis in a liver allograft. In addition, this category includes paediatric candidates with severe acute or chronic liver disease who have deteriorated and are in a paediatric intensive care unit. It is subject to discussion between the directors (or delegates) of donor and recipient state (or New Zealand) liver transplant centres.
- Category 2b. Paediatric patients suitable for transplantation who suffer from severe metabolic disorders or hepatoblastoma (after initial treatment) for whom a limited time period exists during which liver transplant is possible.
- Category 2c. Patients awaiting combined liver-intestinal transplantation by the National Intestinal Transplantation programme in Victoria. If a potentially suitable donor is identified, the home unit must discuss allocation of donor organs with the Victoria unit unless the home unit has a suitable liver recipient with a MELD score of 25 or greater.

Good outcomes have been achieved for patients listed as urgent category 1 and 2 (Figure 5 and Figure 6).

The urgent category 1 waiting list mortality rate for 2018 – 2022 was 8.6% (eight deaths in 93 category 1 listings). However, the waiting list mortality for 2023 has risen to 21.7% (5 of 23 patients in category 1).

The urgent category 2 waiting list mortality rate for 2018 – 2022 was 3.9% (three deaths in 76 category 2 listings). There were no deaths on the waiting list under category 2 in 2023.

Figure 5. Urgent category 1 waiting list outcomes
Data show the outcome of urgent listings for each year. The outcomes of patients still listed at the end of the year are reported in the subsequent year.

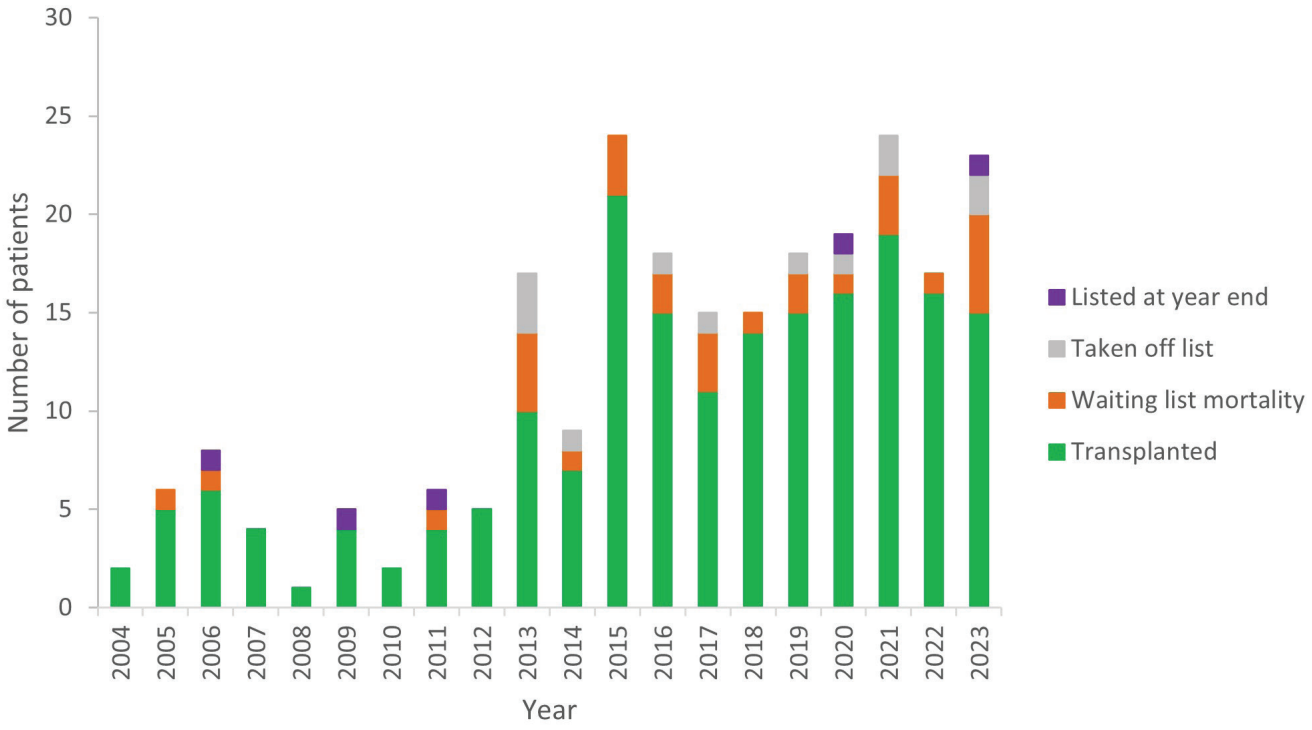
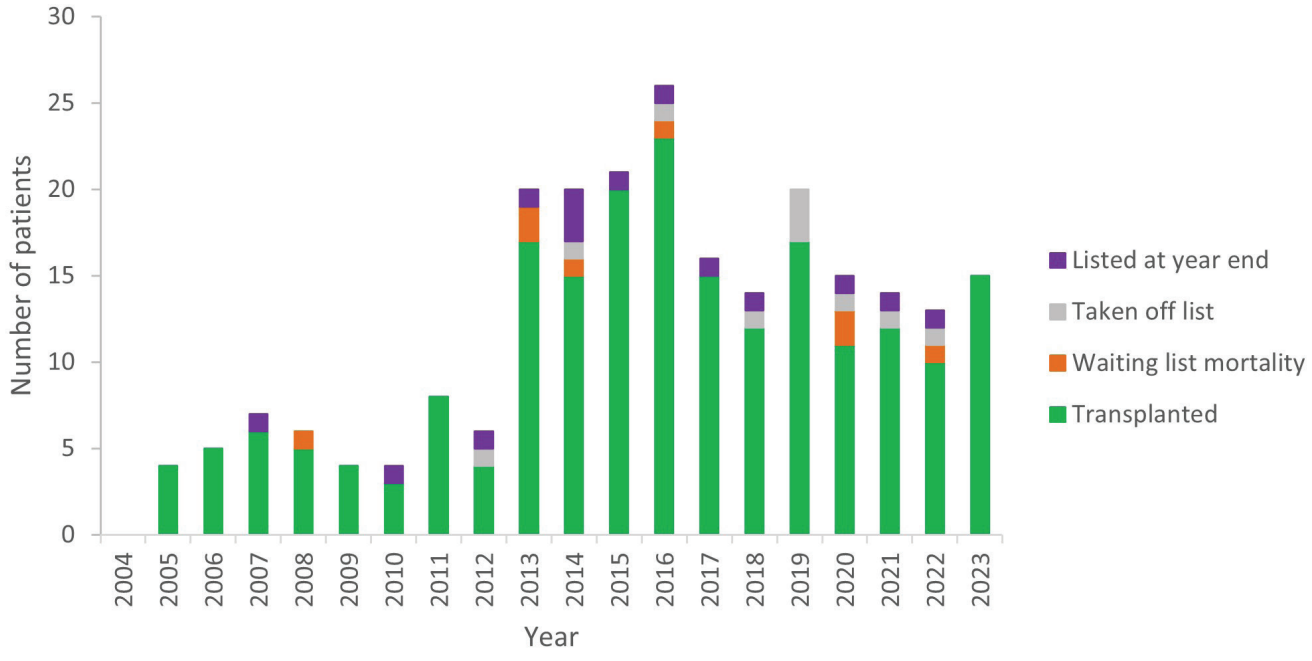


Figure 6. Urgent category 2 waiting list outcomes
Data show the outcome of urgent listings for each year. The outcomes of patients still listed at the end of the year are reported in the subsequent year.



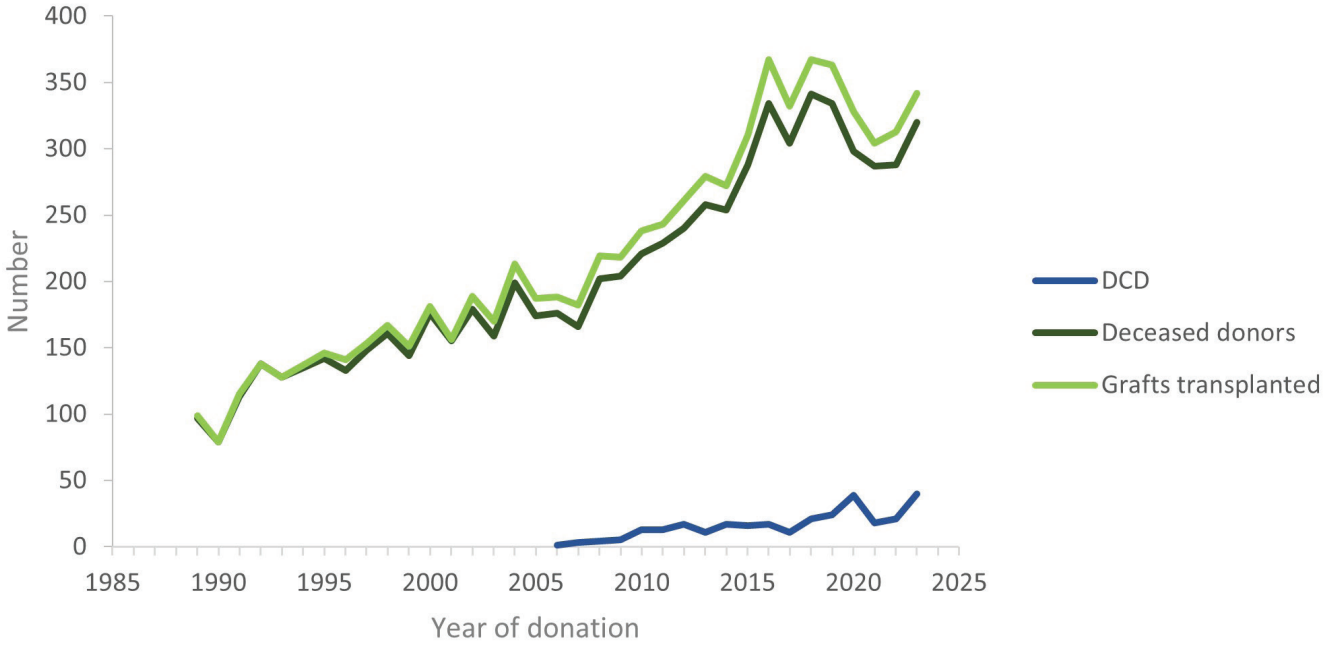
6 Deceased Liver Donors

Of 7,925 liver transplants, 7,803 (98.5%) were sourced from deceased donors, with only a small proportion from living donors (122, 1.5%). Collection of deceased donor information commenced in 1989. There is no deceased donor information on 126 transplants from 1985 to 1988. Subsequent analysis is limited 7,202 deceased donors and 7,677 grafts from 1989 onwards with donor data.

6.1 Deceased Donors and Grafts Transplanted Per Year

Of 7,202 deceased donors with donor data, 476 donated livers were split (one graft was not utilised from one split liver, so there were 951 split grafts transplanted), resulting in a total of 7,677 grafts. The number of deceased donors has grown steadily over the years until recently (Figure 7). In 2022 there were 288 deceased donors providing 313 grafts. The number of deceased donors and grafts have not returned to the peak that occurred in 2018. In 2023, the number of deceased donors increased to 320 providing 342 grafts. Of the 320 deceased donors, 40 (12.5%) were donation after circulatory death donors.

Figure 7. Deceased donors and grafts transplanted by year



Abbreviation: DCD, donation after circulatory death

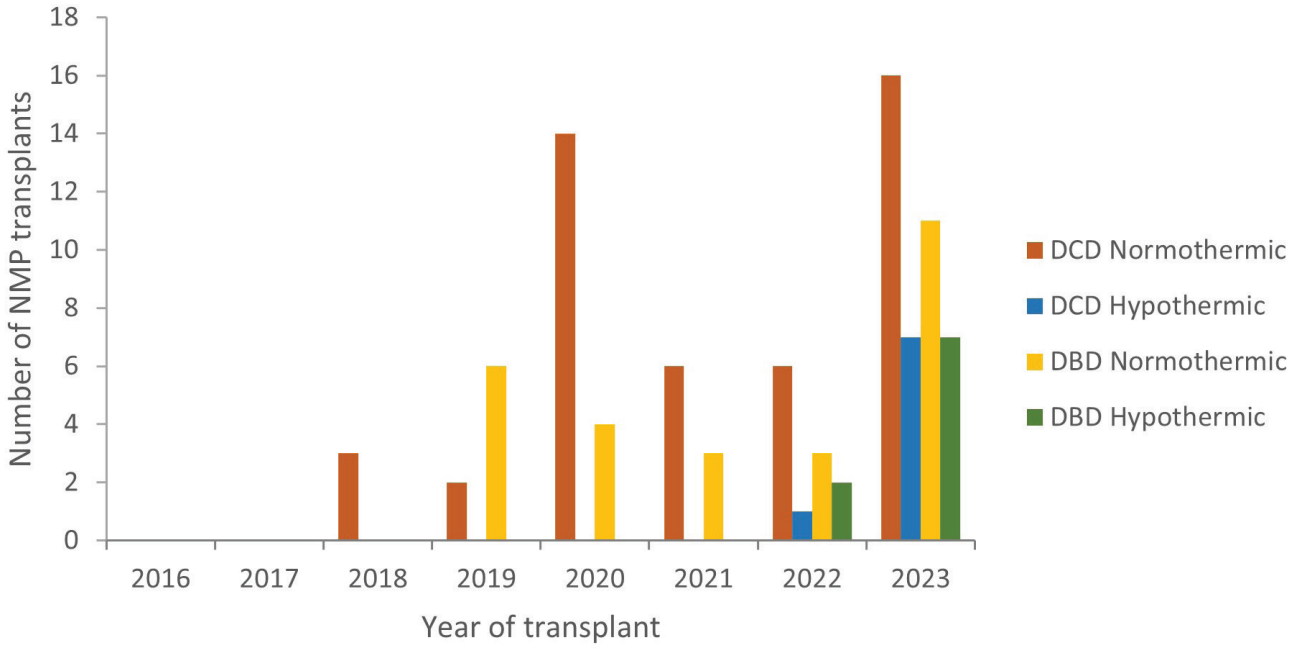
6.2 Machine Perfusion of Deceased Donor Livers

Machine perfusion has been introduced as a preservation method in liver transplantation in recent years. Machine perfusion enables assessment of graft function prior to transplantation (at least during normothermic perfusion) and it has been shown to improve early graft function after transplantation and can safely extend the time between procurement and transplantation.

Queensland commenced normothermic machine perfusion (NMP) in 2018 and Victoria in 2019. New Zealand commenced hypothermic oxygenated perfusion (HOPE) in 2022.

There have been 74 transplants using NMP and 17 using HOPE. In 2022, seven (33.3%) of the 21 transplanted livers sourced from DCD donors were supported using machine perfusion and in 2023, this has increased to 23 (57.5%) of 40 transplanted livers (Figure 8, Table 1).

Figure 8. Transplants utilising machine perfusion with donor source type



Abbreviations: DCD, donation after circulatory death; DBD, donation after brain death

Table 1. Transplants with donor source type and use of machine perfusion

	Donation after circulatory death					Donation after Brain Death				
Transplant Year	**DCD NMP**	**DCD HOPE**	**DCD no MP**	**DCD Total**	***% DCD with MP***	**DBD NMP**	**DBD HOPE**	**DBD no MP**	**DBD Total**	***% DBD with MP***
2017	0	0	11	**11**	*0.0%*	0	0	321	**321**	*0.0%*
2018	3	0	18	**21**	*14.3%*	0	0	346	**346**	*0.0%*
2019	2	0	22	**24**	*8.3%*	6	0	333	**339**	*1.8%*
2020	14	0	25	**39**	*35.9%*	4	0	285	**289**	*1.4%*
2021	6	0	12	**18**	*33.3%*	3	0	283	**286**	*1.0%*
2022	6	1	14	**21**	*33.3%*	3	2	287	**292**	*1.7%*
2023	16	7	17	**40**	*57.5%*	11	7	284	**302**	*6.0%*

Abbreviations: DCD, donation after circulatory death; DBD, donation after brain death; NMP, normothermic machine perfusion; HOPE, hypothermic oxygenated perfusion; MP, machine perfusion

6.3 Age of Deceased Donors

There has been a progressive increase in donor age from a median of 28 years in 1990-94 to 46 years in 2010-14. The median age plateaued at 45-46 years over the subsequent eras (Figure 9).

Figure 9. Median age of deceased donors by transplant era
Box and whisker plot: median, interquartile range and 1.5 times interquartile range shown

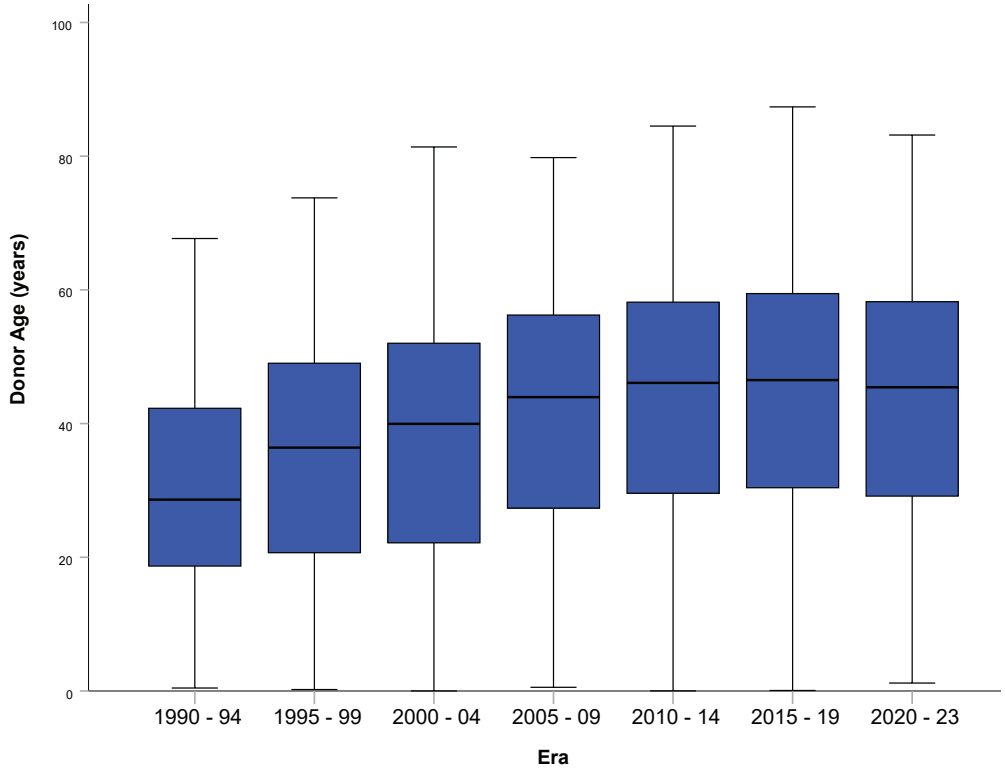
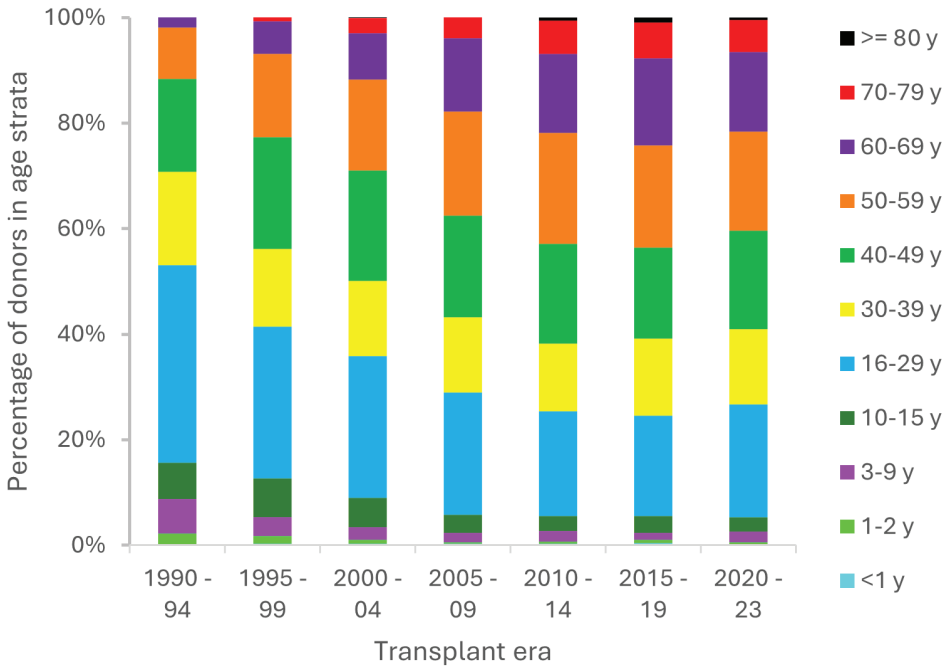


Figure 10 demonstrates the changing deceased donor age profile over the various transplant eras. There has been a progressive increase in the proportion of donors aged 50-59, 60-69, 70-79 and ≥ 80 years from 10%, 2% 0% and 0%, respectively in the 1990-94 era to 21%, 15%, 6% and 1%, respectively in the 2010-14 era but stabilisation in these proportions subsequently.

Figure 10. Deceased donor age by transplant era



7 Living Liver Donors

Of 7,925 liver transplants, 122 (1.5%) were sourced from living donors (including five domino livers). Paediatric recipients received the majority (82.0%) of living liver donations (Table 2). There have been no deaths of living liver donors.

Table 2. Living liver donor demographics

Living Donors	**Paediatric Recipient** (<16 years)	**Adult Recipient** (≥16 years)	**All Recipients**
Number of living donors	**100**	**22**	**122**
% living donors	82.0%	18.0%	
Gender of living donor			
Female *(% age category)*	48 *(48.0%)*	8 *(36.4%)*	**56 *(45.9%)***
Male *(% age category)*	52 *(52.0%)*	14 *(63.6%)*	**66 *(54.1%)***
Age of living donor (years)			
Median	34	33	**34**
Range	19 – 54	18 – 63	**18 – 63**
Living donor relationship			
Father	42	1	43
Mother	26	0	26
Aunt	11	0	11
Family friend	8	1	9
Brother	2	3	5
Domino whole liver	0	5	5
Son	0	5	5
Cousin	4	0	4
Sister	0	3	3
Uncle	3	0	3
Daughter	0	2	2
Grandmother	2	0	2
Grandfather	1	0	1
Half sister	0	1	1
Husband	0	1	1
Second cousin	1	0	1

8 Liver Transplantation in 2023

There were 344 liver transplants performed on 336 recipients in 2023. The number of liver transplants this year has increased from 314 in 2022 but has not returned to the pre-COVID peak of 369 transplants in 2018.

The liver transplant rates in 2023 for Australia and New Zealand were 10.7 and 10.4 liver transplants per million population, respectively (Australia population in 2023: 26.9 million; New Zealand population in 2023: 5.3 million, source: https://www.abs.gov.au/statistics/people/population, https://www.stats.govt.nz/topics/population).

8.1 Demographic Data for Patients Transplanted in 2023

Of the 336 patients receiving a transplant in 2023, 11.9% were children. Females represented 60.0% of paediatric patients transplanted but only 42.9% of the adult population (Table 3. Patient demographics by age group (2023).

Table 3. Patient demographics by age group (2023)

Patients Transplanted in ANZ in 2023	**Children** (<16 years)	**Adults** (≥16 years)	**Total Patients**
Number of patients *(% total patients)*	40 *(11.9%)*	296 *(88.1%)*	336
Sex			
Female *(% age category)*	24 *(60.0%)*	127 *(42.9%)*	151 *(44.9%)*
Male *(% age category)*	16 *(40.0%)*	169 *(57.1%)*	185 *(55.1%)*
Age at first ANZ transplant in 2023			
Mean ± SD (years)	3 ± 4	53 ± 13	47 ± 20
Median (years)	2	56	53
Range	17 d - 14 y	18y - 72 y	17 d - 72 y
Interquartile range	8 m - 5 y	45 y - 64 y	37 y - 64 y
Status of patients at 31/12/2023			
Alive *(% age category)*	40 *(100.0%)*	284 *(95.9%)*	324 *(96.4%)*
Deceased *(% age category)*	0 (*0.0%)*	12 (*4.1%)*	12 *(3.6%)*

Abbreviations: ANZ, Australia or New Zealand; d, day; y, year

8.2 Transplants in 2023

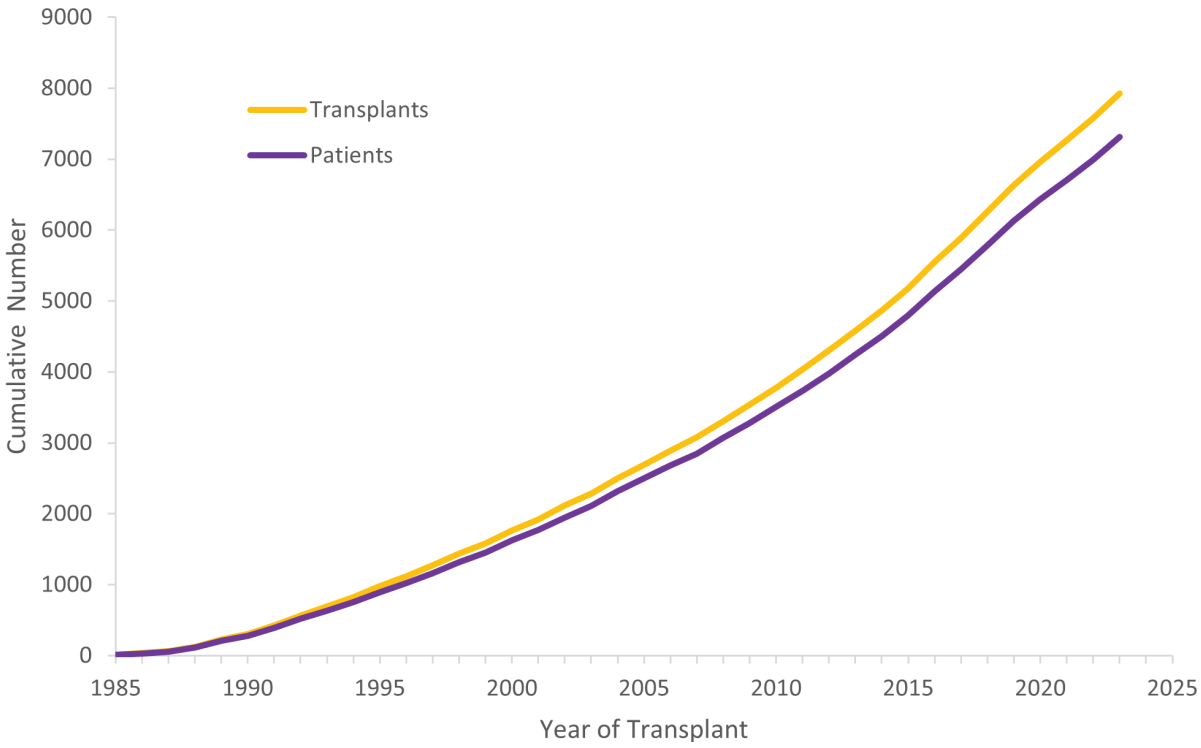
The majority of the 344 transplants were for adult patients (304, 88.4%), whilst 40 (11.6%) transplants were performed on children.

Of the 336 patients transplanted in 2023, 328 (97.6%) patients had their first transplant in 2023. Of these, eight required retransplantation.

9 Liver Transplantation from 1985 – 2023

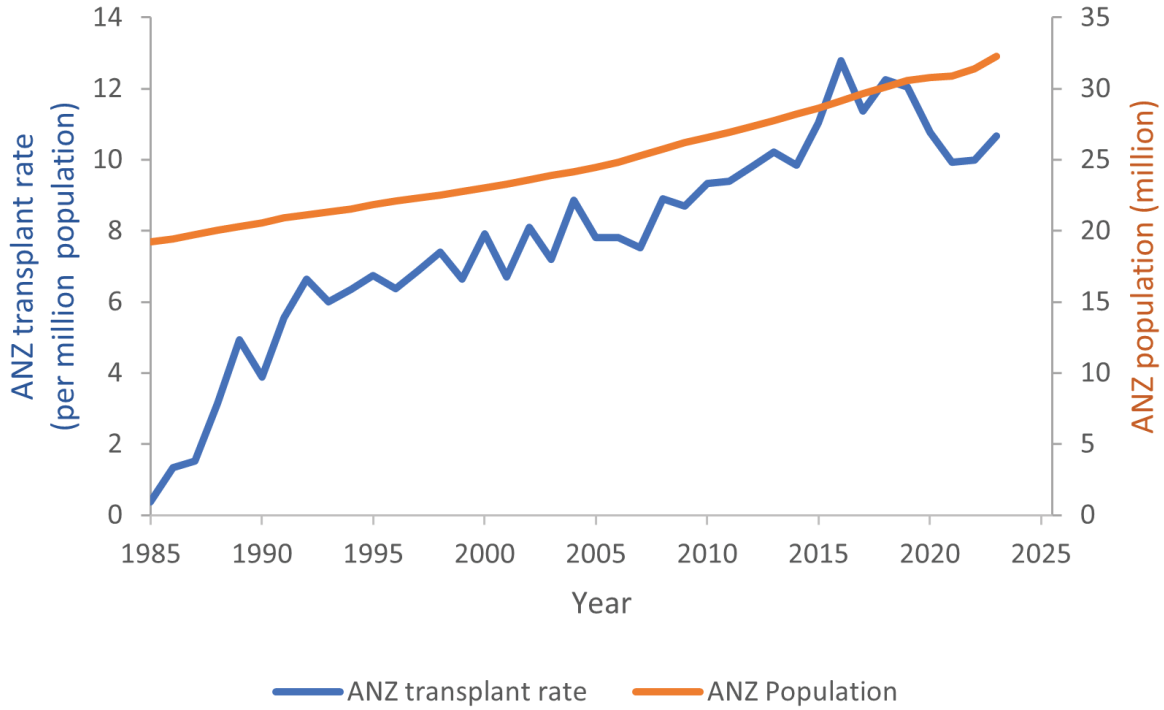
There have been 7,925 liver transplants undertaken on 7,310 patients between 1985 and 2023. Figure 11 shows the cumulative number of patients and transplants.

Figure 11. Cumulative number of liver transplants and new patients transplanted



There has been an increase over time of the number of transplants per million population from 5.6 in 1991, peaking at 12.8 in 2016 and then falling to 10.7 in 2023. (Australia and New Zealand population source: https://www.abs.gov.au/statistics/people/population, https://www.stats.govt.nz/topics/population, Figure 12).

Figure 12. Liver transplant rate and total Australia and New Zealand population



9.1 Demographic Data for Patients Transplanted from 1985 - 2023

Demographic data are based on the first liver transplant undertaken in Australia or New Zealand across all years. Six patients had their first liver transplant overseas prior to undergoing retransplantation in Australia and New Zealand, including one patient who had two liver transplants overseas. (7,310 patients, 7,304 graft 1, 5 graft 2, 1 graft 3).

Of 7,310 patients receiving a transplant from 1985 to 2023, 16.0% were children. Females comprised 51.5% of paediatric patients but only 34.1% of adult patients (Table 4).

Table 4. Patient demographics by age group (1985 – 2023)

Patients Transplanted in ANZ from 1985 to 2023	**Children** (<16 years)	**Adults** (≥16 years)	**Total Patients**
Number of patients *(% total patients)*	1,171 *(16.0%)*	6,139 *(84.0%)*	7,310
Sex			
Female *(% age category)*	603 *(51.5%)*	2,095 *(34.1%)*	2,698 *(36.9%)*
Male *(% age category)*	568 *(48.5%)*	4,044 *(65.9%)*	4,612 *(63.1%)*
Age at first ANZ transplant			
Mean ± SD (years)	4 ± 4	51 ± 12	43 ± 20
Median (years)	2	53	50
Range	11 d - 16 y	16 y - 75 y	11 d - 75 y
Interquartile range	11 m - 7 y	45 y - 60 y	34 y - 59 y
Status of patient			
Alive *(% age category)*	972 *(83.0%)*	3,991 *(65.0%)*	4,963 *(67.9%)*
Deceased *(% age category)*	199 *(17.0%)*	2,148 *(35.0%)*	2,347 *(32.1%)*

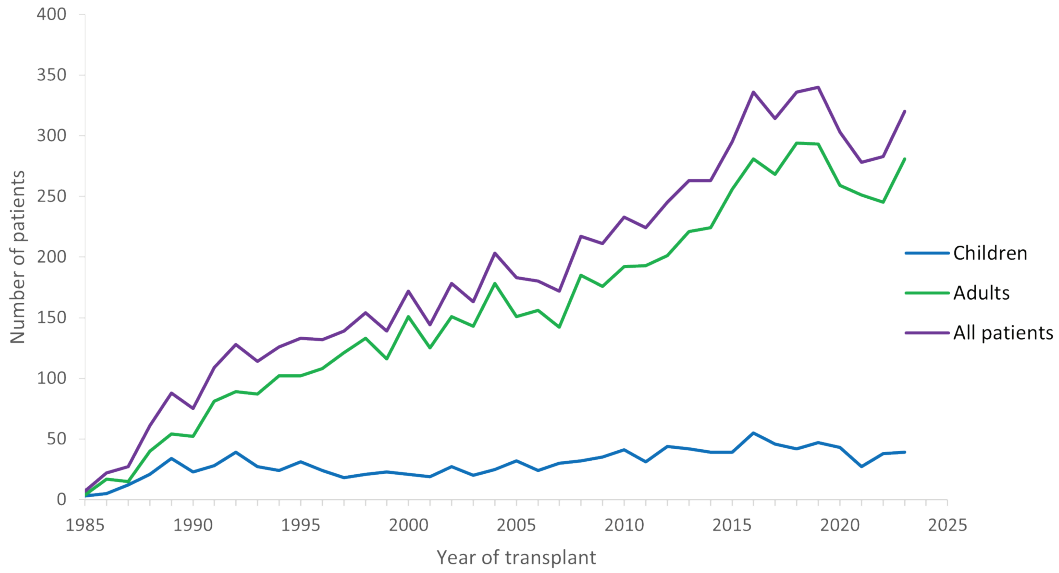
Abbreviations: ANZ, Australia or New Zealand; m, month; y, year

9.1.1 Patients Transplanted by Year of First Transplant

From 2007 to 2019, there was a 97.7% increase in the number of patients transplanted per year, based on the year of their first transplant, from 172 to 340, including a 56.7% increase in the number of children transplanted (30 to 47) and a 106.3% increase in the number of adults transplanted (142 to 293, Figure 13). From 2019 to 2021, there was a 18.2% decrease in the number of patients transplanted per year, from 340 to 278, including a 42.6% decrease in the number of children transplanted (47 to 27) and a 14.3% decrease in the number of adults transplanted (293 to 251).

From 2021 to 2022, there was a 40.7% increase in the number of children transplanted (27 to 38) with a small 2.4% decrease in the number of adults transplanted (251 to 245). Furthermore, there has been a 13.1% increase in the number of patients transplanted between 2022 to 2023 with a 14.7% increase in the number of adults transplanted (245 to 281) and a slight 2.6% increase in the number of children transplanted (38 to 39).

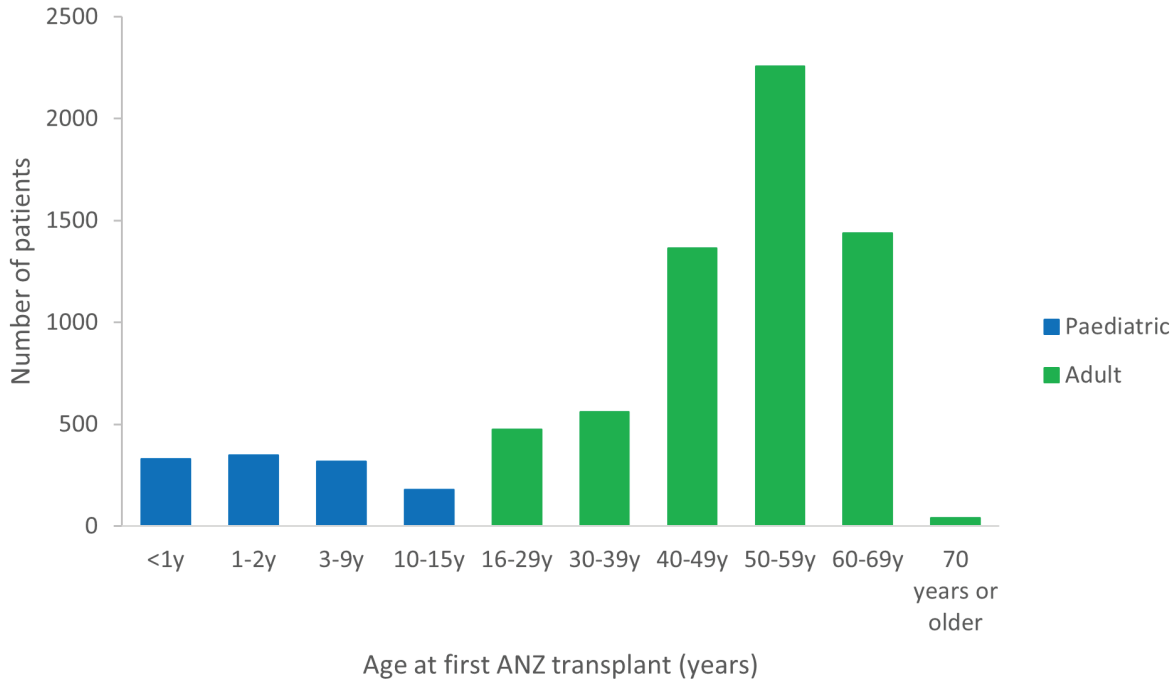
Figure 13. Number of patients transplanted by age group by year of first transplant



9.1.2 Recipient Age at First Transplant (1985 – 2023)

Of the 1,171 paediatric transplant recipients, 28.1% were infants less than one year old and 15.2% were adolescents 10 to 15 years old (Figure 14). Of the 6,139 adult recipients, 36.8% were in their 50s and only 0.7% were in their 70s.

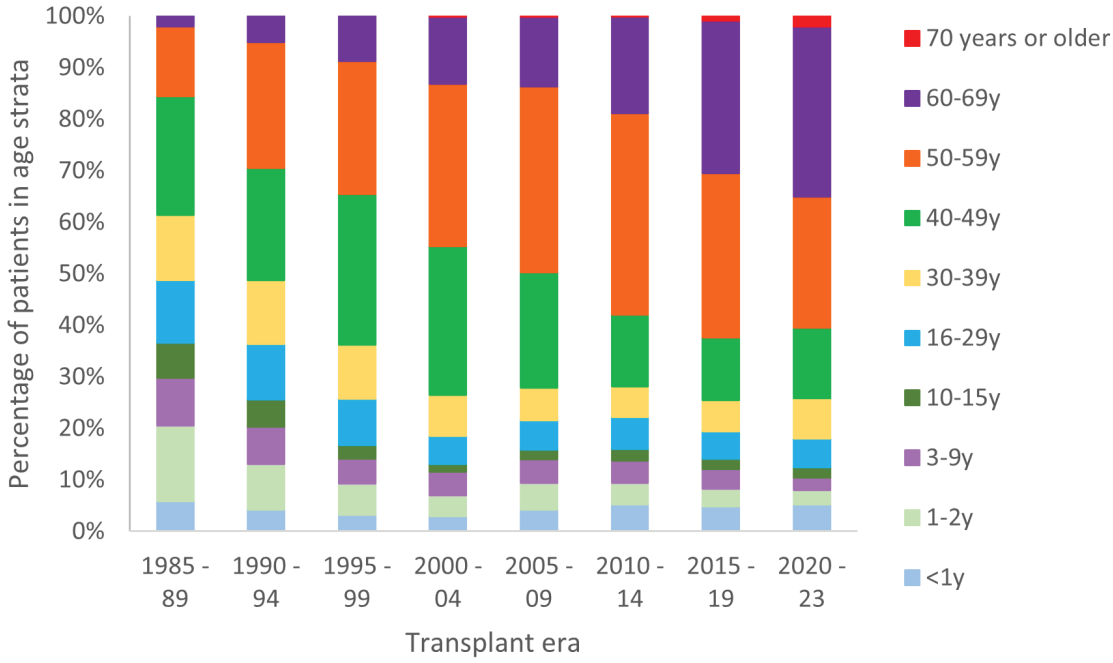
Figure 14. Recipient age strata at first Australian or New Zealand transplant (1985 – 2023)



9.1.3 Recipient Age at First Transplant by Era of Transplant

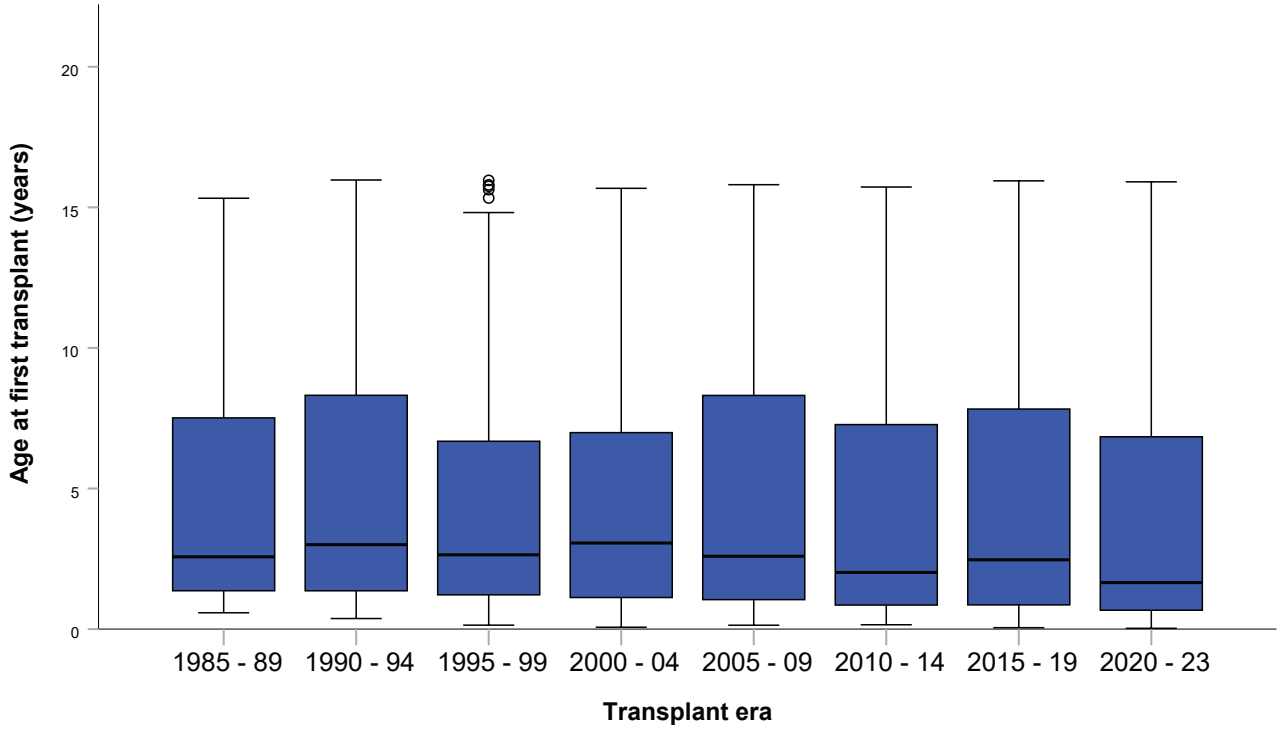
Figure 15 demonstrates the changing recipient age profile over the various transplant eras. There has been a progressive increase in the proportion of recipients aged 60-69 and ≥ 70 years from 2.0% and 0%, respectively in the 1985 - 89 era to 33.0% and 2.0%, respectively in the 2020 - 23 era. Whilst the proportion of recipients aged 50-59 years has increased over eras to peak in 2010 - 14 era at 39.1%, it has decreased to 31.8% in the 2015 - 19 era and to 25.4% in 2020 – 23 era. The proportion of recipients aged less than one year ranged between 2.9% and 5.9% in all eras.

Figure 15. Recipient age strata (percentages) by transplant era



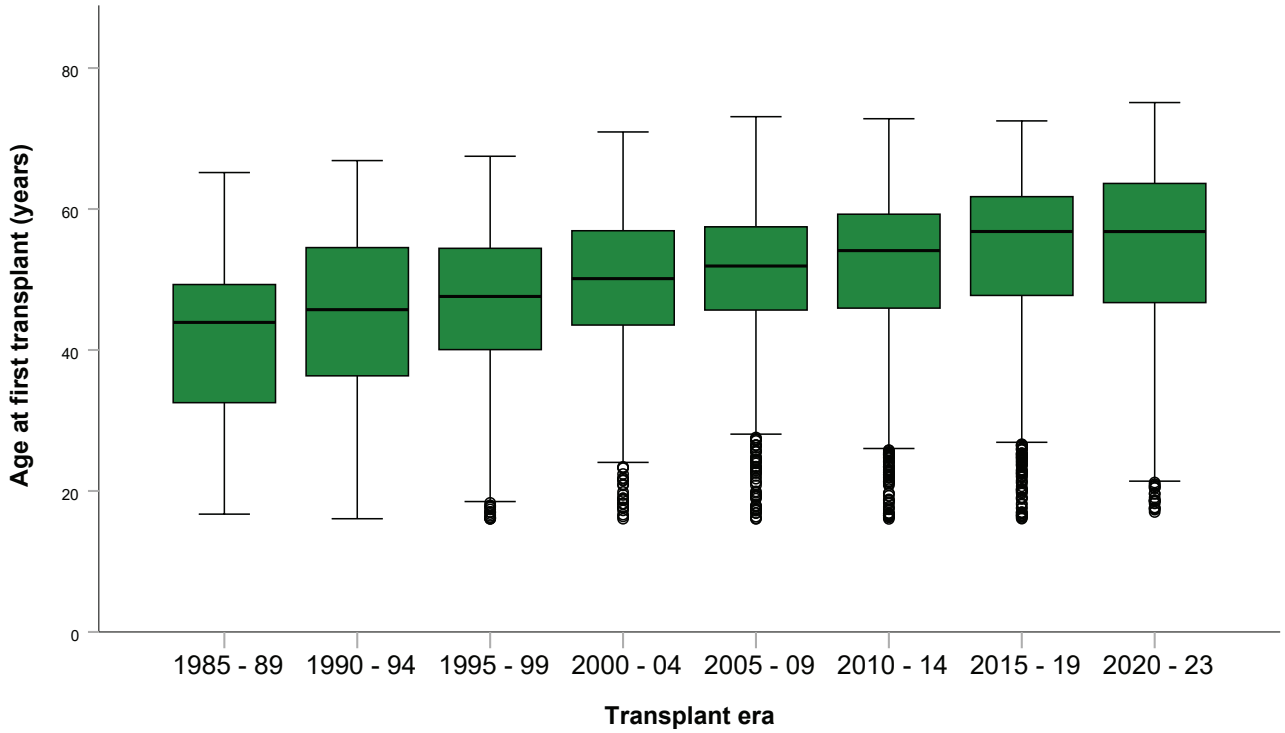
The median paediatric recipient age has been gradually decreasing over the transplant eras, from 2 years and 6 months in 1985-89 to 1 year and 7 months in 2020-23 (P = 0.02, Figure 16).

Figure 16. Paediatric age at first transplant by transplant era
Box and whisker plot: median, interquartile range, 1.5 times interquartile range and outliers shown



The median adult recipient age has been gradually increasing over the transplant eras, from 43 years in 1985-89 to 57 years in 2020-22 (P < 0.001, Figure 17).

Figure 17. Adult age at first transplant by transplant era
Box and whisker plot: median, interquartile range, 1.5 times interquartile range and outliers shown



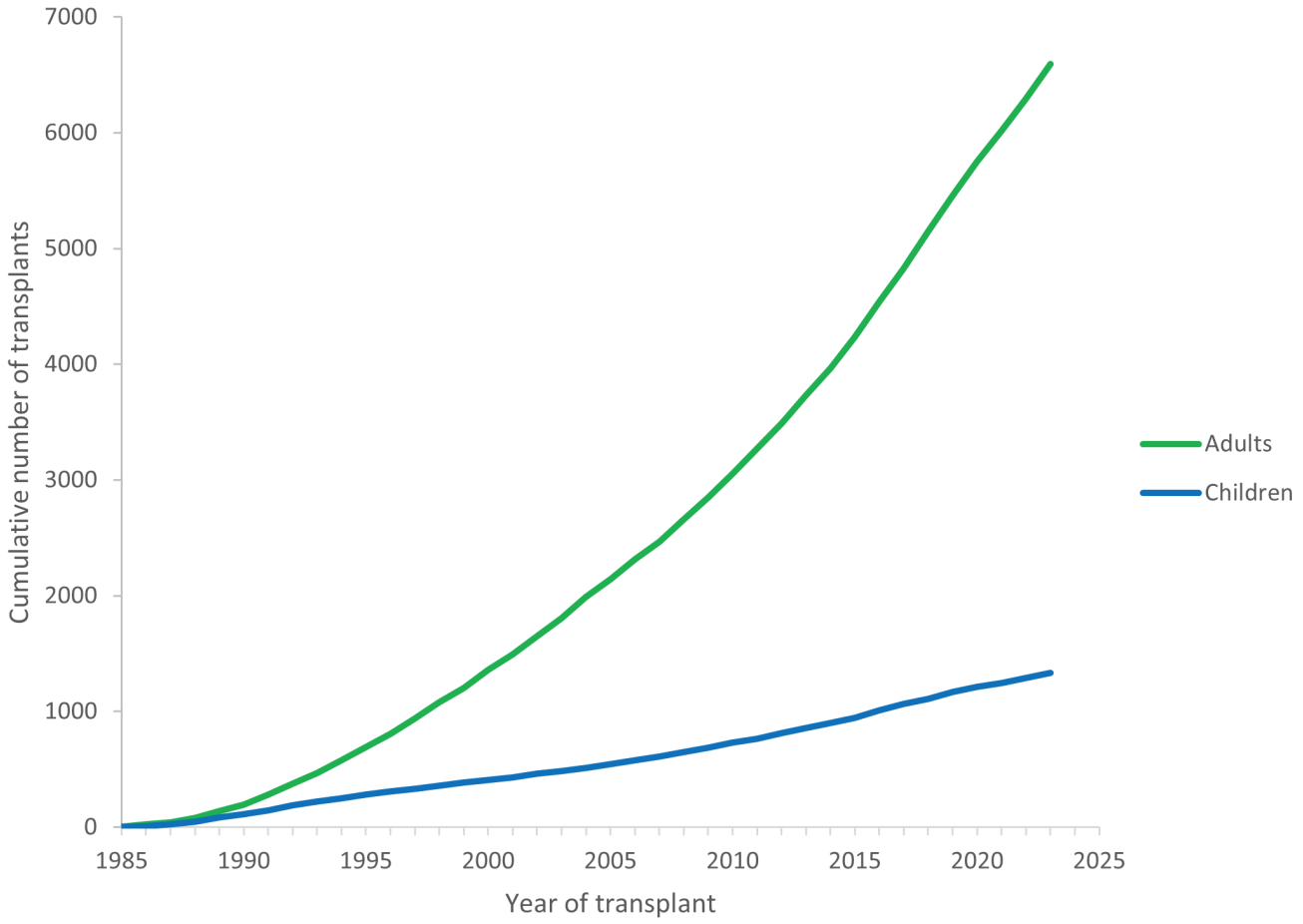
9.2 Transplants (1985 – 2023)

Of the 7,925 transplants, 6,594 (83.2%) were performed in adults and 1,331 (16.8%) in children (<16 years, Table 5, Figure 18). Since the first transplant in 1985, 553 (7.0%) recipients have undergone retransplantation in Australia or New Zealand. Of these, 485 patients had one retransplant, 62 patients have required two retransplants and two patients had three retransplants.

Table 5. Transplants by age group (1985 – 2023)

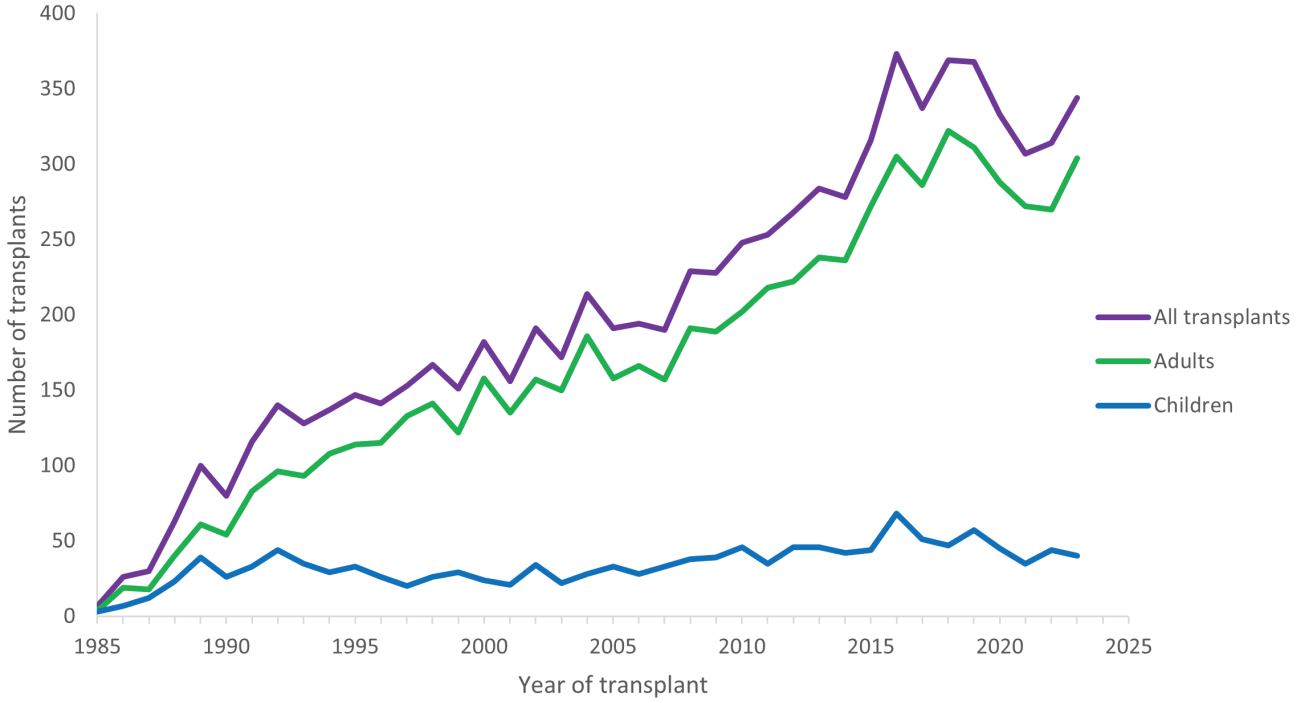
Transplants Transplanted in ANZ from 1985 to 2023	**Children** (<16 years)	**Adults** (≥16 years)	**Total**
Number of transplants *(% total transplants)*	1,331 *(16.8%)*	6,594 *(83.2%)*	**7,925**
Number of patients *(% total patients)*	1,171 *(16.0%)*	6,139 *(84.0%)*	**7,310**

Figure 18. Cumulative number of liver transplants per year by age category



There was a 9.6% increase in the number of transplants from 2022 to 2023, following the 7.8% reduction in liver transplants in 2020 to 2021 and the slight 2.3% increase in liver transplants in 2021 to 2022. The number of transplants performed increased from 314 in 2022 to 344 in 2023, due to the increased number of transplants in adults from 270 to 304. There was a small decrease (44 in 2022, 40 in 2023) in transplantation in children (Figure 19).

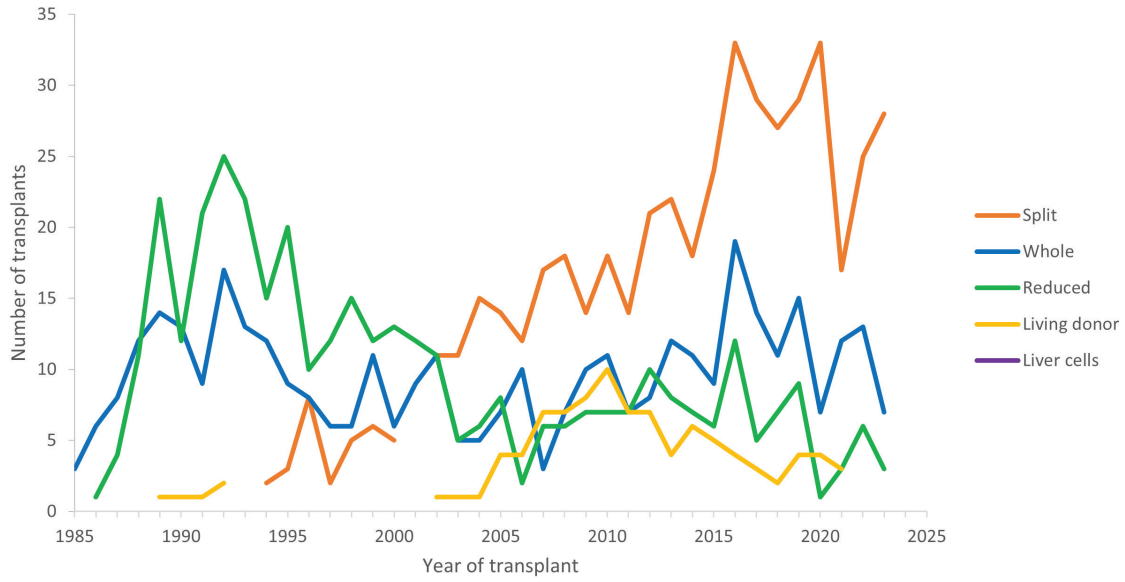
Figure 19. Number of liver transplants per year by recipient age category



9.2.1 Type of Graft – Paediatric Recipients, All Years

The first paediatric liver transplant (whole liver) was performed in 1985, the first reduced size liver transplant in 1986, the first split liver transplant in 1989 and the first successful living donor liver transplant in the world was performed by Professor Strong in Brisbane in July 1989. In the 1990s, the majority of partial grafts were reduced grafts. However, since 2000, the proportion of split grafts has increased to become the dominant method of transplantation in children, peaking at 73.3% in 2020, decreasing to 48.6% in 2021 and increasing again to 70.0% in 2023 (Figure 20). The number of living donors peaked at 10 in 2010 and subsequently this has become an infrequent method of transplantation in children (no living donor transplants in 2022 and 2 living donor transplants in 2023).

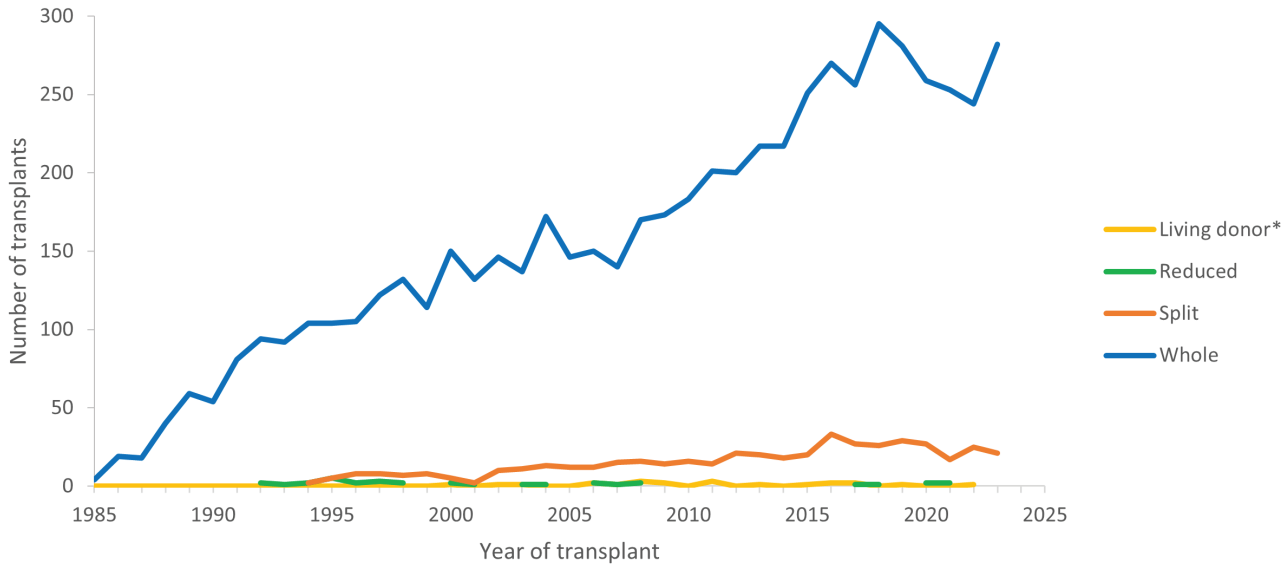
Figure 20. Type of graft for paediatric recipients – all years



9.2.2 Type of Graft – Adult Recipients, All Years

The dominant form of liver transplantation in adults is whole liver transplantation (282 of 304 transplants, 92.8% in 2023, Figure 21). The number of deceased donor split liver transplants in adults has increased from 5 of 158 transplants (3.2%) in 2000 to 21 of 304 (6.9%) in 2023. There has been a total of 22 adult-to-adult living donor liver transplants performed, including five domino liver transplants.

Figure 21. Type of graft for adult recipients – all years



* Includes domino grafts

10 Diagnoses at First Transplant

10.1 Diagnoses in Children

Of 1,168 children who underwent their first liver transplant in Australia or New Zealand, the most common primary diagnoses were biliary atresia (53.2%), metabolic disorders (14.8%) and fulminant hepatic failure (FHF, 10.5%, Table 6). The primary diagnosis and up to three additional diagnoses are collected in the ANZLITR. There were 30 secondary diagnoses and no tertiary or quaternary diagnoses recorded for children.

Table 6. Diagnosis in children

Diagnosis	Primary Diagnosis	% of Children with Primary Diagnosis	All Diagnoses	% of Children with Diagnosis
Biliary atresia	621	53%	622	53%
Metabolic disorders*	173	15%	176	15%
Fulminant hepatic failure#	123	11%	125	11%
Cancers	56	4.8%	67	5.7%
- Hepatoblastoma	*41*	*3.5%*	*42*	*3.6%*
- Hepatocellular carcinoma	*10*	*0.9%*	*16*	*1.4%*
- Histiocytosis X	*5*	*0.4%*	*6*	*0.5%*
- Cholangiocarcinoma	*0*	*0.0%*	*3*	*0.3%*
Alagille syndrome	44	3.8%	45	3.9%
PFIC	33	2.8%	33	2.8%
Cryptogenic cirrhosis	26	2.2%	26	2.2%
Cystic fibrosis	22	1.9%	22	1.9%
Autoimmune cirrhosis	12	1.0%	13	1.1%
Primary sclerosing cholangitis	9	0.8%	12	1.0%
Neonatal hepatitis	6	0.5%	6	0.5%
Caroli's disease	4	0.3%	4	0.3%
Choledochal cyst	3	0.3%	4	0.3%
Intestinal failure associated liver disease	4	0.3%	4	0.3%
Congenital intrahepatic portosystemic shunt	3	0.3%	3	0.3%
Ductopenia	3	0.3%	3	0.3%
Secondary biliary cirrhosis	3	0.3%	3	0.3%
Autoimmune sclerosing cholangitis	2	0.2%	2	0.2%
Common variable immune deficiency	2	0.2%	2	0.2%
Gestational alloimmune liver disease	2	0.2%	2	0.2%
Hepatic veno-occlusive disease	2	0.2%	2	0.2%
Hepatopulmonary syndrome	0	0.0%	3	0.3%
Polycystic liver +/- kidney disease	2	0.2%	2	0.2%
Arterio-venous malformation	1	0.1%	1	0.1%
Bile salt synthetic defect	1	0.1%	1	0.1%
Congenital hepatic fibrosis	1	0.1%	1	0.1%
Cornelia de Lange syndrome	1	0.1%	1	0.1%
Enterovirus hepatitis	1	0.1%	1	0.1%
Established cirrhosis with marked cholestasis	1	0.1%	1	0.1%
Hepatic fibrosis / polycystic kidney disease	1	0.1%	1	0.1%
Hepatic lymphangiomatosis	1	0.1%	1	0.1%
Hepatitis B virus cirrhosis	0	0.0%	1	0.1%
Idiopathic copper toxicosis	1	0.1%	1	0.1%
Ischaemic sclerosing cholangitis	1	0.1%	1	0.1%
Ivemark Syndrome	0	0.0%	1	0.1%
Mainzer-Saldinho Syndrome	1	0.1%	1	0.1%
Nephronophthisis	0	0.0%	1	0.1%
Nodular regenerative hyperplasia	1	0.1%	1	0.1%
Total	**1,168**	**100.0%**	**1198**	**102.6%**

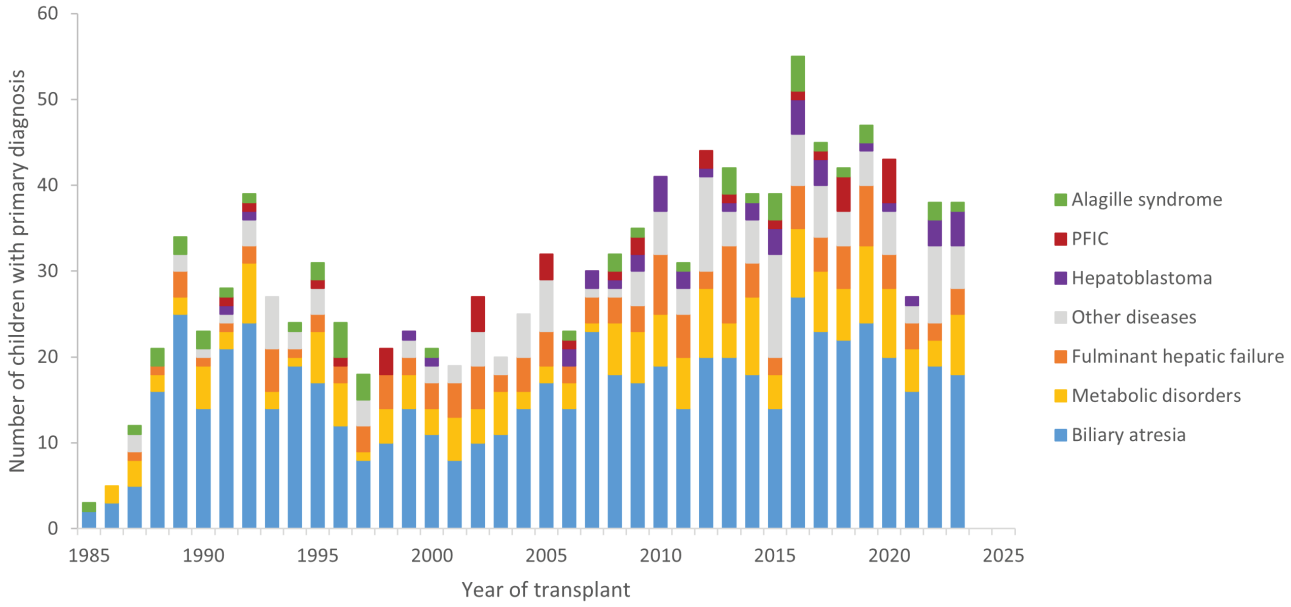
* See Table 9 for breakdown of metabolic disorders

See Table 8 for breakdown of causes of fulminant hepatic failure

10.2 Primary Diagnosis Trend in Children

The primary diagnosis indications for liver transplantation in children have remained relatively stable over time (Figure 22).

Figure 22. Primary paediatric diagnosis

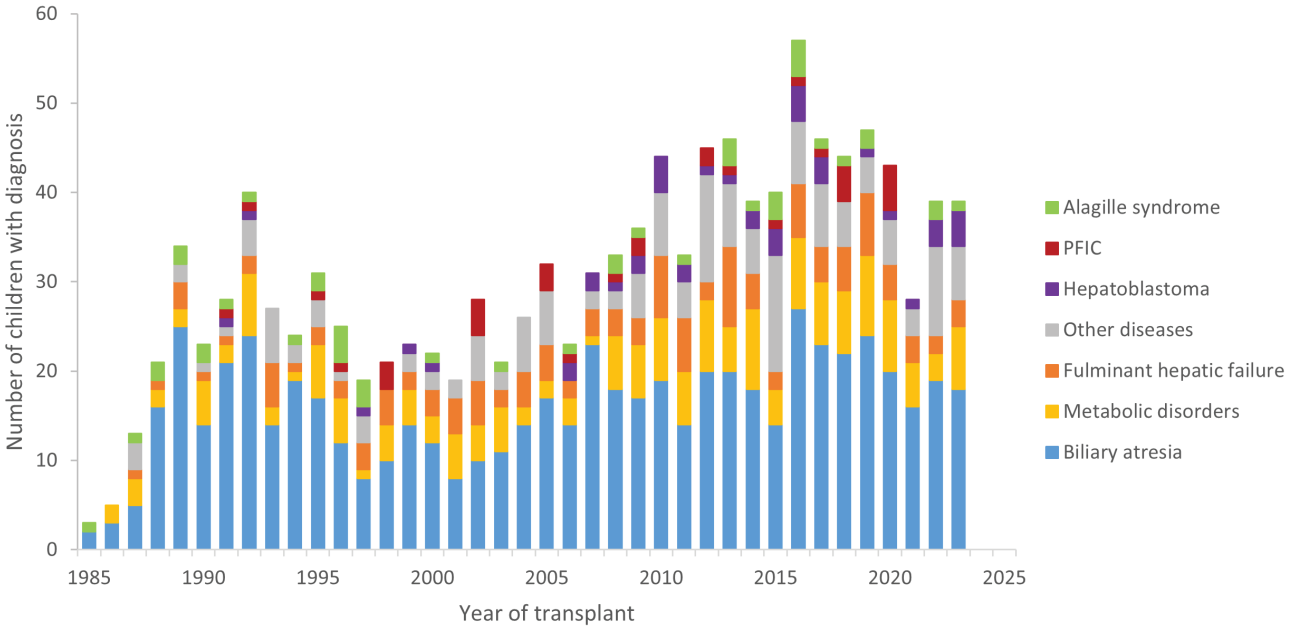


Abbreviation: PFIC, Progressive familial intrahepatic cholestasis

10.3 All Diagnoses Trend in Children

All diagnosis indications for liver transplantation in children have remained relatively stable over time (Figure 23).

Figure 23. All paediatric diagnoses



Abbreviation: PFIC, Progressive familial intrahepatic cholestasis

10.4 Diagnoses in Adults

Of 6,135 adults who underwent their first liver transplant in Australia or New Zealand, the most common primary diagnoses were hepatitis C virus cirrhosis (18.5%), alcohol-related cirrhosis (14.4%) and hepatocellular carcinoma (13.2%, Table 7).

The primary diagnosis and up to three additional diagnoses are collected in the ANZLITR. In addition to the 6,135 primary diagnoses, there were 2,686 additional diagnoses recorded for adults. The proportion of patients with hepatitis C virus cirrhosis accounts for 18.5% as a primary diagnosis and 26.4% across all diagnoses. The proportion of patients with hepatocellular carcinoma as a primary diagnosis was 13.2% and increased to 26.5% across all diagnoses. The proportion of patients with alcohol-related cirrhosis as a primary diagnosis was 14.4% and increased to 25.0% across all diagnoses.

Table 7. Primary and additional diagnoses in adults

Diagnosis	Primary Diagnosis	% of Adults with Primary Diagnosis	All Diagnoses	% of Adults with Diagnosis
Hepatitis C virus cirrhosis	1138	19%	**1617**	26%
Cancers	850	14%	**1706**	28%
- Hepatocellular carcinoma	*811*	*13%*	*1628*	*27%*
- Cholangiocarcinoma	*14*	*0.2%*	*49*	*0.8%*
- Epithelioid haemangioendothelioma	*14*	*0.2%*	*15*	*0.2%*
- Metastatic neuroendocrine tumour	*6*	*0.1%*	*7*	*0.1%*
- Histiocytosis X	*3*	*0.05%*	*3*	*0.05%*
- Angiosarcoma	*1*	*0.02%*	*2*	*0.03%*
- Hepatoblastoma	*0*	*0%*	*1*	*0.02%*
- Secondary liver tumours - Colorectal	*1*	*0.02%*	*1*	*0.02%*
Alcoholic cirrhosis	886	14%	**1534**	25%
NAFLD / Cryptogenic cirrhosis	607	10%	**810**	13%
Primary sclerosing cholangitis	617	10%	**644**	10%
Fulminant hepatic failure#	545	8.9%	**594**	10%
Hepatitis B virus cirrhosis	337	5.5%	**560**	9.1%
Metabolic disorder*	246	4.0%	**332**	5.4%
Primary biliary cirrhosis	299	4.9%	**303**	4.9%
Autoimmune cirrhosis	206	3.4%	**249**	4.1%
Polycystic liver +/- kidney disease	79	1.3%	**82**	1.3%
Biliary atresia	58	0.9%	**60**	1.0%
Hepatic veno-occlusive disease	46	0.7%	**50**	0.8%
Cystic fibrosis	38	0.6%	**38**	0.6%
Secondary biliary cirrhosis	24	0.4%	**27**	0.4%
Hepatopulmonary syndrome	0	0.0%	**21**	0.3%
Caroli's disease	20	0.3%	**20**	0.3%
Granulomatous hepatitis / sarcoidosis	15	0%	**18**	0.3%
Alagille syndrome	11	0.2%	**11**	0.2%
Hereditary haemorrhagic telangiectasia	10	0.2%	**11**	0.2%
Adenomatosis	5	0.1%	**9**	0.1%
Cholestatic cirrhosis / Secondary cholangitis	6	0.1%	**9**	0.1%
Nodular regenerative hyperplasia	8	0.1%	**9**	0.1%
Congenital hepatic fibrosis	7	0.1%	**7**	0.1%
Progressive familial intrahepatic cholestasis	7	0.11%	**7**	0.1%
Cirrhosis - Virus related cirrhosis - Other viruses	2	0%	**6**	0.1%
Drug hepatotoxicity	5	0.08%	**6**	0.10%
Haemangioma	5	0.08%	**6**	0.10%
Portopulmonary hypertension	0	0.00%	**6**	0.10%
Ductopenia	5	0.08%	**5**	0.08%
Haemolytic uraemic syndrome	5	0.08%	**5**	0.08%
Intestinal failure associated liver disease	5	0.08%	**5**	0.08%

(table continued on next page)

Diagnosis	Primary Diagnosis	% of Adults with Primary Diagnosis	All Diagnoses	% of Adults with Diagnosis
Non-cirrhotic portal hypertension	5	0.08%	**5**	0.08%
Post hepatitic cirrhosis - Drug related	3	0.05%	**5**	0.08%
Recurrent cholangitis	3	0.05%	**5**	0.08%
Secondary biliary cirrhosis - hepatolithiasis	4	0.07%	**5**	0.08%
Chronic cholestatic liver disease	4	0.07%	**4**	0.07%
Oriental cholangiohepatitis	3	0.05%	**3**	0.05%
Choledochal cyst	2	0.03%	**2**	0.03%
Congenital biliary fibrosis	2	0.03%	**2**	0.03%
Other cirrhosis	1	0%	**2**	0.03%
Parasitic disease - Schistosomiasis (Bilharzia)	0	0.00%	**2**	0.03%
Portal biliopathy	2	0.03%	**2**	0.03%
Abernethy malformation	1	0%	**1**	0.02%
Acute alcohol-related hepatitis	0	0.00%	**1**	0.02%
Arterio-venous malformation	1	0.02%	**1**	0.02%
Biliary adenofibroma	1	0.02%	**1**	0.02%
Biliary papillomatosis	1	0.02%	**1**	0.02%
COACH syndrome	1	0.02%	**1**	0.02%
Common variable immune deficiency	1	0.02%	**1**	0.02%
Congenital heart disease	1	0.02%	**1**	0.02%
Drug induced cholestasis	1	0.02%	**1**	0.02%
Fasciola	1	0%	**1**	0.02%
Focal nodular hyperplasia	0	0.00%	**1**	0.02%
Graft vs host disease - bone marrow transplant	1	0.02%	**1**	0.02%
Hepatic fibrosis / polycystic kidney disease	0	0.00%	**1**	0.02%
Ischaemic sclerosing cholangitis	1	0.02%	**1**	0.02%
Liver trauma	1	0.02%	**1**	0.02%
Mesenchymal hamartoma	1	0.02%	**1**	0.02%
Parasitic disease - Infected hydatid cysts	1	0.02%	**1**	0.02%
Total	**6,135**	**100%**	**8,821**	**144%**

See Table 8 for breakdown of causes of fulminant hepatic failure

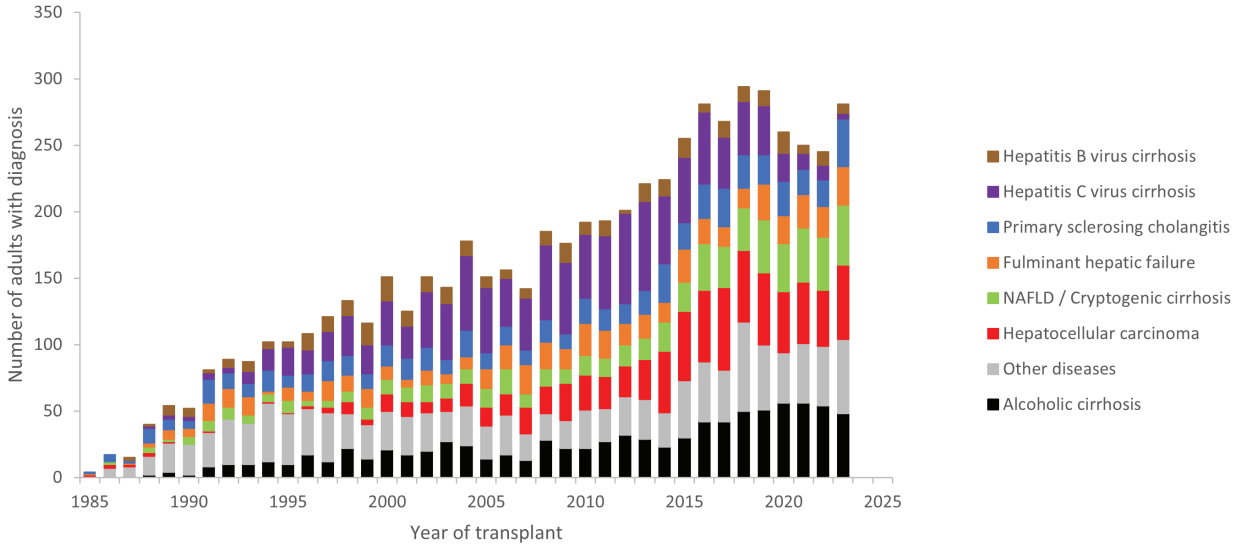
* See Table 9 for breakdown of metabolic disorders

Abbreviations: COACH, cerebellar vermis aplasia, oligophrenia, congenital ataxia, coloboma and hepatic fibrosis; NAFLD, Non-alcoholic fatty liver disease

10.5 Primary Diagnosis Trend in Adults

The commonest primary indication for transplantation in adults was hepatitis C virus cirrhosis until 2014, after which alcohol-related cirrhosis, non-alcoholic fatty liver disease and hepatocellular carcinoma have become the commonest indications. The proportion of patients transplanted primarily for hepatitis C has decreased from 33.8% in 2012 to 1.4% in 2023 (Figure 24). The proportion of patients transplanted for alcohol-related cirrhosis has increased from 15.9% in 2012 to 17.1% in 2023 and hepatocellular carcinoma has increased from 11.4% in 2012 to 19.9% in 2023. Over the same time period, the proportion of patients transplanted for non-alcoholic fatty liver disease increased from 8.0% to 16.0%.

Figure 24. Primary diagnosis trend in adults

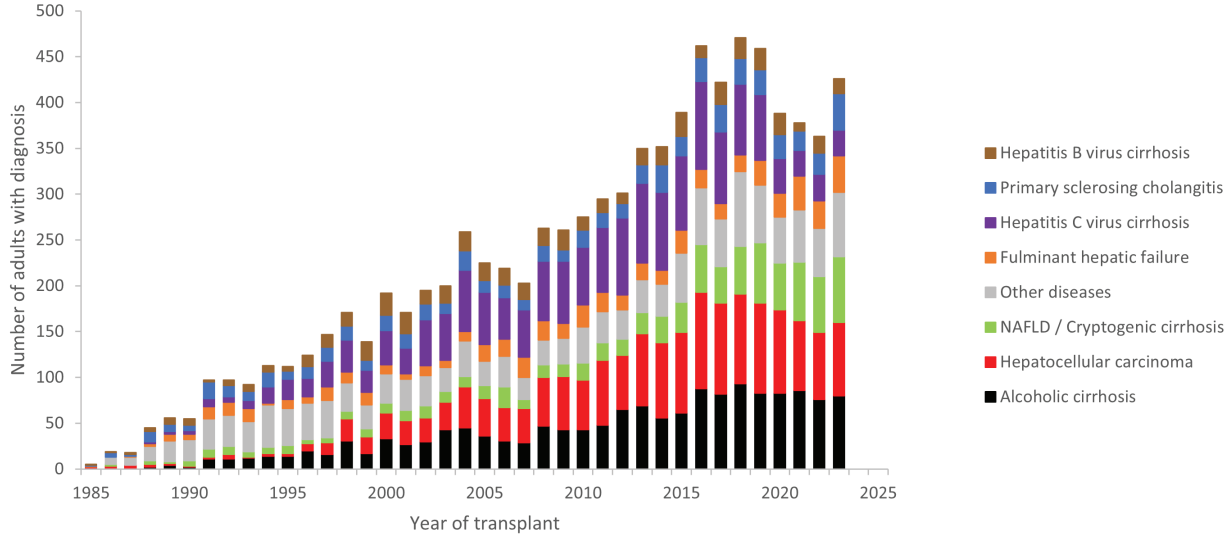


Abbreviation: NAFLD, non-alcoholic fatty liver disease

10.6 All Diagnoses Trend in Adults

Including any diagnosis recorded for each patient, alcohol-related cirrhosis has become the commonest indication for liver transplantation in adults, rising from 5.0% in 1988 to 28.5% in 2023. Hepatocellular carcinoma has increased from 1.1% in 1993 to 28.5% in 2023 and non-alcoholic fatty liver disease has increased from 3.7% in 1996 to 25.6% in 2023, commensurate with the obesity epidemic. Meanwhile, there has been a dramatic fall in hepatitis C virus cirrhosis as an indication for liver transplantation, from a high of 41.8% in 2012 to just 10.0% in 2023. This reduction corresponds to the time periods of initial compassionate availability in 2014 in Australia and subsequent wide availability of effective direct acting antiviral therapy for hepatitis C virus in 2016 in Australia and New Zealand.

Figure 25. All diagnoses trend in adults



Abbreviation: NAFLD, non-alcoholic fatty liver disease

10.7 Fulminant Hepatic Failure – All Diagnoses

Table 8 lists the detailed breakdown of the causes of fulminant hepatic failure as any diagnosis in children and adults.

Table 8. Detailed breakdown of fulminant hepatic failure category as a primary or additional diagnosis by age group

Fulminant hepatic failure	Children (<16 years)	Adults (≥16 years)	Total	% of all patients
Acute hepatic failure - Idiopathic	85	143	228	3.1%
Acute hepatic failure - Hepatitis B	0	107	107	1.5%
Acute hepatic failure - Other drugs	3	40	43	0.6%
Acute hepatic failure - Wilson's	9	28	37	0.5%
Subacute hepatitis - Hepatitis B	0	37	37	0.5%
Subacute hepatitis - Type unknown	5	31	36	0.5%
Acute hepatic failure - Paracetamol	4	30	34	0.5%
Subacute hepatitis - Hepatitis C	0	34	34	0.5%
Subacute hepatitis - Autoimmune hepatitis	2	31	33	0.5%
Acute hepatic failure - Autoimmune hepatitis	1	27	28	0.4%
Subacute hepatitis - Drugs	1	19	20	0.3%
Acute hepatic failure - Herbs / mushrooms	0	13	13	0.2%
Subacute hepatic failure - Wilson's	2	7	9	0.1%
Acute hepatic failure - Post-operative	2	6	8	0.1%
Acute hepatic failure - Alpha-1-antitrypsin	2	5	7	0.1%
Subacute hepatitis - Non A-G	0	6	6	0.08%
Acute hepatic failure - Budd Chiari	0	5	5	0.07%
Acute hepatic failure - Hepatitis A	1	4	5	0.07%
Acute hepatic failure - Toxic (non-drug)	1	4	5	0.07%
Acute hepatic failure - Acute alcohol-related hepatitis	0	3	3	0.04%
Acute hepatic failure - Other specified	1	2	3	0.04%
Subacute hepatic failure - Budd Chiari	1	2	3	0.04%
Subacute hepatic failure - Post surgical resection	1	1	2	0.03%
Subacute hepatitis - Hepatitis A	0	2	2	0.03%
Subacute hepatitis - Herbs	0	2	2	0.03%
Acute hepatic failure - Epstein-Barr virus hepatitis	1	0	1	0.01%
Acute hepatic failure - Hepatitis D	0	1	1	0.01%
Acute hepatic failure - Hepatitis E	0	1	1	0.01%
Acute hepatic failure - Herpes simplex hepatitis	0	1	1	0.01%
Acute hepatic failure - La foie vide	1	0	1	0.01%
Acute hepatic failure - Other virus	1	0	1	0.01%
Acute hepatic failure - Post traumatic	0	1	1	0.01%
Subacute hepatitis - Giant cell	1	0	1	0.01%
Subacute hepatitis - Ischaemic	0	1	1	0.01%
Total	**125**	**594**	**719**	**9.8%**
All patients	*1,168*	*6,135*	*7,303*	

10.8 Metabolic Disorders – All Diagnoses

Alpha-1 antitrypsin deficiency, haemochromatosis and Wilson's disease were the most common primary or additional diagnoses in the metabolic disorders category (Table 9).

Table 9. Detailed breakdown of metabolic disorders category as a primary or additional diagnosis by age group

Metabolic disorders	Children (<16 years)	Adults (≥16 years)	Total	% of all patients
Alpha-1-antitrypsin deficiency	45	114	159	2%
Haemochromatosis	3	68	71	1%
Wilson's disease	8	45	53	0.7%
Familial amyloid polyneuropathy	0	47	47	0.6%
Urea cycle disorders	39	7	46	0.6%
- Ornithine transcarbamylase (OTC) deficiency	*25*	*1*	*26*	*0.4%*
- Citrullinaemia, argininosuccinate synthetase (ASS) deficiency	*7*	*1*	*8*	*0.1%*
- Argininosuccinate lyase (ASL) deficiency	*4*	*2*	*6*	*0.08%*
- Carbamyl phosphate synthetase (CPS) 1 deficiency	*3*	*3*	*6*	*0.08%*
Primary hyperoxaluria	12	11	23	0.3%
Glycogen storage disease	5	16	21	0.3%
Crigler-Najjar	13	1	14	0.2%
Maple syrup urine disease	9	2	11	0.2%
Propionic acidaemia	10	0	10	0.1%
Homozygous hypercholesterolaemia	7	2	9	0.1%
Tyrosinaemia	8	1	9	0.1%
Bile acid synthesis / transport disorder	4	0	4	0.05%
Methylmalonic acidaemia	3	1	4	0.05%
Mitochondrial disease	2	2	4	0.05%
Other metabolic disorder	0	4	4	0.05%
Protoporphyria	0	4	4	0.05%
Protein C deficiency	1	2	3	0.04%
Carnitine acylcarnitine translocase deficiency	2	0	2	0.03%
Hereditary lysozyme amyloidosis	0	2	2	0.03%
Niemann-Pick type C	1	1	2	0.03%
Acute intermittent porphyria	0	1	1	0.01%
Factor V Leiden deficiency	0	1	1	0.01%
Familial immunodeficiency syndrome	1	0	1	0.01%
Indian childhood cirrhosis	1	0	1	0.01%
Polymerase gamma mitochondrial disorder	1	0	1	0.01%
Pyridoxamine 5-phosphate oxidase deficiency	1	0	1	0.01%
Total	**176**	**332**	**508**	**7%**
All patients	*1,168*	*6,135*	*7,303*	

11 Incidental Liver Cancer Found at Explant

All explanted livers are examined by a pathologist to provide a pathological diagnosis. This is then compared to the listing diagnosis. An incidental liver cancer, as reported in this section, refers to a previously unknown liver cancer type being detected at pathology. It does not include the finding of additional lesions of a cancer type already identified at listing.

Incidental liver cancers were found at explant in 239 recipients (3.3% of transplanted patients).

11.1 Incidental Cancers Found at Explant in Children

Incidental liver cancers were found at explant in four children (0.3% of children transplanted). One child had both HCC and cholangiocarcinoma found at explant, resulting a total of five new liver cancers identified (three cancer types) occurring in four children (Table 10).

Two of these children have died but their death was not because of the incidental cancer diagnosis.

Table 10. Incidental cancers found at explant in children

Incidental cancers – children	Number incidental cancers	% incidental cancers	Deaths	% deaths for this cancer type	Died of this cancer	% patients died of this cancer
Hepatocellular carcinoma	3	60%	1	33%	0	0%
Hepatoblastoma	1	20%	1	100%	0	0%
Cholangiocarcinoma	1	20%	0	0%	0	0%
Total incidental liver cancers in children	**5**					
Total children with one or more incidental liver cancers*	**4**		**2**	**50%**	**0**	**0%**
% paediatric liver transplant patients (n=1,172)		0.3%		0.2%		0%

* One child had both hepatocellular carcinoma and cholangiocarcinoma found at explant

11.2 Incidental Cancers Found at Explant in Adults

Incidental liver cancers were found at explant in 235 adults (3.8% of adults transplanted). One adult had both HCC and cholangiocarcinoma found at explant, resulting a total of 236 new liver cancers identified (Table 11).

One hundred and seven adults have died and in 37 adults (16%), their deaths were because of their incidental cancer.

Table 11. Incidental cancers found at explant in adults

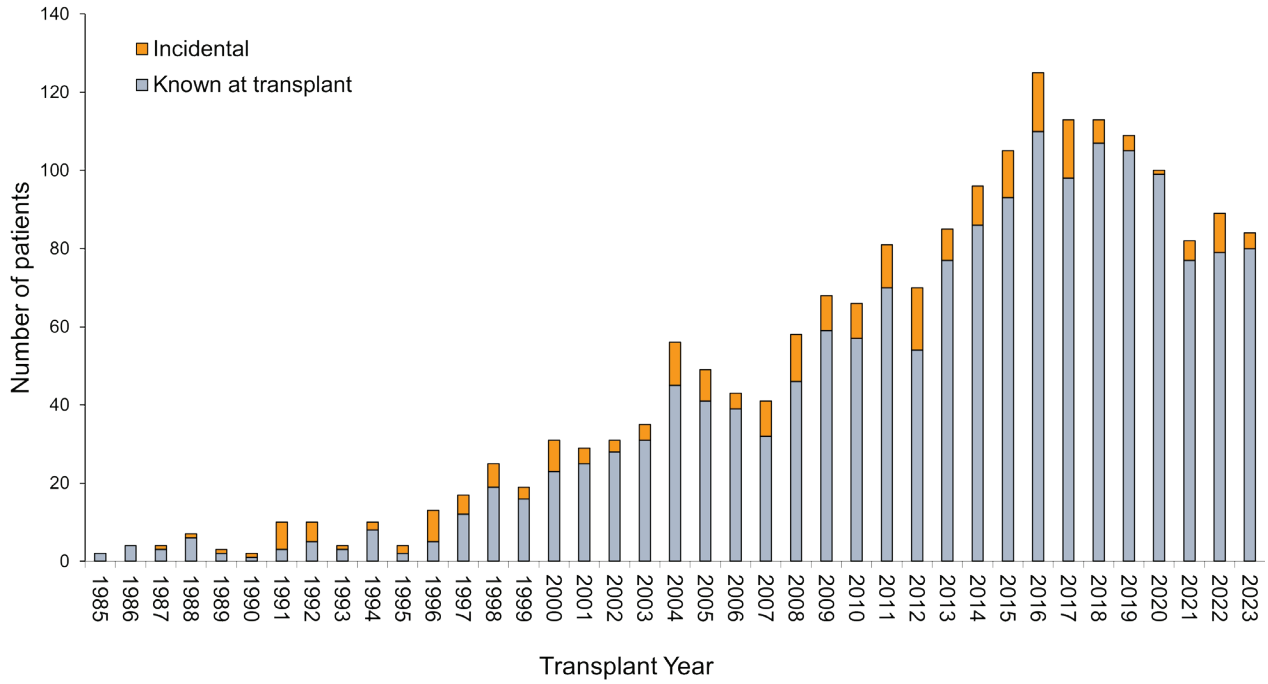
Incidental cancers – adults	Number incidental cancers	% incidental cancers	Deaths	% deaths for this cancer type	Died of this cancer	% patients died of this cancer
Hepatocellular carcinoma*	177	75.0%	68	38%	13	7%
Cholangiocarcinoma*	46	19.5%	32	72%	20	43%
Adenocarcinoma	8	3.4%	6	86%	3	38%
Angiosarcoma	2	0.8%	1	50%	1	50%
Epithelioid haemangioendothelioma	1	0.4%	0	0%	0	0%
Fibrolamellar	1	0.4%	0	0%	0	0%
Metastatic neuroendocrine tumour	1	0.4%	0	0%	0	0%
Total incidental liver cancers in adults	**236**					
Total adults with one or more incidental liver cancers*	**235**		**107**	**46%**	**37**	16%
% adult liver transplant patients (n=6,136)		3.8%		1.7%		0.6%

* One adult had both hepatocellular carcinoma and cholangiocarcinoma found at explant

11.3 Liver Cancer Known Prior to Transplant Versus Incidental Liver Cancer by Transplant Era

The number of patients found to have incidental liver cancer remains relatively stable (Figure 26).

Figure 26. Liver cancer known prior to transplant versus incidental liver cancer by transplant year



12 Donor-Derived Cancer

There were seven cases of donor-derived cancers. Three recipients have died as a result of a donor-derived tumour. One died of donor-transmitted melanoma, one from metastatic adenocarcinoma, most likely of colorectal origin, and one from a tumour of unknown primary, with human leukocyte antigen (HLA) match with donor tissue typing.

Four recipients were retransplanted soon after a transplant due to a donor-derived tumour. One donor liver had neuroendocrine tumours, one had metastatic adenocarcinoma of unknown primary, one donor liver had lymphoma and one donor gall bladder had adenocarcinoma (liver was cancer free). Three of these patients were alive as of 31/12/2023. The patient who received the donor liver with neuroendocrine tumour passed away due to lung cancer.

13 *De Novo* Cancer Development and Liver Cancer Recurrence After Liver Transplantation

One or more *de novo* cancers developed after transplantation in 1,264 (17.3%) patients. *De novo* non-skin cancer developed in 614 (12%) patients and *de novo* skin cancer developed in 1,101 patients (15% of all patients). Four hundred and fifty-one patients (6.2%) developed both a non-skin and skin cancer.

13.1 *De Novo* Non-Skin Cancer

13.1.1 *De Novo* Non-Skin Cancer Types

Six hundred and fourteen patients (12%) developed 664 *de novo* non-skin cancers post-transplant with 39 patients developing more than one non-skin cancer type. Of the 614 patients, 293 (48%) died of their *de novo* non-skin cancer. Median time from first transplant to development of a non-skin cancer post-transplant ranged from 10 to 117 months.

Table 12. De novo non-skin cancer types

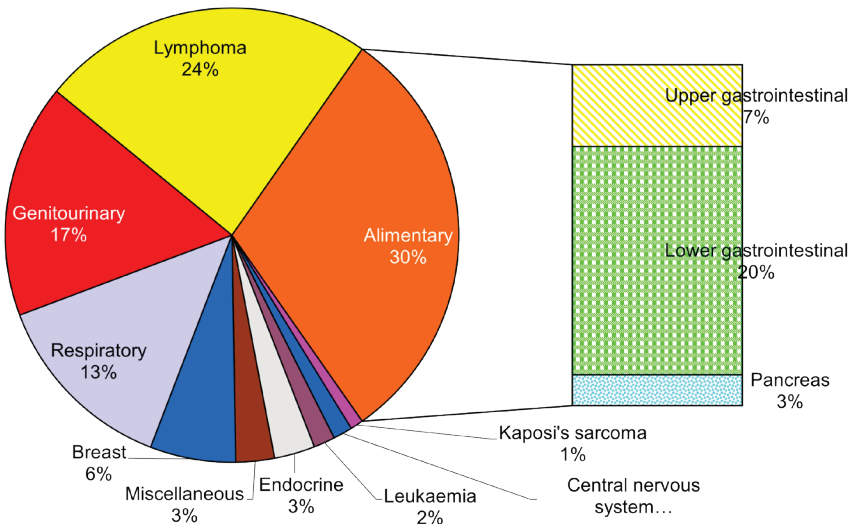
	Number of cancers	Male	Female	Median Age	Age patients (years)	Time to diagnosis (months)	Median time to diagnosis (months)	Died of This Cancer	
Alimentary*	209	155	54	61	5 – 84	1 – 372	93	109	52%
Lymphoma*	156	91	65	51	1 – 82	1 – 324	66	65	42%
Genitourinary*	109	72	37	63	21 – 82	1 – 444	117	16	15%
Respiratory*	88	64	24	62	29 – 83	7 – 294	102	65	74%
Breast*	40	1	39	58	30 – 74	11 – 288	98	14	35%
Endocrine	19	10	9	56	32 – 77	10 – 343	110	4	21%
Miscellaneous*	18	10	8	65	55 – 76	5 – 298	114	8	44%
Leukaemia*	10	8	2	66	3 – 66	1 – 188	27	4	40%
CNS	9	6	3	59	16 – 78	13 – 210	93	7	78%
Kaposi's	6	5	1	49	31 – 64	1 – 35	10	1	17%
Total cancers	**664**	**422**	**242**	**60**	**1 – 84**	**1 – 372**	**88**		
Total patients	**614**	**396**	**218**					**293**	**48%**

*Thirty-nine patients had two or more *de novo* non-skin malignancies

Abbreviation: CNS, central nervous system

The three most common types of cancers were of the alimentary tract (209, 31%), lymphoma (156, 23%) and genitourinary tract (109, 16%, Figure 27). Lower gastrointestinal cancers account for 68% of alimentary tract cancers and 21% of all *de novo* non-skin cancers.

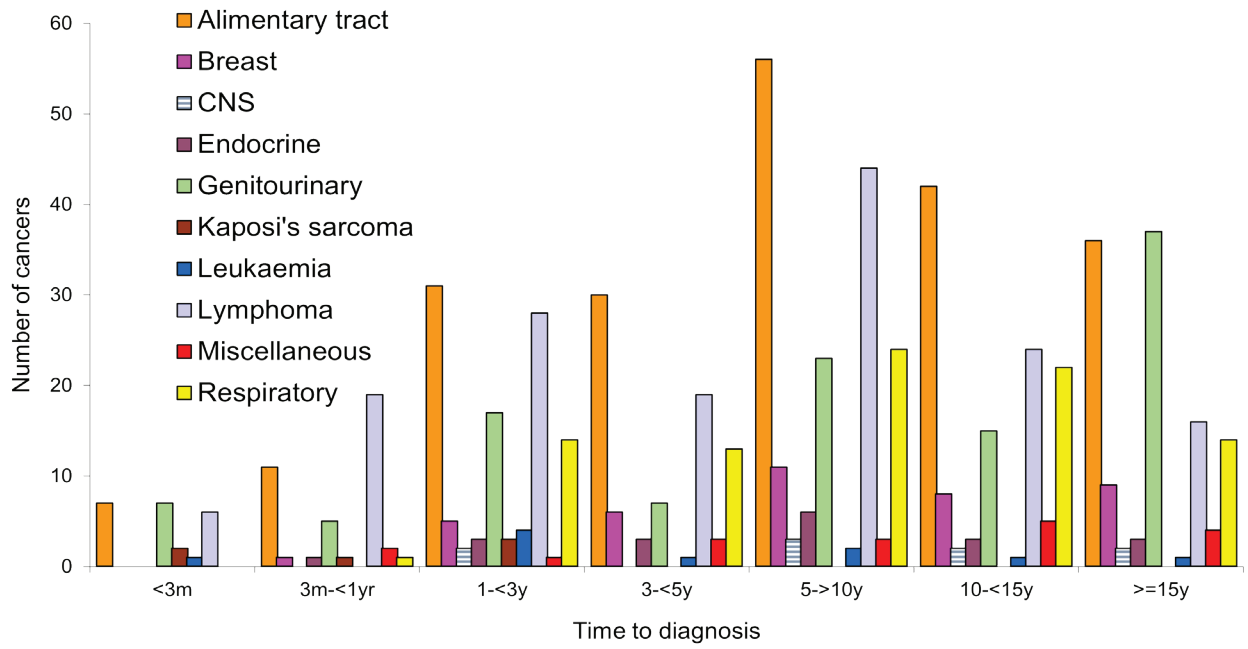
Figure 27. De novo non-skin cancer types



13.1.2 Time to Diagnosis of *De Novo* Non-Skin Cancers by Cancer Type

Cancers of the alimentary tract and lymphoma were predominantly diagnosed 5 to 10 years post-transplant whilst cancers of the genitourinary tract gradually increased over time (Figure 28).

Figure 28. Time to diagnosis of de novo non-skin cancer



Twenty-three patients either developed a *de novo* non-skin cancer within 90 days of their liver transplant or were found to have a non-liver cancer at liver transplant. Lymphoma / post-transplant lymphoproliferative disorder (PTLD) occurred in six of these patients. (Table 13).

Table 13. De novo non-skin cancer types that developed within 90 days of transplantation

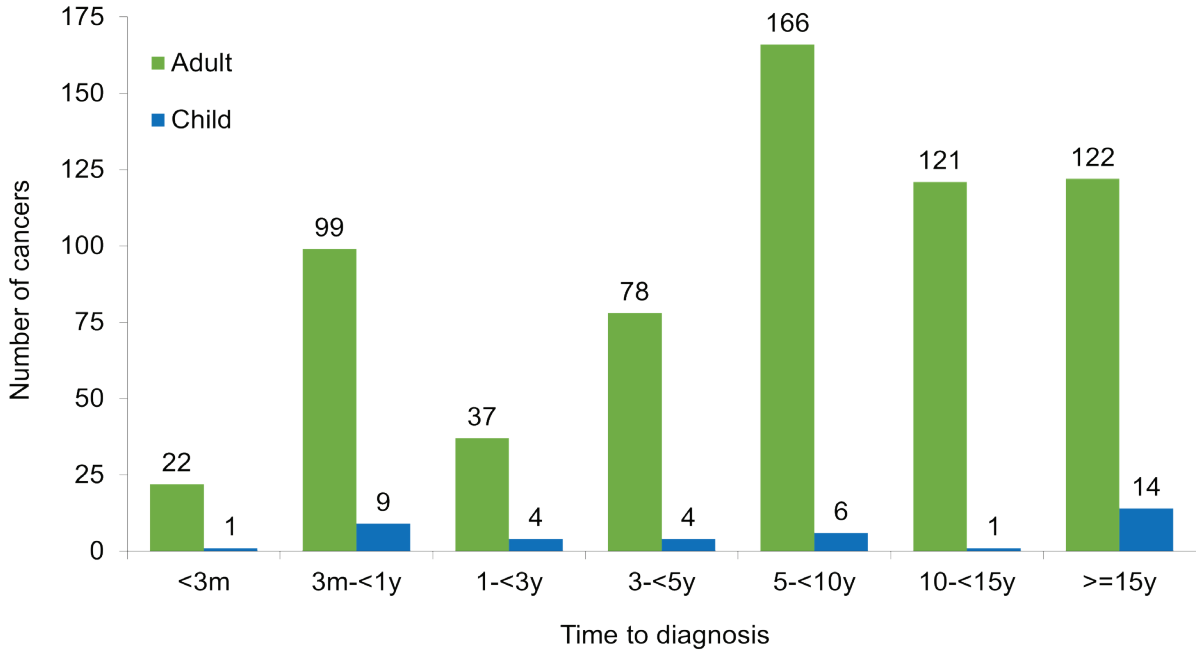
***De novo* non-skin cancer type**	**Developed within 90 days of transplantation**
Lymphoma/PTLD	6
Colon	3
Kaposi's sarcoma/HHV8	2
Prostate	2
Renal cell	3
Angiosarcoma	1
Cervix	1
Gastro-intestinal stromal tumour	1
Leukaemia	1
Ovary	1
Pancreas	1
Schwannomma	1
Total	**23**

Abbreviations: PTLD, post-transplant lymphoproliferative disorder; HHV8, human herpesvirus-8

13.1.3 Time to Diagnosis of *De Novo* Non-Skin Cancers by Age Category

The largest number of *de novo* non-skin cancers diagnosed per 5-year period was within the first 5 years post-transplant for children (18) and adults (236, Figure 29).

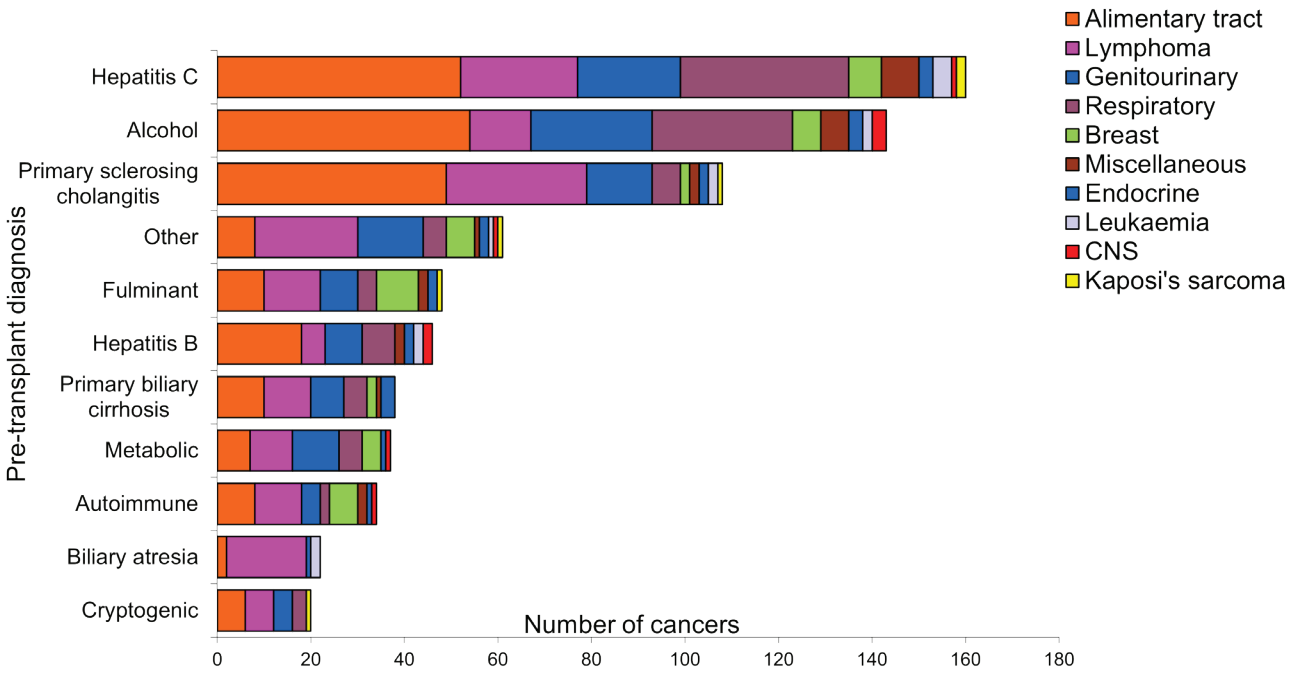
Figure 29. Time to diagnosis of any non-skin cancer by age category



13.1.4 *De Novo* Non-Skin Cancers by Pre-Transplant Diagnosis

The incidence of *de novo* non-skin cancers appears to be related to the type of pretransplant underlying disease. Most notable is the number of *de novo* non-skin cancers in patients with underlying hepatitis C virus, alcohol and primary sclerosing cholangitis, being statistically significant (P < 0.001, Figure 30, Table 14).

*Figure 30. Pretransplant diagnosis and de novo non-skin cancer types**



* All listing diagnoses (1-4) included, not just primary diagnosis

Recipients with a pre-transplant diagnosis of primary sclerosing cholangitis, malignancy and autoimmune cirrhosis were most likely to develop a *de novo* non-skin cancer (17%, 14% and 13% respectively, Table 14). Whilst more *de novo* cancers were observed in recipients with a pre-transplant diagnosis of alcohol-related cirrhosis or hepatitis C, there were more recipients with these diagnoses, resulting in 10% of each developing a *de novo* non-skin cancer.

*Table 14. Pre-transplant diagnosis and de novo non-skin cancer types**

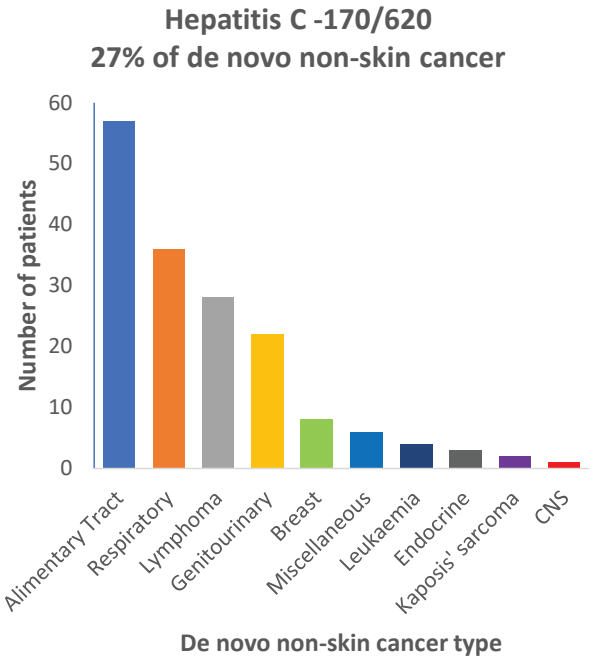
Listing Diagnosis	Alimentary tract	Lymphoma	Genitourinary	Respiratory	Breast	Endocrine	Leukaemia	CNS	Kaposi's sarcoma	Miscellaneous	Total *de novo* cancers	% of patients with diagnosis	Patients with Listing Diagnosis
PSC	50	30	14	5	2	2	1	0	1	3	108	17%	629
Malignancy	20	26	21	39	5	2	7	1	0	4	125	14%	908
Autoimmune	9	10	4	2	6	1	0	1	0	2	35	13%	276
Alcohol	54	13	26	31	5	3	3	3	0	10	148	10%	1515
Hepatitis C	57	28	22	36	8	3	4	1	2	6	167	10%	1738
Hepatitis B	19	6	11	8	0	0	2	1	0	4	51	9%	572
Cryptogenis cirrhosis	7	6	5	3	0	0	0	0	1	0	22	8%	266
PBC	10	10	8	5	2	3	0	0	0	1	39	8%	510
FHF	9	12	8	4	9	1	0	1	1	2	47	7%	636
Biliary atresia	2	18	0	1	1	1	1	0	0	0	24	3%	693
Metabolic	10	11	11	5	4	1	2	1	0	1	46	3%	1454
Other	10	22	14	6	6	1	1	1	1	1	63	7%	876

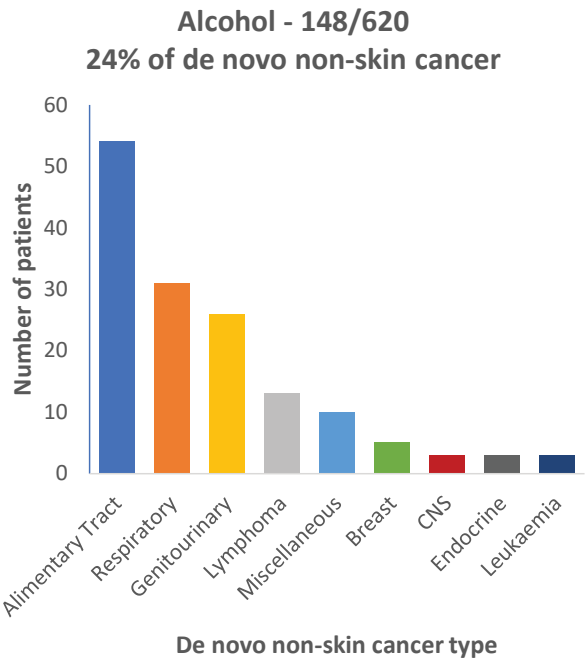
Abbreviations: CNS, central nervous system; PSC, primary sclerosing cholangitis; FHF, fulminant hepatic failure; PBC, primary biliary cirrhosis

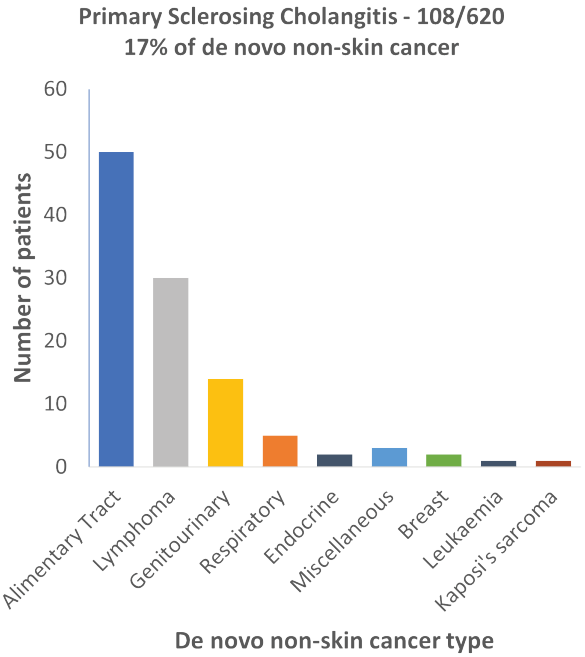
* All listing diagnoses (1-4) included, not just primary diagnosis

Pretransplant hepatitis C infection, alcohol-related liver disease and primary sclerosing cholangitis were the dominant underlying disease in those patients who developed alimentary tract cancers (Figure 31). Pretransplant hepatitis C infection and alcohol-related liver disease were the dominant underlying disease for those who developed respiratory cancers.

Figure 31. Hepatitis C virus, alcohol diagnosis and primary sclerosing cholangitis and types of de novo skin cancer



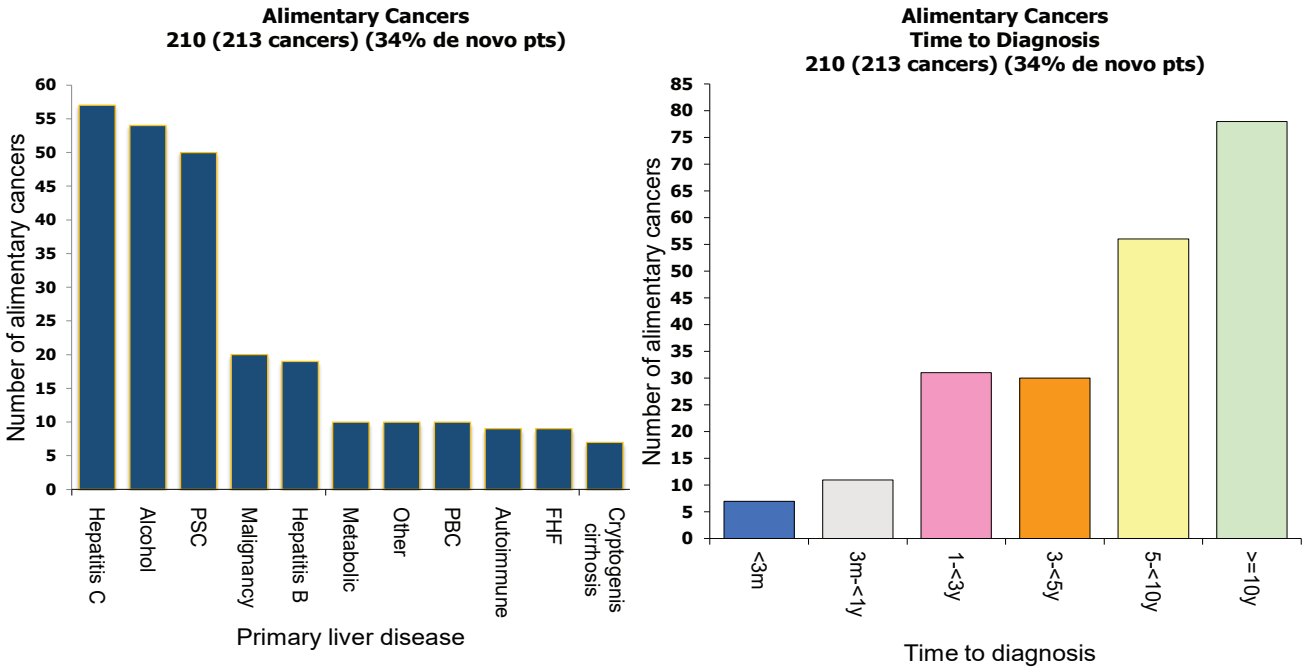




13.1.5 *De Novo* Alimentary Cancers

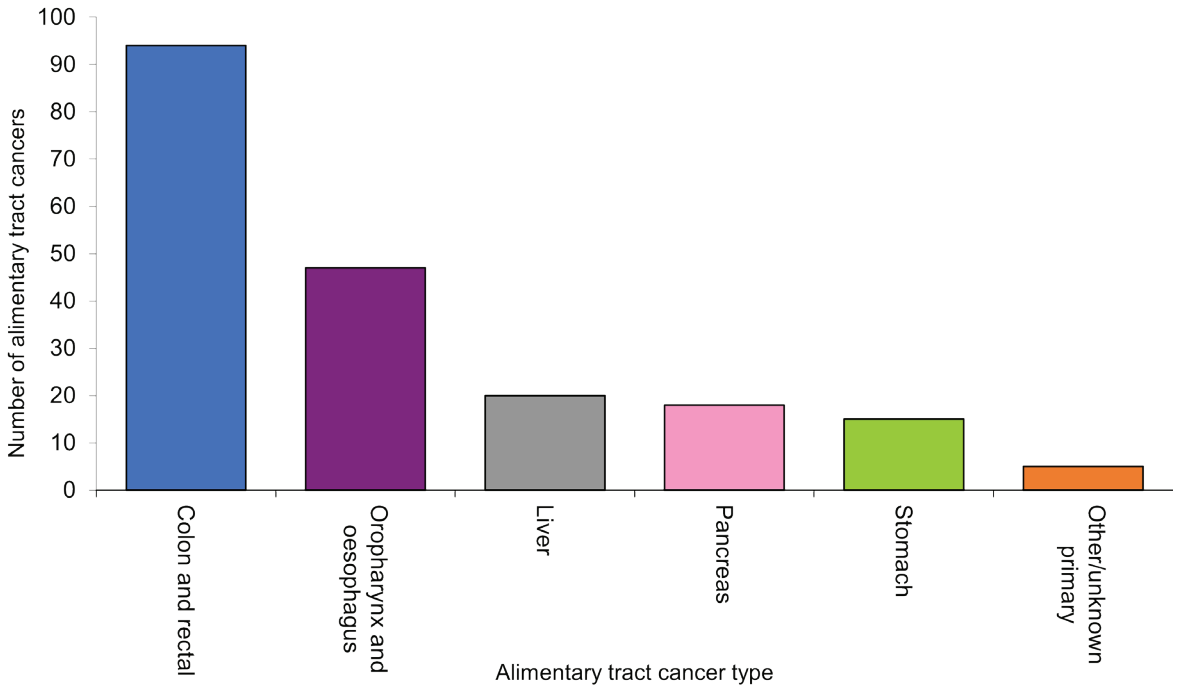
Cancer of the alimentary tract was the most prevalent non-skin cancer to develop post-transplant affecting 210 patients. Time to development ranged from one month to greater than 30 years with 62% being diagnosed after 5 years (Figure 32). Median time to diagnosis was 91 months. Pretransplant liver disease was predominantly primary sclerosing cholangitis, alcohol-related liver disease and hepatitis C infection.

Figure 32. Pretransplant diagnosis and de novo alimentary cancers



Forty-five percent of alimentary cancers were of the colon and rectum; 22% were oropharynx and oesophagus (Figure 33).

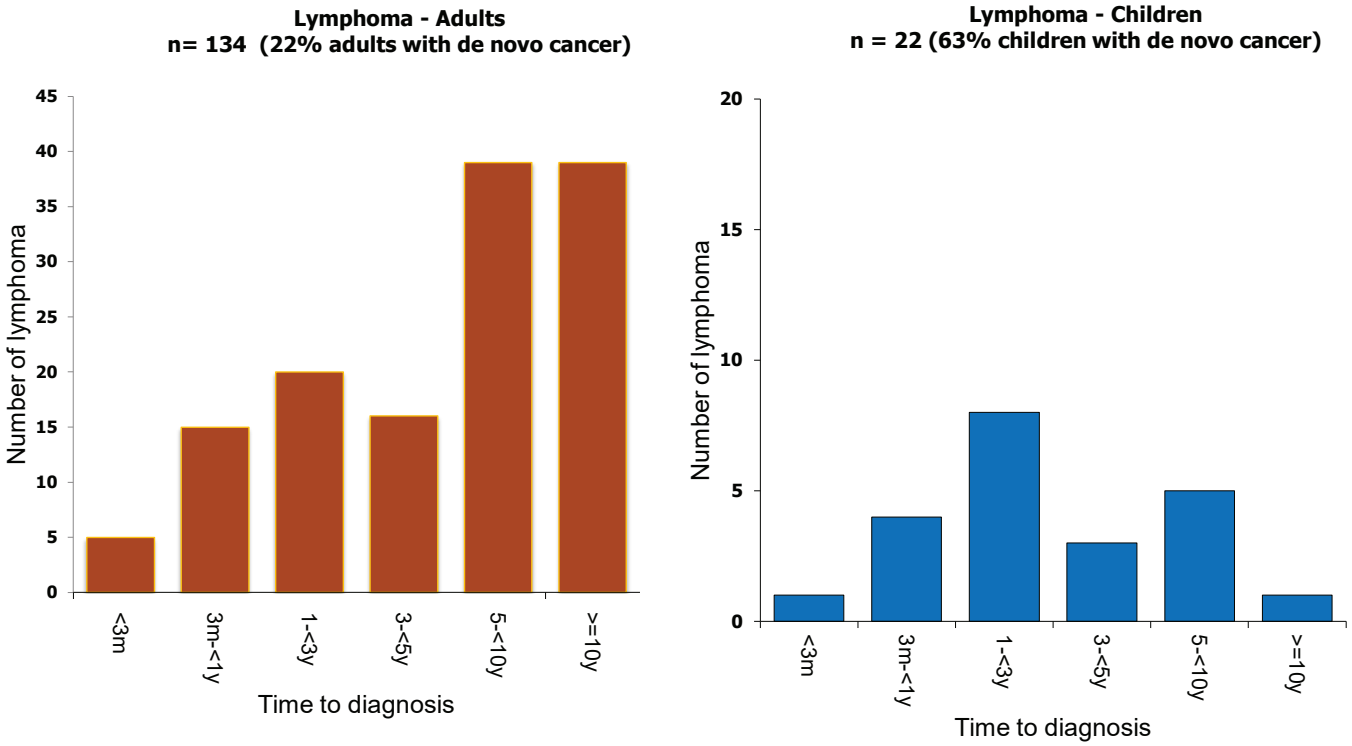
Figure 33. Incidence of de novo alimentary tract cancers by type



13.1.6 *De Novo* Lymphoma

Lymphoma was the second most prevalent non-skin cancer to develop post-transplant affecting 134 adults and 22 children. Time to development ranged from one month to 24 years with 56% developing after 5 years in adults and 29% after 5 years in children (Figure 34). Median time to diagnosis in adults and children was 69 and 33 months respectively.

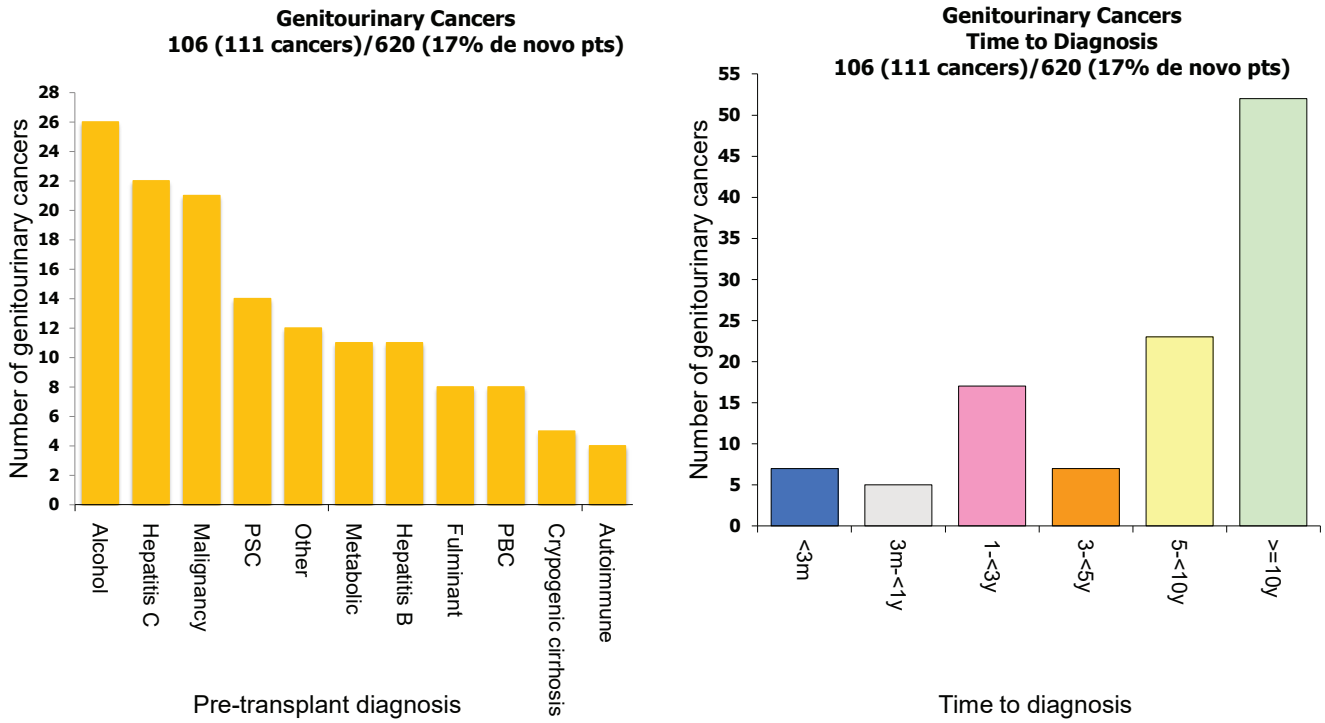
Figure 34. Time to diagnosis of de novo lymphoma by age category



13.1.7 *De Novo* Genitourinary Cancers

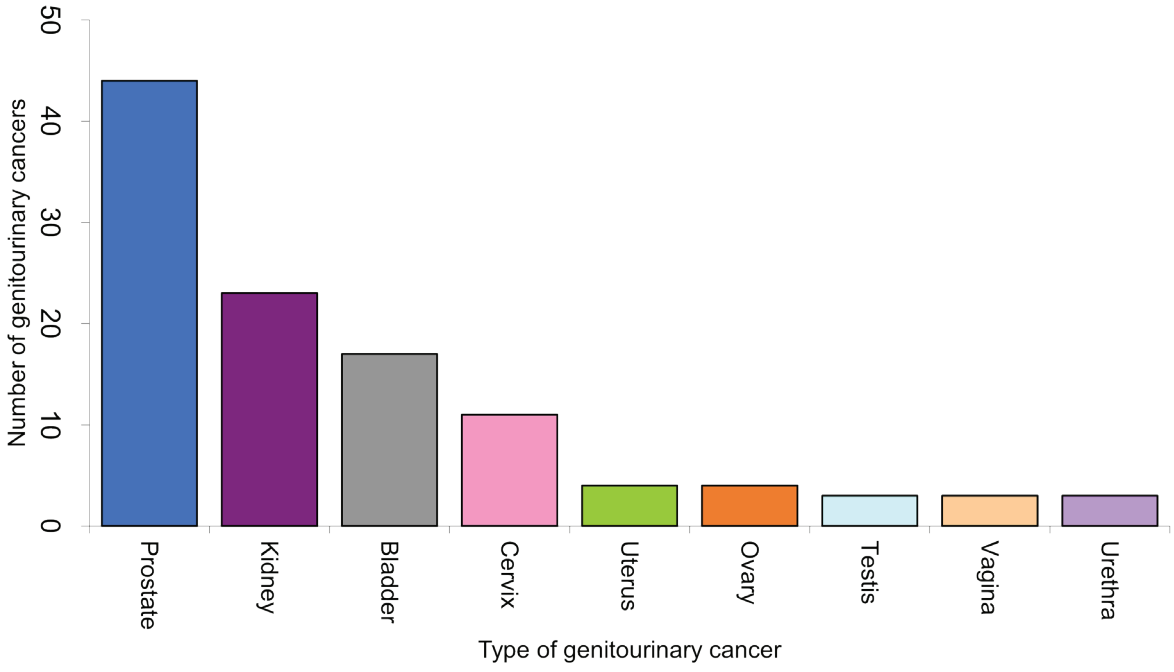
Cancers of the genitourinary tract represented 17% of all *de novo* non-skin cancers. Sixty-nine (65%) of these patients were transplanted for alcohol-related liver disease, hepatitis C infection or a liver cancer (Figure 35). Time to development ranged from one month to 37 years. Median time to diagnosis was 10 years.

Figure 35. Pretransplant diagnosis and de novo genitourinary cancers



Forty-four (39.2%) of genitourinary tract cancers were cancers of the prostate (Figure 36).

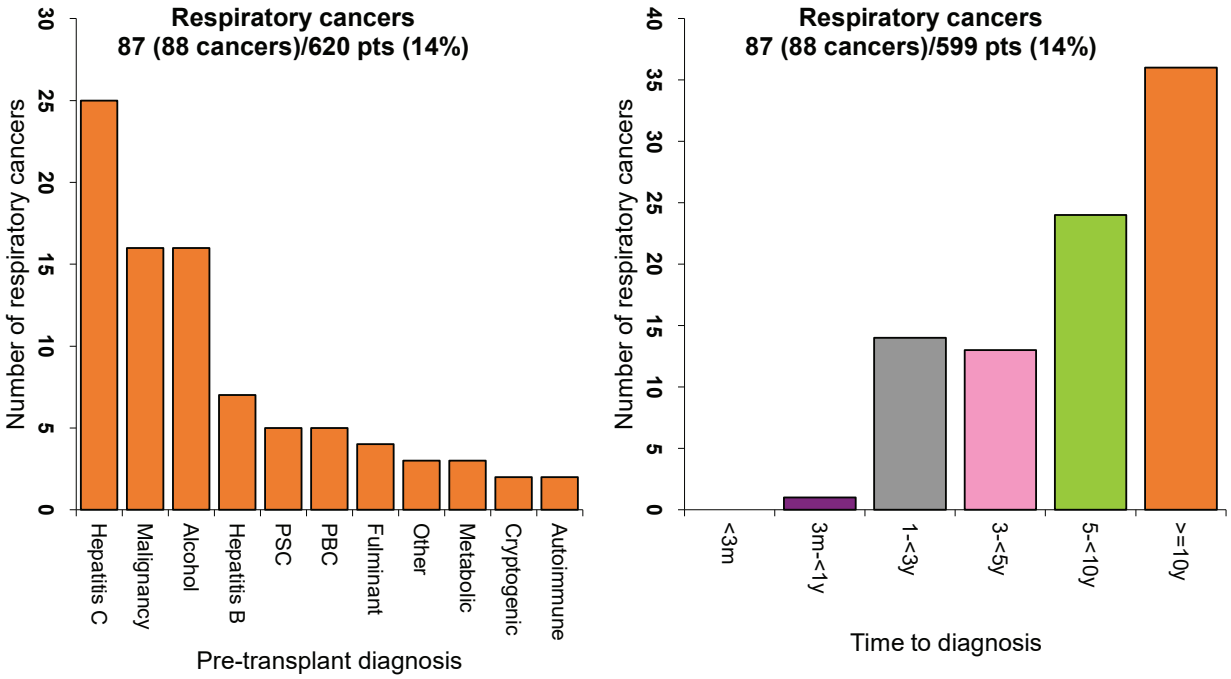
Figure 36. Incidence of de novo genitourinary tract cancers by type



13.1.8 *De Novo* Respiratory Cancers

Respiratory cancers represented 13% of all *de novo* non-skin cancers. Fifty-five (65%) of these patients were transplanted for hepatitis C infection, pretransplant liver cancer or alcohol-related liver disease (Figure 37). Time to development ranged from two months to 24 years with 68% developing after 5 years. Median time to diagnosis was 103 months. 93.2% of respiratory cancers were of the lung (Figure 38).

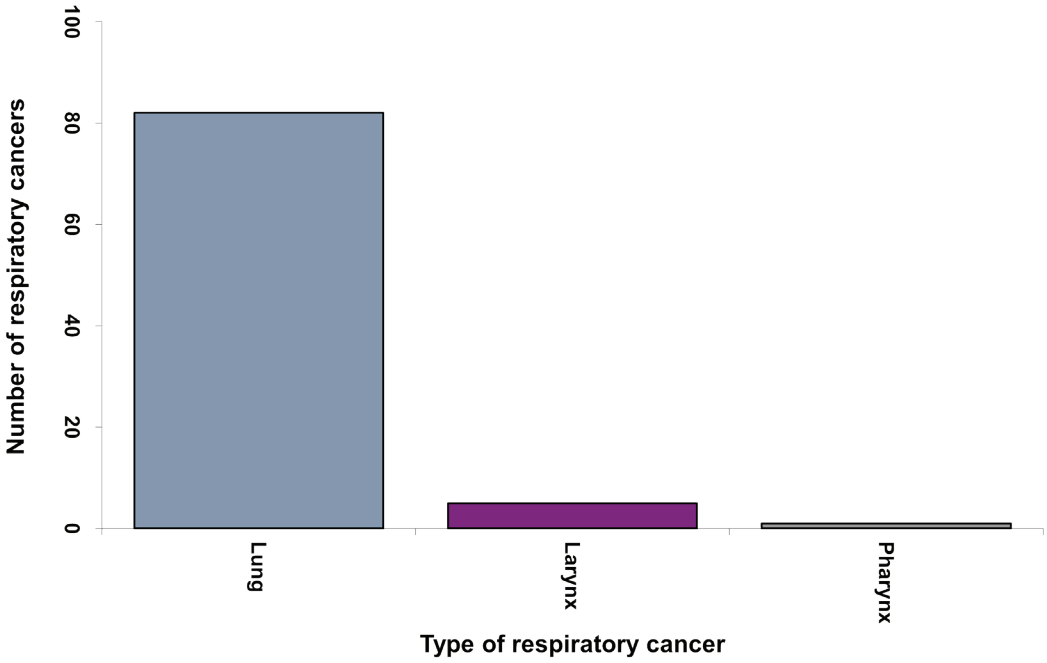
Figure 37. Pretransplant diagnosis and de novo respiratory cancers



*1 patient had 2 respiratory cancers

Abbreviations: PSC, primary sclerosing cholangitis; PBC, primary biliary cirrhosis

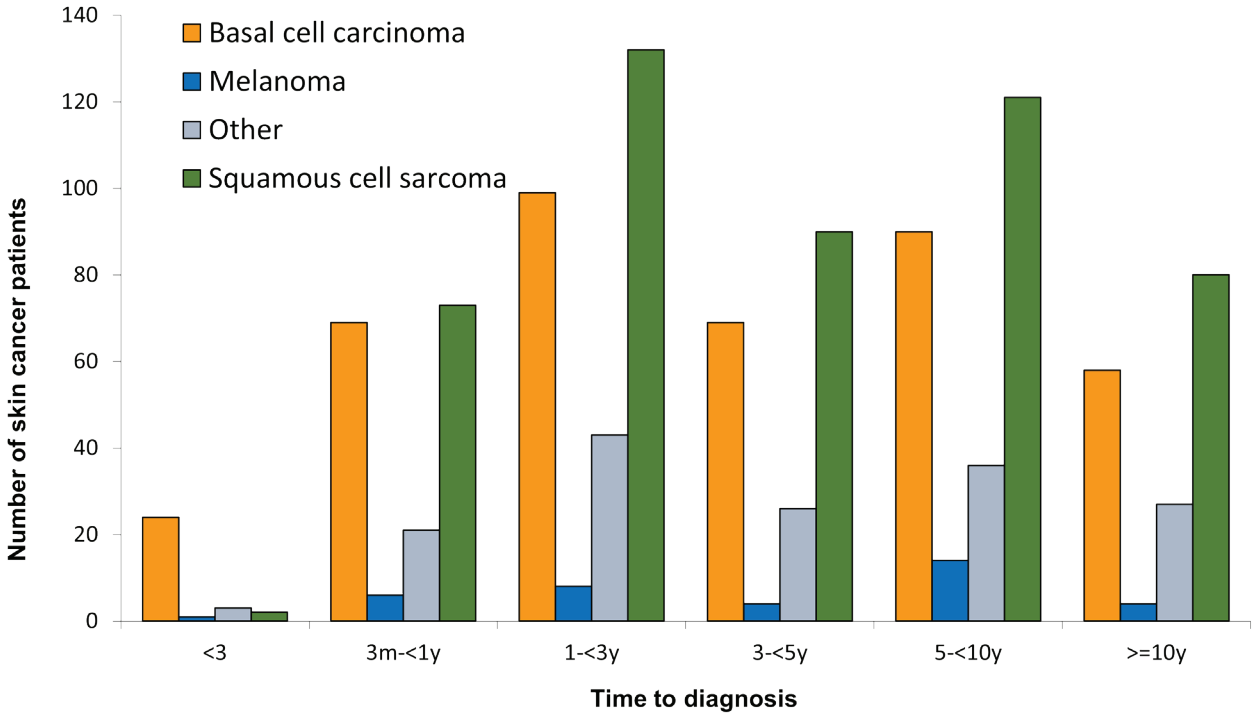
Figure 38. Incidence of de novo respiratory tract cancers by type



13.2 Skin Cancer Development Post-Transplant

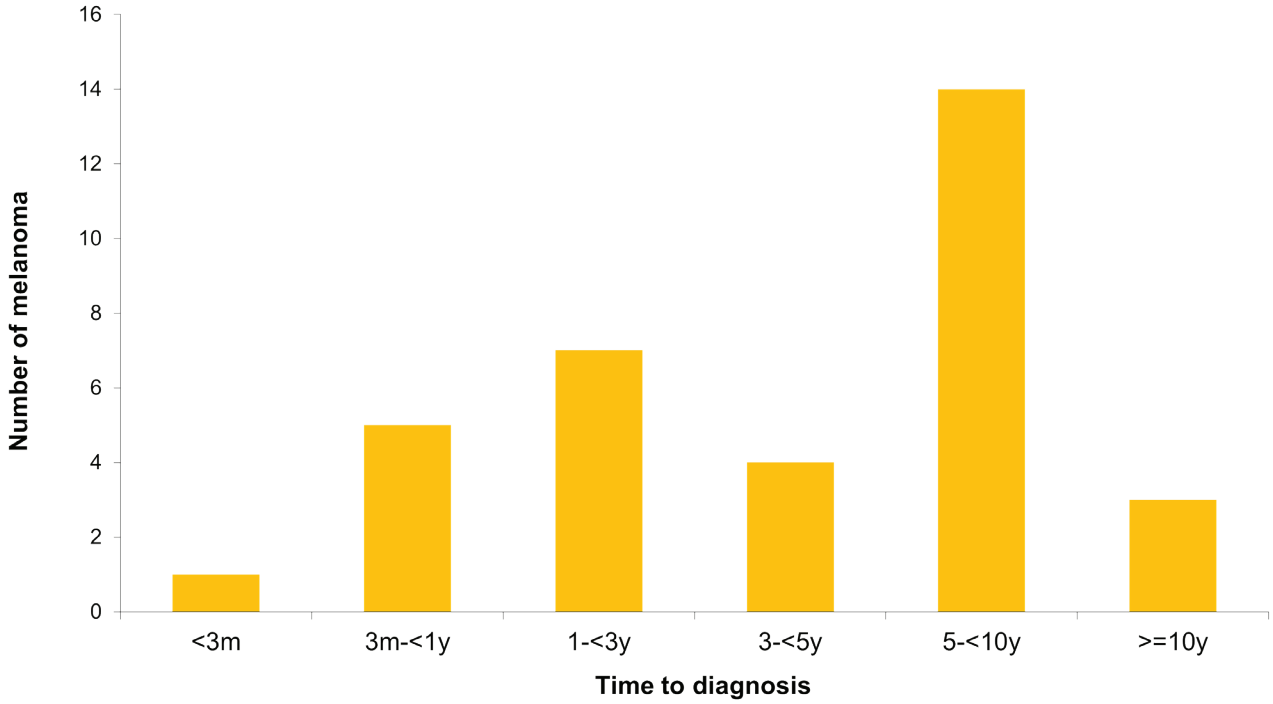
One thousand one hundred and one patients (15%) developed a first skin cancer post-transplant with 531 going on to develop multiple skin cancer types (Figure 39).

Figure 39. Time to first skin cancer development post-transplant by type of skin cancer



Eighty-three patients (1% of all patients) developed eighty-seven melanomas (Figure 40). Thirty-seven patients developed melanoma as a first skin cancer post-transplantation.

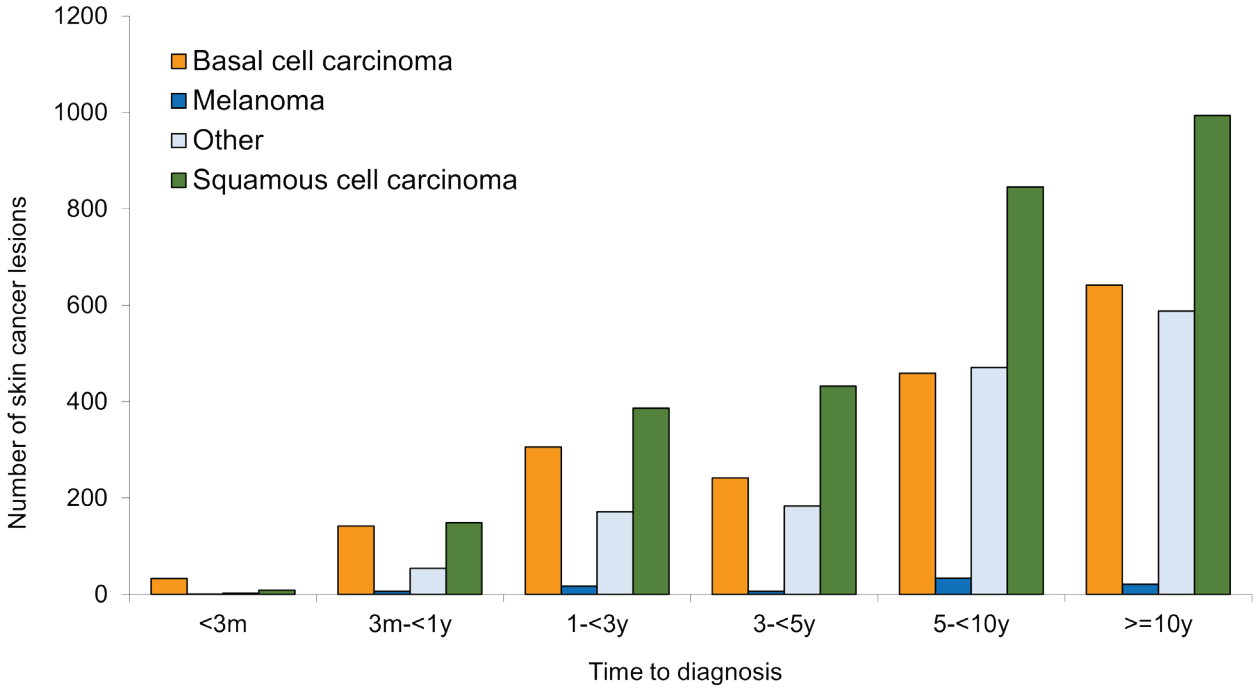
Figure 40. Time to first melanoma development post-transplant
Note: This includes patients who developed melanoma after a non-melanoma skin cancer (first skin cancer)



** 4 patients developed 2 melanomas*

The number of skin cancer lesions increased over time (Figure 41).

Figure 41. Time to all skin cancer lesions development post-transplant



Males were more likely to develop skin cancer post-transplant than females (16% versus 13%, P < 0.001). Males were more likely to die from squamous cell cancer (3% versus 2%) but less likely than females to die of melanoma (17% versus 29%) (Table 15).

Table 15. Skin Cancer Development Post-Transplant

		Male				Female			
	Number of patients that developed one or more skin cancers	**Male recipients**	% of all male transplant recipients	Died of this cancer	% males with this skin cancer type that died of this cancer	**Female recipients**	% of all female transplant recipients	Died of this cancer	% females with this skin cancer type that died of this cancer
Squamous cell	772	545	12%	19	3%	227	8%	5	2%
Basal cell	630	456	10%	1	0%	174	6%	0	0%
Bowen's disease	307	201	4%	0	0%	106	4%	0	0%
Miscellaneous	92	61	1%	0	0%	31	1%	0	0%
Melanoma	83	57	1%	11	17%	26	1%	7	29%
Merkel cell	11	11	0.2%	4	29%	0	0%	0	0%
Total skin cancer patients*	**1,101**	**761**	**16%**	**35**	**4%**	**340**	**13%**	**12**	**4%**
Total transplant recipients	**7,302**	**4,624**				**2,678**			

** Note: Some patients developed more than one skin cancer type. 1,101 patients developed 6,196 skin cancers. 531 patients developed more than one skin cancer type.*

13.3 Cumulative Risk of Developing *De Novo* Skin or Non-Skin Cancer Post Liver Transplant

The cumulative risk of developing any *de novo* cancer post-transplant is 40% by 20 years and 50% by 30 years (Figure 42, Table 16). The cumulative risk of developing any cancer, skin cancer or non-skin cancer at 10 years post-transplant is 26%, 20% and 8% respectively.

Figure 42. Cumulative risk of diagnosis of skin or non-skin cancer following liver transplantation

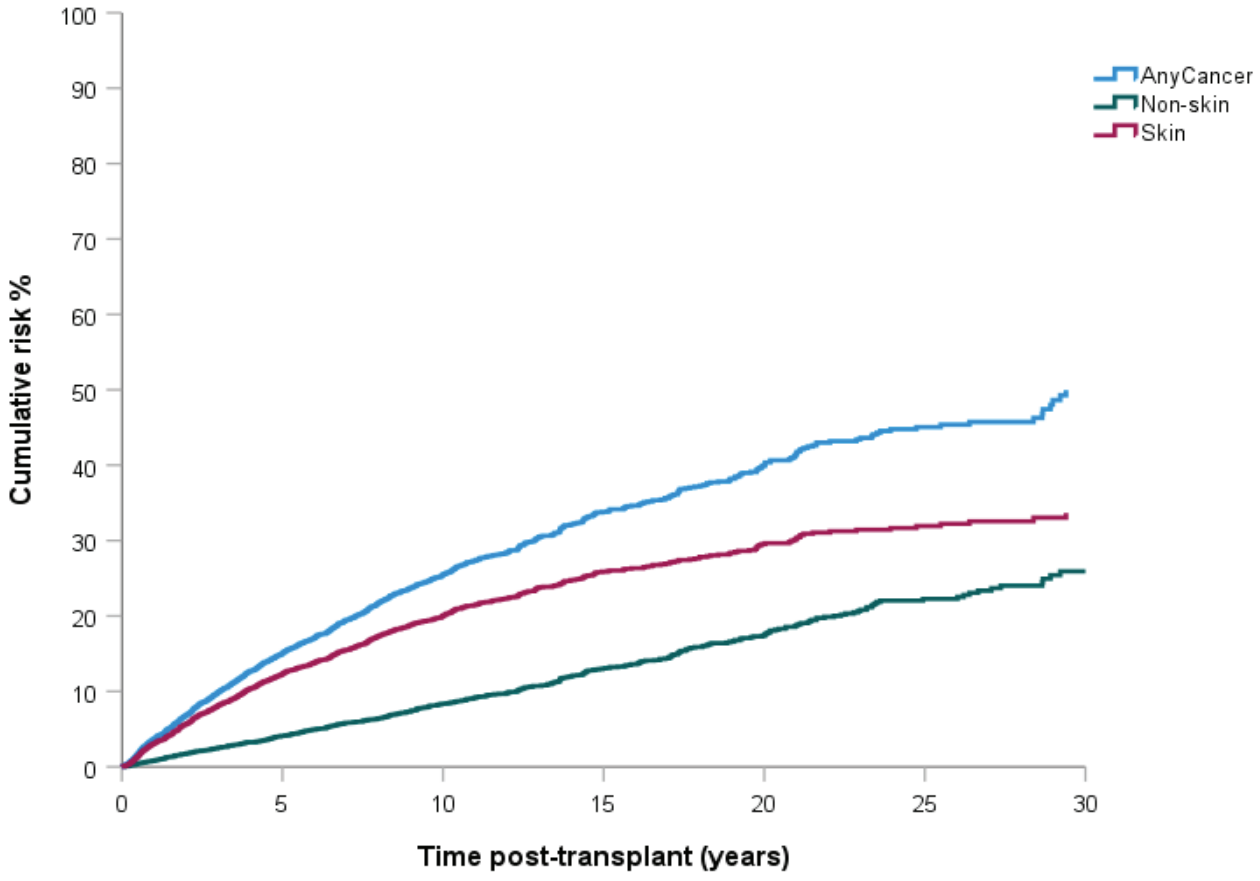


Table 16. Cumulative risk of diagnosis of cancer following liver transplantation

***De novo* cancer group**	**Time post-transplant (years)**							
	0	**1**	**5**	**10**	**15**	**20**	**25**	**30**
Any *de novo* cancer	0%	3%	15%	26%	34%	40%	45%	50%
De novo skin cancer	0%	3%	12%	20%	26%	30%	32%	34%
De novo non-skin cancer	0%	1%	4%	8%	13%	17%	22%	26%

13.4 Liver Cancer Recurrence after Transplant

Recurrent liver cancer has occurred in 13% of patients that had either known liver cancer prior to transplant or had an incidental liver cancer found at explant (Table 17).

Table 17. Liver cancer recurrence in liver cancer patients

	Children	Adults	Total Patients	% of all liver transplant patients n = 7,308
Liver Cancer Known at Transplant	62	1,583	**1,645**	23%
Incidental Liver Cancer Found at Transplant	4	235	**239**	3%
Total Liver Cancer Patients	**66**	**1,818**	**1,884**	**26%**
Recurrent Liver Cancer	8	232	**240**	3%
% of liver cancer patients with recurrence	12%	13%	**13%**	

14 Patient Survival

PPatient survival (alive/deceased) is based on patients who had their initial liver transplant in Australia or New Zealand (i.e. Graft 1). Both deceased and living donor grafts are included in this analysis.

14.1 All patients

7,304 patients had their first liver transplant in Australia or New Zealand (i.e. Graft 1, Figure 43 and Table 18). Six patients who had their first liver transplant overseas and subsequently had a liver transplant in Australia or New Zealand have been excluded from this patient survival analysis. Ten-year patient survival was 74.1%. The median patient survival post-transplant was 21.2 years.

Figure 43. Patient survival curve

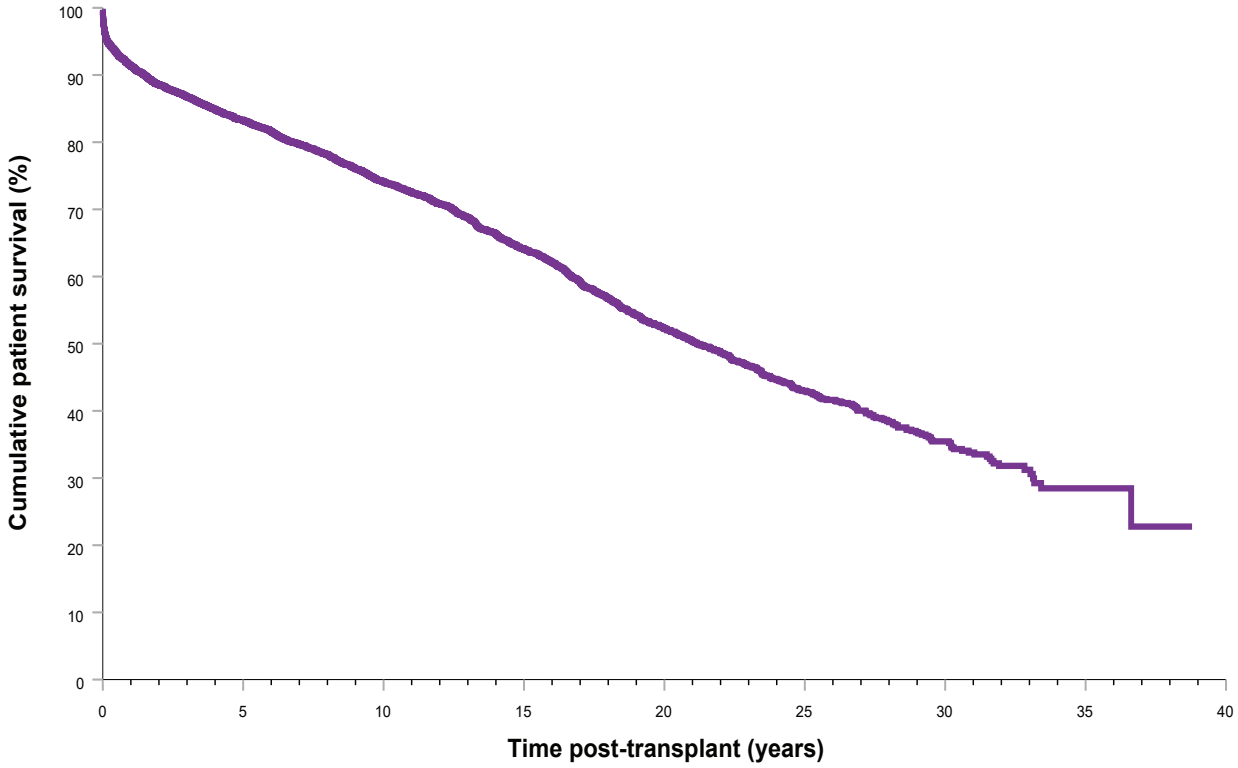


Table 18. Patient survival

Patient Survival	Time post-transplant (years)								
	0	1	3	5	10	20	30	35	40
No. at risk	7,304	6,272	5,392	4,587	2,900	927	158	14	0
Survival (%)		91%	87%	83%	74%	52%	36%	29%	

14.2 Patient Survival by Age Group

Paediatric cases are defined as less than 16 years of age at time of first transplant (n = 1,169). Adult cases are defined as greater than or equal to 16 years at time of first transplant (n = 6,135). Post-transplant survival was superior in the paediatric population compared to the adult population (P < 0.001, Figure 44, Table 19). Ten-year patient survival was 85.7% for children and 71.8% for adults. Median patient survival was not reached for children and was 18.5 years for adults.

Figure 44. Patient survival curve by age category

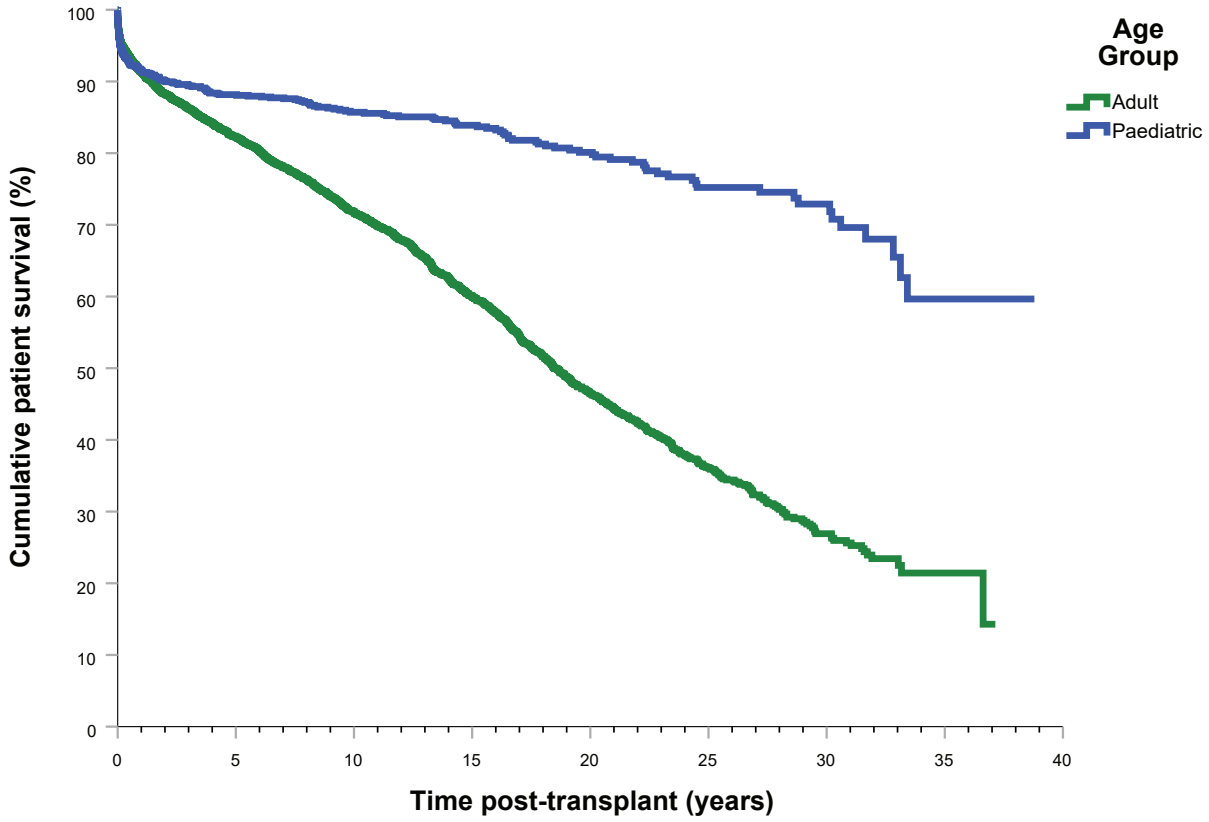


Table 19. Patient survival by age category

Age group	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Paediatric (<16y)	No. at risk	1,169	1,014	923	815	580	252	70	10	0
	Survival (%)		92%	90%	88%	86%	80%	73%	60%	
Adults (≥16y)	No. at risk	6,135	5,258	4,469	3,772	2,320	675	88	4	0
	Survival (%)		91%	86%	82%	72%	47%	27%	21%	

14.3 Paediatric Patient Survival by Age Strata

There was no significant difference in patient survival by paediatric age strata (P = 0.304, Figure 45, Table 20). Ten-year patient survival was 86.4% for children less than 1 year, 82.6% for 1 – 2-year-olds, 87.6% for 3 – 9-year-olds and 87.6% for 10 – 15-year-olds. Median patient survival was not reached for all paediatric age groups.

Figure 45. Paediatric patient survival curve by age strata

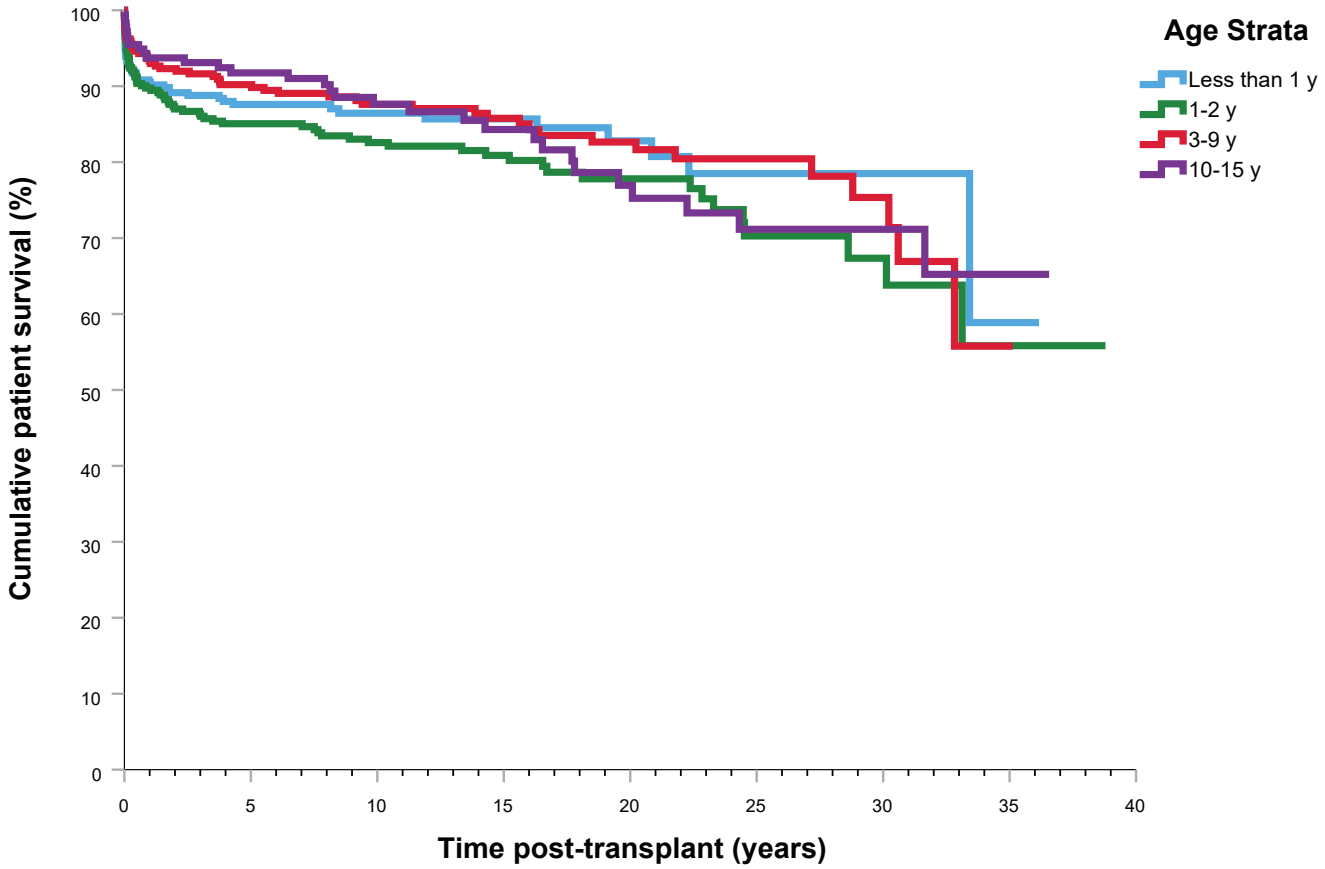


Table 20. Paediatric patient survival by age strata

Age strata	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
< 1 year	No. at risk	329	277	242	202	136	43	16	2	0
	Survival (%)		91%	89%	88%	86%	83%	79%	59%	
1 - 2 years	No. at risk	346	297	271	241	180	79	19	3	0
	Survival (%)		90%	86%	85%	83%	78%	67%	56%	
3 - 9 years	No. at risk	317	281	263	240	169	84	20	1	0
	Survival (%)		93%	92%	90%	88%	83%	75%	56%	
10 – 15 years	No. at risk	177	159	147	132	95	46	15	4	0
	Survival (%)		94%	93%	92%	88%	77%	71%	65%	

14.4 Adult Patient Survival by Age Strata

Post-transplant patient survival in adults was significantly worse with increasing patient age (P < 0.001, Figure 46, Table 21). For patients aged 16 to 29, 30 to 39, 40 to 49, 50 to 59, 60 to 69 and 70 to 79 years, 10-year patient survival was 79.4%, 77.5%, 73.9%, 70.8%, 64.3% and 66.3%, respectively. For patients aged 16 to 29 years, 30 to 39, 40 to 49, 50 to 59, 60 to 69 and 70 to 79 years, median patient survival was 31.9, 25.0, 22.0, 16.9, 14.2 and 11.0 years, respectively.

Figure 46. Adult patient survival curve by age strata

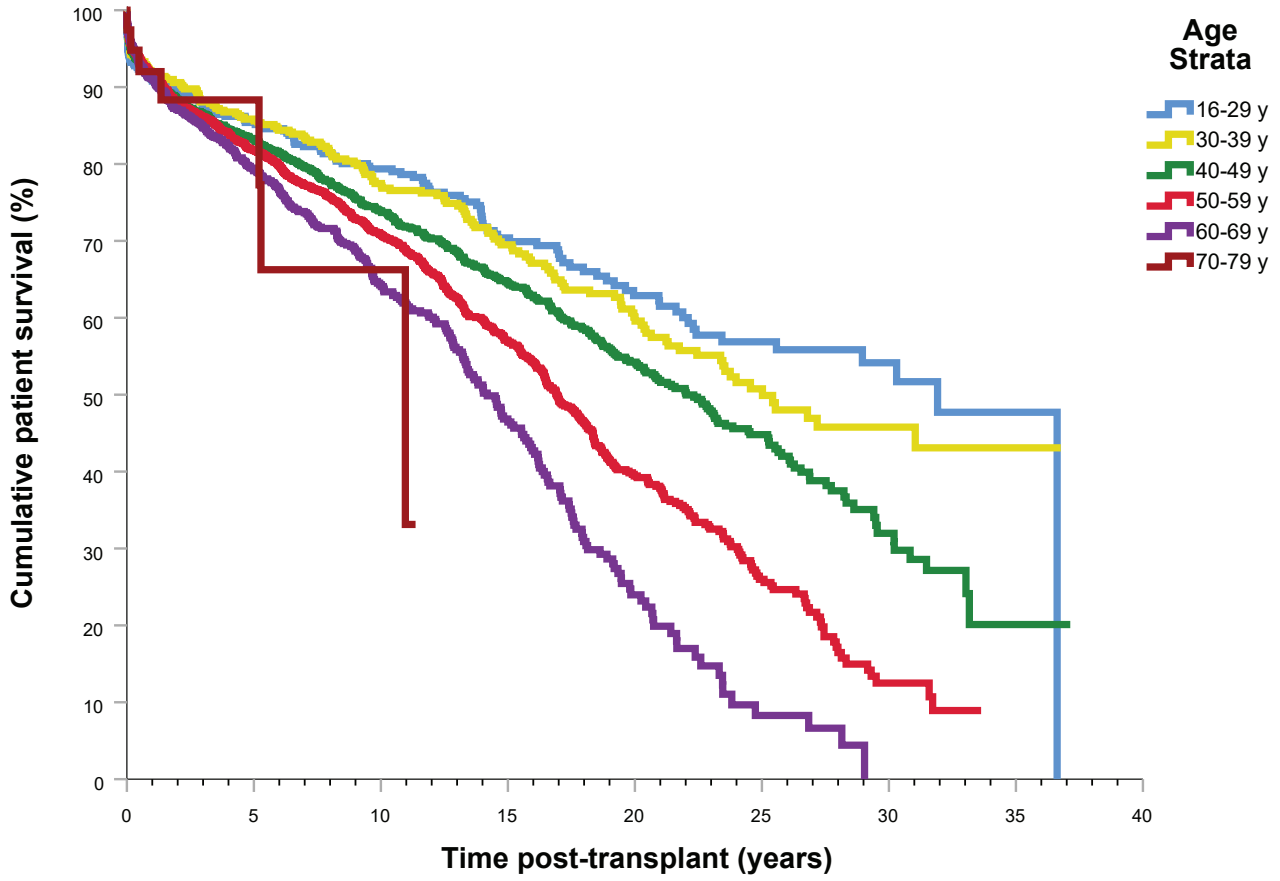


Table 21. Adult patient survival by age strata

Age strata	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
16-29 y	No. at risk	474	401	359	319	225	96	23	2	0
	Survival (%)		91%	88%	85%	79%	63%	54%	48%	
30-39 y	No. at risk	561	476	413	364	257	115	23	1	0
	Survival (%)		92%	88%	86%	78%	60%	46%	43%	
40-49 y	No. at risk	1,364	1,198	1,042	923	671	243	29	1	0
	Survival (%)		91%	87%	83%	74%	54%	32%	20%	
50-59 y	No. at risk	2,257	1,968	1,707	1,462	880	190	13	0	
	Survival (%)		91%	86%	82%	71%	39%	13%		
60-69 y	No. at risk	1,438	1,185	930	694	285	31	0		
	Survival (%)		91%	85%	79%	64%	24%			
70-79 y	No. at risk	41	30	18	710	2	0			
	Survival (%)		92%	88%	88%	66%				

14.5 Patient Survival by Era of Transplant

There has been a progressive improvement in patient survival over eras of transplantation (P < 0.001, Figure 47, Table 22), although survival rates have been similar since 2000. Patient survival in the most recent era was 93.5% at 1 year, 88.3% at 3 years, 87.0% at 5 years and 76.0% at 10 years. Median patient survival was not reached for recent eras since 2010 and was 18.7 years for 2005 – 2009, 20.8 years for 2000 – 2004, 19.8 years for 1995 – 99, 19.6 years for 1990 – 94 and 11.8 years for 1985 – 89.

Figure 47. Patient survival curve by era of transplant

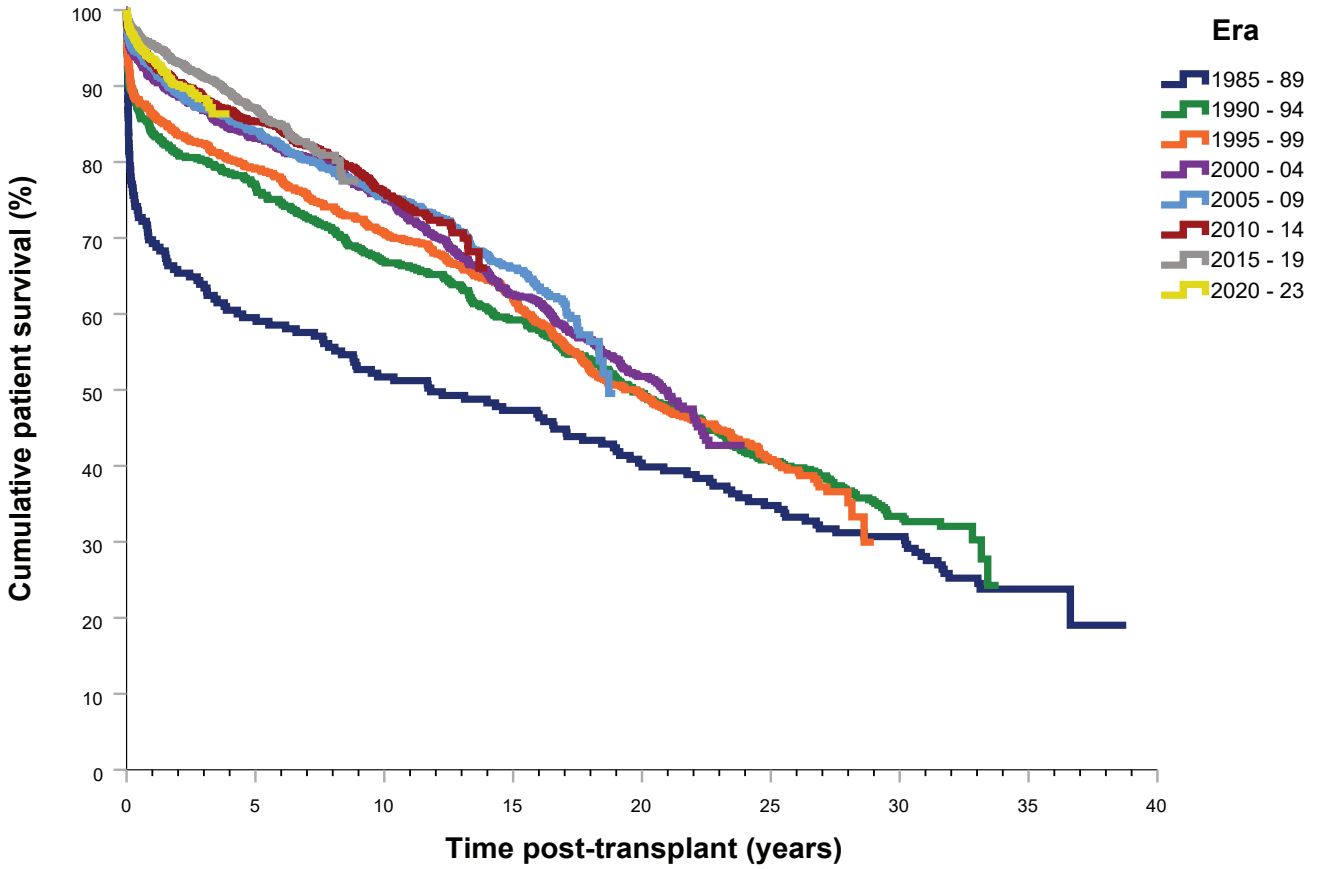


Table 22. Patient survival by transplant era

Transplant Era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1985 - 89	No. at risk	205	143	131	122	106	80	60	14	0
	Survival (%)		70%	64%	60%	52%	40%	31%	24%	
1990 - 94	No. at risk	552	461	438	419	355	246	98	0	
	Survival (%)		84%	80%	77%	67%	50%	33%		
1995 - 99	No. at risk	697	597	566	540	478	321	0		
	Survival (%)		86%	82%	79%	71%	49%			
2000 - 04	No. at risk	860	777	736	699	631	280	0		
	Survival (%)		91%	87%	83%	76%	52%			
2005 - 09	No. at risk	962	886	832	803	714	0			
	Survival (%)		93%	87%	84%	75%				
2010 - 14	No. at risk	1,228	1,140	1,079	1,035	616	0			
	Survival (%)		93%	88%	85%	76%				
2015 - 19	No. at risk	1,617	1,539	1,427	969	0				
	Survival (%)		96%	91%	87%					
2020 - 23	No. at risk	1,183	729	183	0					
	Survival (%)		94%	88%						

14.6 Paediatric Patient Survival by Era of Transplant

There has been a progressive improvement in paediatric patient survival over eras of transplantation (P < 0.001, Figure 48, Table 23). Paediatric patient survival in the most recent era was 97.4% at 1 year, 97.4% at 3 years, 95.6% at 5 years and 88.7% at 10 years. Median paediatric patient survival was not reached for all eras other than 1985 – 89 and 1990 – 1994 which had median survival times of 20.8 and 33.4 years respectively.

Figure 48. Paediatric patient survival curve by era of transplant

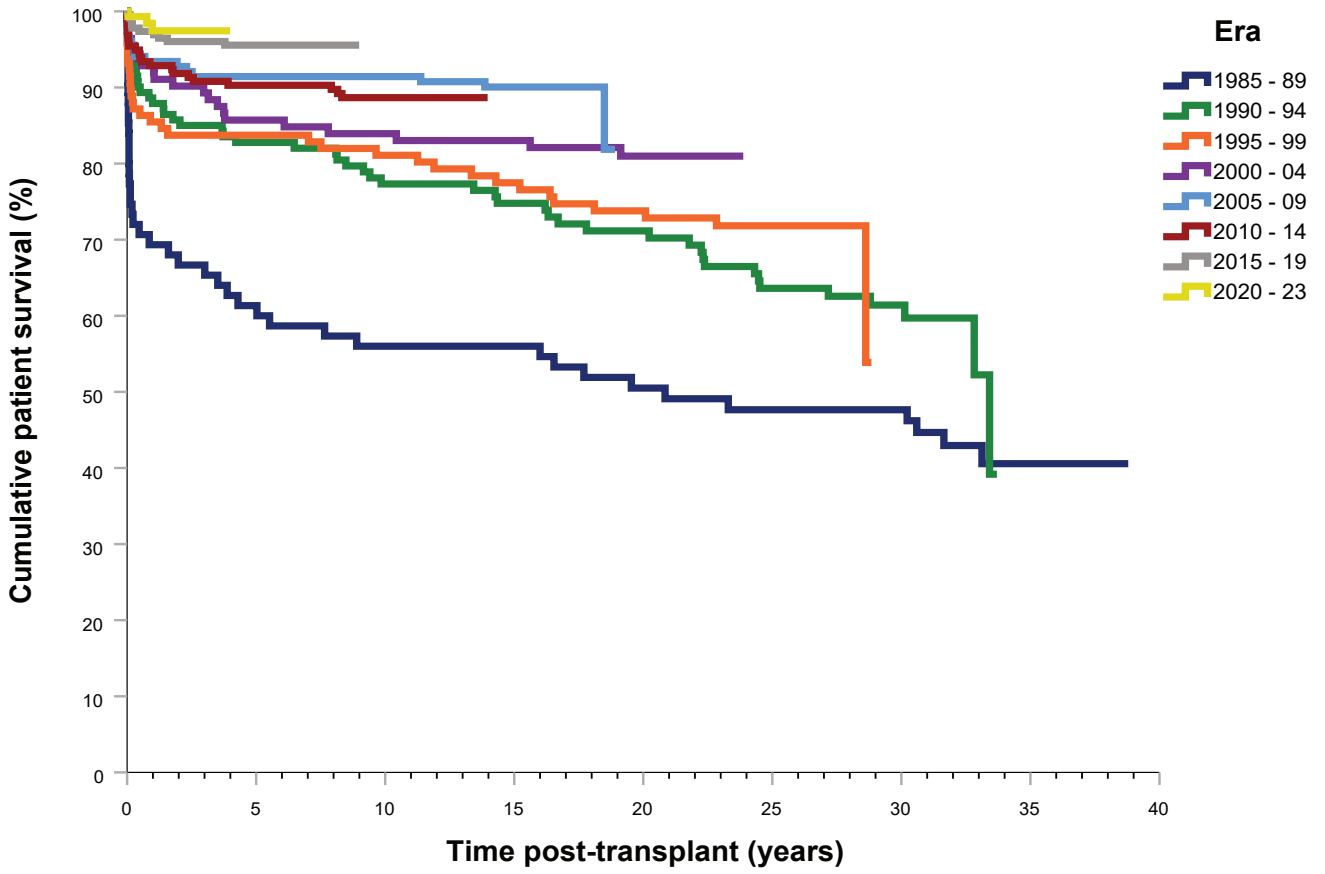


Table 23. Paediatric patient survival by transplant era

Transplant Era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1985 - 89	No. at risk	75	52	50	46	42	36	33	10	0
	Survival (%)		69%	67%	61%	56%	51%	48%	41%	
1990 - 94	No. at risk	141	122	115	111	96	77	37	0	
	Survival (%)		88%	85%	83%	77%	71%	61%		
1995 - 99	No. at risk	117	99	96	96	91	79	0		
	Survival (%)		86%	84%	84%	81%	74%			
2000 - 04	No. at risk	112	104	100	96	93	60	0		
	Survival (%)		93%	89%	86%	84%	81%			
2005 - 09	No. at risk	152	141	138	138	137	0			
	Survival (%)		93%	91%	91%	91%				
2010 - 14	No. at risk	197	181	176	174	121	0			
	Survival (%)		93%	91%	90%	89%				
2015 - 19	No. at risk	228	219	215	154	0				
	Survival (%)		97%	96%	96%					
2020 - 23	No. at risk	147	96	33						
	Survival (%)		97%	97%						

14.7 Adult Patient Survival by Era of Transplant

There has been a progressive improvement in adult patient survival over eras of transplantation (P < 0.001, Figure 49, Table 24), although survival rates have been similar since 2000. Patient survival in the most recent era was 92.9% at 1 year, 87.0% at 3 years, 85.6% at 5 years and 73.6% at 10 years. Median adult patient survival was not reached for recent eras since 2010 and was 18.0 years for 2005 – 2009, 18.9 years for 2000 – 04, 17.6 years for 1995 – 99, 17.0 years for 1990 – 94 and 9.5 years for 1985 – 89.

Figure 49. Adult patient survival curve by era of transplant

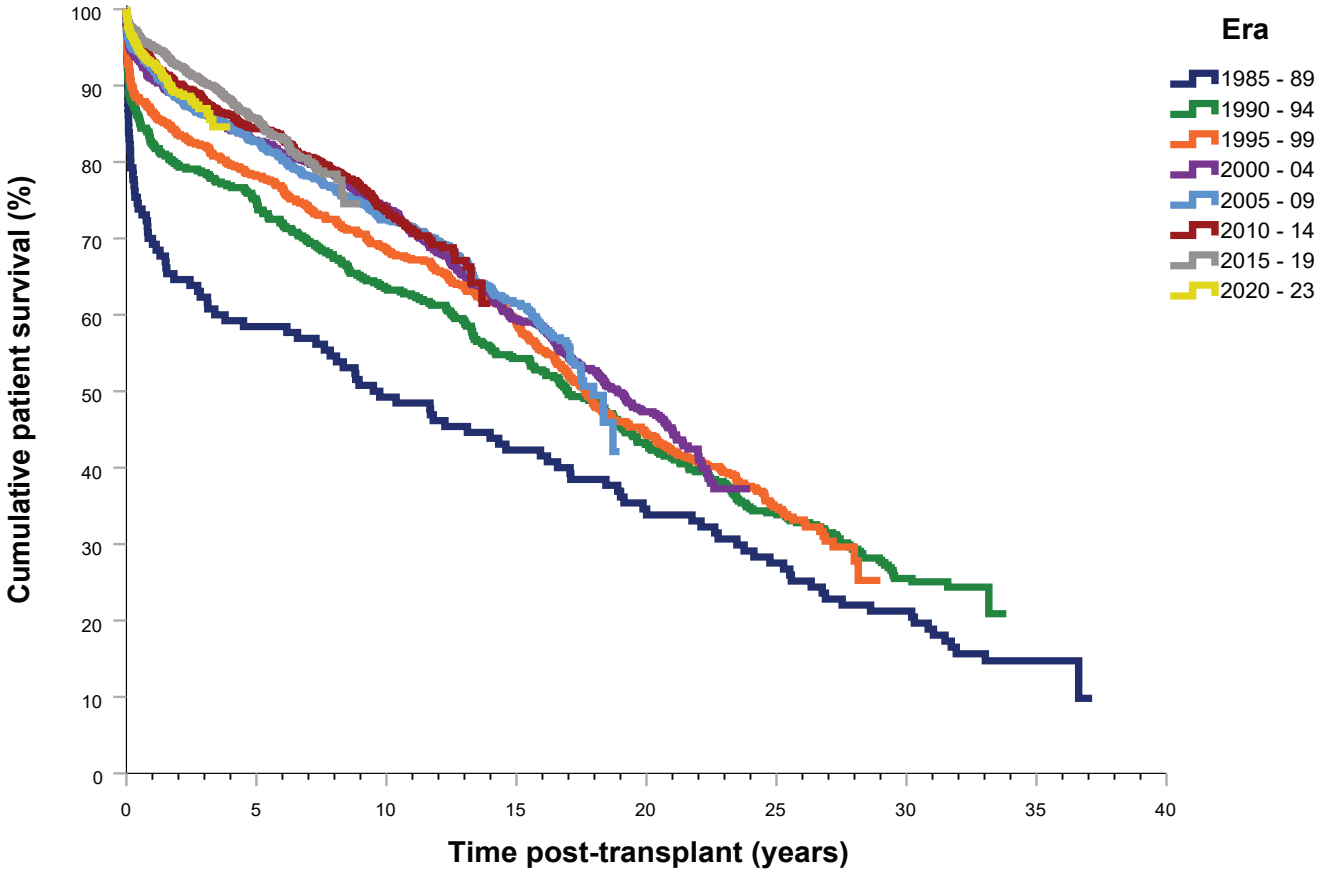


Table 24. Adult patient survival by transplant era

Transplant Era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1985 - 89	No. at risk	130	91	81	76	64	44	27	4	0
	Survival (%)		70%	62%	59%	49%	35%	21%	15%	
1990 - 94	No. at risk	411	339	323	308	259	169	61	0	
	Survival (%)		83%	79%	75%	64%	43%	26%		
1995 - 99	No. at risk	580	498	470	444	387	242	0		
	Survival (%)		87%	82%	78%	69%	44%			
2000 - 04	No. at risk	748	673	636	603	538	220	0		
	Survival (%)		91%	86%	83%	74%	47%			
2005 - 09	No. at risk	810	745	694	665	577	0			
	Survival (%)		92%	86%	83%	72%				
2010 - 14	No. at risk	1,031	959	903	861	495	0			
	Survival (%)		93%	88%	84%	74%				
2015 - 19	No. at risk	1,389	1,320	1,212	815	0				
	Survival (%)		95%	90%	86%					
2020 - 23	No. at risk	1,036	633	150	0					
	Survival (%)		93%	87%						

14.8 Paediatric Patient Survival by Type of Primary Graft

Children transplanted with a living donor graft or split liver graft had survival that was slightly superior to those transplanted with a whole graft and survival after reduced liver transplantation was inferior to other forms of transplantation (P < 0.001, Figure 50, Table 25). However, this may be partly due to era effect, since more reduced liver transplantation was performed in the earlier eras. One case of hepatocyte transplantation was excluded from this analysis. Ten-year patient survival was 92.2% for split liver grafts, 90.3% for living donor grafts, 86.3% for whole liver grafts and 76.0% for reduced grafts. Median paediatric patient survival was 33.1 years for reduced grafts and was not reached for other graft types.

Figure 50. Paediatric patient survival curve by type of primary graft

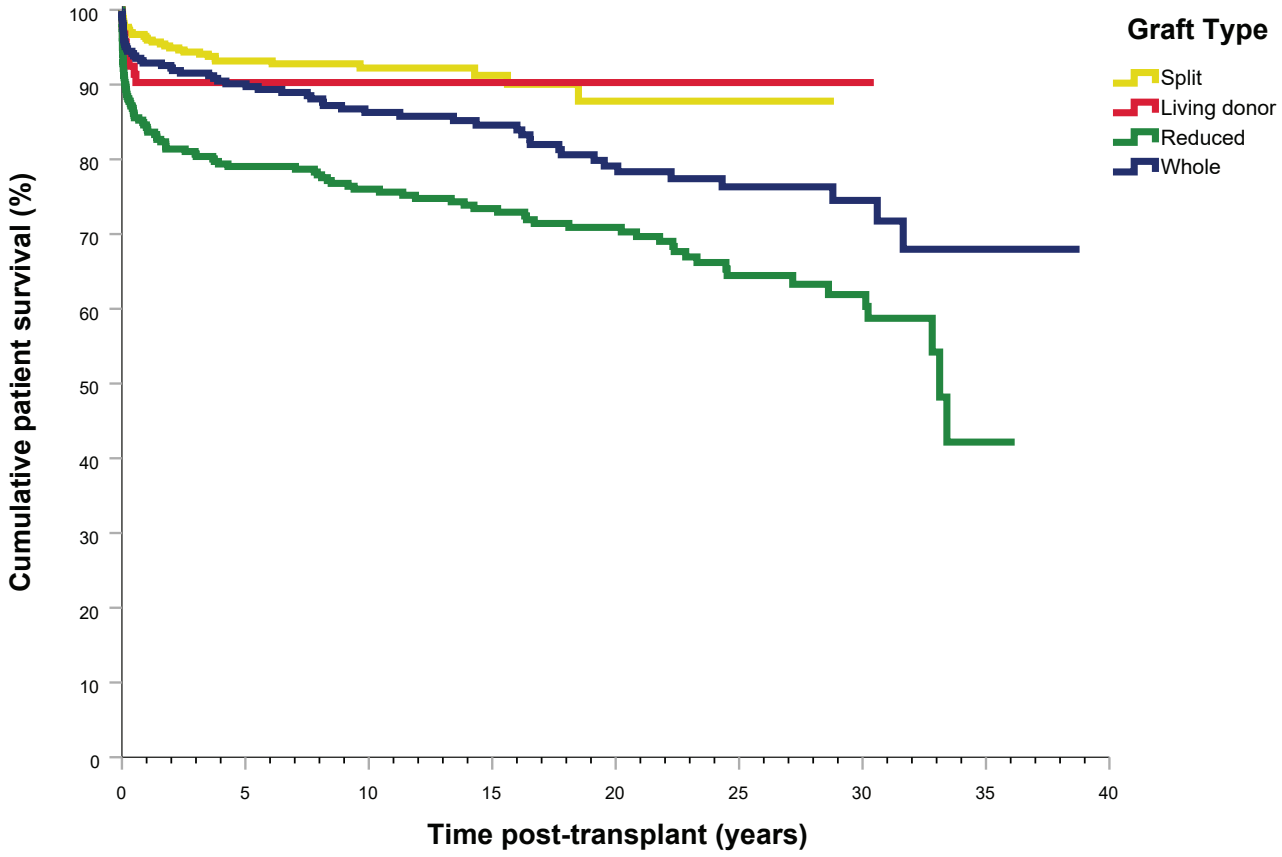


Table 25. Paediatric patient survival by type of primary graft

Graft Type Category	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Living donor	No. at risk	93	82	78	68	50	4	1	0	
	Survival (%)		90%	90%	90%	90%	90%	90%		
Split	No. at risk	431	381	336	274	154	24	0		
	Survival (%)		96%	94%	93%	92%	88%			
Whole	No. at risk	325	288	265	240	181	105	30	7	0
	Survival (%)		93%	92%	90%	86%	79%	75%	68%	
Reduced	No. at risk	319	262	243	232	194	119	39	3	0
	Survival (%)		84%	81%	79%	76%	71%	62%	42%	

14.9 Adult Patient Survival by Type of Primary Graft

Although early survival after reduced liver transplantation appeared to be inferior to other graft types, there was no significant difference in patient survival in adults by type of primary graft (P = 0.642, Figure 51, Table 26). Ten-year patient survival was 79.8% for living donor grafts, 75.7% for split grafts, 71.6% for whole grafts and 55.6% for reduced grafts. Median adult patient survival was not reached for living and reduced donor grafts and was 19.0 years for split grafts, 18.4 years for whole grafts and 9.4 years for domino grafts.

Figure 51. Adult patient survival curve by type of primary graft

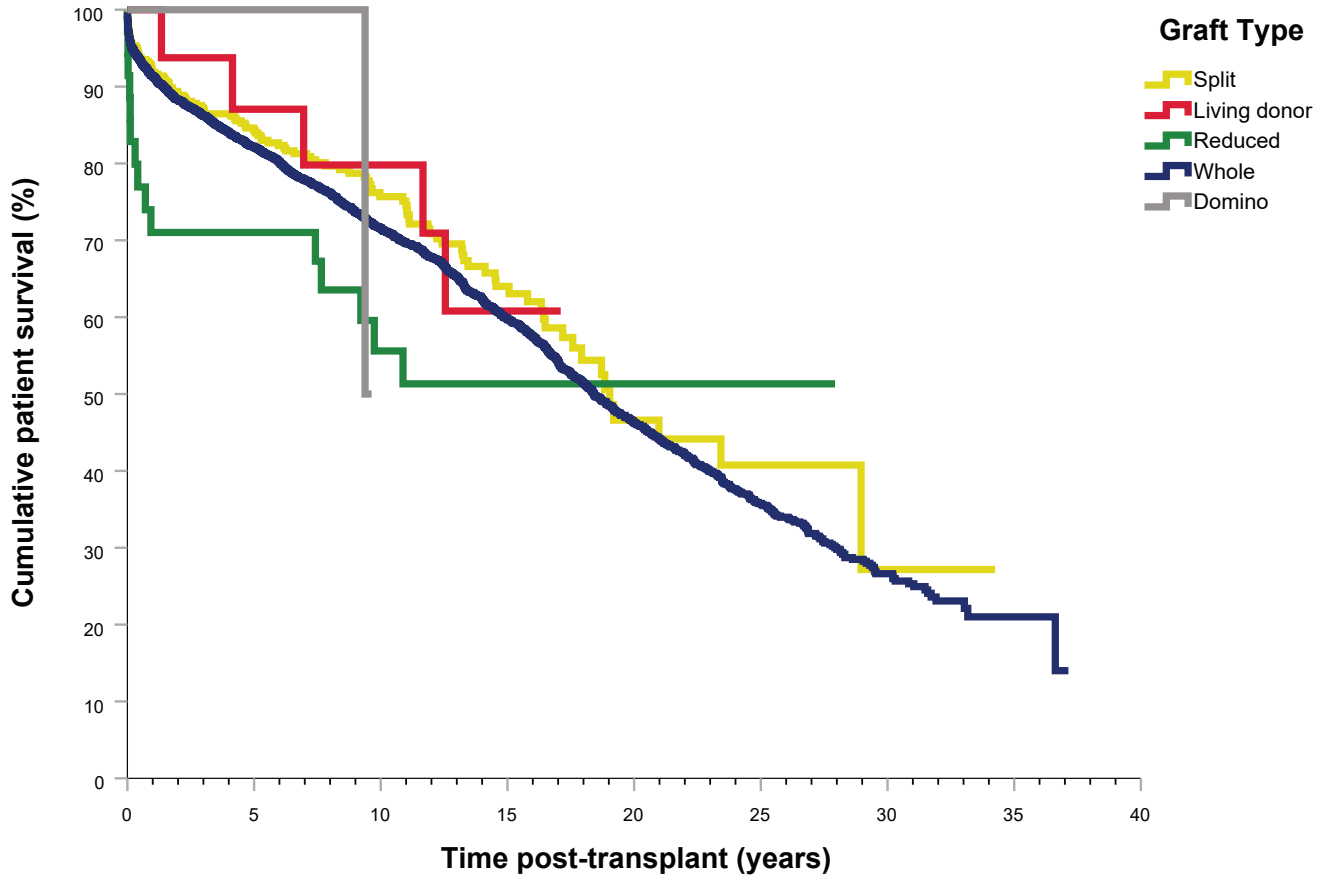


Table 26. Adult patient survival by type of primary graft

Graft Type Category	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Living donor	No. at risk	16	16	15	13	11	0			
	Survival (%)		100%	94%	87%	80%				
Split	No. at risk	451	386	319	266	140	20	2	0	
	Survival (%)		92%	87%	84%	76%	47%	27%		
Reduced	No. at risk	35	24	22	21	14	8	0		
	Survival (%)		71%	71%	71%	56%	51%			
Whole	No. at risk	5,628	4,828	4,109	3,468	2,155	647	86	4	0
	Survival (%)		91%	86%	82%	72%	46%	27%	21%	
Domino	No. at risk	5	4	4	4	0				
	Survival (%)		100%	100%	100%					

14.10 Paediatric Patient Survival by Weight

Although children weighing less than 5 kg had poorer early survival in comparison to other weights, there was no significant difference in patient survival of children of different weights (P = 0.220, Figure 52 and Table 27). Ten-year paediatric patient survival was 88.7% for children over 20 kg, 85.7% for children weighing between 8.01 and 20 kg, 82.8% for children between 5 and 8 kg and 73.3% for children under 5 kg. Median patient survival was 33.41 years for children between 5 and 8 kg and was not reached for other weight categories.

Figure 52. Paediatric patient survival curve by transplant weight

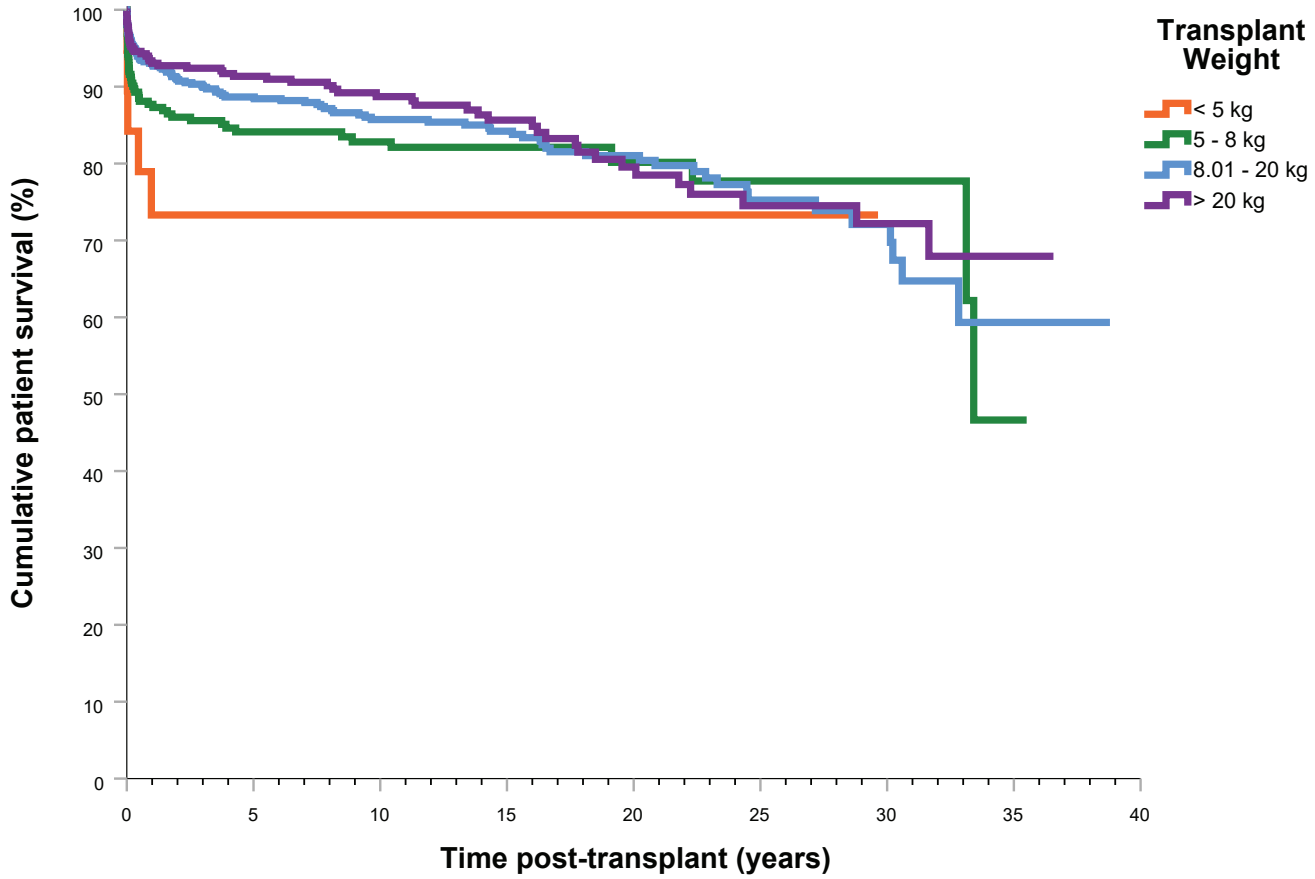


Table 27. Paediatric patient survival by transplant weight

Transplant weight	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
< 5 kg	No. at risk	19	13	11	9	5	3	0		
	Survival (%)		73%	73%	73%	73%	73%			
5 - 8 kg	No. at risk	262	217	189	168	121	38	15	1	0
	Survival (%)		88%	86%	84%	83%	80%	77%	47%	
8.01 - 20 kg	No. at risk	554	487	444	388	282	134	31	4	0
	Survival (%)		93%	90%	89%	86%	81%	72%	59%	
> 20 kg	No. at risk	333	296	278	249	172	77	24	5	0
	Survival (%)		93%	92%	91%	89%	80%	72%	68%	

14.11 Paediatric Patient Survival by Primary Disease

There was no significant difference in patient survival between different disease categories in children (P = 0.07, Figure 53, Table 28). Children with fulminant hepatic failure had poorer early survival and had the poorest ten-year survival of 77.4%. All other paediatric disease categories had a 10-year survival of 83% or higher. Median patient survival was 31.6 years for children with other diseases, 27.1 years for children with progressive familial intrahepatic cholestasis and was not reached for all other disease groups.

Figure 53. Paediatric patient survival curve by primary disease

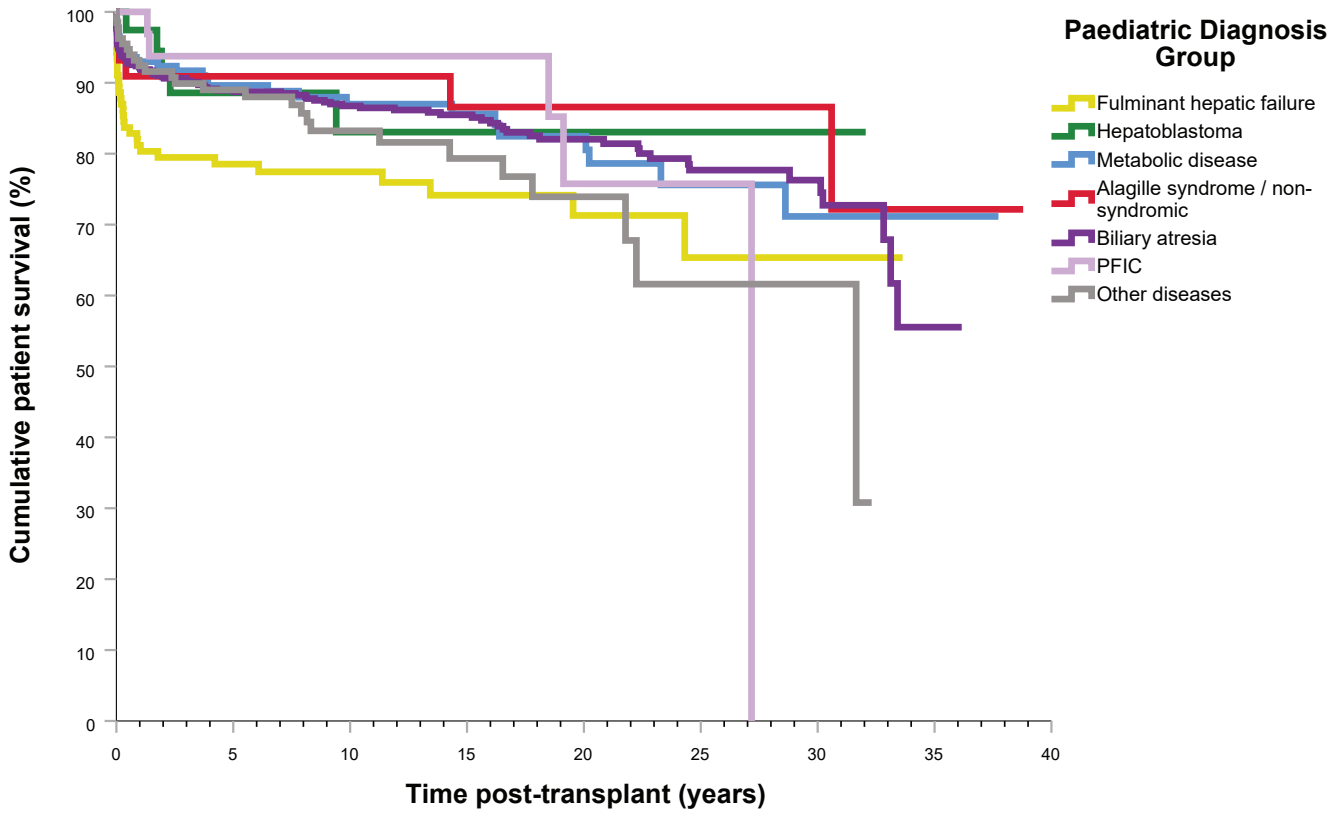


Table 28. Paediatric patient survival by primary disease

Primary Disease	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
PFIC	No. at risk	33	32	30	25	19	8	0		
	Survival (%)		100%	94%	94%	94%	76%			
Alagille syndrome / non-syndromic	No. at risk	44	37	37	35	23	16	6	2	0
	Survival (%)		91%	91%	91%	91%	87%	87%	72%	
Hepatoblastoma	No. at risk	41	36	29	25	14	2	1	0	
	Survival (%)		97%	89%	89%	83%	83%	83%		
Metabolic Diseases	No. at risk	173	153	140	122	88	43	12	3	0
	Survival (%)		93%	92%	90%	87%	83%	71%	71%	
Biliary atresia	No. at risk	621	545	491	738	321	141	44	5	0
	Survival (%)		92%	91%	89%	87%	82%	76%	56%	
Fulminant hepatic failure	No. at risk	123	96	90	76	57	24	5	0	
	Survival (%)		81%	80%	79%	77%	71%	65%		
Other Diseases	No. at risk	133	115	106	94	58	18	2	0	
	Survival (%)		93%	90%	89%	83%	74%	62%		

Abbreviation: PFIC, Progressive familial intrahepatic cholestasis

14.12 Adult Patient Survival by Primary Disease

There was a significant difference in the survival between different disease categories in adults (P < 0.001, Figure 54, Table 29). Patients with hepatocellular carcinoma, hepatitis C virus cirrhosis and non-alcoholic fatty liver disease / cryptogenic cirrhosis had the poorest 10-year patient survival (65.3%, 68.6% and 71.8%, respectively), while those with alcohol-related cirrhosis, hepatocellular carcinoma and hepatitis C virus cirrhosis had the poorest median survival (16.2 years, 16.6 years and 17.0 years, respectively). Patients with fulminant hepatic failure had poorer early survival than other diagnoses (1-year patient survival 83.2%), but long-term survival was similar to patients transplanted for other diagnoses.

Figure 54. Adult patient survival curve by primary disease

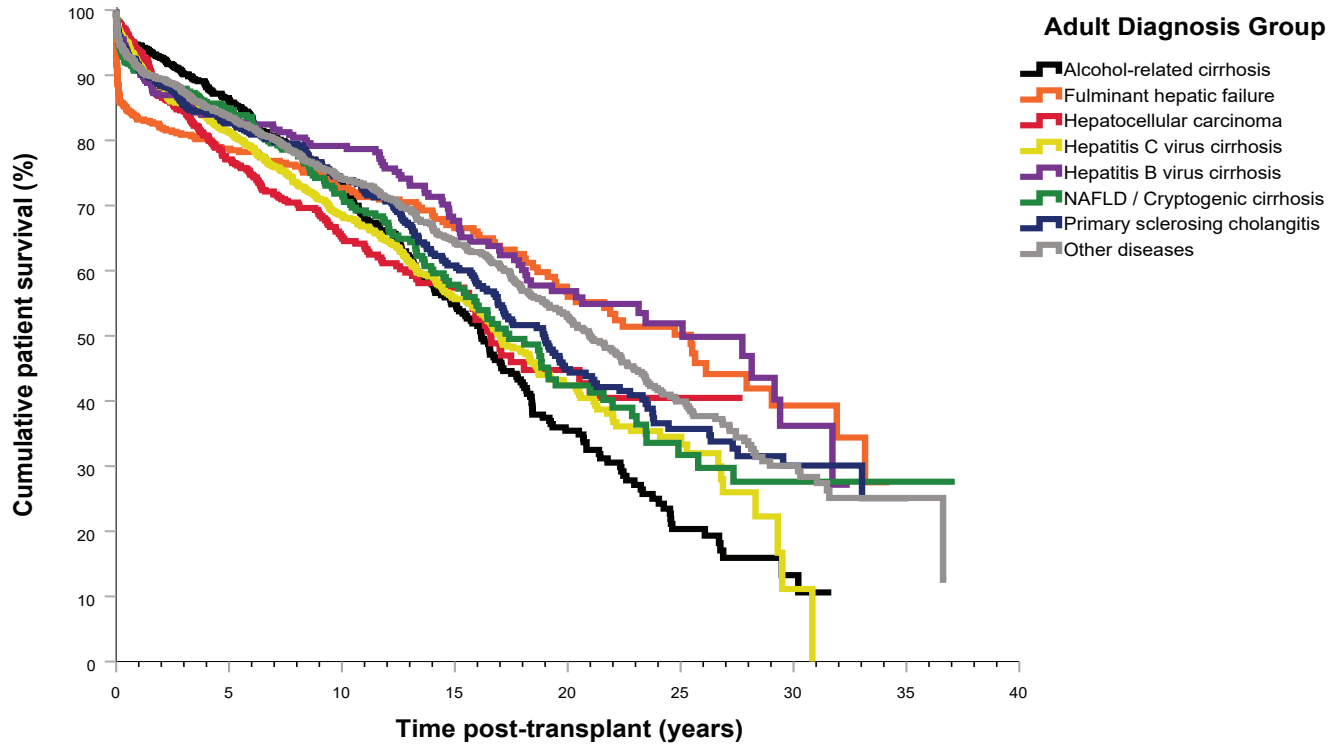


Table 29. Adult patient survival by primary disease

Primary Disease	Patient Survival	Time post-transplant (years) 0	1	3	5	10	20	30	35	40
Alcohol-related cirrhosis	No. at risk	886	772	623	502	295	68	5	0	
	Survival (%)		95%	90%	86%	73%	35%	13%		
Fulminant hepatic failure	No. at risk	545	416	364	311	210	72	13	0	
	Survival (%)		83%	81%	79%	73%	57%	39%		
Hepatocellular carcinoma	No. at risk	811	699	550	418	179	24	0		
	Survival (%)		94%	85%	77%	65%	45%			
Hepatitis B virus cirrhosis	No. at risk	337	295	259	227	167	62	7	0	
	Survival (%)		91%	86%	84%	79%	57%	36%		
Hepatitis C virus cirrhosis	No. at risk	1,138	1,035	930	824	519	97	1	0	
	Survival (%)		92%	86%	81%	69%	42%	11%		
NAFLD / Cryptogenic cirrhosis	No. at risk	607	496	407	332	169	44	10	1	0
	Survival (%)		91%	88%	85%	72%	42%	28%	28%	
Primary sclerosing cholangitis	No. at risk	617	524	459	397	258	86	17	1	0
	Survival (%)		91%	85%	83%	74%	45%	30%	25%	
Other diseases	No. at risk	1,194	1,021	877	761	523	222	35	2	0
	Survival (%)		91%	87%	84%	74%	53%	30%	25%	

Abbreviation: NAFLD, non-alcoholic fatty liver disease

14.13 Patient Survival by Age Group with Fulminant Hepatic Failure

There was no significant difference in the survival between adults and children with fulminant hepatic failure as a primary diagnosis or other diagnosis (P = 0.09, Figure 55 and Table 30). Ten-year patient survival was 77.8% for children and 73.1% for adults. Median patient survival was not reached for children and was 25.4 years for adults.

Figure 55. Patient survival curve by age group with fulminant hepatic failure – all diagnoses

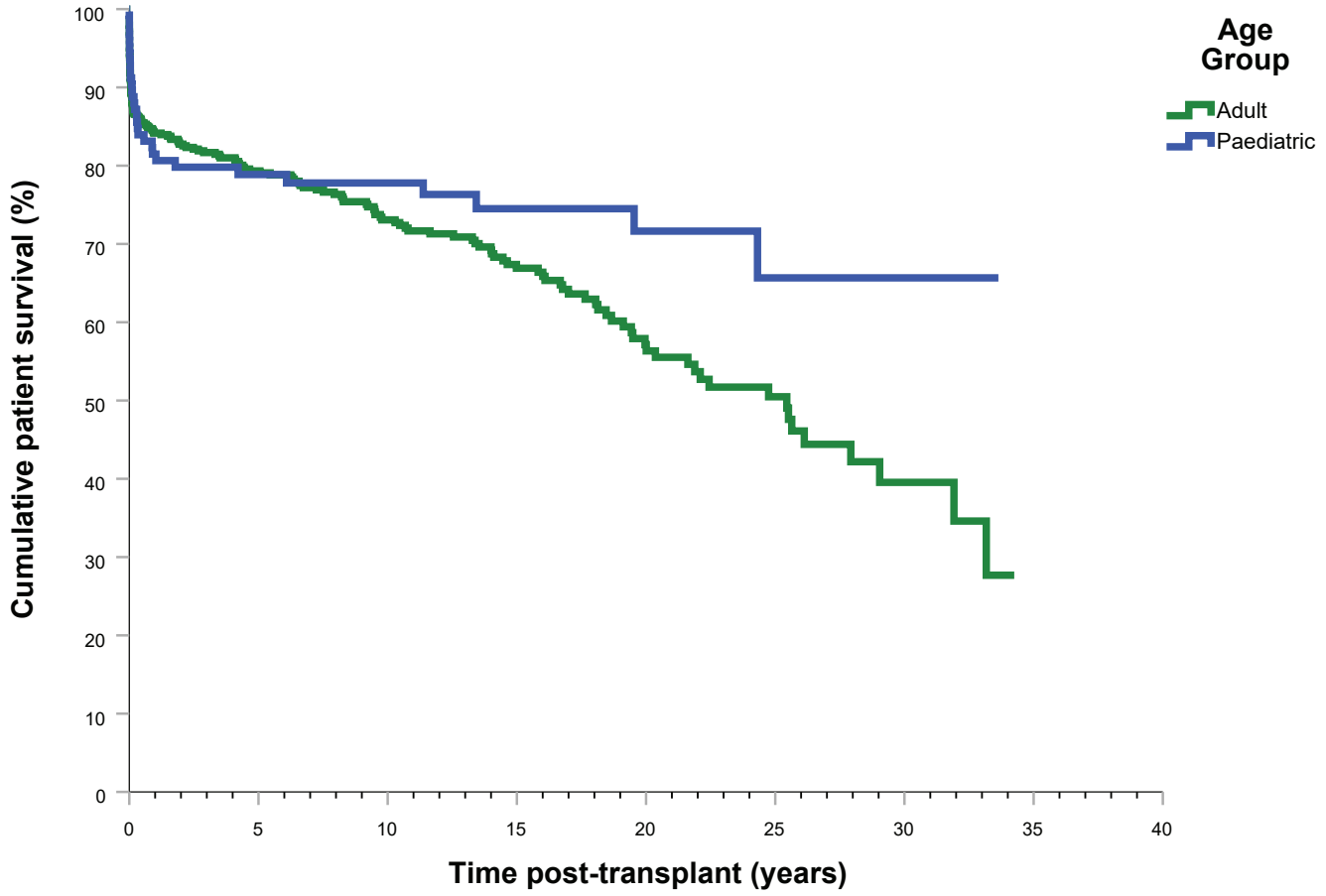


Table 30. Patient survival by age group with fulminant hepatic failure – all diagnoses

Primary Diagnosis	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Paediatric	No. at risk	125	98	92	77	58	24	5	0	
	Survival (%)		82%	80%	79%	78%	72%	66%		
Adult	No. at risk	586	443	372	317	212	72	13	0	
	Survival (%)		84%	82%	79%	73%	57%	40%		

14.14 Patient Survival by Transplant Era with Hepatitis B Virus Cirrhosis

There has been an improvement in patient survival over the transplant eras for patients with a diagnosis of hepatitis B virus cirrhosis as a primary diagnosis or other diagnosis (P < 0.001, Figure 56, Table 31). Patient survival in the most recent era was 95.3% at 1 year, 90.3% at 3 years, 84.3% at 5 years and 80.7% at 10 years. Median patient survival was not reached for the recent eras since 2000 and was 27.7 years for 1990 – 94, 18.0 years for 1995 – 99 and 0.6 years for 1985 – 89.

Figure 56. Patient survival curve by transplant era with hepatitis B virus cirrhosis – all diagnoses

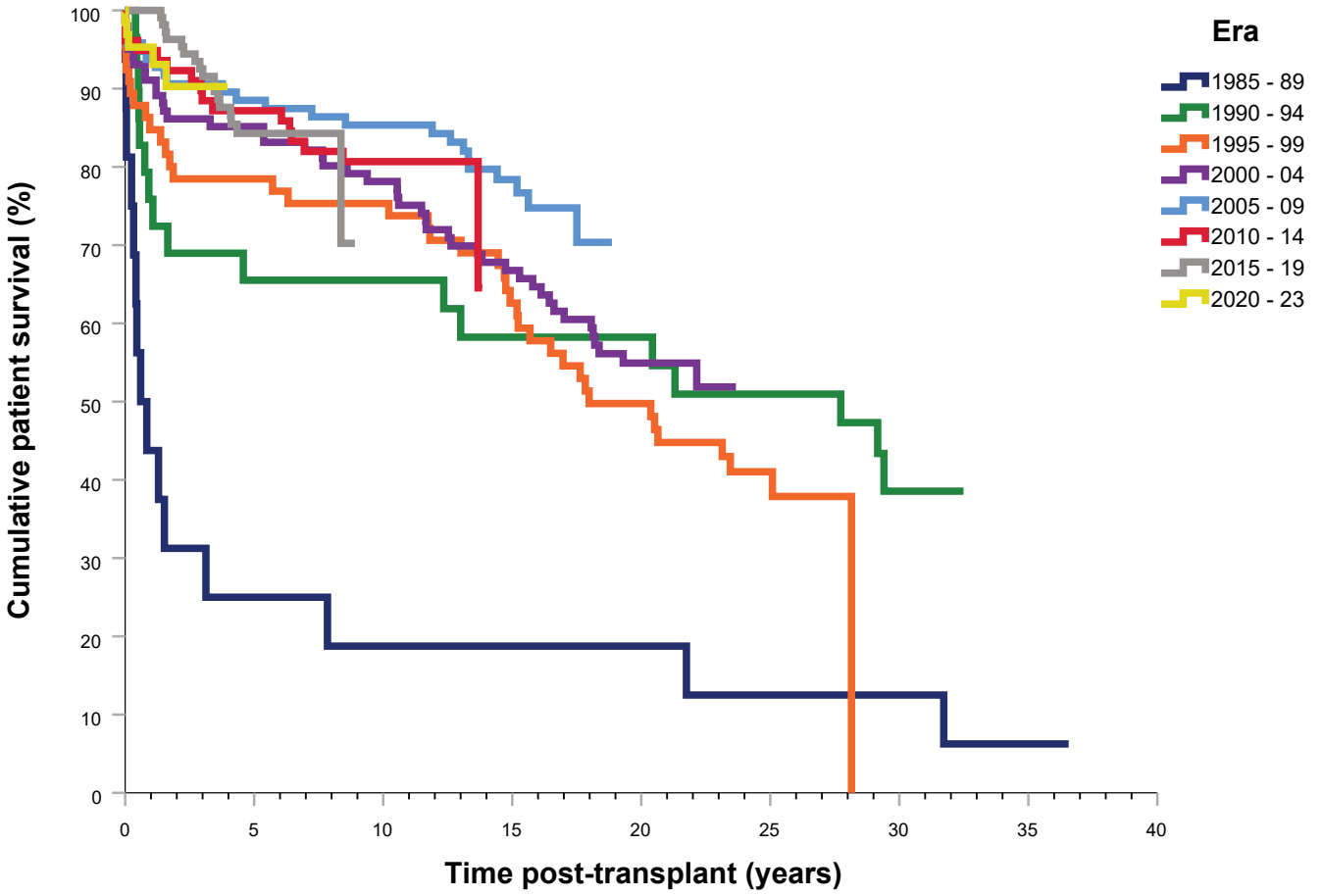


Table 31. Patient survival by transplant era with hepatitis B virus cirrhosis – all diagnoses

Transplant era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1985 - 89	No. at risk	16	7	5	4	3	3	2	1	0
	Survival (%)		44%	31%	25%	19%	19%	13%	6%	
1990 - 94	No. at risk	29	22	20	19	19	16	6	0	
	Survival (%)		76%	69%	66%	66%	58%	39%		
1995 - 99	No. at risk	66	54	50	50	48	30	0		
	Survival (%)		85%	79%	79%	75%	50%			
2000 - 04	No. at risk	101	92	87	85	77	39	0		
	Survival (%)		91%	86%	85%	78%	55%			
2005 - 09	No. at risk	96	90	86	84	80	0			
	Survival (%)		94%	91%	89%	85%				
2010 - 14	No. at risk	78	74	69	68	36	0			
	Survival (%)		95%	89%	87%	81%				
2015 - 19	No. at risk	109	109	97	64	0				
	Survival (%)		100%	93%	84%					
2020 - 23	No. at risk	66	45	16	0					
	Survival (%)		95%	90%						

14.15 Patient Survival by Transplant Era with Hepatitis C Virus Cirrhosis

There was no significant difference in patient survival after transplantation for hepatitis C virus cirrhosis as a primary diagnosis or other diagnosis over transplant eras (P = 0.294). The best 5-year survival (82.7%) was in the most recent era, 2015 – 2019 (Figure 57 and Table 32). Median patient survival was not reached for the recent eras since 2010 and was 17.9 years for 2000 - 04, 17.1 years for 1985 – 89, 16.7 years for 2005 – 09, 13.5 years for 1990 – 94 and 12.7 years for 1995 – 99.

Figure 57. Patient survival curve by transplant era with hepatitis C virus cirrhosis – all diagnoses

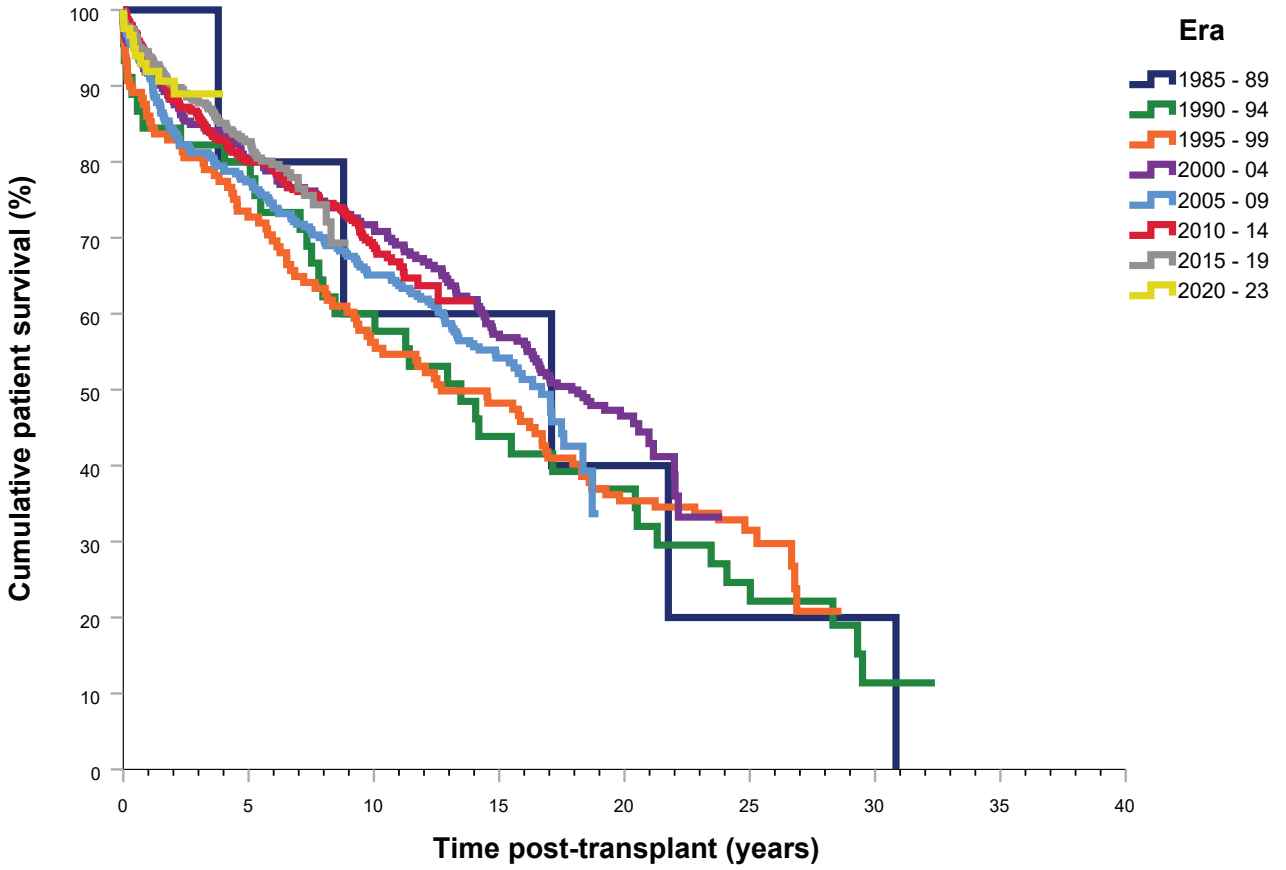


Table 32. Patient survival curve by transplant era with hepatitis C virus cirrhosis – all diagnoses

Transplant era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1985 - 89	No. at risk	5	5	5	4	3	2	1	0	
	Survival (%)		100%	100%	80%	60%	40%	20%		
1990 - 94	No. at risk	45	38	37	36	26	15	2	0	
	Survival (%)		84%	82%	80%	60%	37%	11%		
1995 - 99	No. at risk	129	110	103	93	71	44	0		
	Survival (%)		86%	81%	73%	56%	35%			
2000 - 04	No. at risk	233	214	196	183	161	55	0		
	Survival (%)		92%	85%	81%	72%	47%			
2005 - 09	No. at risk	288	263	233	222	185	0			
	Survival (%)		92%	81%	77%	65%				
2010 - 14	No. at risk	391	365	334	309	183	0			
	Survival (%)		93%	86%	80%	69%				
2015 - 19	No. at risk	403	379	343	240	0				
	Survival (%)		94%	88%	83%					
2020 - 23	No. at risk	123	85	24	0					
	Survival (%)		92%	89%						

14.16 Patient Survival with Hepatocellular Carcinoma by Era of Transplant

There has been an improvement in patient survival over the transplant eras for patients with hepatocellular carcinoma as a primary diagnosis or other diagnosis (P < 0.001, Figure 58, Table 33). Patient survival in the most recent era was 93.1% at 1 year, 85.0% at 3 years, 81.9% at 5 years and 68.6% at 10 years. Median patient survival was not reached for the recent eras since 2010 and was 17.5 years for 2005 – 09, 16.6 years for 2000 – 04, 14.5 years for 1995 – 99, 9.9 years for 1990 – 94 and 1.5 years for 1985 – 89.

Figure 58. Patient survival curve with a diagnosis of hepatocellular carcinoma by transplant era – all diagnoses

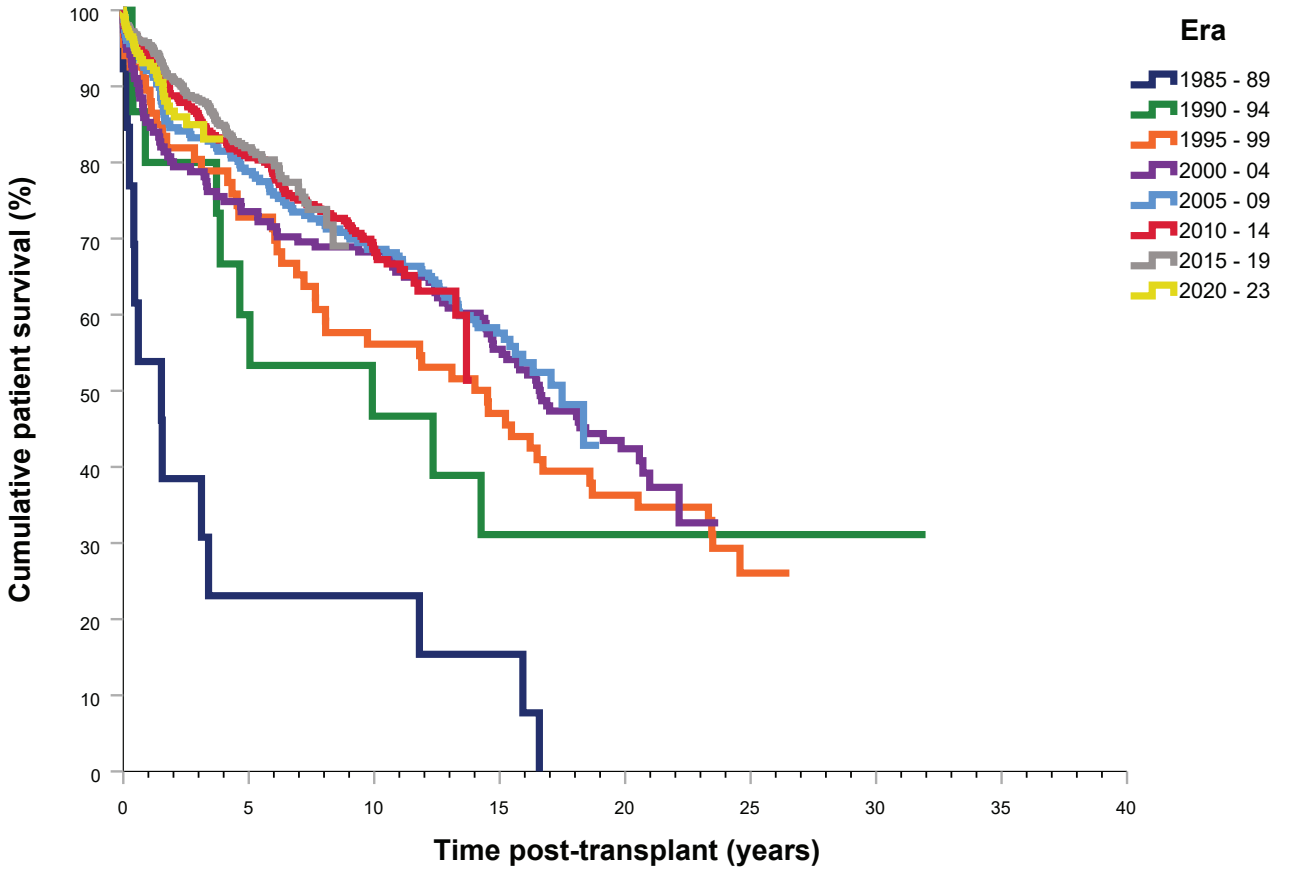


Table 33. Patient survival curve with a diagnosis of hepatocellular carcinoma by transplant era – all diagnoses

Transplant era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1985 - 89	No. at risk	13	7	5	3	3	0			
	Survival (%)		54%	39%	23%	23%				
1990 - 94	No. at risk	15	12	12	9	6	4	3	0	
	Survival (%)		80%	80%	60%	47%	31%	31%		
1995 - 99	No. at risk	67	59	53	48	37	23	0		
	Survival (%)		90%	80%	73%	56%	36%			
2000 - 04	No. at risk	156	133	121	111	103	35	0		
	Survival (%)		85%	79%	74%	68%	42%			
2005 - 09	No. at risk	227	209	188	178	154	0			
	Survival (%)		92%	83%	79%	69%				
2010 - 14	No. at risk	347	325	296	277	153	0			
	Survival (%)		94%	86%	81%	69%				
2015 - 19	No. at risk	494	472	422	285	0				
	Survival (%)		96%	88%	82%					
2020 - 23	No. at risk	325	203	57	0					
	Survival (%)		93%	85%						

14.17 Survival of Patients by Hepatocellular Carcinoma Status at Transplant

There was no significant difference in patient survival between patients with known hepatocellular carcinoma at transplant and incidental hepatocellular carcinoma (HCC) detected in the explant (P = 0.48, Figure 59, Table 34). Ten-year patient survival was 67.6% when there was known hepatocellular carcinoma and 66.3% when the hepatocellular carcinoma was found incidentally at explant. The median survival was 16.6 and 16.2 years for known HCC at transplant and incidental HCC detected in explant.

Figure 59. Survival of patients by hepatocellular carcinoma status at transplant

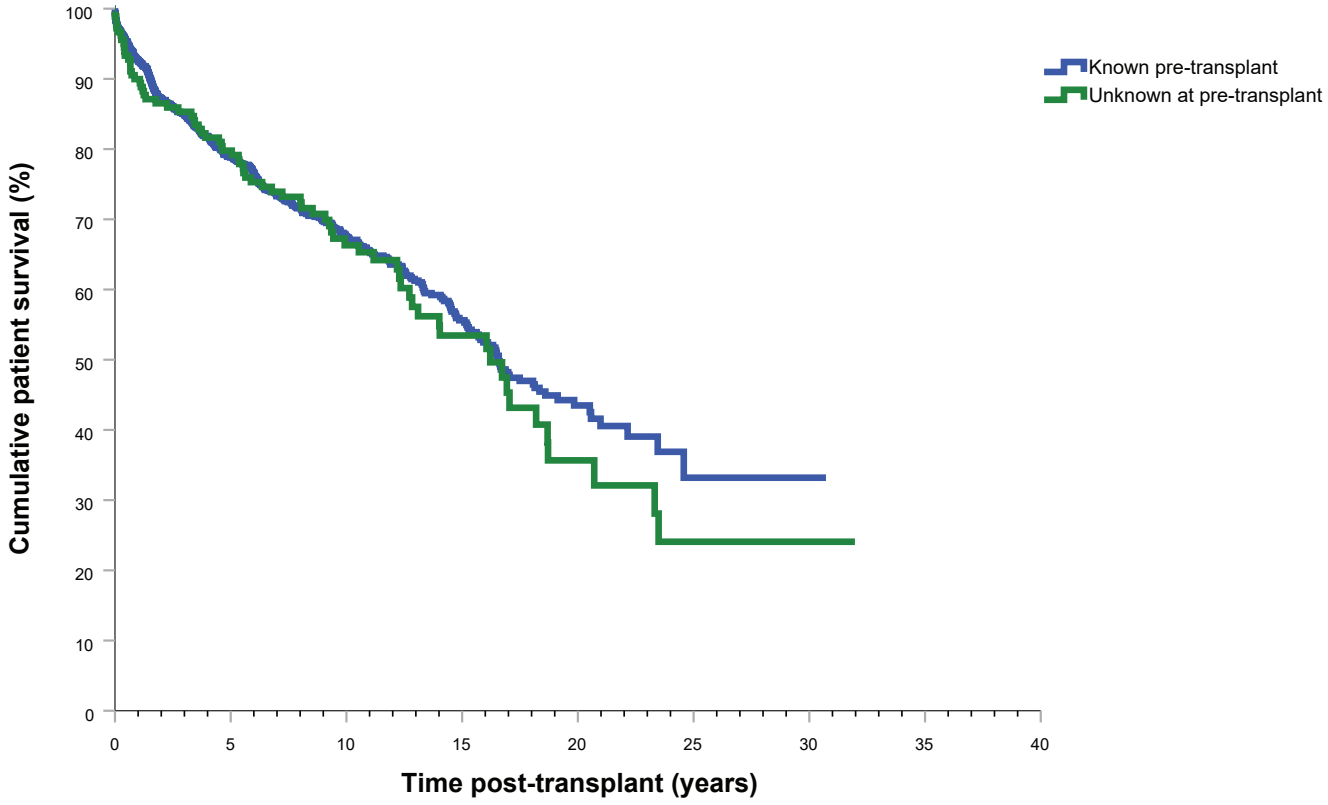


Table 34. Survival of patients by hepatocellular carcinoma status at transplant

HCC Category	Patient Survival	Time post-transplant (years)							
		0	1	3	5	10	20	30	35
Known pretransplant	No at risk	1,530	1,323	1,075	837	402	54	1	0
	Survival %		93%	85%	79%	68%	44%	33%	
Found incidentally at explant	No at risk	180	161	140	128	70	10	1	0
	Survival %		90%	85%	80%	66%	36%	24%	

Note: 32 patients were excluded from this analysis as they were treated HCC or suspected HCC that was not confirmed HCC on explant

14.18 Paediatric Patient Survival with Diagnosis of Malignancy

Survival of children with cholangiocarcinoma or histiocytosis X was superior to those with hepatoblastoma which was in turn superior to those with hepatocellular carcinoma (P = 0.021, Figure 60 and Table 35). Ten-year paediatric patient survival was 100% for cholangiocarcinoma and histiocytosis X, 83.7% for hepatoblastoma and 64.8% for hepatocellular carcinoma. Median paediatric patient survival was not reached for cholangiocarcinoma, histiocytosis X and hepatoblastoma and was 14.3 years for hepatocellular carcinoma.

Figure 60. Paediatric patient survival curve with a malignancy diagnosis

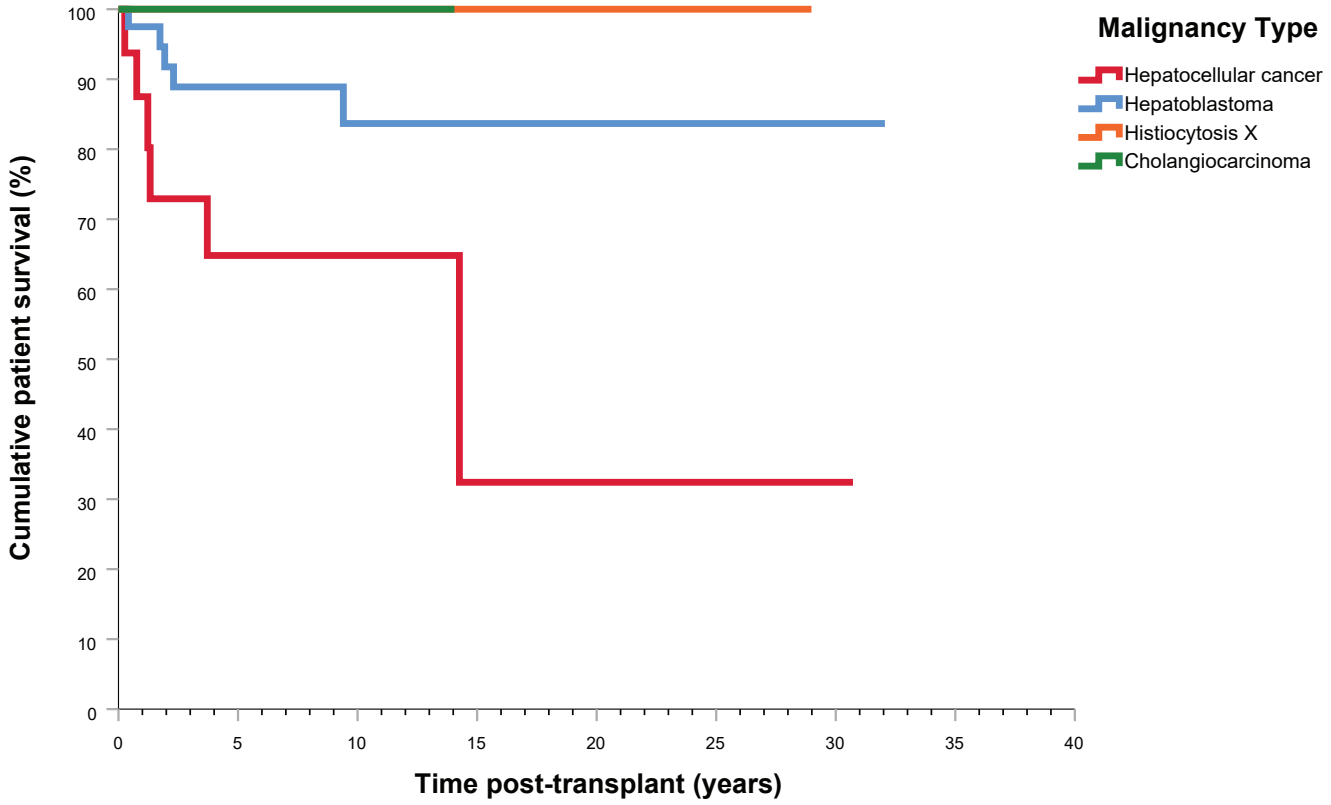


Table 35. Paediatric patient survival with malignancy diagnosis – all diagnoses

Primary Diagnosis	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Cholangiocarcinoma	No. at risk	3	3	3	3	2	3	0		
	Survival (%)		100%	100%	100%	100%	100%			
Histiocytosis X	No. at risk	6	6	6	6	5	3	0		
	Survival (%)		100%	100%	100%	100%	100%			
Hepatoblastoma	No. at risk	42	37	30	26	15	3	1	0	
	Survival (%)		98%	89%	89%	84%	84%	84%		
Hepatocellular carcinoma	No. at risk	16	12	9	7	2	1	1	0	
	Survival (%)		88%	73%	65%	65%	32%	32%		

14.19 Adult Patient Survival with a Diagnosis of Malignancy

Adult patient survival after transplantation for malignancy as a primary or other diagnosis varied by diagnosis (P <0.001, Figure 61 and Table 36). Ten-year patient survival was 100% for hepatoblastoma (only one patient), 74.2% for epithelioid haemangio-endothelioma, 67.9% for hepatocellular carcinoma, 66.7% for histiocytosis X, 27.9% for cholangiocarcinoma, 0% for angiosarcoma and 14.3% for metastatic neuroendocrine tumours. Median adult patient survival was 16.7 years for hepatoblastoma, 16.6 years for hepatocellular carcinoma, 14.2 years for epithelioid haemangio-endothelioma, 3.3 years for cholangiocarcinoma, 3.1 years for metastatic neuroendocrine tumours and 0.8 years for angiosarcoma.

Figure 61. Adult patient survival curve with a malignancy diagnosis

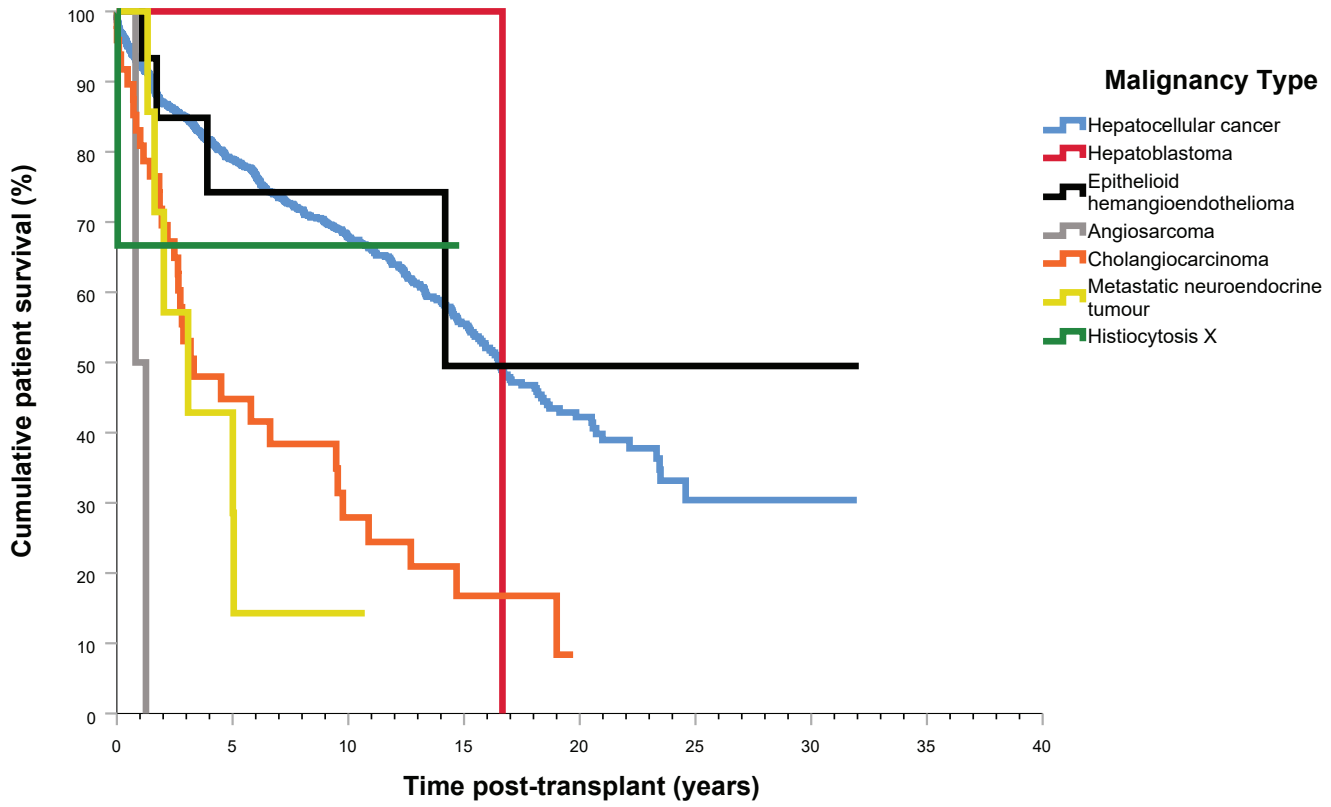


Table 36. Adult patient survival curve with a malignancy diagnosis - all diagnosis

Primary Diagnosis	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Histiocytosis X	No. at risk	3	2	1	1	1	0			
	Survival (%)		67%	67%	67%	67%				
Hepatoblastoma	No. at risk	1	1	1	1	1	0			
	Survival (%)		100%	100%	100%	100%				
Hepatocellular carcinoma	No. at risk	1,628	1,408	1,145	904	454	61	2	0	
	Survival (%)		93%	85%	79%	68%	42%	30%		
Epithelioid haemangio-endothelioma	No. at risk	15	15	9	6	3	1	1	0	
	Survival (%)		100%	85%	74%	74%	50%	50%		
Cholangiocarcinoma	No. at risk	49	38	21	14	8	0			
	Survival (%)		83%	53%	45%	28%				
Metastatic neuroendocrine tumour	No. at risk	8	7	4	3	1				
	Survival (%)		100%	57%	43%	14%				
Angiosarcoma	No. at risk	2	1	0						
	Survival (%)		50%							

14.20 Patient Survival for Adult Patients with Incidental Liver Cancer

Ten-year patient survival was 60.0% for adults with liver cancer found incidentally at explant. Median patient survival was 13.1 years for adults (Figure 62 and Table 37).

Figure 62. Patient Survival for Adult Patients with Incidental Liver Cancer

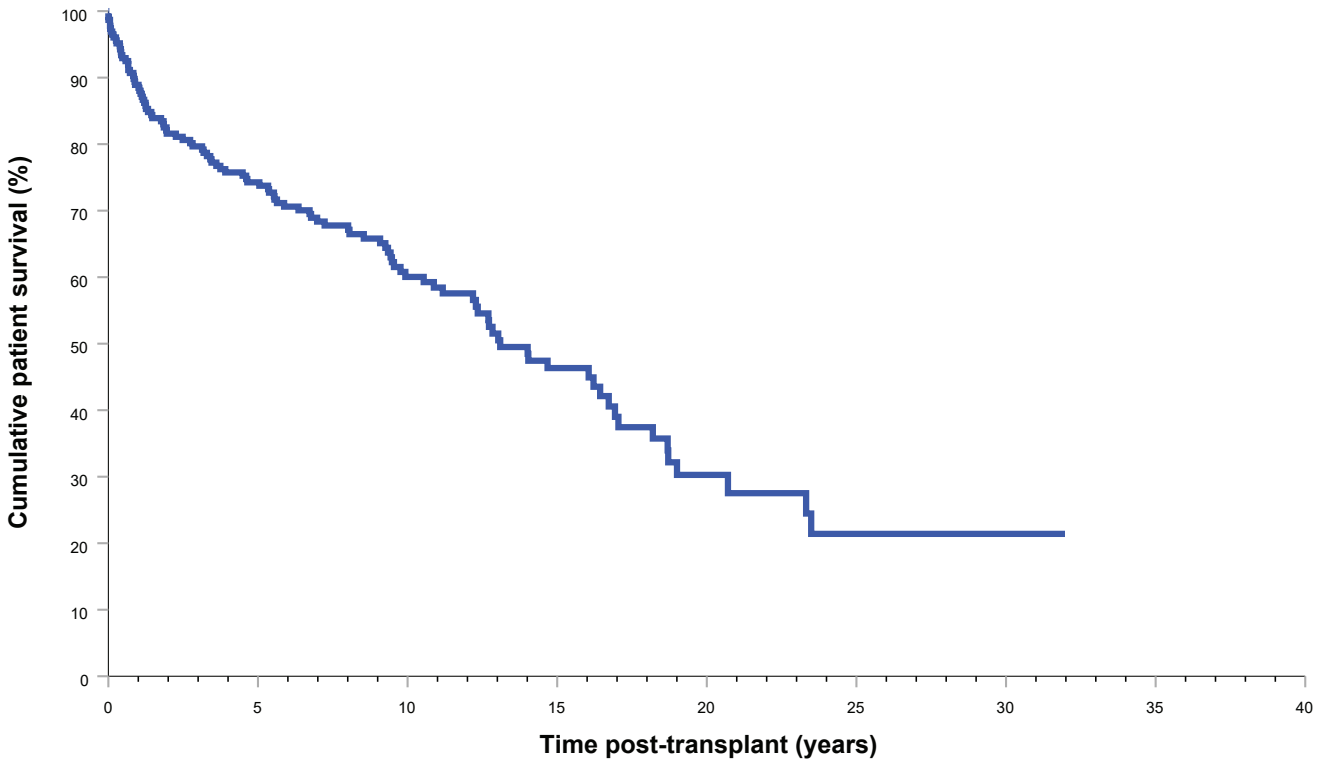


Table 37. Patient Survival for Adult Patients with Incidental Liver Cancer

Adults	Patient Survival	Time post-transplant (years)						
		0	1	5	10	20	30	35
Unknown pretransplant	No at risk	228	199	146	80	11	2	0
	Survival %		89%	74%	60%	30%	21%	

14.21 Patient Survival for Adult Patients by Type of Incidental Liver Cancer

There was a significant difference in patient survival between patients with different liver cancer types found incidentally at explant (P < 0.001). Ten-year adult patient survival for those with fibrolamellar variant, hepatocellular carcinoma, cholangiocarcinoma and other liver cancers was 100%, 66.3%, 37.5%, and 20% respectively (Figure 63, Table 38).

Figure 63. Patient Survival for Adult Patients by Type of Incidental Liver Cancer

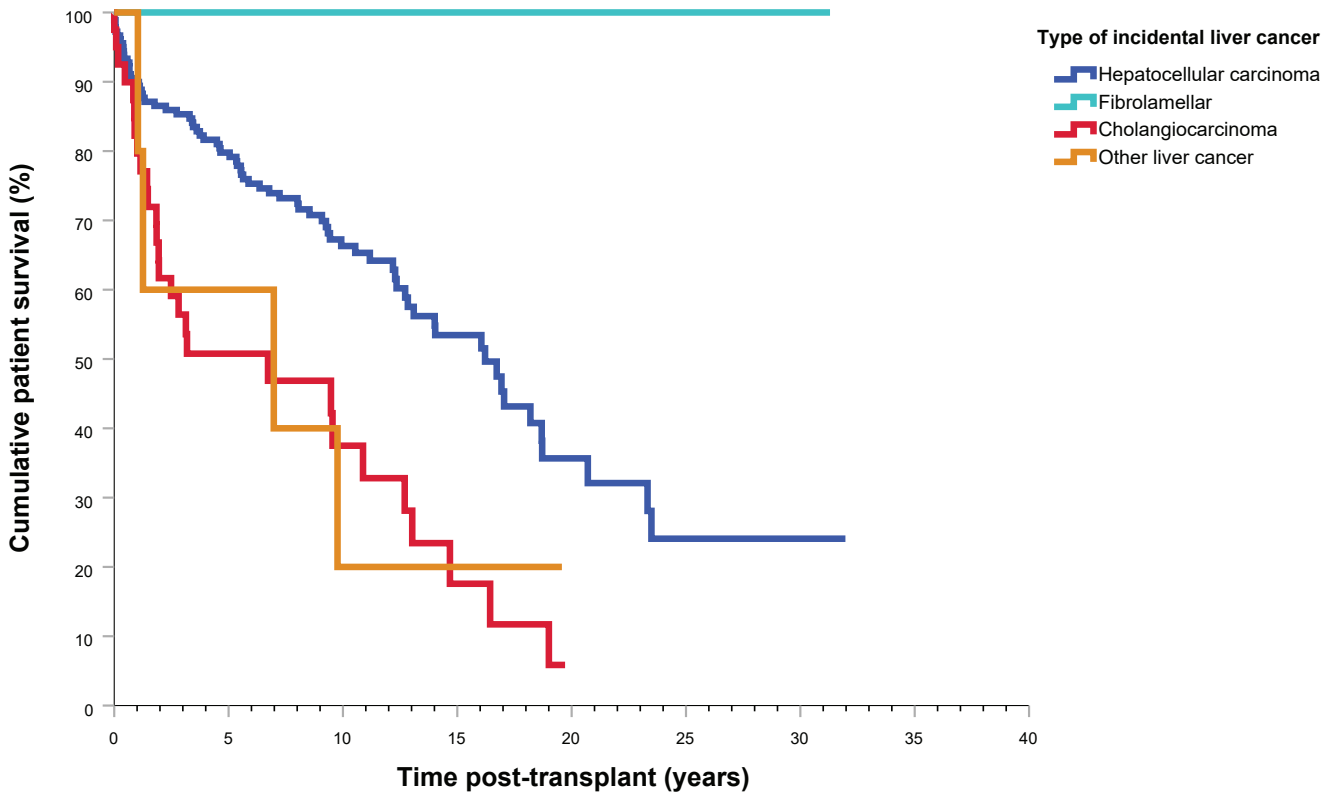


Table 38. Patient Survival for Adult Patients by Type of Incidental Liver Cancer

Transplant era	Patient Survival	Time post-transplant (years)							
		0	1	5	10	20	30	35	40
Hepatocellular carcinoma	No. at risk	180	161	128	70	10	1	0	
	Survival (%)		90%	80%	66%	36%	24%		
Cholangiocarcinoma	No. at risk	40	32	14	8	0			
	Survival (%)		82%	51%	38%				
Other liver cancer	No. at risk	7	5	3	1	0			
	Survival (%)		100%	60%	20%				
Fibrolamellar	No. at risk	1	1	1	1	1	1	1	0
	Survival (%)		100%	100%	100%	100%	100%	100%	

14.22 Patient Survival by Transplant Unit

Benchmarking analysis using hierarchical regression models estimated that <0.0001% of the variation in 1-year -post-transplant mortality and 0.001% of the variation in 5-year post-transplant mortality was due to variation between liver transplant units.

15 Graft Outcome

Graft survival analysis is based on all Australian and New Zealand liver transplants. This includes both initial transplantation and retransplantation. Both deceased and living donor grafts are included in this analysis. Grafts are classified as functioning or failed (death or retransplantation).

15.1 All Grafts Outcome

There were 7,925 grafts in 7,310 patients (Figure 64 and Table 39). Ten-year graft survival was 68.3% across all grafts. The median graft survival was 18.3 years.

Figure 64. Graft survival curve for all grafts

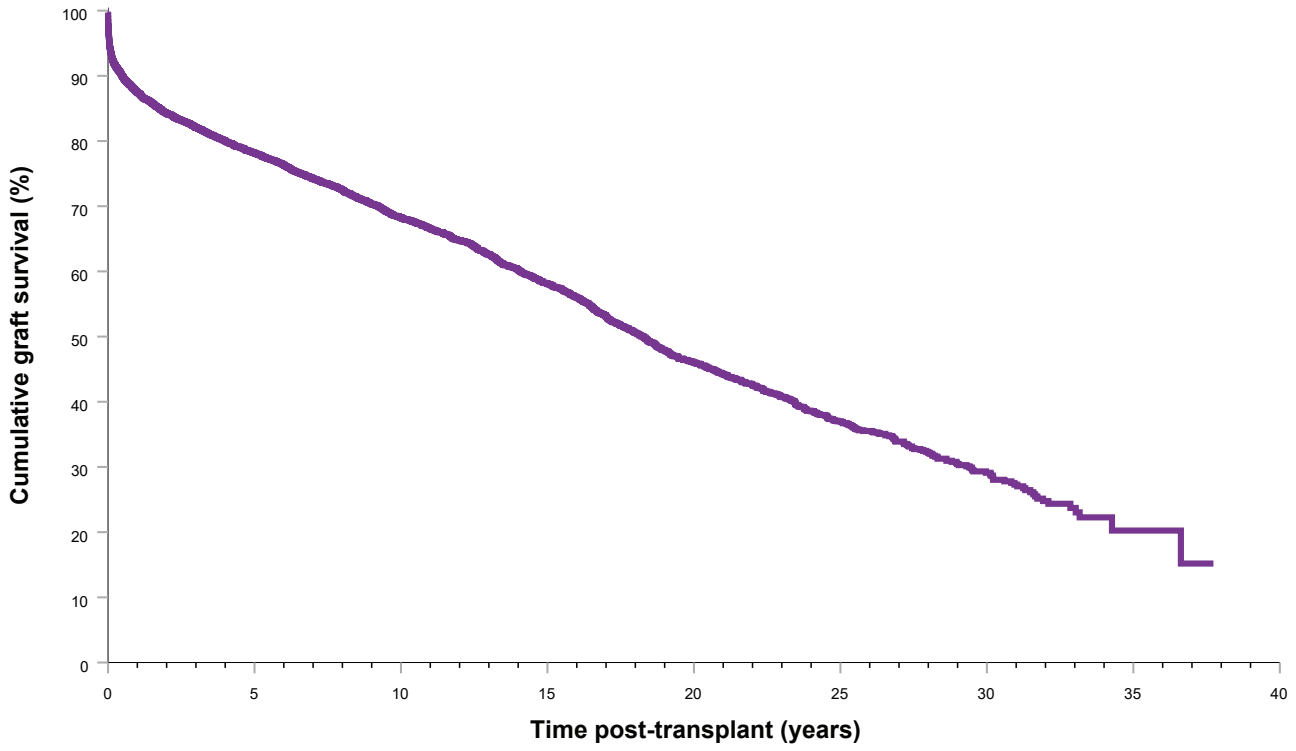


Table 39. Graft survival - all grafts

Graft Survival	Time post-transplant (years)								
	0	1	3	5	10	20	30	35	40
No. at risk	7,925	6,498	5,522	4,643	2,872	877	128	7	0
Survival (%)		88%	82%	78%	68%	46%	29%	20%	

15.2 Outcome of All Grafts by Age Group

A A total of 1,331 transplants were performed in children and 6,594 in adults. Post-transplant graft survival was superior in the paediatric population (P < 0.001, Figure 65, Table 40). Ten-year graft survival was 73.8% for children and 67.1% for adults. Median graft survival was 30.9 years in children and 17.0 years in adults. Although 1-year survival was slightly worse in children (85.5% children versus 87.9% adults), the survival curve for children was subsequently flatter. However, there were several late graft losses occurring over 30 years after paediatric transplantation.

Figure 65. Graft survival curve for all grafts by age group

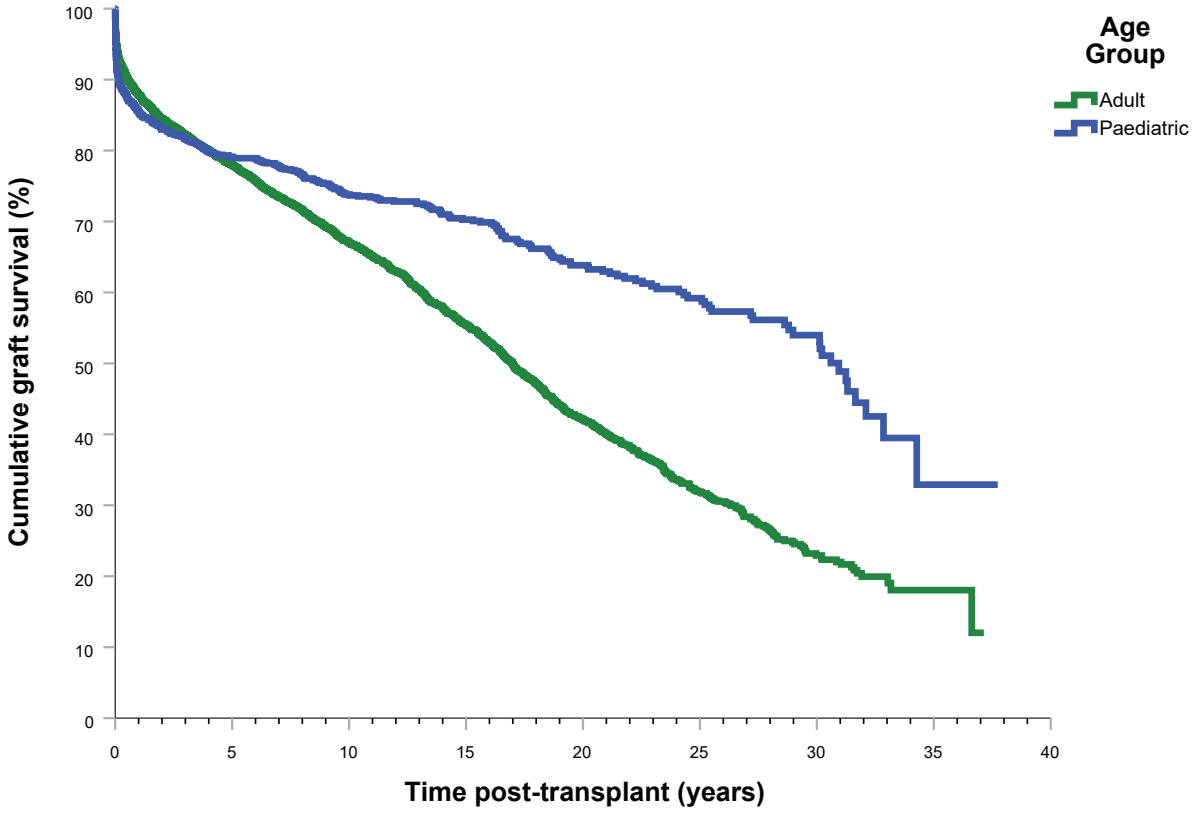


Table 40. Graft survival by age group - all grafts

Age Group	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Paediatric <16 years	No. at risk	1,331	1,078	955	826	559	231	58	4	0
	Survival (%)		86%	82%	79%	74%	64%	54%	33%	
Adult ≥16 years	No. at risk	6,594	5,417	4,567	3,817	2,313	646	80	3	0
	Survival (%)		88%	82%	78%	67%	42%	23%	18%	

15.3 Outcome by Graft Number

There was a significant difference in graft survival by graft number (P < 0.001, Figure 66 and Table 41). Ten-year graft survival was 69.1% for the first graft, 58.0% for the second graft, 64.4% for the third graft and not reached for the fourth graft. Median graft survival was 18.4 years for the first graft, 13.5 years for the second graft, 21.1 years for the third graft and 4.3 years for the fourth graft.

Figure 66. Graft survival curve for all grafts by graft number

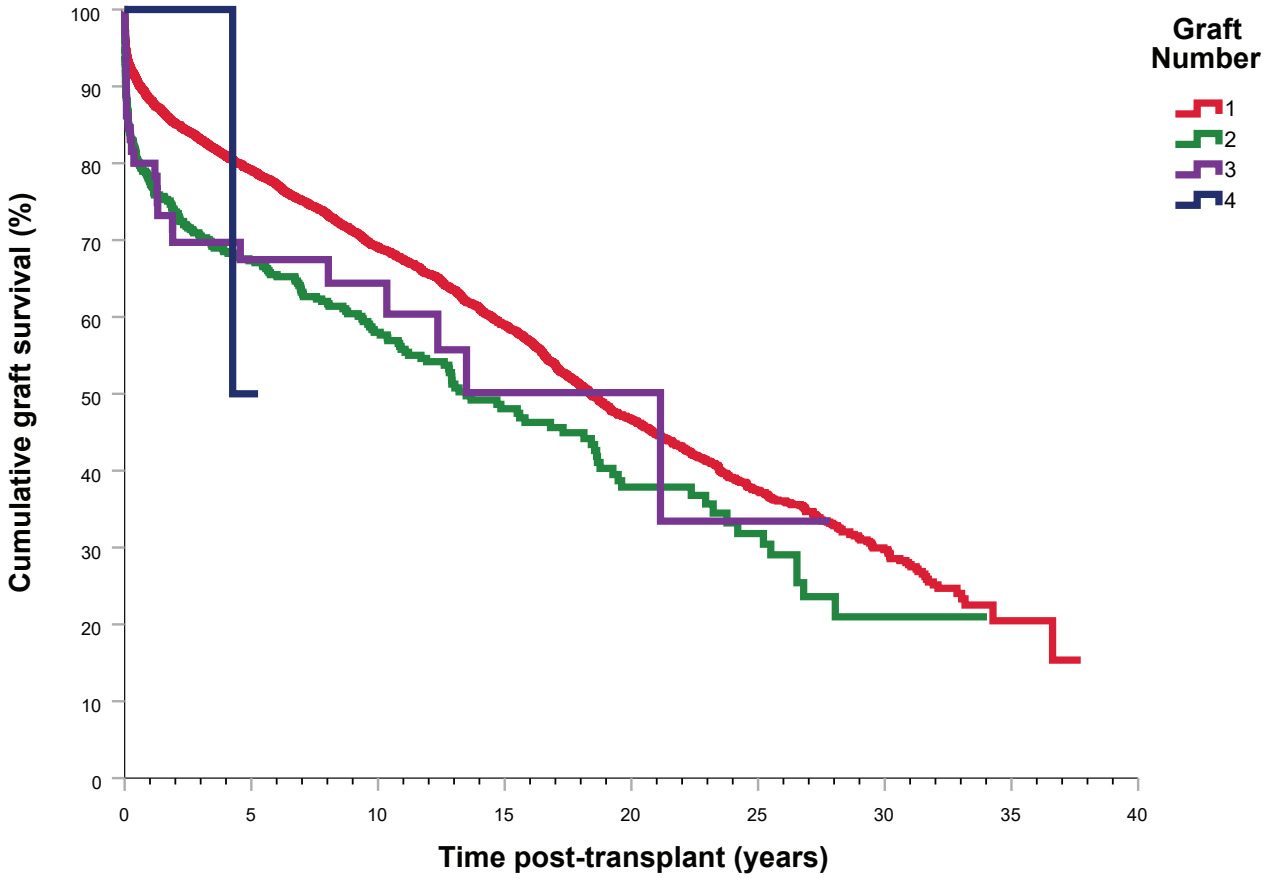


Table 41. Graft survival - all grafts

Graft Number	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1	No. at risk	7,304	6,041	5,157	4,343	2,690	829	131	7	0
	Survival (%)		88%	83%	79%	69%	47%	30%	21%	
2	No. at risk	553	404	325	269	165	45	7	0	
	Survival (%)		78%	71%	67%	58%	38%	21%		
3	No. at risk	66	48	38	30	17	3	0		
	Survival (%)		80%	70%	68%	64%	50%			
4	No. at risk	2	2	2	1	0				
	Survival (%)		100%	100%	50%					

15.4 Paediatric Outcome by Graft Number

There was a significant difference in graft survival by graft number in children (P < 0.001, Figure 67 and Table 42). Ten-year graft survival was 76.5% for the first graft, 53.5% for the second graft and 59.3% for the third graft. Median graft survival was 31.3 years for the first graft, 11.9 years for the second graft and 21.1 years for the third graft.

FFigure 67. Graft survival curve for paediatric recipients by graft number

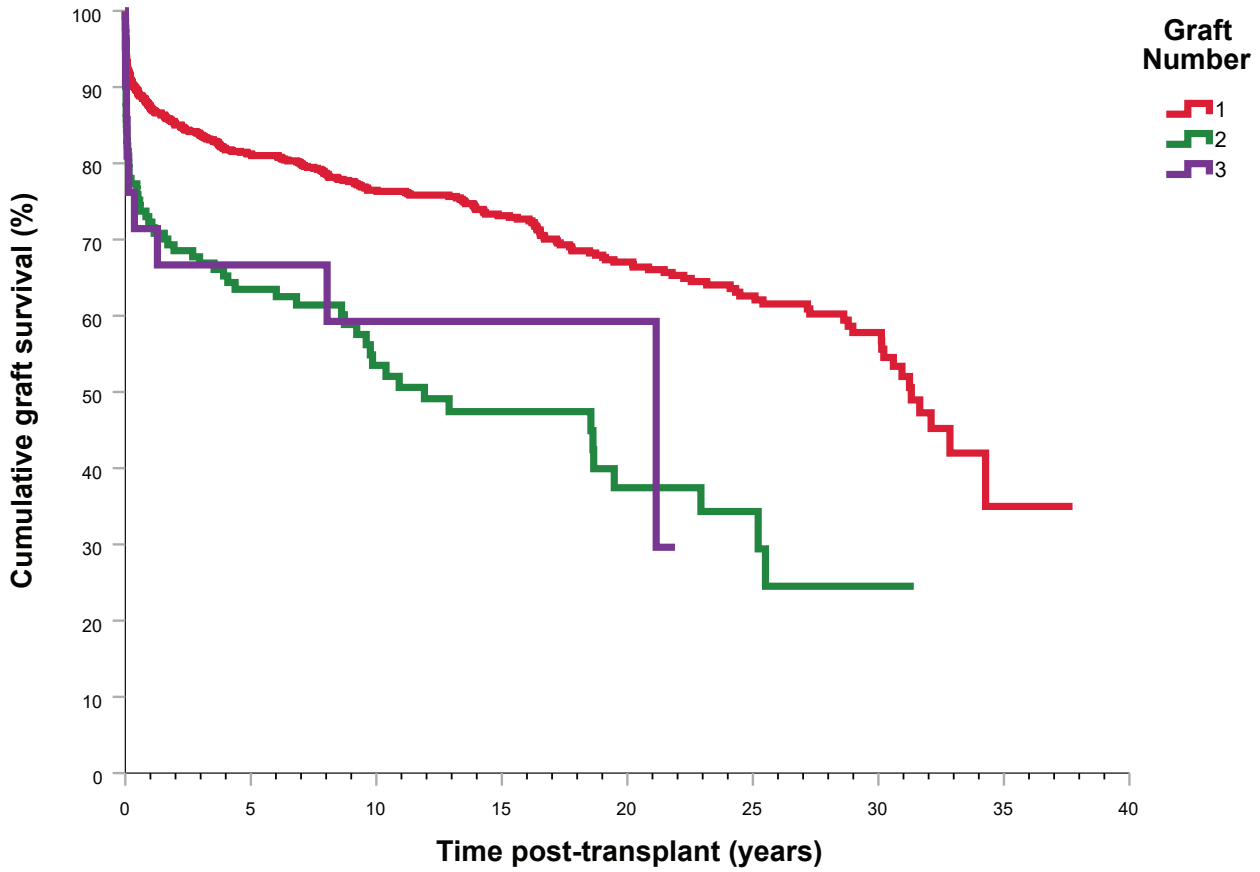


Table 42. Graft survival - paediatric by graft number

Graft Number	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1	No. at risk	1,169	963	860	846	513	214	55	4	0
	Survival (%)		87%	84%	81%	77%	67%	58%	35%	
2	No. at risk	141	100	81	68	39	15	3	0	
	Survival (%)		72%	67%	64%	54%	37%	25%		
3	No. at risk	21	15	14	12	7	2	0		
	Survival (%)		71%	67%	67%	59%	59%			

15.5 Adult Outcome by Graft Number

There was a significant difference in graft survival by graft number in adults (P < 0.001, Figure 68 and Table 43). Ten-year graft survival was 67.6% for the first graft, 59.5% for the second graft, 67.0% for the third graft and not reached for the fourth graft. Median graft survival was 17.1 years for the first graft, 13.7 years for the second graft, 12.4 years for the third graft and 4.3 years for the fourth graft.

Figure 68. Graft survival curve for adults by graft number

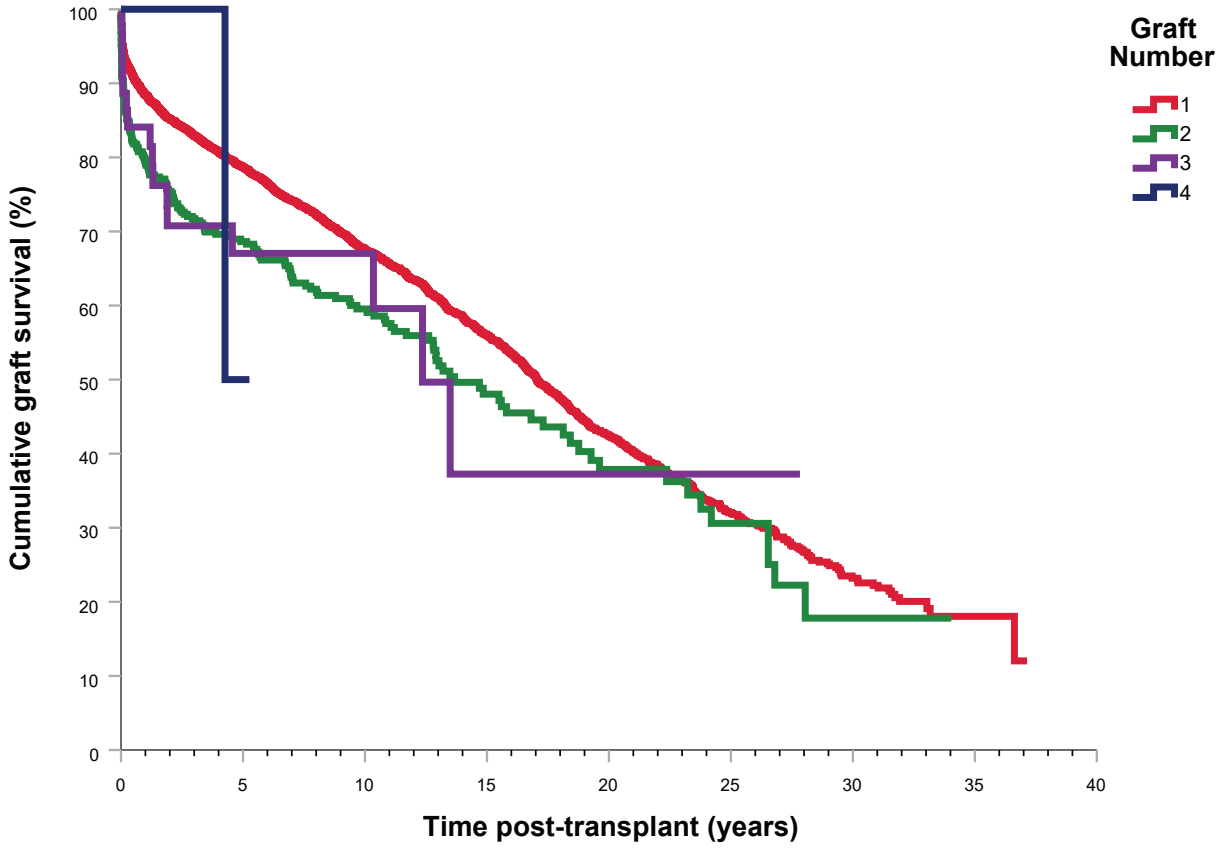


Table 43. Graft survival – adults by graft number

Graft Number	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1	No. at risk	6,315	5,078	4,297	3,597	2,177	615	76	3	0
	Survival (%)		89%	83%	79%	68%	42%	23%	18%	
2	No. at risk	412	304	244	201	126	30	4	0	
	Survival (%)		80%	72%	69%	60%	38%	18%		
3	No. at risk	45	33	24	18	10	1	0		
	Survival (%)		84%	71%	67%	67%	37%			
4	No. at risk	2	2	2	1	0				
	Survival (%)		100%	100%	50%					

15.6 Graft Survival by Type of Graft

There was a significant difference in graft survival by graft type, with improved survival in living donor transplants after 10 years and worse survival in reduced liver transplants up to 15 years (P = 0.005, Figure 69 and Table 44). Ten-year graft survival was 79.4% for living donor grafts, 72.2% for split grafts, 68.0% for whole grafts, 59.5% for reduced grafts and not reached for domino grafts. Median graft survival was not reached for living donor grafts, 19.5 years for split grafts, 22.9 years for reduced grafts, 17.5 years for whole grafts and 9.4 years for domino grafts.

Figure 69. Graft survival curve for type of graft

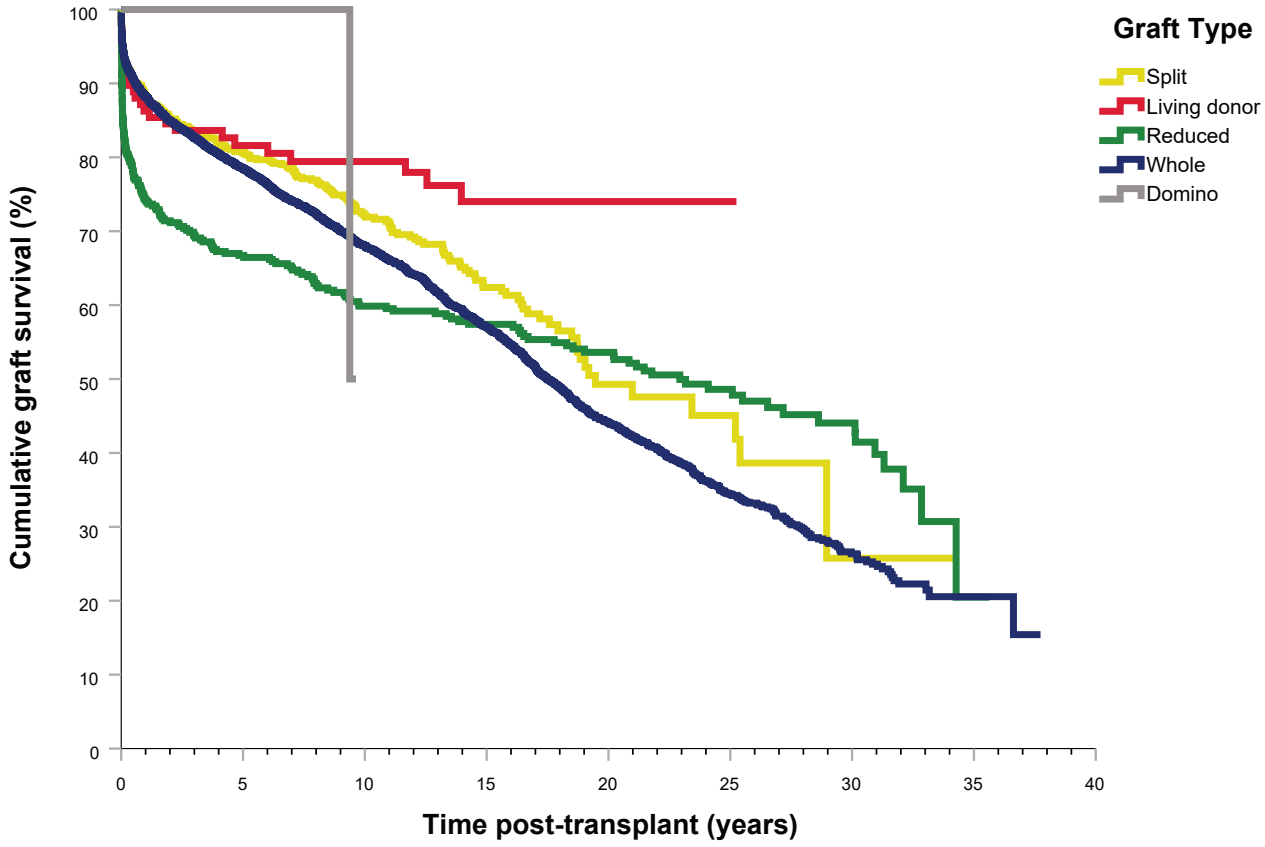


Table 44. Graft survival by type of graft - all grafts

Graft Type	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Domino	No. at risk	5	4	4	4	0				
	Survival (%)		100%	100%	100%					
Living donor	No. at risk	117	99	92	78	59	3	0		
	Survival (%)		86%	84%	82%	79%	74%			
Split	No. at risk	951	772	646	528	271	37	2	0	
	Survival (%)		88%	83%	81%	72%	49%	26%		
Reduced	No. at risk	408	296	267	248	190	112	34	1	0
	Survival (%)		74%	69%	67%	60%	54%	44%	21%	
Whole	No. at risk	6,443	5,323	4,513	3,785	2,352	725	102	6	0
	Survival (%)		88%	83%	79%	68%	44%	26%	21%	

15.7 Graft Survival by Graft Type in Children

Graft survival in children differed significantly by graft type, with improved survival after 10 years for living donor grafts and worse survival after reduced liver transplantation (P < 0.001, Figure 70 and Table 45). Ten-year graft survival was 81.6% for living donor liver transplantation, 79.0% for whole liver transplantation, 78.4% for split liver transplantation and 60.9% for reduced liver transplantation. Median graft survival was not reached for living donor grafts and was 31.6 years for whole grafts, 25.4 for split grafts and 24.1 years for reduced grafts.

Figure 70. Paediatric graft survival curve for type of graft

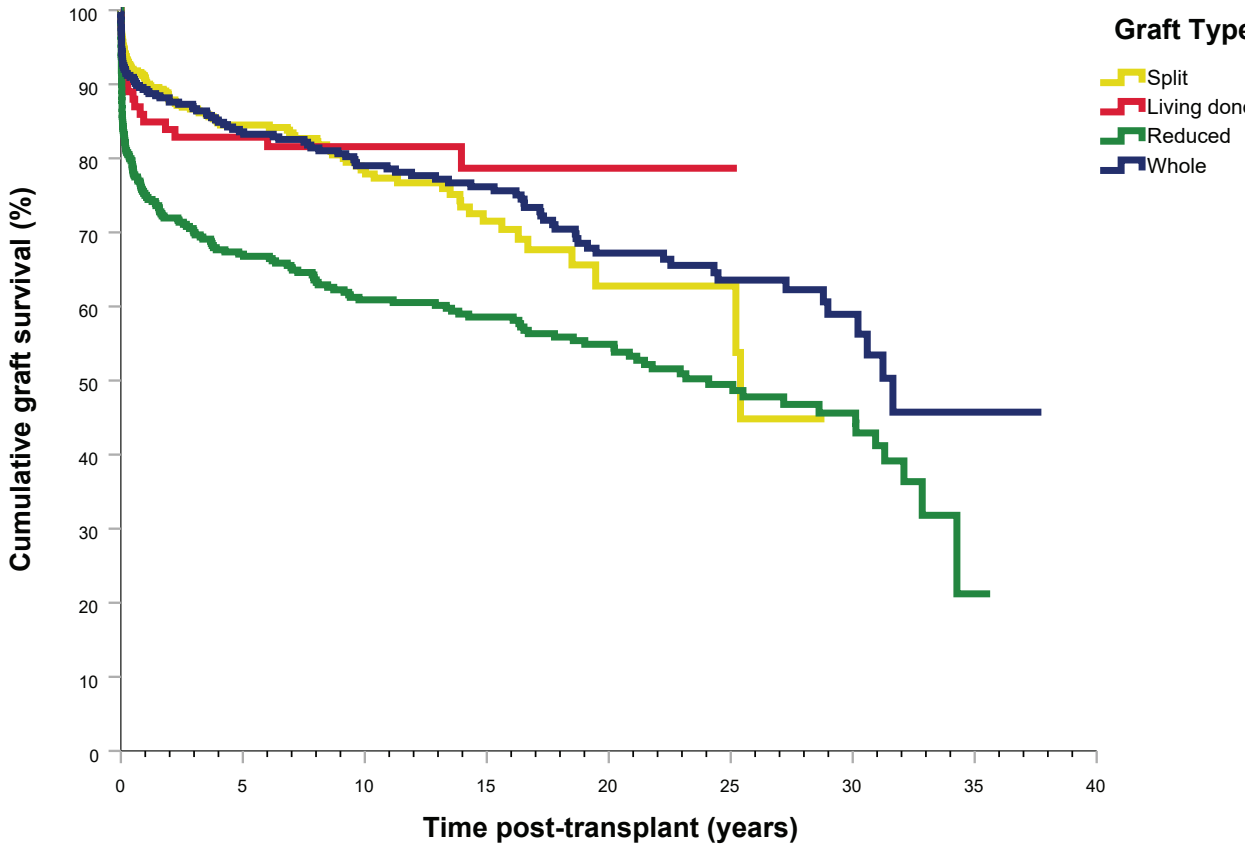


Table 45. Paediatric recipient graft survival by type of graft - all grafts

Graft Type	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Living donor	No. at risk	100	83	77	66	49	3	0		
	Survival (%)		85%	83%	83%	82%	79%			
Whole	No. at risk	376	321	290	254	188	102	24	3	0
	Survival (%)		89%	87%	84%	79%	67%	59%	46%	
Split	No. at risk	485	402	343	279	145	21	0		
	Survival (%)		91%	87%	85%	78%	63%			
Reduced	No. at risk	369	271	245	227	177	105	34	1	0
	Survival (%)		75%	70%	67%	61%	55%	46%	21%	

15.8 Graft Survival by Graft Type in Adults

Although there appeared to be worse graft survival after reduced liver transplantation, there was no significant difference in graft survival in adults by graft type (P = 0.617, Figure 71 and Table 46). Ten-year graft survival was 68.8% for living donor liver transplantation, 67.3% for whole liver transplantation, 65.8% for split liver transplantation, 49.0% for reduced liver transplantation and not reached for domino liver transplantation. Median graft survival was 17.0 years for whole liver transplantation, 17.2 years for split transplantation, 9.7 years for reduced liver transplantation, 9.4 years for domino liver transplantation and was not reached for living donor transplantation.

Figure 71. Adult graft survival curve for type of graft, all grafts

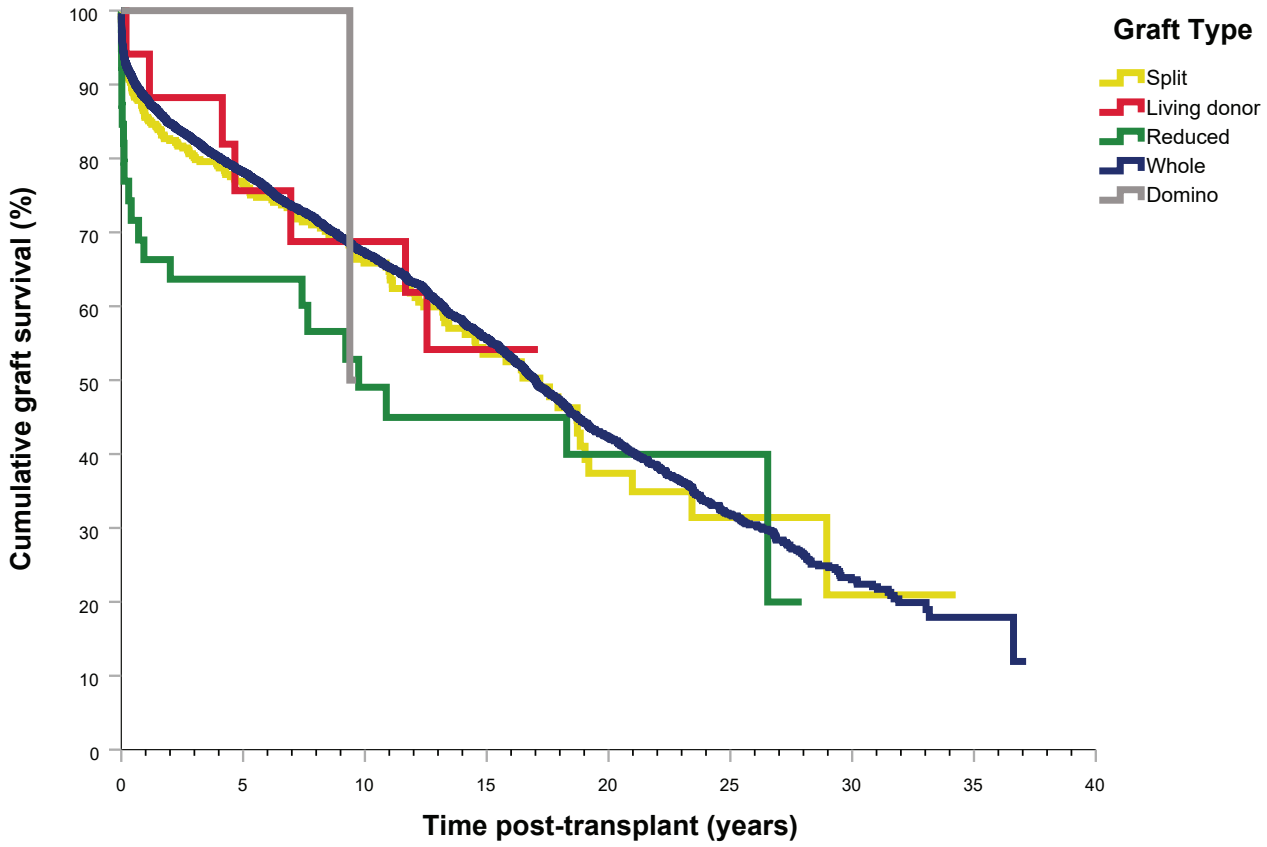


Table 46. Adult graft survival for type of graft, all grafts

Graft Type	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Split	No. at risk	466	370	203	249	126	16	2	0	
	Survival (%)		86%	80%	77%	66%	37%	21%		
Whole	No. at risk	6,067	5,002	4,223	3,531	2,164	623	78	3	0
	Survival (%)		88%	82%	78%	67%	42%	23%	18%	
Living donor	No. at risk	17	16	15	12	10	0			
	Survival (%)		94%	88%	76%	69%				
Reduced	No. at risk	39	25	22	21	13	7	0		
	Survival (%)		66%	64%	64%	49%	40%			
Domino	No. at risk	5	4	4	4	0				
	Survival (%)		100%	100%	100%					

15.9 Graft Survival by Era of Transplant

There has been an improvement in graft survival over eras of transplantation, with better outcomes since 2000 – 04 (P < 0.001, Figure 72, Table 47). Graft survival in the most recent era was 89.8% at 1 year, 83.6% at 3 years, 82.0% at 5 years and 71.1% at 10 years. Median graft survival was not reached for recent eras since 2010 and was 18.3 years for 2005 – 09, 18.3 years for 2000 – 04, 16.5 years for 1995 – 99, 16.7 years for 1990 – 94 and 7.7 years for 1985 – 89.

Figure 72. Graft (deceased and living donors) survival curve by era of transplant

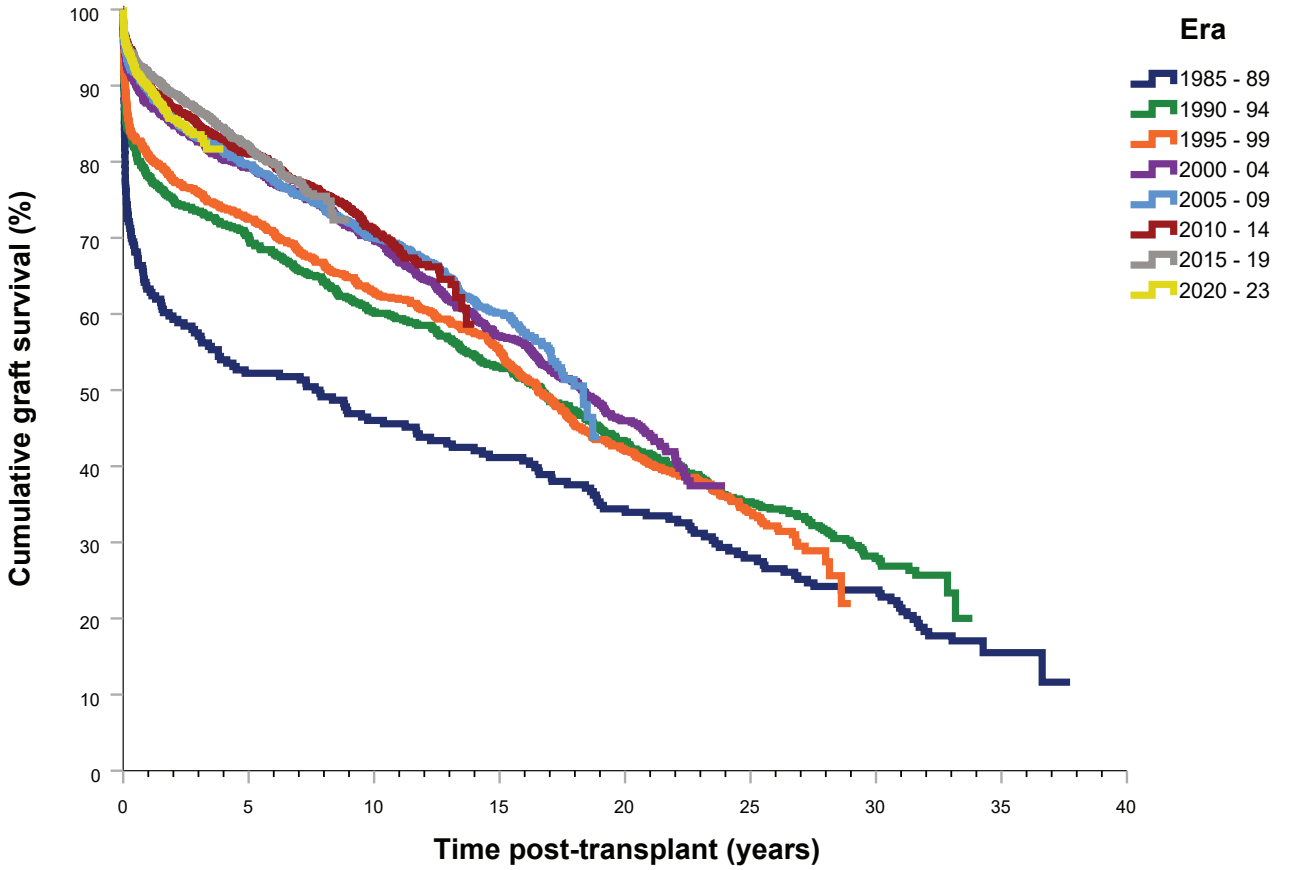


Table 47. Graft (deceased and living donors) survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years) 0	1	3	5	10	20	30	35	40
1985 - 89	No. at risk	226	143	129	118	104	75	51	4	0
	Survival (%)		63%	57%	52%	46%	34%	24%	16%	
1990 - 94	No. at risk	601	468	437	416	348	233	87	0	
	Survival (%)		78%	74%	70%	60%	43%	28%		
1995 - 99	No. at risk	759	609	568	539	464	300	0		
	Survival (%)		81%	76%	73%	63%	42%			
2000 - 04	No. at risk	915	794	745	708	621	269	0		
	Survival (%)		88%	83%	79%	70%	46%			
2005 - 09	No. at risk	1,032	920	853	816	711	0			
	Survival (%)		90%	83%	80%	70%				
2010 - 14	No. at risk	1,331	1,198	1,122	1,067	624	0			
	Survival (%)		90%	85%	81%	71%				
2015 - 19	No. at risk	1,763	1,611	1,482	979	0				
	Survival (%)		92%	87%	82%					
2020 - 23	No. at risk	1,298	752	186						
	Survival (%)		90%	84%						

15.10 Graft Survival by Era of Transplant in Children

There has been a progressive improvement in graft survival in children over eras of transplantation, (P < 0.001, Figure 73, Table 48). Graft survival in the most recent era was 94.3% at 1 year, 93.4% at 3 years, 86.0% at 5 years and 78.6% at 10 years. Median paediatric graft survival was not reached for transplant eras since 2000 and was 25.4 years for 1995 – 99, 27.2 years for 1990 – 94 and 7.7 years for 1985 – 89.

Figure 73. Paediatric graft (deceased and living donors) survival curve by era of transplant

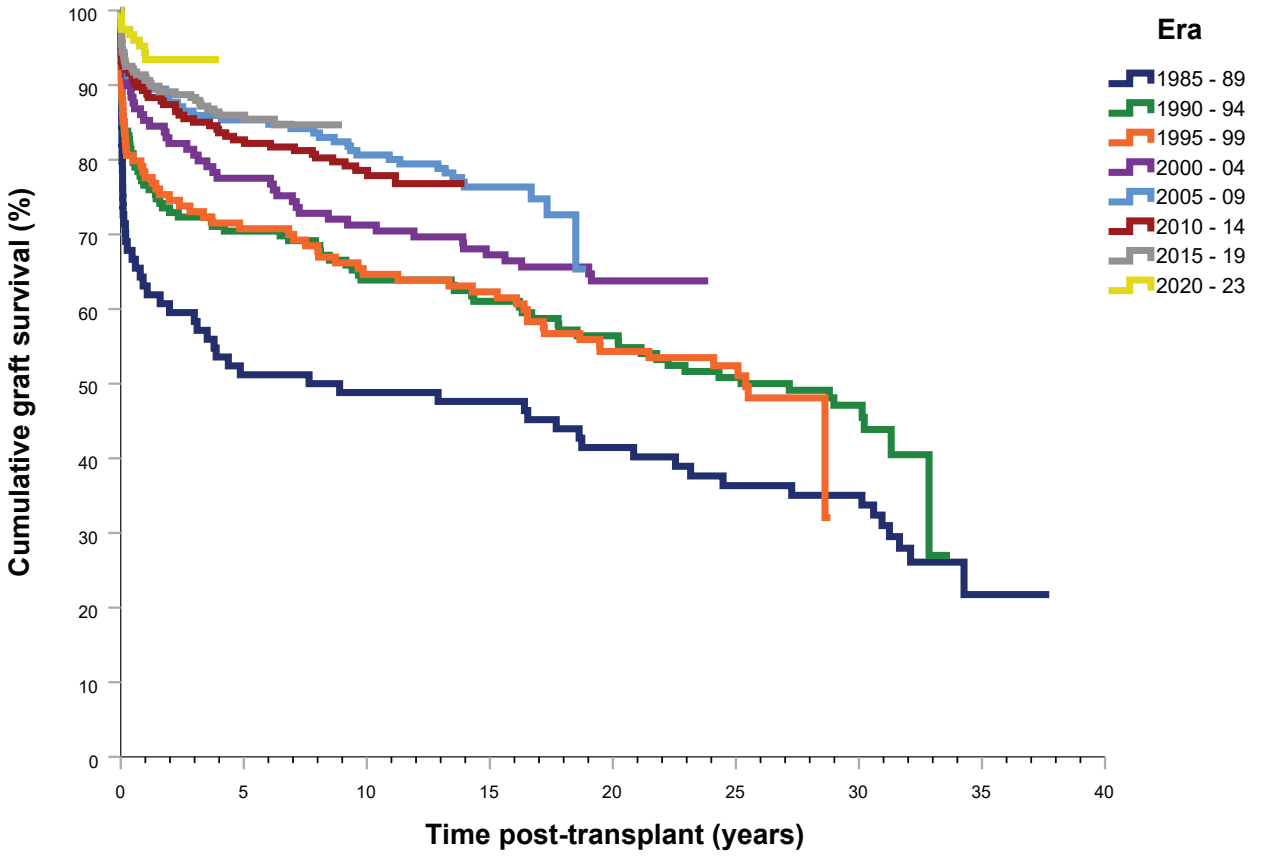


Table 48. Paediatric graft (deceased and living donors) survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1985 - 89	No. at risk	84	53	49	43	41	33	27	4	0
	Survival (%)		63%	58%	51%	49%	41%	35%	22%	
1990 - 94	No. at risk	167	126	116	112	94	72	31	0	
	Survival (%)		77%	72%	70%	64%	56%	47%		
1995 - 99	No. at risk	134	103	96	93	84	68	0		
	Survival (%)		78%	73%	71%	65%	54%			
2000 - 04	No. at risk	129	110	104	100	90	58	0		
	Survival (%)		85%	81%	78%	71%	64%			
2005 - 09	No. at risk	171	153	146	145	136	0			
	Survival (%)		90%	86%	85%	81%				
2010 - 14	No. at risk	215	190	180	174	114	0			
	Survival (%)		89%	85%	83%	79%				
2015 - 19	No. at risk	267	240	231	159	0				
	Survival (%)		91%	88%	86%					
2020 - 23	No. at risk	164	103	33	0					
	Survival (%)		94%	93%						

15.11 Graft Survival by Era of Transplant in Adults

There has been a progressive improvement in graft survival in adults over eras of transplantation, albeit relatively modest since 2000 (P < 0.001, Figure 74, Table 49). Graft survival in the most recent era was 89.1% at 1 year, 82.0% at 3 years, 81.3% at 5 years and 69.7% at 10 years. Median adult graft survival was not reached for transplant eras since 2010 and was 17.1 years for 2005 – 09, 17.2 years for 2000 – 04, 15.8 years for 1995 – 99, 15.5 years for 1990 – 94 and 7.3 years for 1985 – 89.

Figure 74. Adult graft (deceased and living donors) survival curve by era of transplant

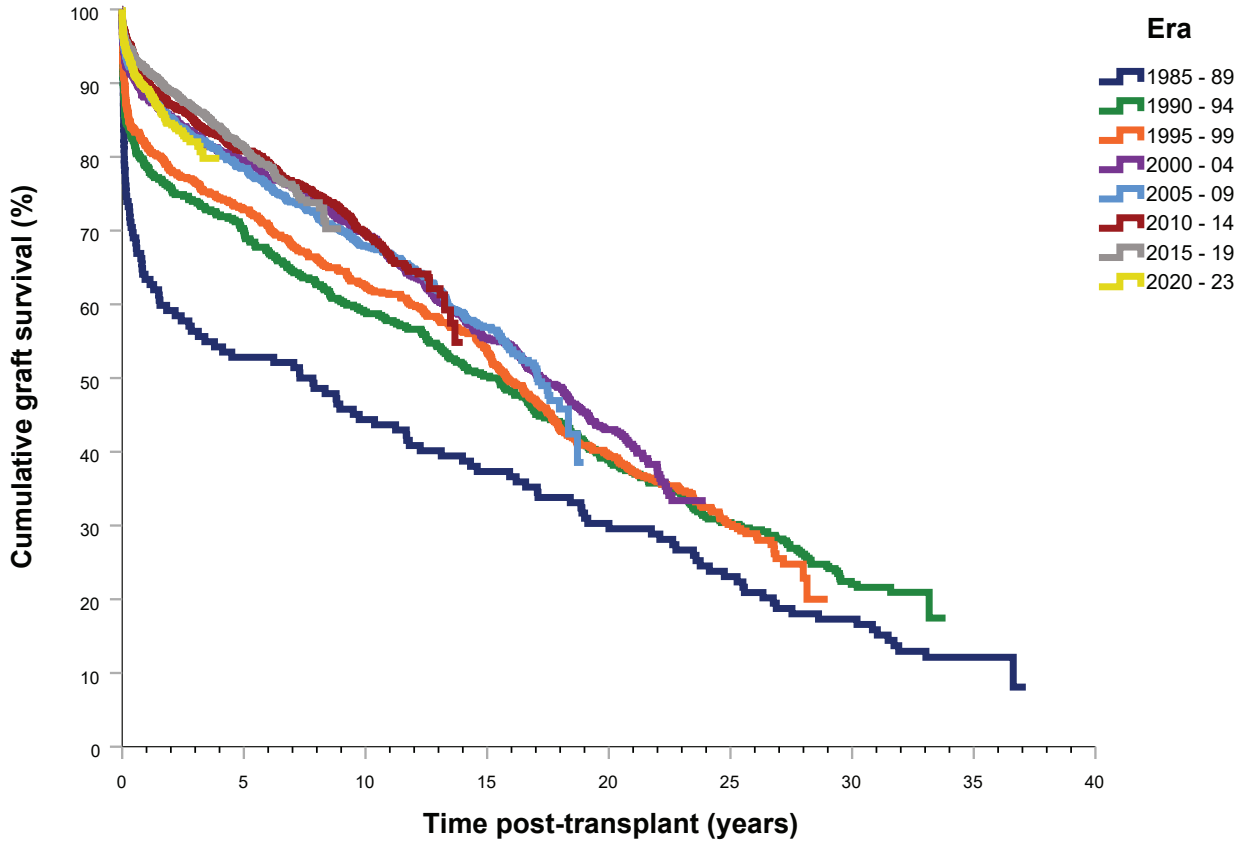


Table 49. Adult graft (deceased and living donors) survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years) 0	1	3	5	10	20	30	35	40
1985 - 89	No. at risk	142	90	80	75	63	42	24	3	0
	Survival (%)		63%	56%	53%	44%	30%	17%	12%	
1990 - 94	No. at risk	434	342	321	304	254	161	56	0	
	Survival (%)		79%	74%	70%	59%	39%	22%		
1995 - 99	No. at risk	625	506	472	446	380	232	0		
	Survival (%)		82%	77%	73%	63%	40%			
2000 - 04	No. at risk	786	684	641	608	531	211	0		
	Survival (%)		88%	83%	79%	70%	43%			
2005 - 09	No. at risk	861	767	707	671	575	0			
	Survival (%)		89%	83%	78%	68%				
2010 - 14	No. at risk	1,116	1,008	942	893	510	0			
	Survival (%)		90%	85%	81%	70%				
2015 - 19	No. at risk	1,496	1,371	1,251	820	0				
	Survival (%)		92%	87%	81%					
2020 - 23	No. at risk	1,134	649	153	0					
	Survival (%)		89%	82%						

15.12 Whole Graft Survival by Era of Transplant

There has been an improvement in graft survival after whole liver transplantation over eras of transplantation up to 2000, after which graft survival has been similar over progressive eras (P < 0.001, Figure 75,Table 50). Graft survival in the most recent era was 89.3% at 1 year, 82.3% at 3 years, 82.0% at 5 years and 70.7% at 10 years. Median graft survival was not reached for eras since 2010 and was 17.3 years for 2005 – 09, 18.1 years for 2000 – 04, 16.8 years for 1995 – 99, 16.4 years for 1990 – 94 and 8.3 years for 1985 – 89.

Figure 75. Whole graft survival curve by era of transplant

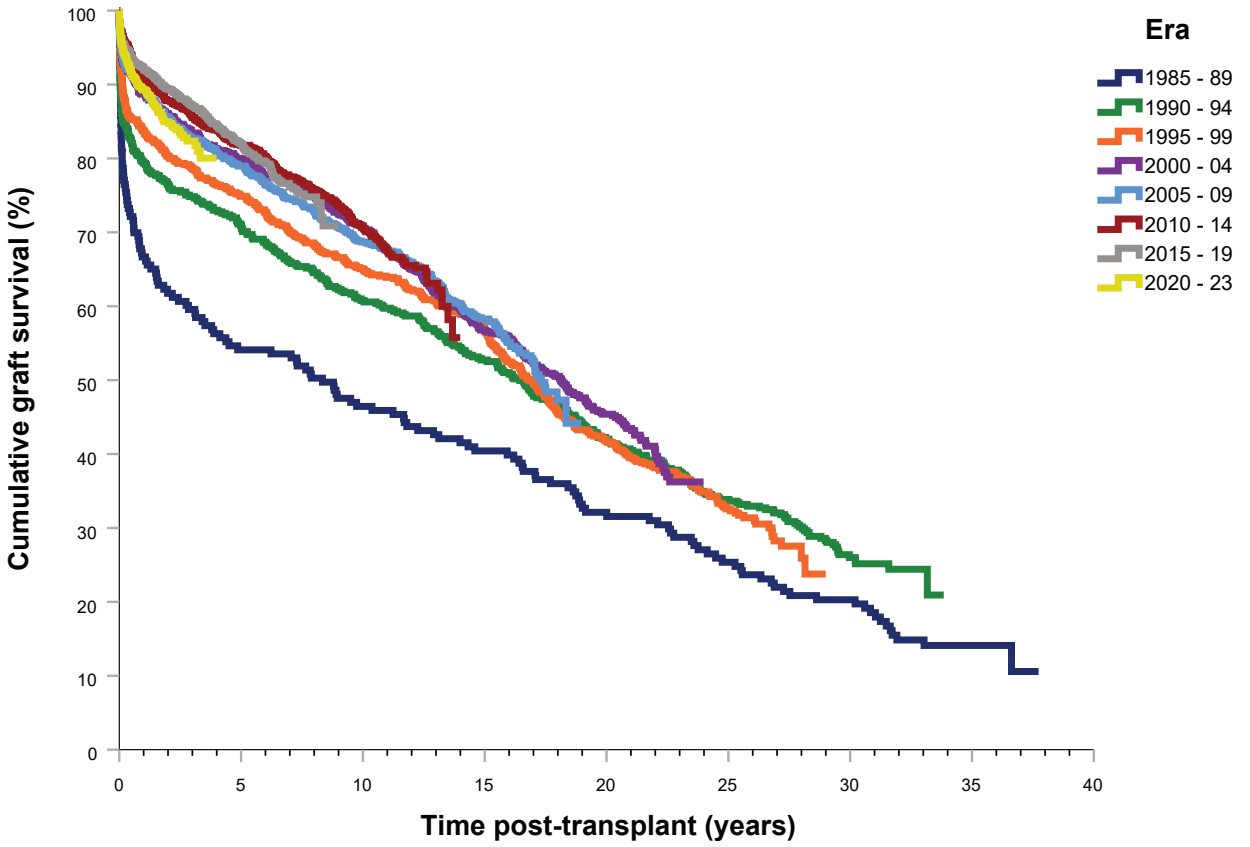


Table 50. Whole graft survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1985 - 89	No. at risk	183	122	109	99	85	57	36	6	0
	Survival (%)		67%	60%	54%	46%	32%	20%	14%	
1990 - 94	No. at risk	489	388	365	345	289	192	66	0	
	Survival (%)		80%	75%	71%	61%	42%	26%		
1995 - 99	No. at risk	617	512	478	452	390	245	0		
	Survival (%)		84%	79%	75%	65%	42%			
2000 - 04	No. at risk	774	678	635	604	533	231	0		
	Survival (%)		89%	83%	80%	71%	45%			
2005 - 09	No. at risk	816	729	671	640	552	0			
	Survival (%)		90%	83%	79%	69%				
2010 - 14	No. at risk	1,067	969	910	864	503	0			
	Survival (%)		91%	86%	82%	71%				
2015 - 19	No. at risk	1,421	1,307	1,196	781	0				
	Survival (%)		92%	87%	82%					
2020 - 23	No. at risk	1,077	618	149	0					
	Survival (%)		89%	82%						

15.13 Reduced Graft Survival by Era of Transplant

Graft survival after reduced liver transplantation varied over transplant eras without a clear trend (P = 0.024, Figure 76, Table 51). Graft survival in the most recent era was 76.9% at 1 year and at 3 years, 80.3% at 5 years and 58.1% at 10 years. Median graft survival was not reached for eras since 2000. It was 9.2 years for 1995 – 99, 20.2 years for 1990 – 94, and 3.0 years for 1985 – 89.

Figure 76. Reduced graft survival curve by era of transplant

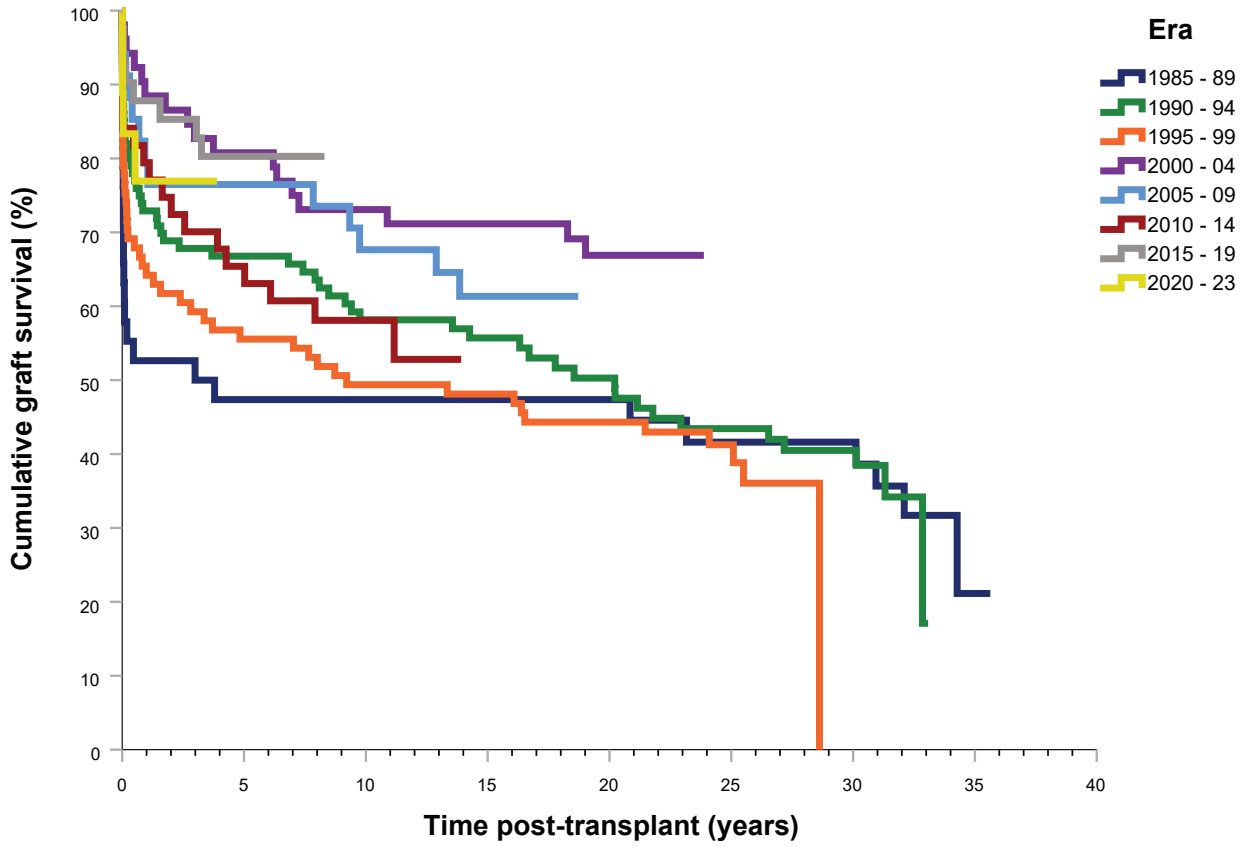


Table 51. Reduced graft (deceased donor) survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1985 - 89	No. at risk	38	20	19	18	18	17	14	1	0
	Survival (%)		53%	50%	47%	47%	47%	42%	21%	
1990 - 94	No. at risk	100	72	65	64	53	36	20	0	
	Survival (%)		73%	68%	67%	58%	50%	41%		
1995 - 99	No. at risk	81	52	48	44	40	34	0		
	Survival (%)		64%	59%	56%	49%	44%			
2000 - 04	No. at risk	52	46	43	42	38	24	0		
	Survival (%)		89%	83%	81%	73%	67%			
2005 - 09	No. at risk	34	27	26	26	23	0			
	Survival (%)		79%	77%	77%	68%				
2010 - 14	No. at risk	44	34	30	28	18	0			
	Survival (%)		79%	70%	65%	58%				
2015 - 19	No. at risk	41	35	34	25	0				
	Survival (%)		88%	85%	80%					
2020 - 23	No. at risk	18	10	2	0					
	Survival (%)		77%	77%						

15.14 Split Graft Survival by Era of Transplant

There has been a progressive improvement in graft survival after split liver transplantation over eras of transplantation, particularly with regard to early graft survival after 2004 (P = 0.001, Figure 77, Table 52). Graft survival in the most recent era was 93.5% at 1 year, 89.7% at 3 years, 82.9% at 5 years and 75.3% at 10 years. Median graft survival was not reached for transplant eras since 2010 and was 18.5 years for 2005 – 09, 16.3 years for 2000 – 04, 14.5 years for 1995 – 99 and 5.0 years for 1985 – 94.

Figure 77. Split graft (deceased donor) survival curve by era of transplant

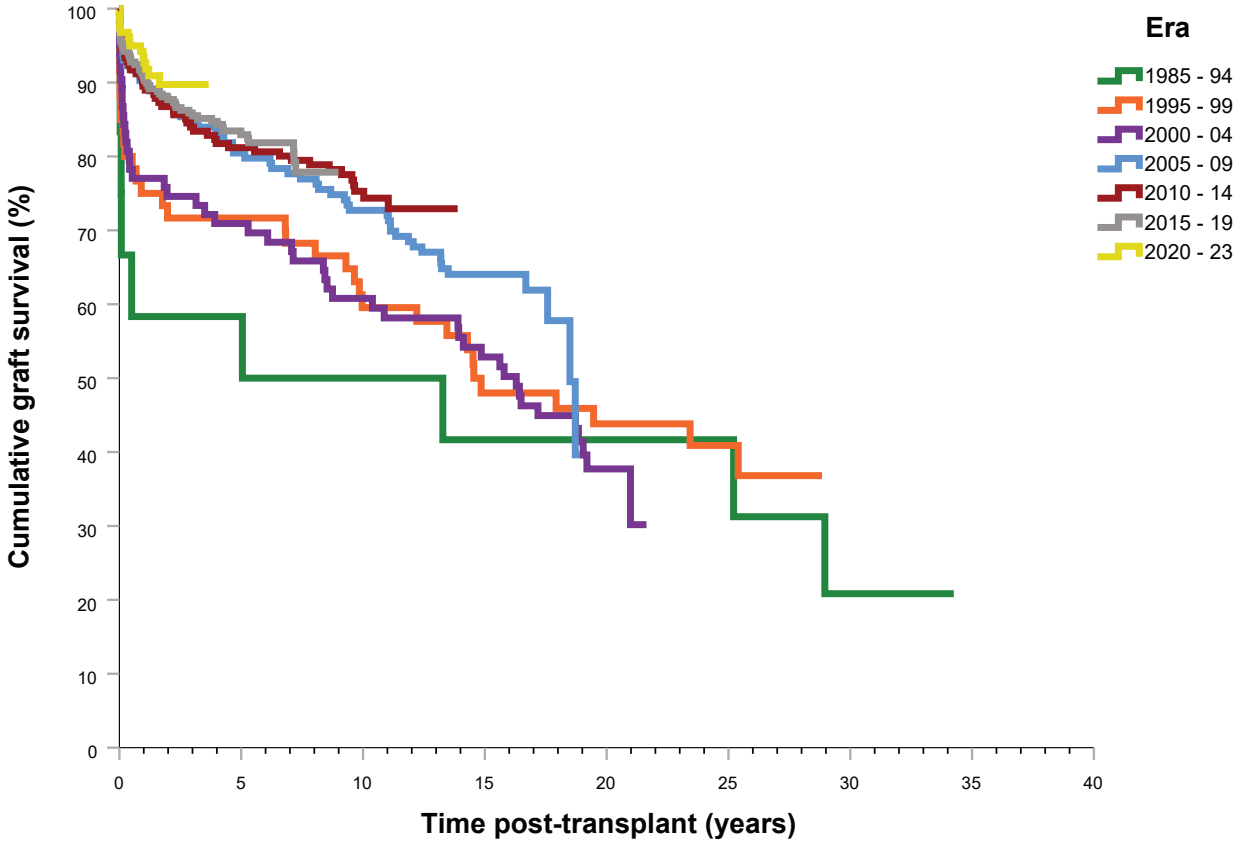


Table 52. Split graft (deceased donor) survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1985 - 94	No. at risk	12	7	7	7	6	4	2	0	
	Survival (%)		58%	58%	58%	50%	42%	21%		
1995 - 99	No. at risk	60	45	42	42	34	21	0		
	Survival (%)		75%	72%	72%	60%	44%			
2000 - 04	No. at risk	83	63	61	56	46	12	0		
	Survival (%)		77%	75%	71%	61%	38%			
2005 - 09	No. at risk	144	128	121	115	103	0			
	Survival (%)		90%	85%	81%	73%				
2010 - 14	No. at risk	182	162	151	145	82	0			
	Survival (%)		90%	84%	81%	75%				
2015 - 19	No. at risk	277	250	233	163	0				
	Survival (%)		91%	86%	83%					
2020 - 23	No. at risk	193	117	31	0					
	Survival (%)		94%	90%						

15.15 Living Donor Graft Survival by Era of Transplant

There were 115 living donor grafts (excluding domino grafts). There had been a progressive deterioration in graft survival after living donor transplantation over eras of transplantation after 2000 until 2019, although there have been no graft losses to date in living donor liver transplants performed in 2020 - 22 (P = 0.005, Figure 78 and Table 53). Graft survival in the most recent era was 100% at 1 year and at 3 years, 71.3% at 5 years and 78.4% at 10 years. Median graft survival was not reached for transplant eras since 2000 and was 0.8 years for 1985 – 99.

Figure 78. Living donor (excluding domino) graft survival curve by era of transplant

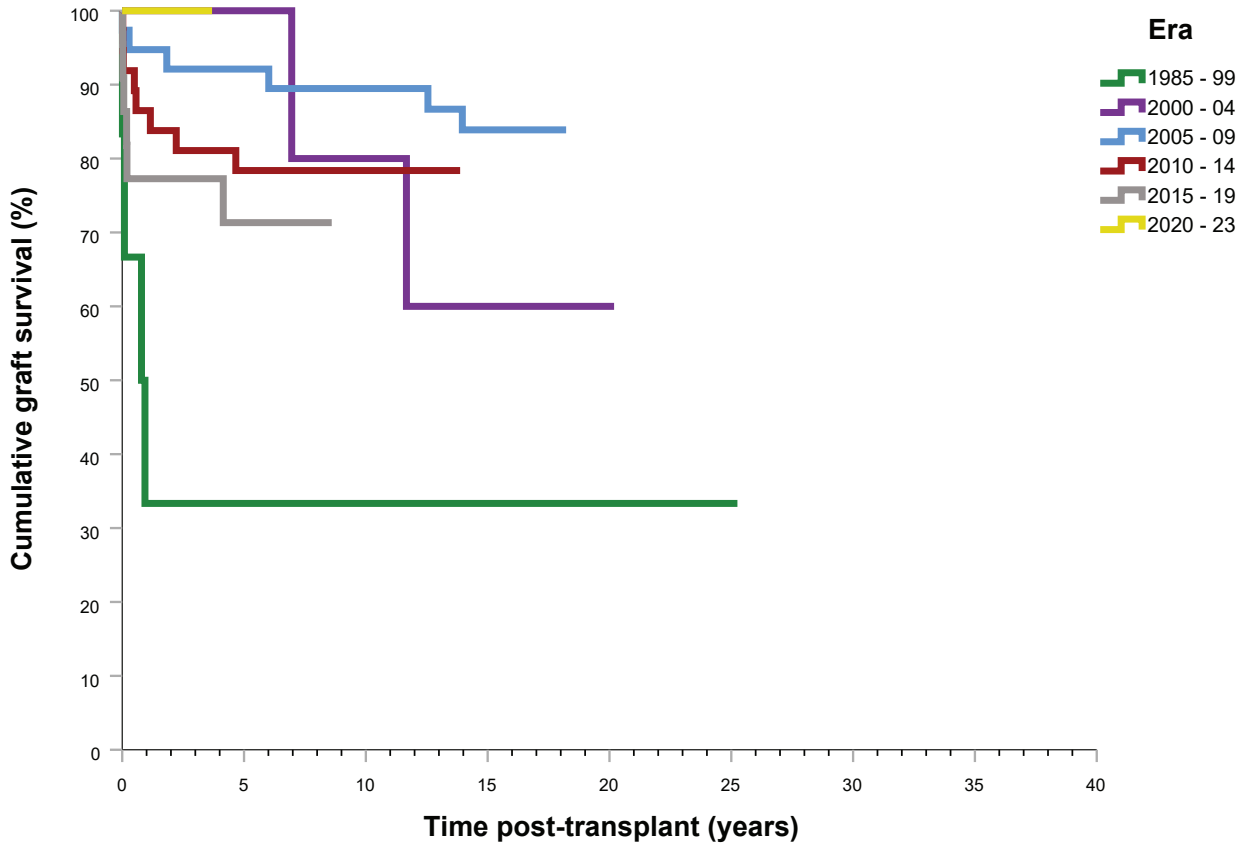


Table 53. Living donor (excluding domino) graft survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1985 - 99	No. at risk	6	2	1	1	1	1	0		
	Survival (%)		33%	33%	33%	33%	33%			
2000 - 04	No. at risk	5	5	5	5	4	2	0		
	Survival (%)		100%	100%	100%	80%	60%			
2005 - 09	No. at risk	38	36	35	35	33	0			
	Survival (%)		95%	92%	92%	90%				
2010 - 14	No. at risk	37	32	30	29	21	0			
	Survival (%)		87%	81%	78%	78%				
2015 - 19	No. at risk	22	17	17	8	0				
	Survival (%)		77%	77%	71%					
2020 - 23	No. at risk	9	7	4	0					
	Survival (%)		100%	100%						

15.16 Graft Survival by Deceased Donor Age

A total of 7,803 grafts were sourced from 7,328 deceased donors, however there is no deceased donor information on 126 grafts from 1985 to 1988. This survival analysis is limited to 7,675 grafts (from 6,884 deceased donors) that have donor information recorded. There is a significant difference in the graft survival outcome based on the age of the deceased donor, with grafts from younger donors having better survival rates (P < 0.001, Figure 79 and Table 54). Ten-year graft survival was 80.3% for donors aged 10 – 15 years, 77.3% for donors aged 0 – 9 years, 71.3% for donors aged 16 – 29 years, 65.1% for donors aged 60 – 69 years, 67.1% for donors aged 30 – 39 years, 67.0% for 40 – 49 years, 64.8% for donors aged 70 years and older, and 64.8% for donors aged 50 – 59 years. Median graft survival was not reached for donors aged 0 – 9 years and was 27.2 years for donors aged 10 – 15 years, 20.1 years for donors aged 16 – 29 years, 17.4 years for donors aged 30 – 39 years, 16.6 years for donors aged 40 – 49 years, 14.8 years for donors aged 60 – 69 years, 15.9 years for donors aged 50 - 59 years and 14.5 years for donors aged 70 years and older.

Figure 79. Graft survival curve by deceased donor age

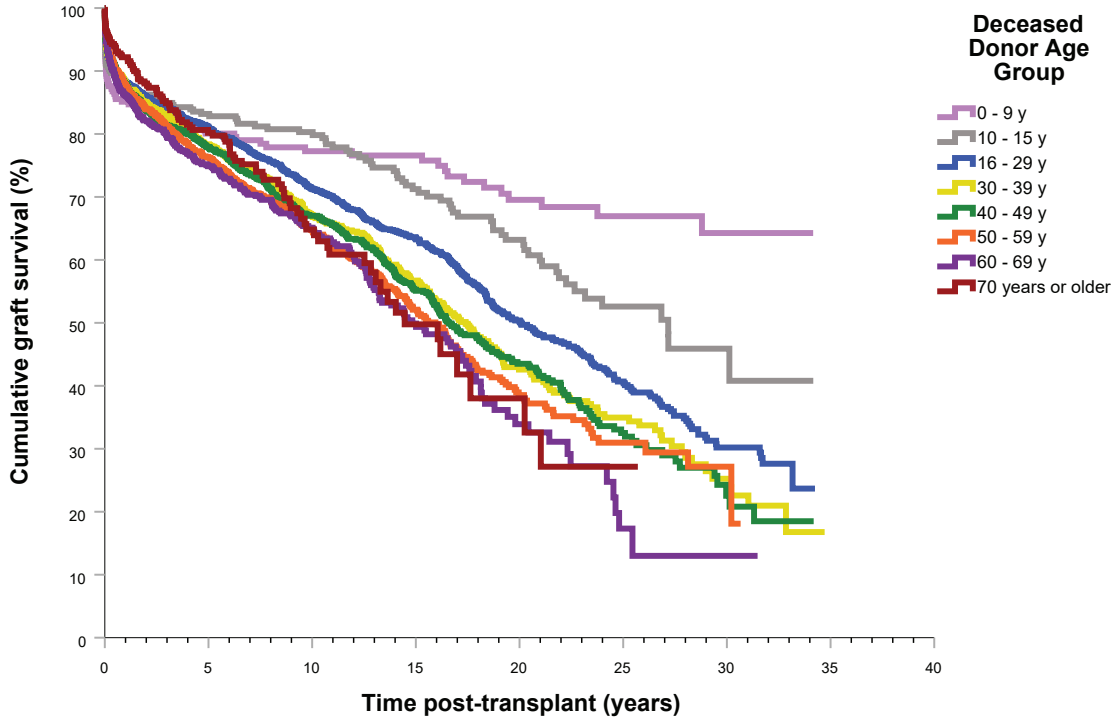


Table 54. Graft survival by deceased donor age

Donor Age	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
0 – 9 y	No. at risk	251	202	182	162	124	72	14	0	
	Survival (%)		85%	83%	80%	77%	70%	64%		
10 – 15 y	No. at risk	334	276	255	227	168	80	10	0	
	Survival (%)		87%	85%	83%	80%	63%	46%		
16 – 29 y	No. at risk	1,949	1,607	1,392	1,207	803	296	53	0	
	Survival (%)		88%	84%	81%	71%	50%	30%		
30 – 39 y	No. at risk	1,138	941	799	659	403	109	19	0	
	Survival (%)		88%	83%	78%	67%	43%	25%		
40 – 49 y	No. at risk	1,447	1,184	997	845	527	155	13	0	
	Survival (%)		88%	81%	78%	67%	44%	23%		
50 – 59 y	No. at risk	1,318	1,089	903	738	421	91	4	0	
	Survival (%)		88%	81%	76%	65%	39%	27%		
60 – 69 y	No. at risk	886	708	589	478	238	27	1	0	
	Survival (%)		86%	80%	75%	65%	34%	13%		
70 years and older	No. at risk	352	300	236	179	73	7	0		
	Survival (%)		92%	85%	80%	65%	38%			

All grafts from deceased donors since 1989 (n=7,675)

15.17 Graft Survival by Donor Type

Graft survival was superior for transplantation from living donors and slightly inferior for transplantation from donation after circulatory death donors in comparison to transplantation from donation after brain death donors (P = 0.013, Figure 80 and Table 55). Ten-year graft survival was 79.0% for transplantation from living donors, 68.2% for transplantation from donation after brain death donors and 65.2% for transplantation from donation after circulatory death donors. Median survival was not reached for transplantation from living donors and donation after circulatory death donors. Median survival was 18.1 years for transplantation from donation after brain death donors.

Figure 80. Graft survival curve by donor type – all grafts

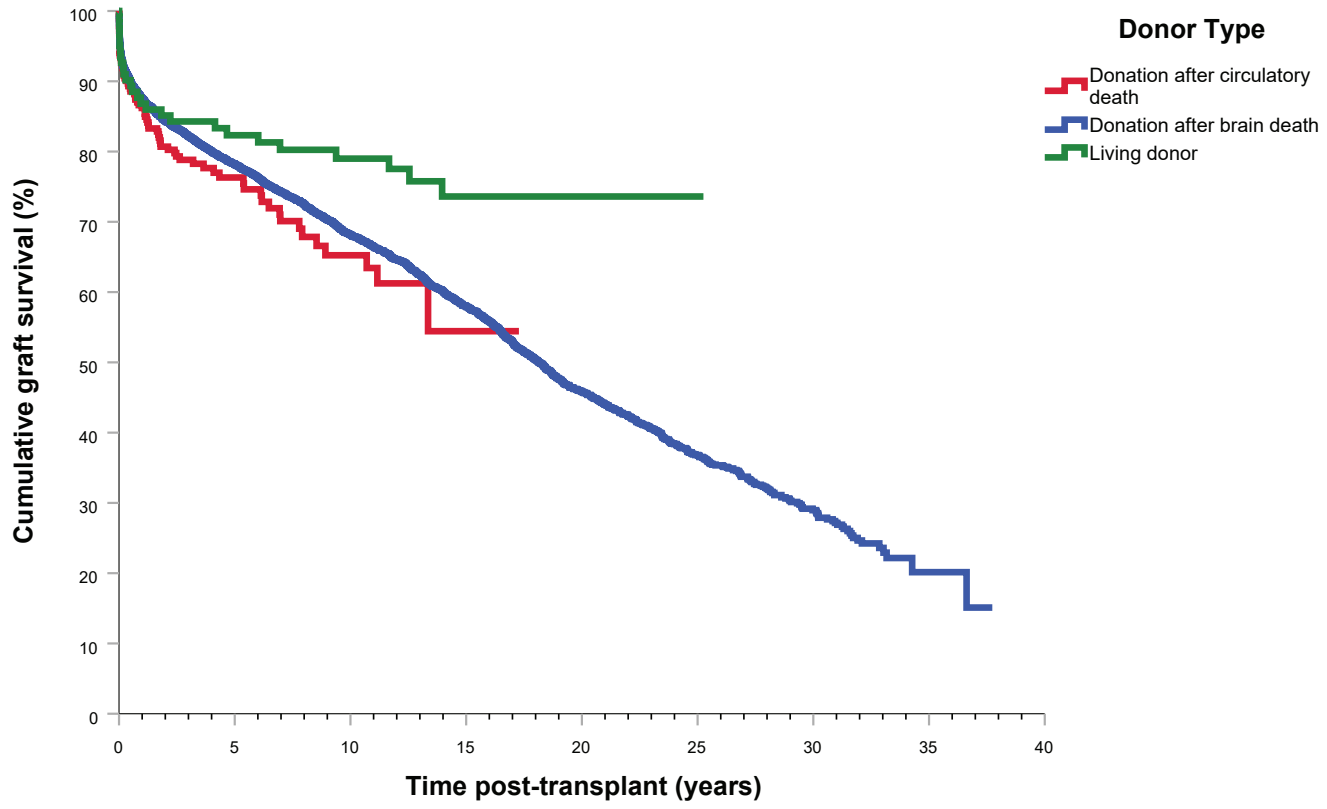


Table 55. Graft survival by donor type – all grafts

Donor Type	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Living donor	No. at risk	122	103	96	82	59	3	0		
	Survival (%)		87%	84%	82%	79%	74%			
DBD	No. at risk	7,511	6,180	5,273	4,463	2,775	874	138	7	0
	Survival (%)		88%	82%	78%	68%	46%	29%	20%	
DCD	No. at risk	291	211	153	98	38	0			
	Survival (%)		86%	79%	76%	65%				

Abbreviations: DBD, donation after brain death; DCD, donation after circulatory death

All grafts (n=7,924)

15.18 Graft Survival by Donor Cause of Death

Graft survival varied significantly by donor cause of death (P < 0.001, Figure 81, Table 56). Ten-year graft survival was 73.2% for other cause, 70.3% for anoxia, 69.6% for trauma and 66.3% for stroke. Median survival was 23.3 years for other cause, 19.3 years for trauma, 18.5 years for anoxia and 16.7 years for stroke.

Figure 81. Graft survival curve by donor cause of death

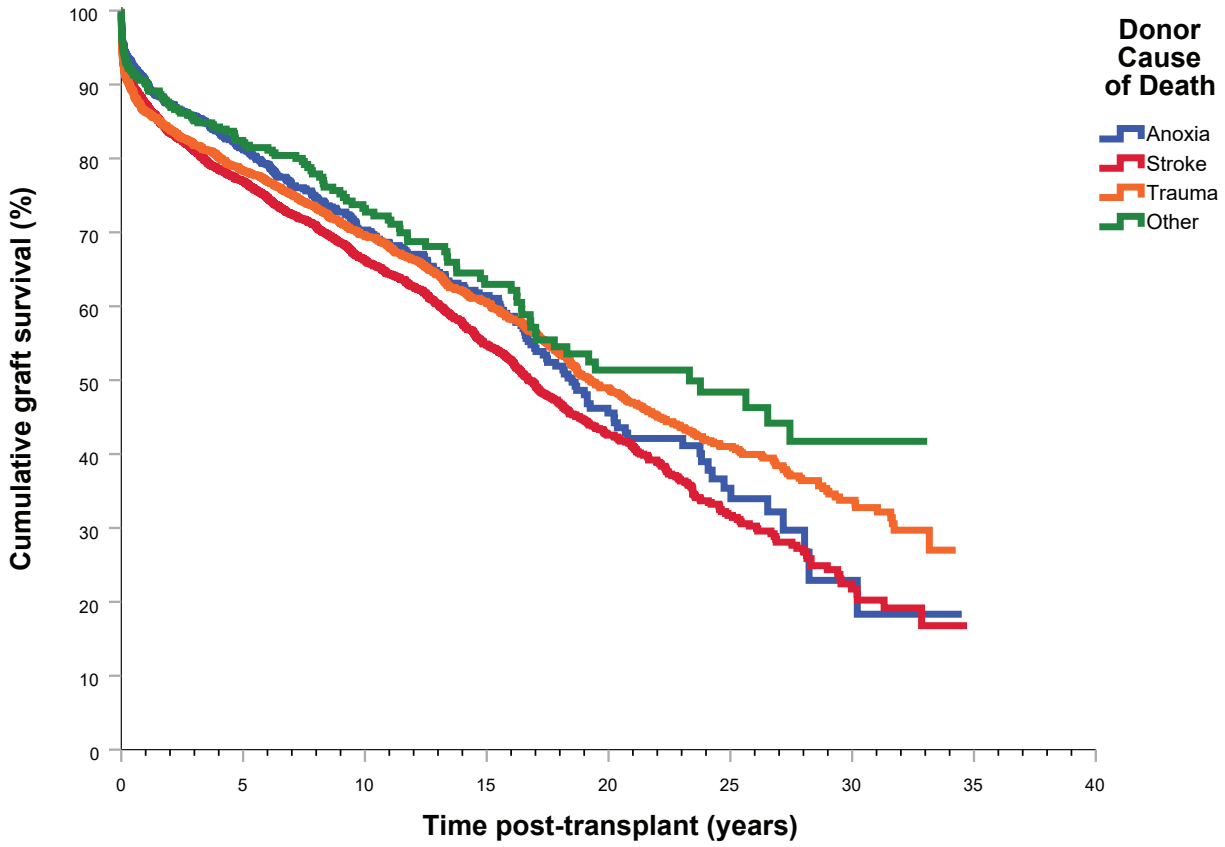


Table 56. Graft survival by donor cause of death

Donor cause of death	Graft Survival	Time post-transplant (years) 0	1	3	5	10	20	30	35	40
Other	No. at risk	455	376	326	255	145	46	8	0	
	Survival (%)		90%	85%	82%	73%	51%	42%		
Trauma	No. at risk	2,119	1,751	1,549	1,378	988	390	70	0	
	Survival (%)		86%	82%	78%	70%	49%	34%		
Stroke	No. at risk	3,472	2,872	2,423	2,065	1,272	330	31	0	
	Survival (%)		87%	81%	77%	66%	43%	22%		
Anoxia	No. at risk	1,629	1,308	1,055	797	352	71	5	0	
	Survival (%)		90%	86%	81%	70%	46%	23%		

All grafts from deceased donors since 1989 (n=7,675)

15.19 Graft Survival by Shipping of Organs

Graft survival was better for transplants performed with a liver from the unit's donor region than shipped grafts (P = 0.003, Figure 82, Table 57). Ten-year graft survival was 69.6% for transplants performed with a non-shipped liver and 65.1% for a liver shipped from another unit. Median graft survival was 18.1 years for transplants performed with a donor liver from the unit's donor region and 17.9 years for a liver shipped from another unit.

Figure 82. Graft survival curve by organ shipping

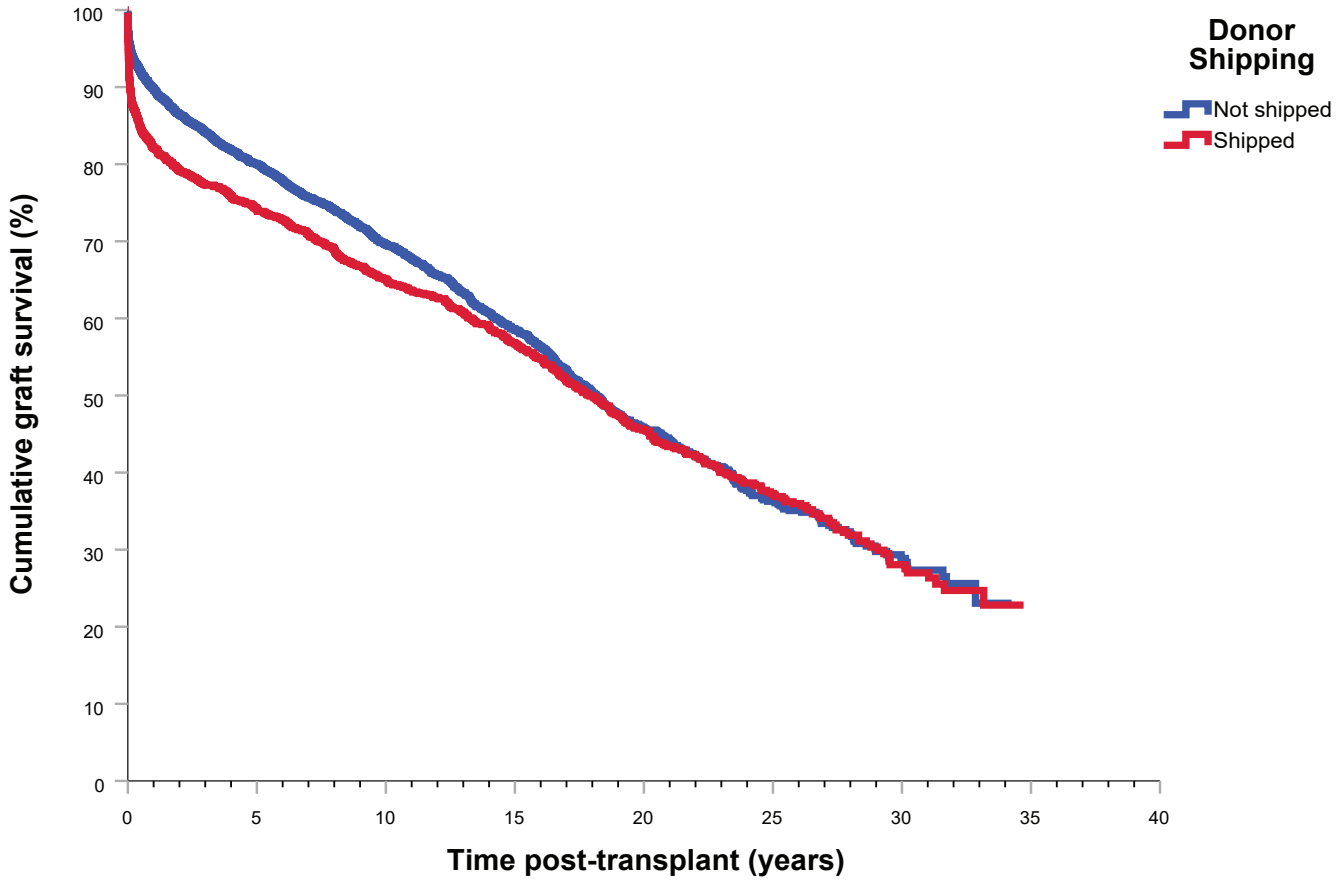


Table 57. Graft survival by organ shipping

Organ Shipping	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Not shipped	No. at risk	5,774	4,823	4,053	3,357	1,961	486	60	0	
	Survival (%)		90%	84%	80%	70%	46%	29%		
Shipped	No. at risk	1,901	1,484	1,300	1,138	796	351	54	0	
	Survival (%)		82%	77%	74%	65%	46%	28%		

All grafts from deceased donors since 1989 (n=7,675)

15.20 Graft Survival by Machine Perfusion used

Machine perfusion has been used as a preservation method in liver transplantation in recent years and this includes hypothermic and normothermic perfusion. There have been 91 transplants using machine perfusion with 74 (81%) under normothermic conditions and 17 (19%) under hypothermic conditions. Currently there is no significant difference in graft survival using the different methods but this may be due to small numbers (P = 0.884, Figure 83 and Table 58).

Figure 83. Graft survival curve of all patients receiving deceased donor livers using machine perfusion

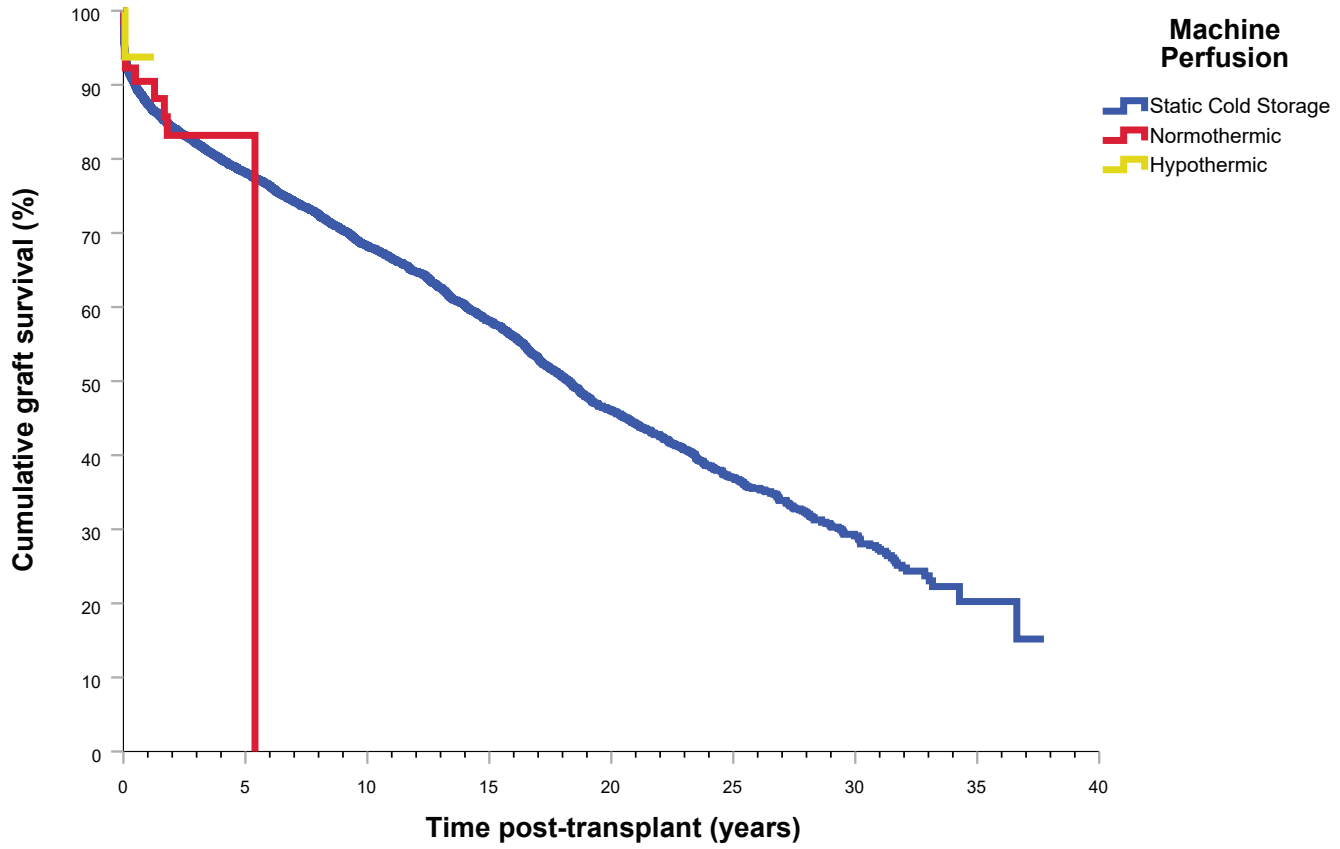


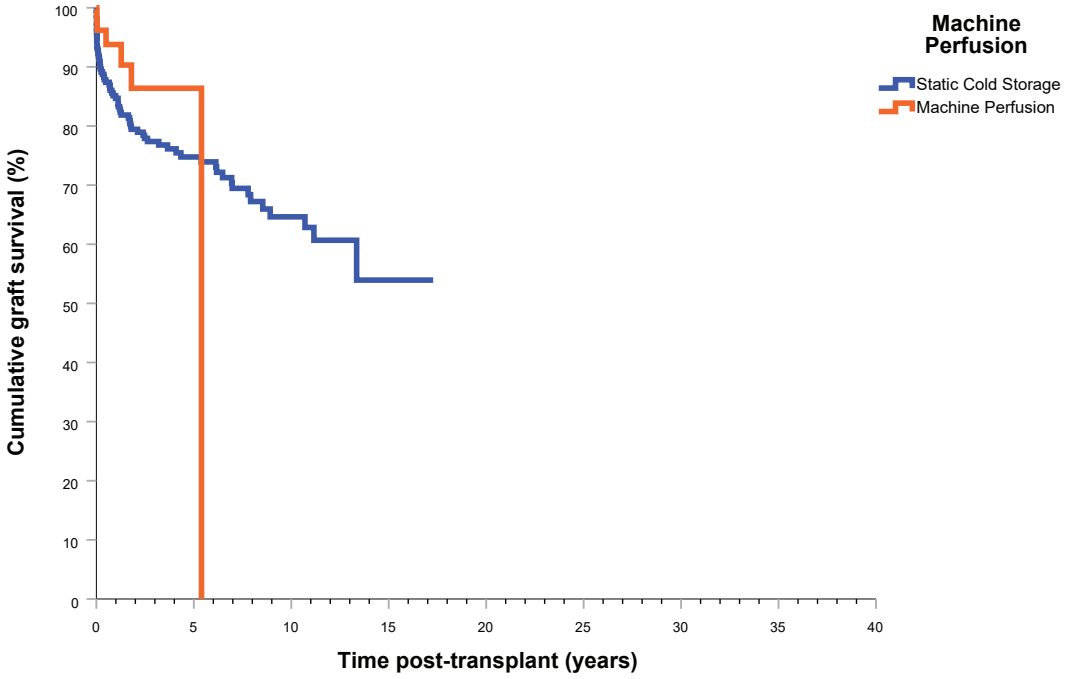
Table 58. Graft survival by machine perfusion

Graft Type	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Static cold storage	No. at risk	7,833	6,452	5,499	4,641	2,872	877	138	7	0
	Survival (%)		88%	82%	78%	68%	46%	29%	20%	
Normothermic	No. at risk	74	40	23	2	0				
	Survival (%)		91%	83%	83%					
Hypothermic	No. at risk	17	2	0						
	Survival (%)		94%							

15.20.1 Machine Perfusion of DCD

There has been a total of 291 liver grafts donated after circulatory death and 55 (19%) were machine perfused compared to 236 (81%) livers using the traditional static cold storage method. Although there are advantages of machine perfusion over the traditional static cold storage of livers, there was no significant difference between the survival of patients receiving livers following machine perfusion versus static cold storage (P = 0.256, Figure 84).

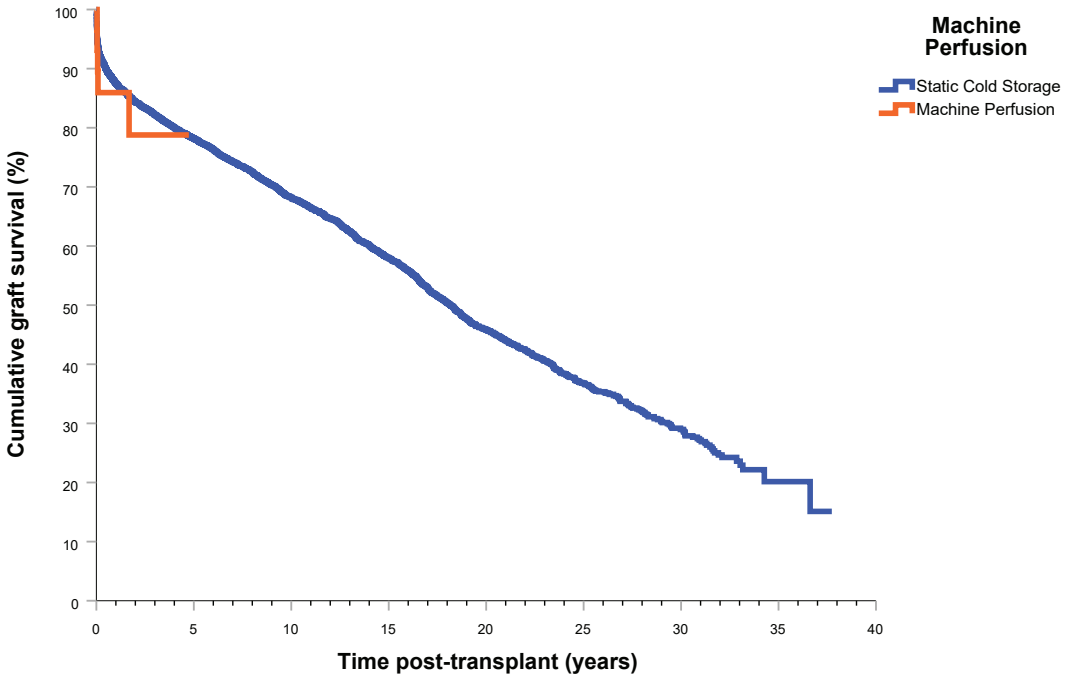
Figure 84. Graft survival curve of patients receiving DCD donors



15.20.2 Machine Perfusion of DBD

Of the 7,511 liver grafts donated after brain death, 36 (0.5%) were machine perfused compared to 7,475 (99.5%) using static cold storage. There was no significant difference between the survival of patients receiving livers following machine perfusion compared to static cold storage (P = 0.639, Figure 85).

Figure 85. Graft survival curve of patients receiving DBD donors



15.21 Graft Survival by Cold Ischaemia Time

Graft survival was significantly better for transplants performed with a cold ischaemia time less than 431 minutes compared to transplants performed with a cold ischaemia time 431 minutes or greater (P < 0.001, see Figure 86 and Table 59). Ten-year graft survival was 72.2% for transplants with a cold ischaemia time less than 431 minutes and 66.4% for transplants with a cold ischaemia time greater than or equal to 431 minutes. Median survival was 18.7 years for transplants with a cold ischaemia time less than 431 minutes and 16.3 years for transplants with a cold ischaemia time greater than or equal to 431 minutes.

Figure 86. Graft survival curve by cold ischaemia time

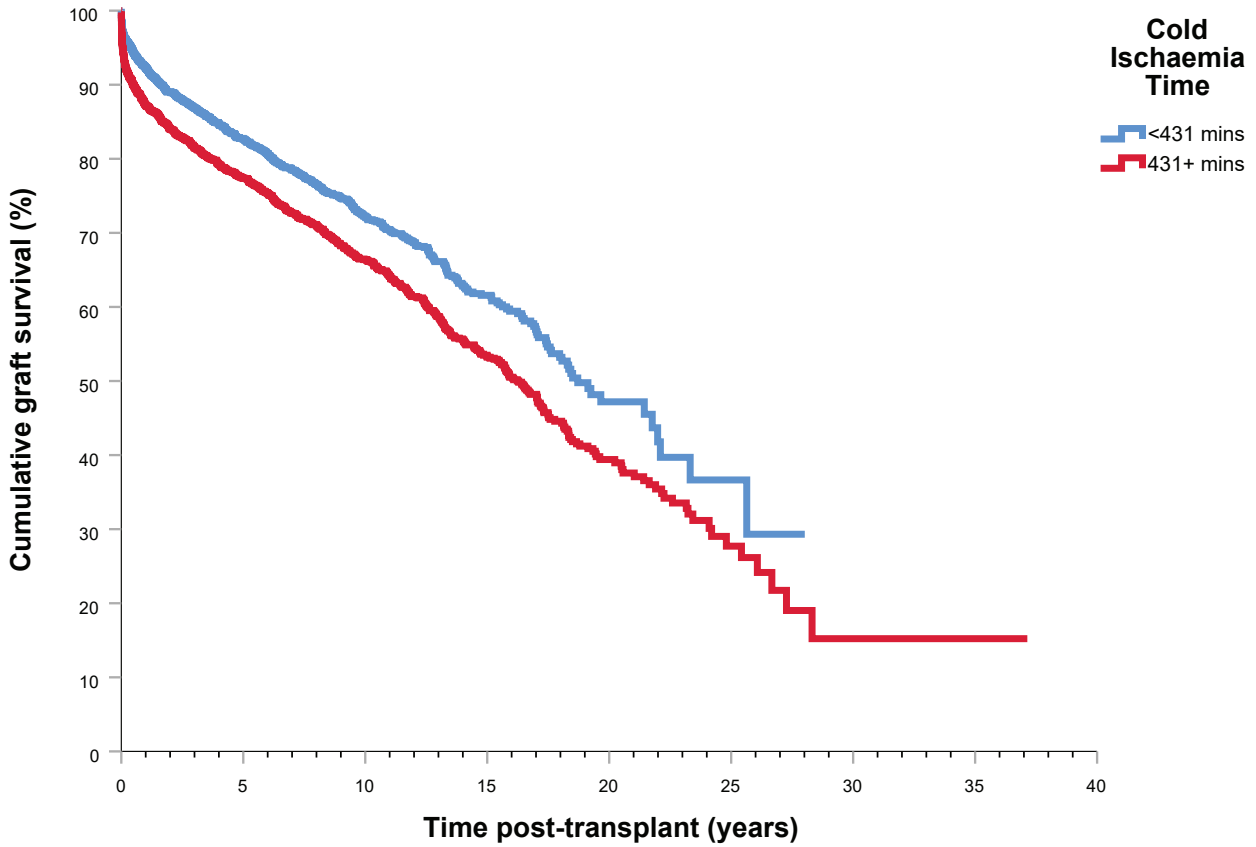


Table 59. Graft survival by cold ischaemia time

Cold Ischaemia Time	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
<431 min	No. at risk	3,617	3,014	2,384	1,824	782	43	0		
	Survival (%)		92%	87%	83%	72%	47%			
431+ min	No. at risk	2,221	1,852	1,626	1,388	854	93	2	2	0
	Survival (%)		87%	82%	77%	66%	39%	15%	15%	

1,964 cases missing

15.22 Graft Survival by Blood Group Compatibility

Recording of A blood subtypes was only done for a small number of cases prior to 2015 in the Registry. Any blood type A without subtyping is classified as A.

There was no difference in graft survival by deceased donor/recipient blood group compatibility (P=0.874, Figure 87 and Table 60). Ten-year graft survival was 70.1% for blood group-incompatible "A2" transplants (i.e. blood group A, non-A1 donor to O or B recipient or blood group AB, non-A1B to B recipient), 71.0% for blood group incompatible transplants (excluding A2 donors), 69.6% for blood group-compatible transplants and 68.3% for blood group-identical transplants. Median graft survival was not reached for blood group incompatible transplants, 20.9 years for incompatible "A2" transplants, 18.5 years for transplants in which the donor and recipient blood groups were compatible and 18.1 years for transplants between identical blood groups.

Figure 87. Graft survival curve by blood group compatibility

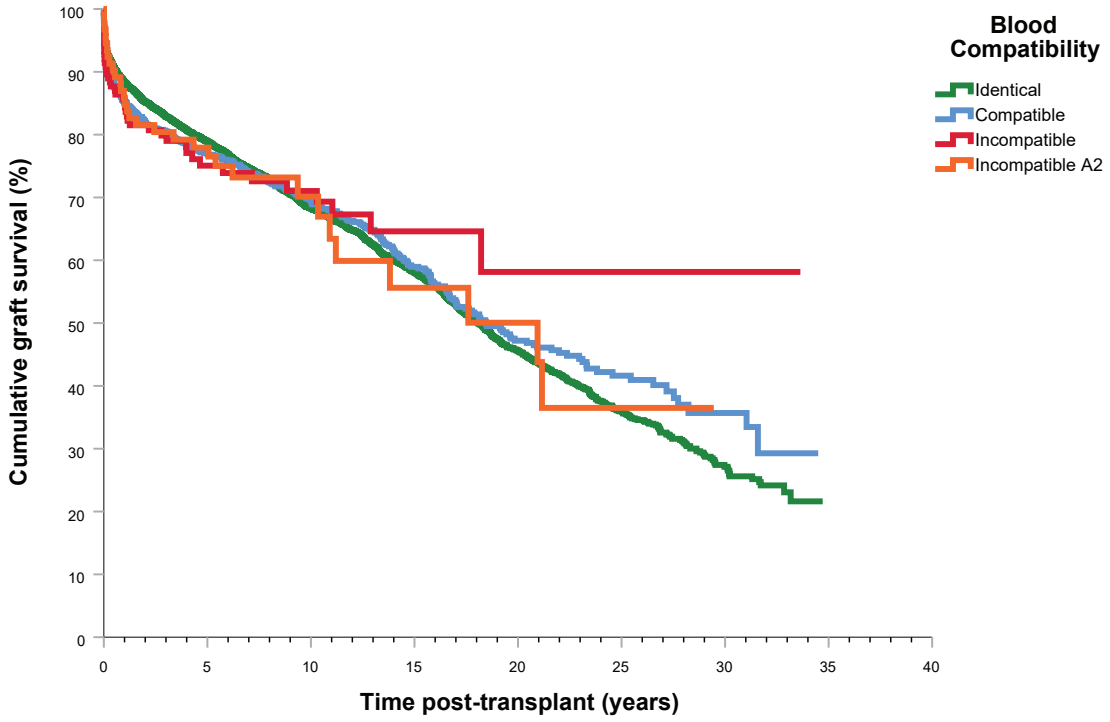


Table 60. Graft survival by blood group compatibility

Compatibility	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Incompatible	No. at risk	167	123	94	70	44	9	3	0	
	Survival (%)		85%	80%	75%	71%	58%	58%		
Incompatible A2	No. at risk	92	79	68	55	22	8	0		
	Survival (%)		86%	80%	78%	70%	50%			
Compatible	No. at risk	1,047	838	720	619	399	136	18	0	
	Survival (%)		85%	81%	77%	70%	47%	36%		
Identical	No. at risk	6,344	5,253	4,468	3,751	2,292	684	93	0	
	Survival (%)		88%	83%	79%	68%	46%	27%		

All grafts from deceased donors since 1989, 16 deceased donor blood types missing from 1989 onwards (n = 7,650)

15.23 Graft Survival by Recipient Urgency at Transplant

Graft survival varied significantly by recipient urgency at transplant with poorer outcomes for category 1 to up 20 years post-transplant (P < 0.001, Figure 88 and Table 61). Ten-year graft survival was 76.2% for category 2, 68.5% for non-urgent and 55.2% for category 1 patients. Median graft survival was 25.6 years for category 2, 18.3 years for non-urgent patients and 11.2 years for category 1.

Figure 88. Graft survival curve by recipient urgency at transplant

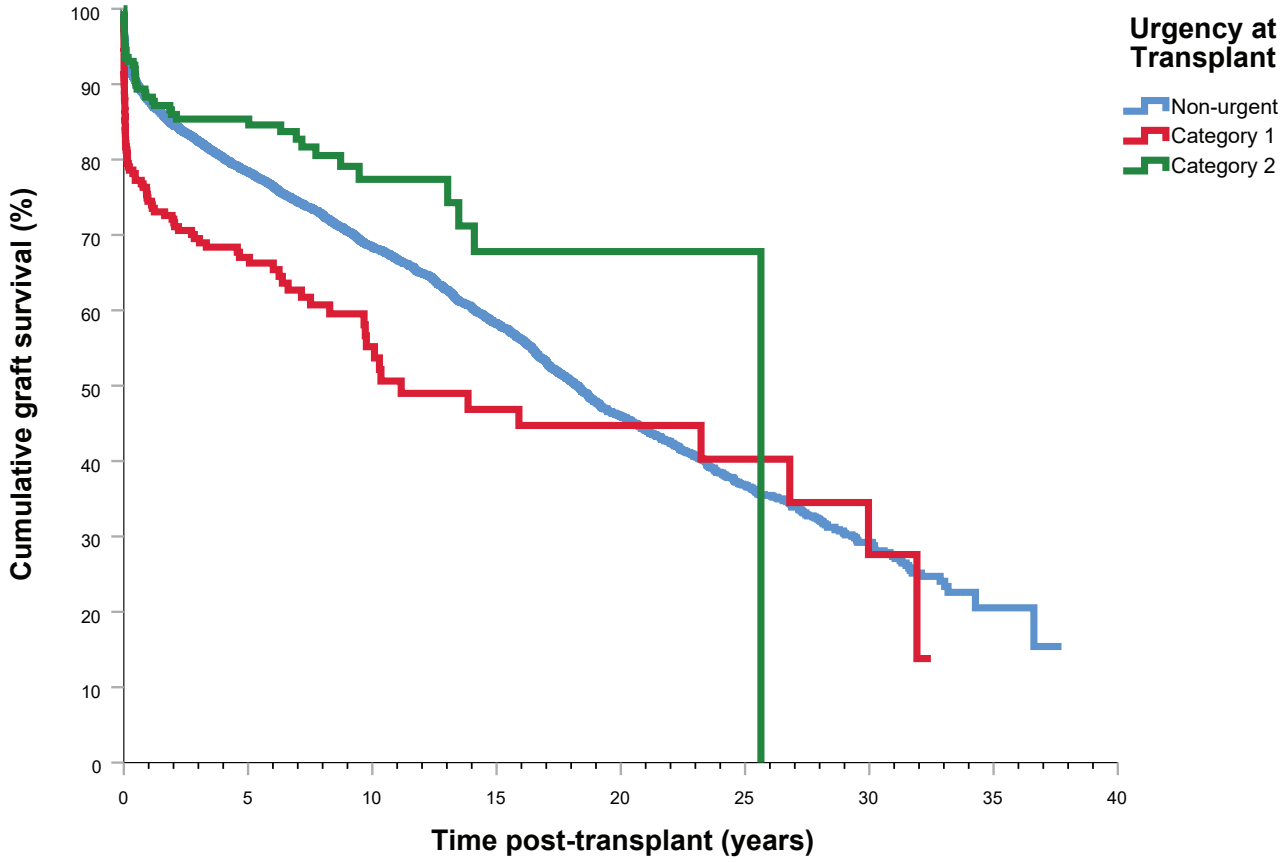


Table 61. Graft survival by recipient urgency at transplant

Urgency at Transplant	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Category 2	No. at risk	203	162	133	110	39	4	0		
	Survival (%)		88%	85%	85%	77%	68%			
Non-urgent	No. at risk	7,488	6,172	5,263	4,442	2,796	861	134	7	0
	Survival (%)		88%	82%	78%	69%	46%	29%	21%	
Category 1	No. at risk	233	160	126	91	37	12	4	0	
	Survival (%)		75%	70%	67%	55%	45%	28%		

15.24 Graft Survival by Transplant Unit

Benchmarking analysis using hierarchical regression models estimated that <0.0001% of the variation in 1-year graft loss and 1.3% of the variation in 5-year post-transplant mortality was due to variation between liver transplant units. One transplant unit appears to be an outlier in 5-year graft survival. A consensus of the Liver and Intestinal Transplant Advisory Committee of the Transplantation Society of Australia and New Zealand recommends that wait list outcomes will be reviewed both by the unit involved and an independent expert panel, to determine factors involved in the variation and whether any action should be undertaken.

16 Indication for Retransplantation

16.1 All Retransplants

There were 615 retransplants after the previous graft failed. There have been 548 second grafts, 65 third grafts and two fourth grafts. The commonest indications for retransplantation were vascular complications (27.3%), biliary complications (19.3%), rejection (17.9%), primary non-function or initial poor function (14.3%) and recurrent disease (13.5%, Table 62).

Table 62. Reason for retransplantation

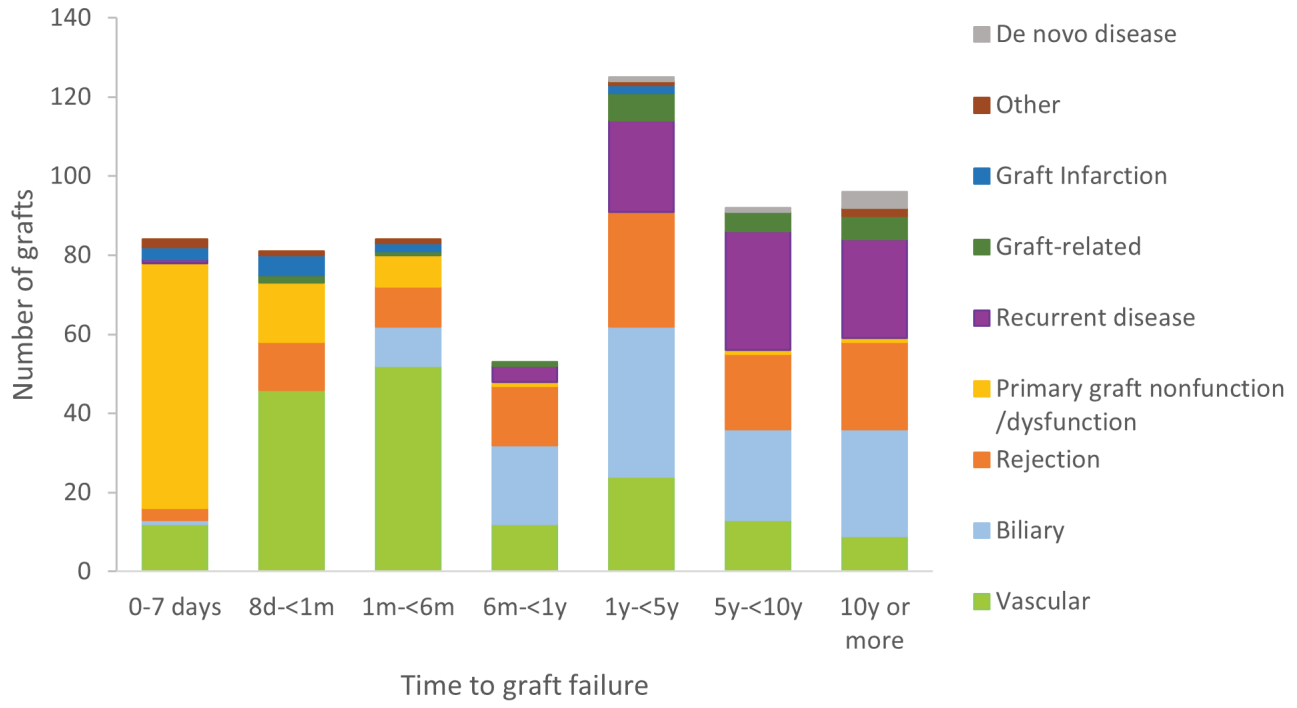
Reason for retransplantation	Graft 2	Graft 3	Graft 4	Total grafts	% Total
Vascular	**151**	**17**	**0**	**168**	**27%**
Hepatic artery thrombosis	*115*	*12*	*0*	*127*	*21%*
Portal vein thrombosis	*13*	*0*	*0*	*13*	*2%*
Hepatic vein thrombosis /Budd Chiari	*9*	*1*	*0*	*10*	*2%*
Haemorrhage (hepatic artery)	*4*	*0*	*0*	*4*	*0.7%*
Hepatic artery stenosis	*3*	*0*	*0*	*3*	*0.5%*
Hepatic vein stenosis	*1*	*2*	*0*	*3*	*0.5%*
Hepatic artery pseudoaneurysm	*2*	*0*	*0*	*2*	*0.3%*
Arterio-portal vein fistula	*1*	*0*	*0*	*1*	*0.2%*
Hepatic artery dissection	*1*	*0*	*0*	*1*	*0.2%*
Hepatic artery injury	*1*	*0*	*0*	*1*	*0.2%*
Other (specify)	*1*	*0*	*0*	*1*	*0.2%*
Recurrent bleeds	*0*	*1*	*0*	*1*	*0.2%*
Ruptured hepatic artery anastomosis	*0*	*1*	*0*	*1*	*0.2%*
Biliary	**111**	**8**	**0**	**119**	**19%**
Cholangiopathy	*75*	*4*	*0*	*79*	*13%*
Cholangitis	*12*	*2*	*0*	*14*	*2%*
Biliary cirrhosis / fibrosis	*10*	*0*	*0*	*10*	*2%*
Anastomotic	*6*	*0*	*0*	*6*	*1%*
Cholestatic disease	*4*	*0*	*0*	*4*	*0.7%*
Biliary necrosis	*1*	*2*	*0*	*3*	*0.5%*
Ductopenia	*2*	*0*	*0*	*2*	*0.3%*
Biliopathy caused by ABO incompatible transplant	*1*	*0*	*0*	*1*	*0.2%*
Rejection	**96**	**13**	**1**	**110**	**18%**
Chronic rejection	*70*	*11*	*0*	*81*	*13%*
Acute rejection	*17*	*1*	*1*	*19*	*3%*
ABO incompatible	*4*	*1*	*0*	*5*	*1%*
Hyperacute rejection	*3*	*0*	*0*	*3*	*0.5%*
Donor antibody mediated	*2*	*0*	*0*	*2*	*0.3%*
Primary graft nonfunction /dysfunction	**75**	**13**	**0**	**88**	**14%**
Primary nonfunction (ReTx ≤ 7 days)	*57*	*11*	*0*	*68*	*11%*
Primary dysfunction (ReTx > 7 days)	*18*	*2*	*0*	*20*	*3%*
Recurrent disease	**75**	**8**	**0**	**83**	**13%**
Primary sclerosing cholangitis	*31*	*6*	*0*	*37*	*6%*
Hepatitis C	*23*	*0*	*0*	*23*	*4%*
Autoimmune hepatitis	*9*	*1*	*0*	*10*	*2%*
Primary biliary cirrhosis	*6*	*1*	*0*	*7*	*1%*
Hepatitis B	*4*	*0*	*0*	*4*	*0.7%*
Crigler-Najjar	*1*	*0*	*0*	*1*	*0.2%*
Erythropoietic protoporphyria	*1*	*0*	*0*	*1*	*0.2%*

(table continued on next page)

Reason for retransplantation	Graft 2	Graft 3	Graft 4	Total grafts	% Total
Graft-related	**17**	**5**	**0**	**22**	**4%**
Post necrotic cirrhosis	*5*	*3*	*0*	*8*	*1%*
Cryptogenic cirrhosis	*3*	*1*	*0*	*4*	*0.7%*
Graft infection	*4*	*0*	*0*	*4*	*0.7%*
Nodular regenerative hyperplasia	*3*	*0*	*0*	*3*	*0.5%*
Immune/nonviral hepatitis	*2*	*0*	*0*	*2*	*0.3%*
Other (specify)	*0*	*1*	*0*	*1*	*0.2%*
Graft Infarction	**11**	**0**	**1**	**12**	**2%**
Thrombotic	*6*	*0*	*0*	*6*	*1%*
Non thrombotic	*5*	*0*	*1*	*6*	*1%*
Other	**6**	**1**	**0**	**7**	**1%**
Donor derived malignancy	*3*	*1*	*0*	*4*	*0.7%*
Unspecified	*2*	*0*	*0*	*2*	*0.3%*
Acute hepatic failure - Drug related: interferon	*1*	*0*	*0*	*1*	*0.2%*
***De novo* disease**	**6**	**0**	**0**	**6**	**1%**
Hepatitis C	*2*	*0*	*0*	*2*	*0.3%*
Hepatocellular cancer	*2*	*0*	*0*	*2*	*0.3%*
Hepatitis B	*1*	*0*	*0*	*1*	*0.2%*
Hepatitis D	*1*	*0*	*0*	*1*	*0.2%*
Total	**548**	**65**	**2**	**615**	

Forty-one percent of graft failures occurred within the first six months post-transplant (13.7% 0 to 7 days, 13.2% day 8 to less than 1 month, 13.7% 1 month to less than 6 months). Primary graft non-function (73.8%) was the main reason for retransplantation in the first 7 days post-transplant whilst vascular causes were the main indication for 8 days to less than 1 month (56.8%) and 1 month to less than 6 months (61.9% Figure 89). Recurrent disease and biliary causes were the leading causes of graft failure after five years post-transplant.

Figure 89. Time to graft failure by reason for retransplantation



16.2 Paediatric Retransplantation

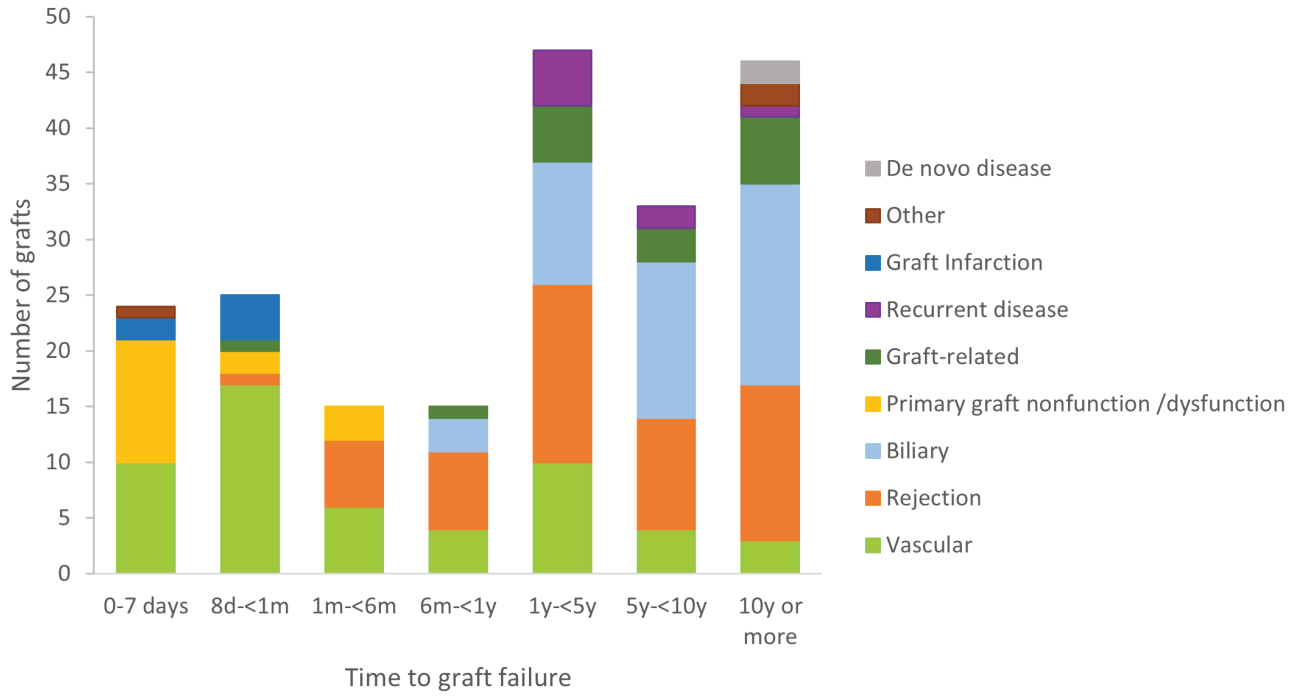
There were 205 retransplants following paediatric graft failure. There have been 176 second grafts and 29 third grafts. The commonest indications for retransplantation were vascular complications (26.3%), rejection (26.3%) and biliary complications (22.4%, Table 63).

Table 63. Reason for retransplantation following paediatric graft failure

Reason for retransplantation	Graft 2	Graft 3	Total grafts	% Total
Vascular	**45**	**9**	**54**	**26%**
Hepatic artery thrombosis	*30*	*6*	*36*	*18%*
Portal vein thrombosis	*8*	*0*	*8*	*4%*
Hepatic vein thrombosis /Budd Chiari	*4*	*1*	*5*	*2%*
Hepatic vein stenosis	*1*	*1*	*2*	*1%*
Arterio-portal vein fistula	*1*	*0*	*1*	*0.5%*
Hepatic artery stenosis	*1*	*0*	*1*	*0.5%*
Recurrent bleeds	*0*	*1*	*1*	*0.5%*
Rejection	**44**	**10**	**54**	**26%**
Chronic rejection	*43*	*9*	*52*	*25%*
Acute rejection	*1*	*1*	*2*	*1%*
Biliary	**44**	**2**	**46**	**22%**
Cholangiopathy	*21*	*1*	*22*	*11%*
Cholangitis	*8*	*0*	*8*	*4%*
Biliary cirrhosis / fibrosis	*7*	*0*	*7*	*3%*
Anastomotic	*4*	*0*	*4*	*2%*
Ductopenia	*2*	*0*	*2*	*1%*
Biliary necrosis	*0*	*1*	*1*	*0.5%*
Biliopathy caused by ABO incompatible transplant	*1*	*0*	*1*	*0.5%*
Cholestatic disease	*1*	*0*	*1*	*0.5%*
Primary graft nonfunction /dysfunction	**12**	**4**	**16**	**8%**
Primary nonfunction (ReTx ≤ 7 days)	*7*	*4*	*11*	*5%*
Primary dysfunction (ReTx > 7 days)	*5*	*0*	*5*	*2%*
Graft-related	**14**	**2**	**16**	**8%**
Post necrotic cirrhosis	*5*	*1*	*6*	*3%*
Cryptogenic cirrhosis	*3*	*1*	*4*	*2%*
Graft infection	*2*	*0*	*2*	*1%*
Immune/nonviral hepatitis	*2*	*0*	*2*	*1%*
Nodular regenerative hyperplasia	*2*	*0*	*2*	*1%*
Recurrent disease	**7**	**1**	**8**	**4%**
Autoimmune hepatitis	*2*	*1*	*3*	*1%*
Primary biliary cirrhosis	*2*	*0*	*2*	*1%*
Primary sclerosing cholangitis	*2*	*0*	*2*	*1%*
Crigler-Najjar	*1*	*0*	*1*	*0.5%*
Graft Infarction	**6**	**0**	**6**	**3%**
Thrombotic	*4*	*0*	*4*	*2%*
Non thrombotic	*2*	*0*	*2*	*1%*
Other	**2**	**1**	**3**	**1%**
Unspecified	*2*	*0*	*2*	*1%*
Donor derived malignancy	*0*	*1*	*1*	*0.5%*
***De novo* disease**	**2**	**0**	**2**	**1%**
Hepatitis C	*1*	*0*	*1*	*0.5%*
Hepatocellular cancer	*1*	*0*	*1*	*0.5%*
Total	**176**	**29**	**205**	

Thirty-one percent of graft failures occurred within the first six months post-transplant (11.7% 0 to 7 days, 12.2% day 8 to less than 1 month, 7.3% 1 month to less than 6 months). Vascular causes were the main reason for retransplantation in the first month post-transplant (Figure 90). Rejection, biliary and vascular causes were the leading causes of graft failure after one-year post-transplant.

Figure 90. Paediatric time to graft failure by reason for retransplantation



16.3 Adult Retransplantation

There were 410 retransplants following adult graft failure. There have been 372 second grafts, 36 third grafts and two fourth grafts. The commonest indications for retransplantation were vascular (27.8%), disease recurrence (18.3%) and biliary complications (17.8%, Table 64).

Table 64. Reason for retransplantation following adult graft failure

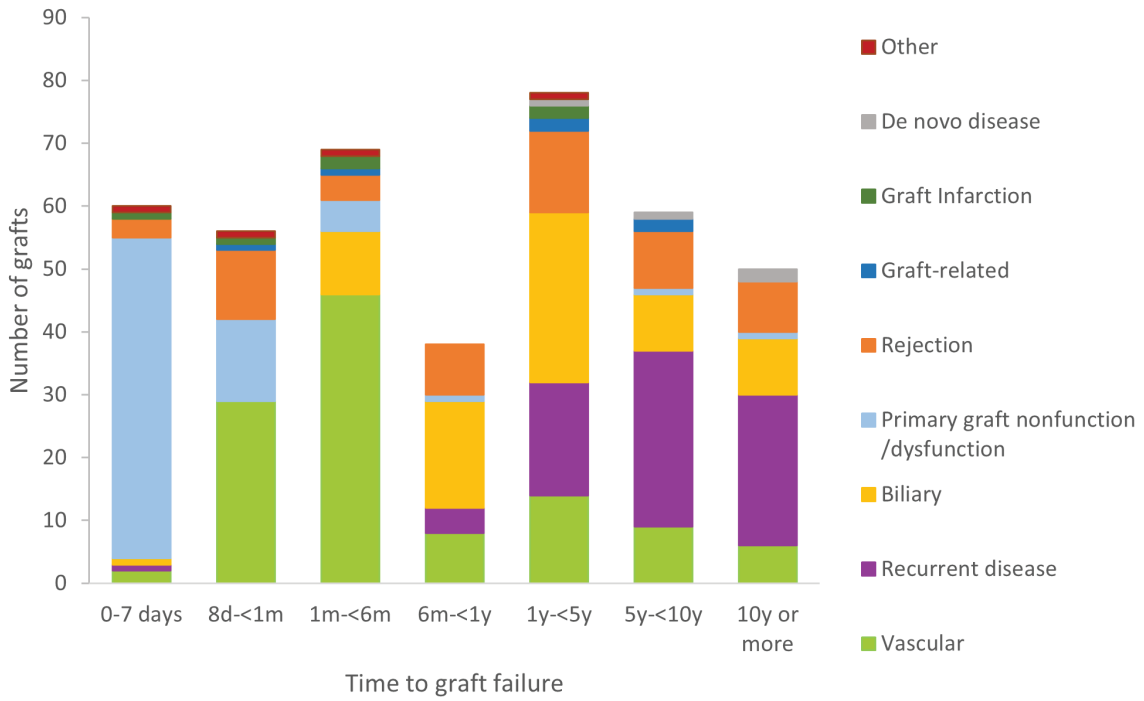
Reason for retransplantation	Graft 2	Graft 3	Graft 4	Total grafts	% Total
Vascular	**106**	**8**	**0**	**114**	**28%**
Hepatic artery thrombosis	*85*	*6*	*0*	*91*	*22%*
Hepatic vein thrombosis /Budd Chiari	*5*	*0*	*0*	*5*	*1%*
Portal vein thrombosis	*5*	*0*	*0*	*5*	*1%*
Haemorrhage (hepatic artery)	*4*	*0*	*0*	*4*	*1%*
Hepatic artery pseudoaneurysm	*2*	*0*	*0*	*2*	*0.5%*
Hepatic artery stenosis	*2*	*0*	*0*	*2*	*0.5%*
Hepatic artery dissection	*1*	*0*	*0*	*1*	*0.2%*
Hepatic artery injury	*1*	*0*	*0*	*1*	*0.2%*
Hepatic vein stenosis	*0*	*1*	*0*	*1*	*0.2%*
Other (specify)	*1*	*0*	*0*	*1*	*0.2%*
Ruptured hepatic artery anastomosis	*0*	*1*	*0*	*1*	*0.2%*
Recurrent disease	**68**	**7**	**0**	**75**	**18%**
Primary sclerosing cholangitis	*29*	*6*	*0*	*35*	*9%*
Hepatitis C	*23*	*0*	*0*	*23*	*6%*
Autoimmune hepatitis	*7*	*0*	*0*	*7*	*2%*
Primary biliary cirrhosis	*4*	*1*	*0*	*5*	*1%*
Hepatitis B	*4*	*0*	*0*	*4*	*1%*
Erythropoietic protoporphyria	*1*	*0*	*0*	*1*	*0.2%*
Biliary	**67**	**6**	**0**	**73**	**18%**
Cholangiopathy	*54*	*3*	*0*	*57*	*14%*
Cholangitis	*4*	*2*	*0*	*6*	*1%*
Biliary cirrhosis / fibrosis	*3*	*0*	*0*	*3*	*0.7%*
Cholestatic disease	*3*	*0*	*0*	*3*	*0.7%*
Anastomotic	*2*	*0*	*0*	*2*	*0.5%*
Biliary necrosis	*1*	*1*	*0*	*2*	*0.5%*
Primary graft nonfunction /dysfunction	**63**	**9**	**0**	**72**	**18%**
Primary nonfunction (ReTx ≤ 7 days)	*50*	*7*	*0*	*57*	*14%*
Primary dysfunction (ReTx > 7 days)	*13*	*2*	*0*	*15*	*4%*
Rejection	**52**	**3**	**1**	**56**	**14%**
Chronic rejection	*27*	*2*	*0*	*29*	*7%*
Acute rejection	*16*	*0*	*1*	*17*	*4%*
ABO incompatible	*4*	*1*	*0*	*5*	*1%*
Hyperacute rejection	*3*	*0*	*0*	*3*	*0.7%*
Donor antibody mediated	*2*	*0*	*0*	*2*	*0.5%*
Graft Infarction	**5**	**0**	**1**	**6**	**1%**
Non thrombotic	*3*	*0*	*1*	*4*	*1%*
Thrombotic	*2*	*0*	*0*	*2*	*0.5%*
Graft-related	**3**	**3**	**0**	**6**	**1%**
Graft infection	*2*	*0*	*0*	*2*	*0.5%*
Post necrotic cirrhosis	*0*	*2*	*0*	*2*	*0.5%*
Nodular regenerative hyperplasia	*1*	*0*	*0*	*1*	*0.2%*
Other (specify)	*0*	*1*	*0*	*1*	*0.2%*

(table continued on next page)

Reason for retransplantation	Graft 2	Graft 3	Graft 4	Total grafts	% Total
***De novo* disease**	**4**	**0**	**0**	**4**	**1%**
Hepatitis B	*1*	*0*	*0*	*1*	*0.2%*
Hepatitis C	*1*	*0*	*0*	*1*	*0.2%*
Hepatitis D	*1*	*0*	*0*	*1*	*0.2%*
Hepatocellular cancer	*1*	*0*	*0*	*1*	*0.2%*
Other	**4**	**0**	**0**	**4**	**1%**
Donor derived malignancy	*3*	*0*	*0*	*3*	*0.7%*
Acute hepatic failure - Drug related: interferon	*1*	*0*	*0*	*1*	*0.2%*
Total	**372**	**36**	**2**	**410**	

Forty-five percent of graft failures occurred within the first six months' post-transplant (14.6% 0 to 7 days, 13.7% day 8 to less than 1 month, 16.8% 1 month to less than 6 months). Primary graft non-function was the main reason for retransplantation in the first 7 days post-transplant whilst vascular causes were the main type between 8 days and less than 6 months (Figure 91). Recurrent disease was the leading cause of graft failure after five years post-transplant.

Figure 91. Adult time to graft failure by reason for retransplantation

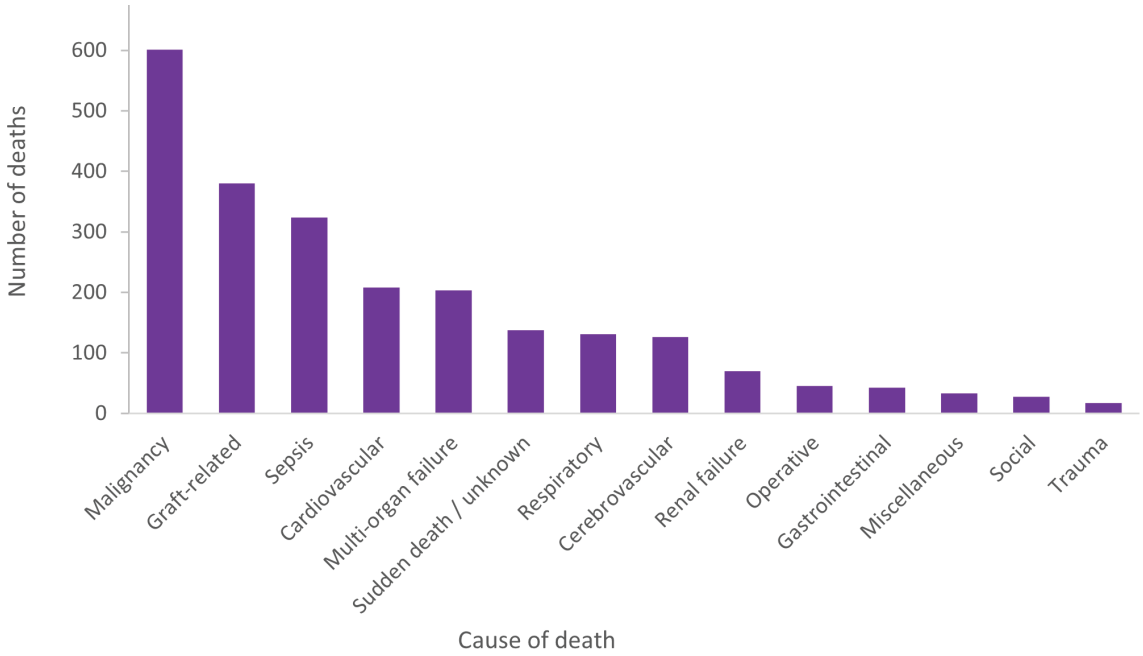


17 Cause of Patient Death

17.1 Cause of Death – All Patients

2,347 liver transplant patients (199 children and 2,148 adults based on age group at first transplant) have died. The commonest causes of death were malignancy (25.6%), graft-related causes (16.2%), sepsis (13.8%), cardiovascular disease (8.9%) and multi-organ failure (8.6%, Figure 92, Table 65).

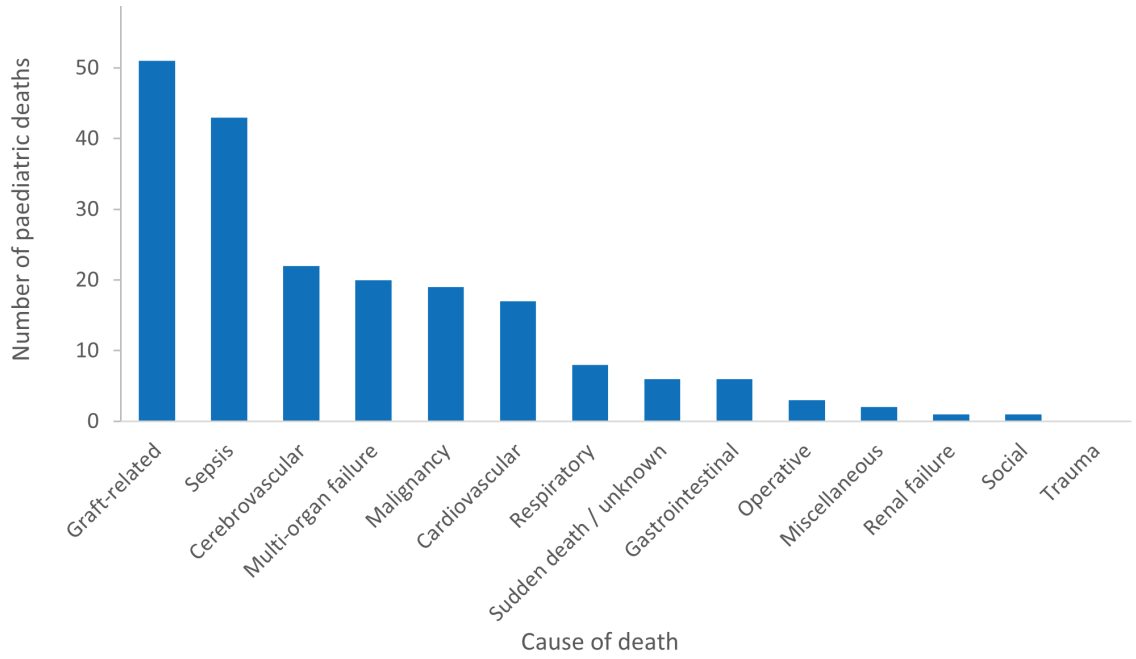
Figure 92. Cause of death by categories



17.2 Paediatric Patients - Cause of Death

Graft-related causes (25.6%) are the leading cause of death in children, with sepsis being the cause of death in a further 21.6% of paediatric patients (Figure 93, Table 65).

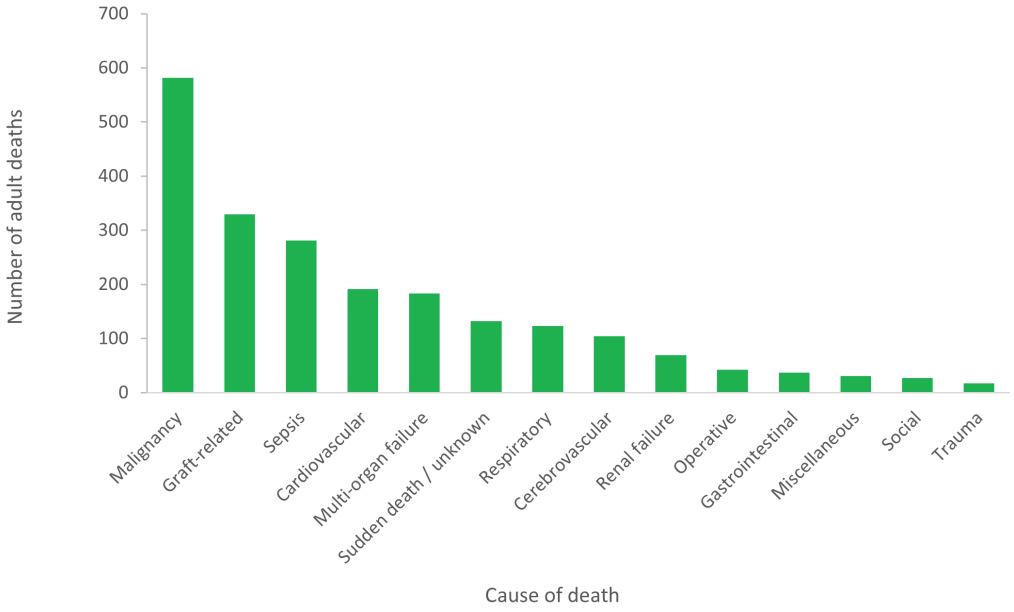
Figure 93. Paediatric cause of death



17.3 Adult Patients – Cause of Death

Malignancy (27.1% total: *de novo* malignancy 15.5%; recurrent malignancy 12.3%; donor transmitted malignancy 0.1%) is the most frequent cause of death in adult patients. Graft-related causes (15.3%) and sepsis (13.1%) are the next largest categories of adult deaths (Figure 94, Table 65).

Figure 94. Adult cause of death



17.4 Cause of Death Types by Age Group

Table 65. Cause of death by age group

Cause of death	Children	Adults	Total deaths	% of all deaths
Malignancy	**19**	**582**	**601**	**26%**
De novo malignancy	11	323	334	14%
Recurrent malignancy	8	256	264	11%
Donor transmitted malignancy	0	3	3	0.1%
Graft-related	**51**	**329**	**380**	**16%**
Other graft related	41	154	195	8%
- Rejection	*18*	*84*	*102*	*4%*
- Primary non-function / dysfunction	*6*	*22*	*28*	*1%*
- Biliary complications	*3*	*18*	*21*	*0.9%*
- Graft vs host disease	*0*	*11*	*11*	*0.5%*
- Late graft failure	*0*	*10*	*10*	*0.4%*
- Unspecified	*2*	*3*	*5*	*0.2%*
- Hepatitis	*4*	*0*	*4*	*0.2%*
- Massive haemorrhagic necrosis	*4*	*0*	*4*	*0.2%*
- Non-thrombotic infarction	*3*	*1*	*4*	*0.2%*
- De novo hepatitis C	*0*	*2*	*2*	*0.09%*
- Hepato-renal syndrome	*0*	*2*	*2*	*0.09%*
- Portopulmonary hypertension	*0*	*1*	*1*	*0.04%*
- Post necrotic cirrhosis	*1*	*0*	*1*	*0.04%*
Disease recurrence	0	156	156	7%
- Hepatitis C	*0*	*96*	*96*	*4%*
- Hepatitis B	*0*	*20*	*20*	*0.9%*
- Alcohol-related cirrhosis	*0*	*13*	*13*	*0.6%*
- Primary sclerosing cholangitis	*0*	*13*	*13*	*0.6%*
- Autoimmune hepatitis	*0*	*4*	*4*	*0.2%*
- Primary biliary cirrhosis	*0*	*4*	*4*	*0.2%*
- NASH	*0*	*3*	*3*	*0.1%*
- Progressive familial amyloid polyneuropathy	*0*	*2*	*2*	*0.09%*
- Erythropoietic protoporphyria	*0*	*1*	*1*	*0.04%*
Vascular complications	10	19	29	1%
- Hepatic artery thrombosis	*6*	*9*	*15*	*0.6%*
- Portal vein thrombosis	*2*	*10*	*12*	*0.5%*
- Hepatic vein thrombosis	*1*	*0*	*1*	*0.04%*
- Inferior vena cava thrombosis	*1*	*0*	*1*	*0.04%*
Sepsis	**43**	**281**	**324**	**14%**
Bacterial	17	117	134	6%
Fungal	8	48	56	2%
Unspecified infection	6	50	56	2%
Viral	6	36	42	2%
Mixed	6	30	36	2%
Cardiovascular	**17**	**191**	**208**	**9%**
Multi-organ failure	**20**	**183**	**203**	**9%**
Sudden death / unknown	**6**	**132**	**138**	**6%**
Respiratory	**8**	**123**	**131**	**6%**

(table continued on next page)

Cause of death	Children	Adults	Total deaths	% of all deaths
Cerebrovascular	**22**	**104**	**126**	**5%**
Renal failure	**1**	**69**	**70**	**3%**
Operative	**3**	**42**	**45**	**2%**
Gastrointestinal	**6**	**37**	**43**	**2%**
Miscellaneous	**2**	**31**	**33**	**1%**
Neurological	0	9	9	0.4%
Old age	0	7	7	0.3%
Haematological	1	5	6	0.3%
Dementia	0	5	5	0.2%
Metabolic	1	2	3	0.1%
Allergy	0	1	1	0.04%
Donor transferred OTC deficiency	0	1	1	0.04%
Veno-occlusive disease	0	1	1	0.04%
Social	**1**	**27**	**28**	**1%**
Treatment withdrawal	0	10	10	0.4%
Suicide	0	8	8	0.3%
Non-compliance immunosupportive therapy	1	5	6	0.3%
Overdose / Substance abuse	0	4	4	0.2%
Trauma	**0**	**17**	**17**	**1%**
Motor vehicle accident	0	8	8	0.3%
Other accident excluding MVA	0	7	7	0.3%
Homicide	0	2	2	0.09%
Total	**199**	**2148**	**2347**	

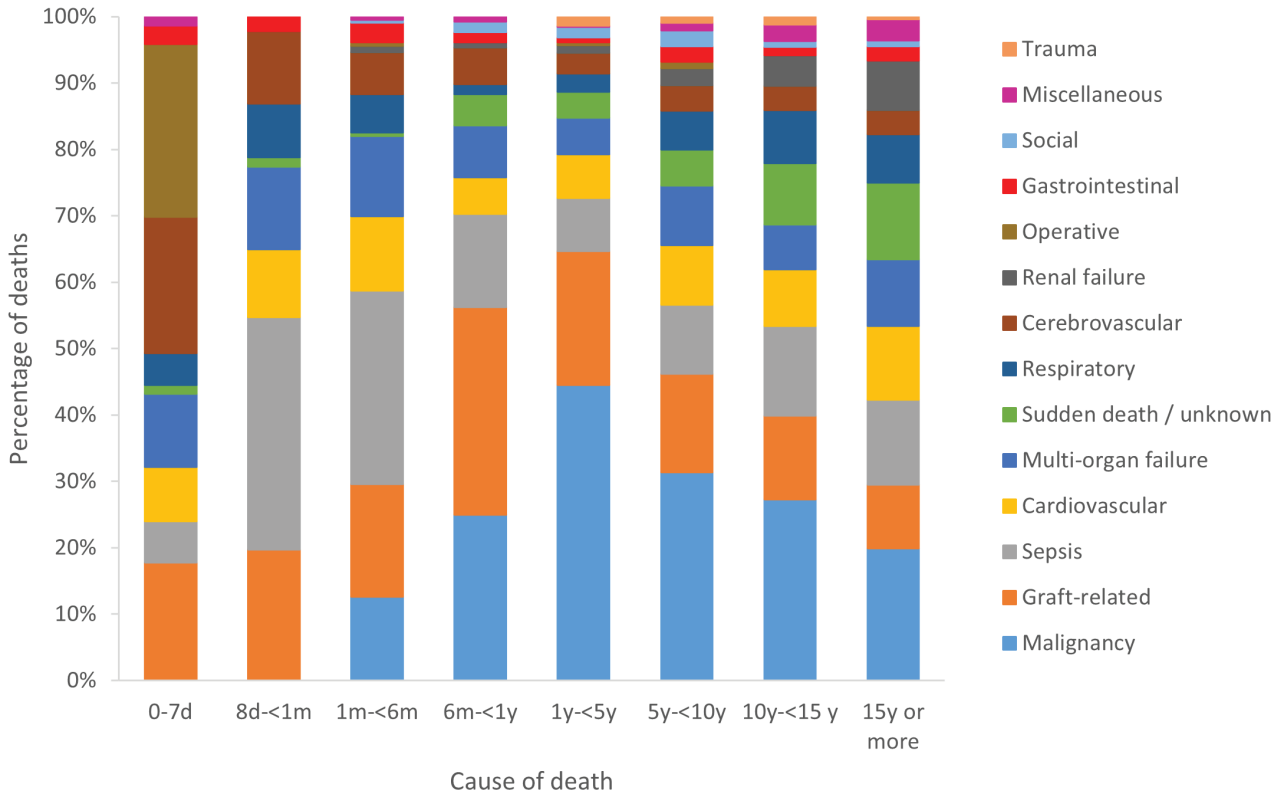
Abbreviations: MVA, motor vehicle accident; NASH, non-alcoholic steatohepatitis; OTC, Ornithine transcarbamylase

17.5 Cause of Death by Time to Death

Just under one third of post-transplant deaths occurred within the first year of transplant (6.2% in the first 7 days, 5.8% from day 8 to the end of the first month and 14.2% after the first month and before the end of the first year), nearly 40% between 1 and 10 years (21.8% between years 1 and 5 and 18.1% between years 5 and 10) and just above one third (33.8%) after 10 years.

The cause of death profile changes over the different post-transplant time periods (Figure 95). Operative, cerebrovascular and graft-related causes of death predominate in the first week, sepsis is commonest from 8 days to 6 months, malignancy and graft-related commonest from 6 months to 5 years and malignancy, graft-related and sepsis causes are dominant causes of death after 5 years.

Figure 95. Cause of death by time to death post-transplant – all patients

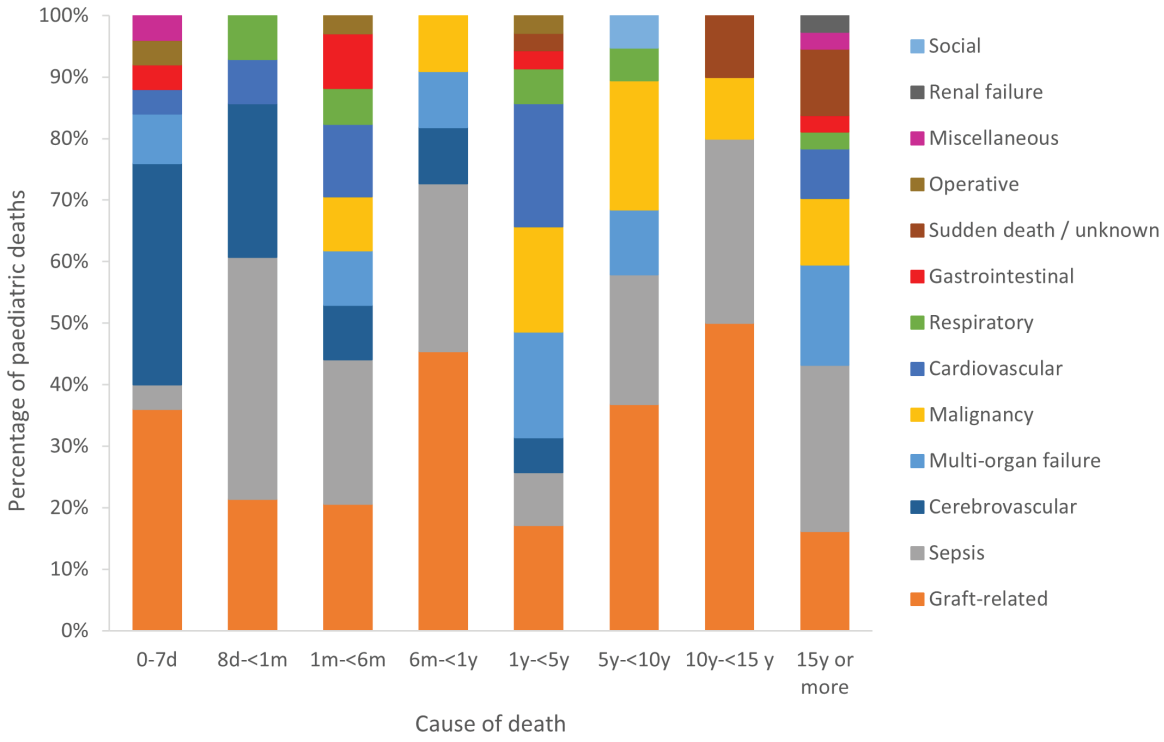


17.6 Paediatric Cause of Death by Time to Death

In children, 49.2% of deaths occurred within the first year of transplant (12.6% in the first 7 days, 14.1% from day 8 to the end of the first month and 22.6% after the first month and before the end of the first year), 17.6% between years 1 and 5, 9.5% between years 5 and 10 and 23.6% after 10 years.

Cerebrovascular and graft-related causes of death predominated in the first week post-transplant (Figure 96). Rejection was the main type of graft-related deaths after one month. Sepsis and graft-related causes were important causes of death in all time periods after the first week and malignancy became an important cause of death after 5 years.

Figure 96. Paediatric cause of death by time to death post-transplant

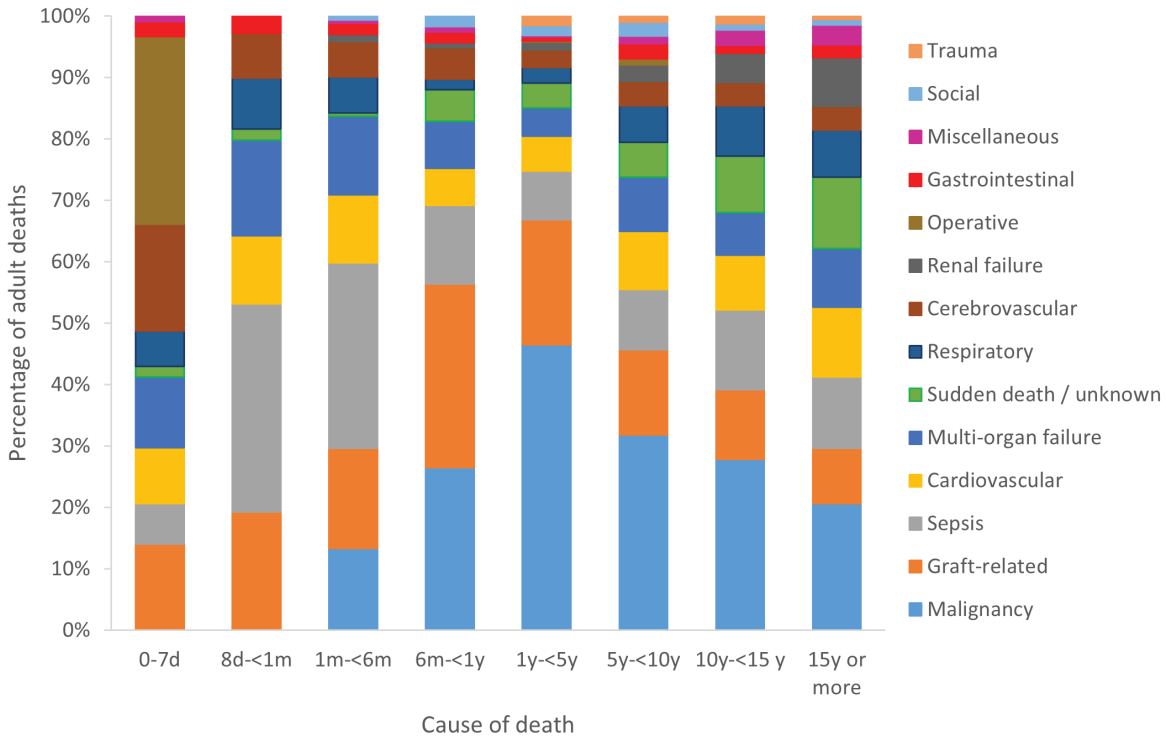


17.7 Adult Cause of Death by Time to Death

In adults, 24.2% of deaths occurred within the first year of transplant (5.6% in the first 7 days, 5.1% from day 8 to the end of the first month and 13.5% after the first month and before the end of the first year), 22.2% between years 1 and 5, 18.9% between years 5 and 10 and 34.8% after 10 years.

Operative, cerebrovascular and graft-related causes and multi-organ failure were prominent in the first week post-transplant (Figure 97). Sepsis was the predominant cause from 8 days to 6 months and malignancy and graft-related causes from 6 months.

Figure 97. Adult cause of death by time to death post-transplant



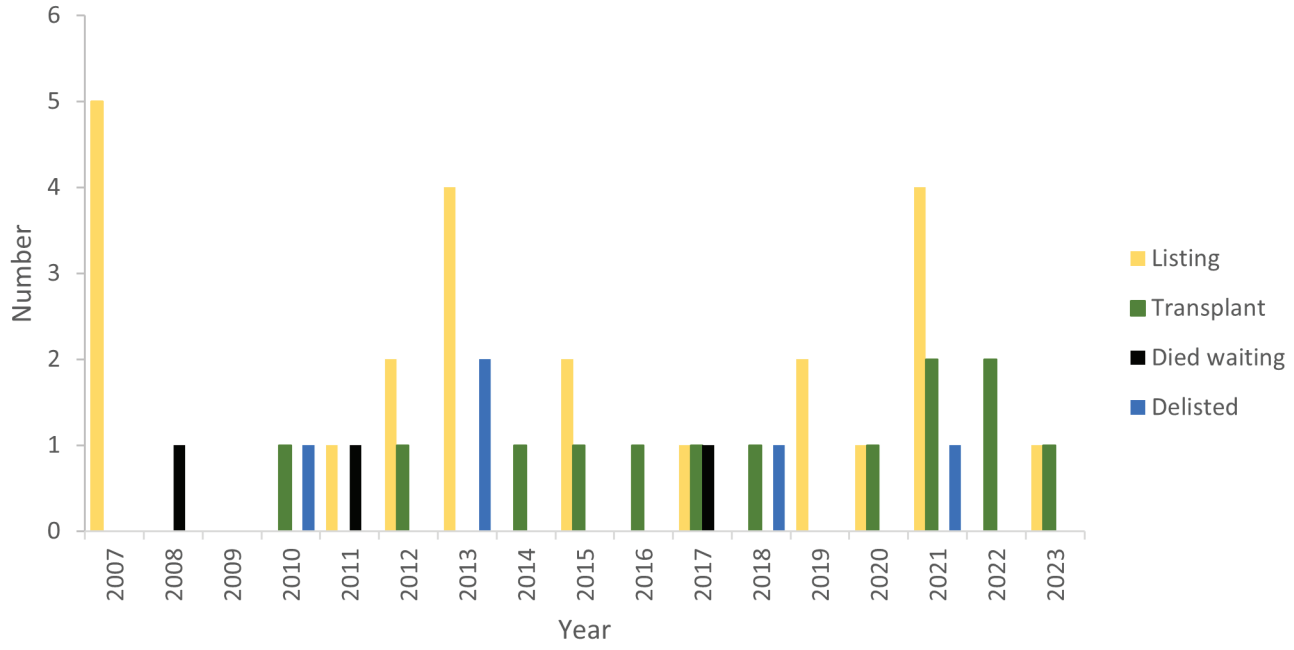
18 Intestinal Transplantation

The Australian Intestinal Transplant Service, co-located with the Victorian Liver Transplant Unit, offers an intestinal transplant service to Australian and New Zealand paediatric and adult patients. The first intestinal transplant was performed by the unit in 2010.

18.1 Waiting List

Twenty-two patients have been listed for intestinal transplantation, with one patient relisted in 2019, six years after initial delisting without transplant (23 listings, see Figure 98). Thirteen patients were transplanted, three died waiting, four were delisted without relisting and one was still waiting at the end of 2023.

Figure 98. Waiting list trends over time for intestinal transplantation



18.2 Demographic Characteristics and Diagnoses

The demographic characteristics and diagnoses of patients listed for intestinal transplantation and for those transplanted are shown in Table 66. The majority of the eight children listed had short bowel syndrome due to gastroschisis, whilst the 14 adults were listed for short bowel syndrome after intestinal resection for a variety of causes, motor disorders and liver failure with porto-mesenteric thrombosis. Five children have been transplanted, three for short bowel syndrome, one for chronic idiopathic intestinal pseudo-obstruction and one for Hirschsprung's disease. Eight adults have been transplanted, three for short bowel syndrome, one for chronic idiopathic intestinal pseudo-obstruction, one for Hirschsprung's disease, one for hollow visceral myopathy and two for liver failure with porto-mesenteric thrombosis.

Table 66. Demographic characteristics and diagnoses of children and adults listed and transplanted for intestinal transplantation. Data are shown as number or median (range).

Characteristic	Listed		Transplanted	
	Children	Adults	Children	Adults
N	8	14	5	8
Age	8 (4-15)	44 (22-60)	10 (5-13)	38 (18-54)
Gender				
Male	4	10	3	6
Female	4	4	2	2
Diagnosis				
Short bowel syndrome				
- Gastroschisis	5	0	3	0
- Intra-abdominal desmoid tumour	0	2	0	2
- Small intestine leiomyoma	0	1	0	0
- Small intestine adenocarcinoma	0	1	0	0
- Volvulus	0	1	0	1
- Other	0	1	0	0
Motor disorder				
- Chronic idiopathic intestinal pseudo-obstruction	2	2	1	1
- Hirschsprung's disease and variants	1	1	1	1
- Hollow visceral myopathy	0	1	0	1
Other				
- Liver failure with porto-mesenteric thrombosis	0	4	0	2

18.3 Organs Transplanted

Nine of the thirteen recipients receiving a small intestine transplant also received a liver graft (Table 67).

Table 67. Organs transplanted with intestinal transplants

Transplanted Organ	Children	Adults	Total transplants
Small intestine, stomach, pancreas, colon	0	2	2
Small intestine, liver, stomach, pancreas	1	1	2
Small intestine, liver, pancreas	2	3	5
Small intestine, liver, pancreas, colon	1	0	1
Small intestine, liver, pancreas, kidney	0	1	1
Small intestine, colon	1	0	1
Small intestine, kidney	0	1	1
Total	5	8	13

18.4 Intestinal Patient Survival

Eleven of the thirteen intestinal transplant recipients are alive with a functioning graft and full enteral autonomy. The intestinal graft has failed for one patient who is alive and supported by total parenteral nutrition (liver and pancreas grafts functioning). Two patients died with a functioning graft, one from respiratory infection at 3 months and one from complications of cardiac surgery at 3.5 years post-transplant. The 1- and 3-year patient survival are 92.3% and the 5- and 10-year patient survival are 76.9% (Figure 99, Table 68).

Figure 99. Patient survival after intestinal transplantation

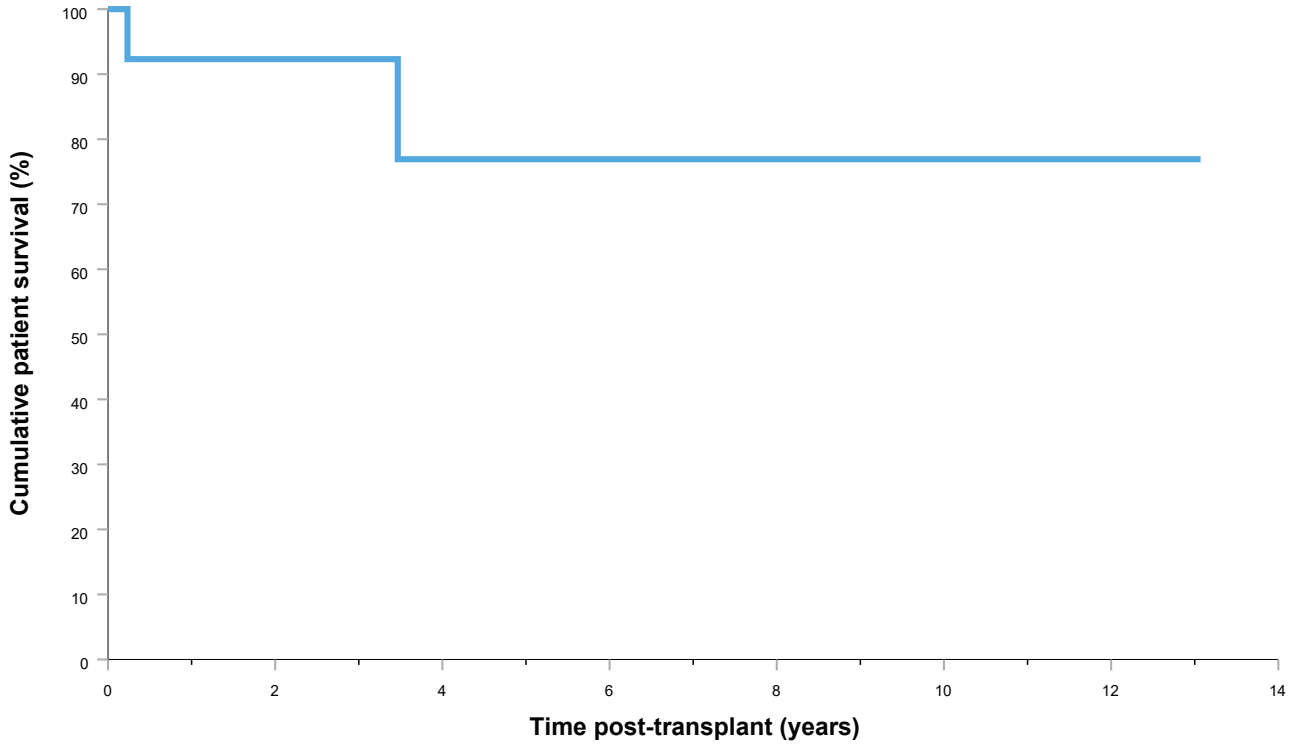


Table 68. Intestinal patient survival

Patient Survival	Time post-transplant (years)					
	0	1	3	5	10	15
No. at risk	13	10	7	4	2	0
Survival (%)		92%	92%	77%	77%	

18.5 Intestinal Graft Survival

The 1- and 3-year graft survival are 84.6% and the 5- and 10-year graft survival are 70.5% (Figure 100, Table 69).

Figure 100. Graft survival after intestinal transplantation

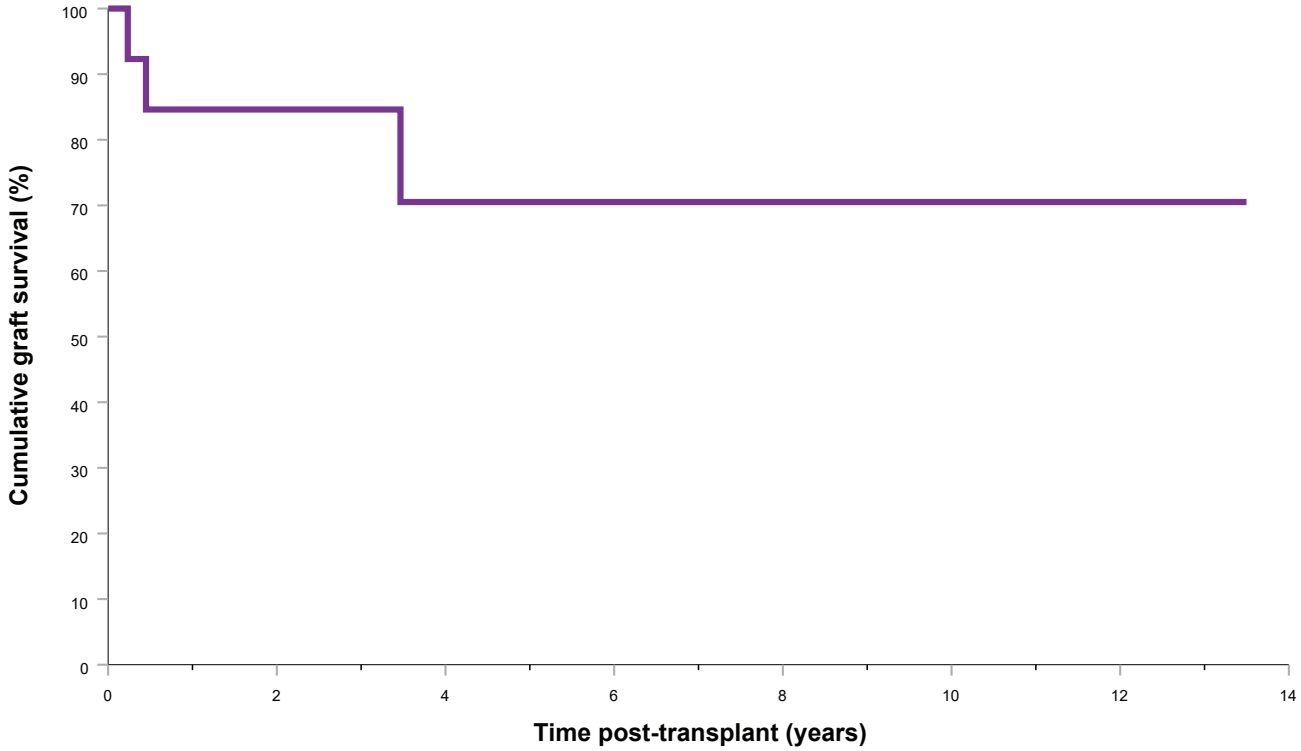


Table 69. Intestinal graft survival

Graft Survival	Time post-transplant (years)					
	0	1	3	5	10	15
No. at risk	13	10	7	4	2	0
Survival (%)		85%	85%	71%	71%	

19 Appendix I. Glossary

Adenocarcinoma — A cancer that arises from tissues that form glands.

Anoxia — Inadequate delivery of oxygen to the brain that can lead to brain death. Examples include drowning and severe asthma.

Biliary atresia — A rare condition that babies can be born with in which the bile ducts do not form properly. Sometimes this can be fixed by doing an operation to join the bile ducts in the liver to the bowel but sometimes a liver transplant is required.

Blood group compatibility — The relationship between the donor and recipient blood groups. These can be identical (A to A, AB to AB, B to B or O to O), compatible (O to A, AB or B, or A or B to AB) or incompatible (A, AB or B to O, AB to A or O, A to B or B to A). Some blood group A patients have a low level of A antigen (a protein on the surface of the cells) that means they are less likely to be rejected when transplanted into a patient who is technically incompatible. This is called blood group A, non-A1 or sometimes A2.

Category 1 — These are patients who have acute liver failure and have become extremely unwell, requiring admission to the Intensive Care Unit and have a breathing tube attached to a ventilator. They have a very high risk of dying without a liver transplant. Because of this, any available donor liver in Australia and New Zealand is offered to the liver transplant unit looking after the patient to try to save their life.

Category 2 — These are patients who are usually not as sick as category 1 patients but who have a high risk of dying without transplantation and who are likely to get worse while they are waiting for transplantation. This includes certain patients with acute liver failure who do not yet require a breathing tube, children with chronic (longstanding) liver disease who have been admitted to an Intensive Care Unit, children with a severe metabolic disorder (disturbance of function of cells) or a rare form of liver cancer that occurs in children, and patients who need a combined liver-intestine transplant. The liver transplant units in Australia and New Zealand are notified when these sorts of patients are waiting for a liver transplant so that if a suitable donor liver becomes available, the liver could be offered to the liver transplant unit looking that patient.

Cholestatic disease — A collection of diseases that affect the bile ducts in the liver that can lead to liver failure.

Cirrhosis — Scarring of the liver accompanied by liver regeneration (regrowth). It can arise from many different disease processes and can lead to liver failure or hepatocellular carcinoma. Some patients with cirrhosis need liver transplantation.

Cold ischaemia time — The time between perfusing the liver with cold preservation solution in the donor to the removal of the organ from the ice bath prior to implantation.

Cryptogenic cirrhosis — Cirrhosis with no known underlying cause (sometimes called idiopathic

Cumulative number — The progressive number of cases occurring over time.

Data validation and cleaning — Processes undertaken in managing the database to ensure completeness and accuracy of data.

***De novo* malignancy**	Cancer that occurs after transplantation that was not present before transplantation.
Delisting	Taking a patient off the waiting list. This can occur because of transplantation, death, progression of liver disease or tumour or other reasons (such as the patient's condition improving, psychosocial issues or non-compliance).
Donor	A person who donates their organ/s (liver or part of their liver and/or intestine) to another person. Donors can be deceased (dead – see glossary entry on donation after brain death and donation after circulatory death) or living (see glossary entry on living donor liver transplantation).
Domino liver transplantation	In some metabolic diseases that progress slowly, it is possible to use the liver that is removed at the time of transplant and use that liver to transplant another (usually older) patient.
Donation after brain death	Death can occur in patients who have no brain function but who still have a beating heart. To determine that the patient is brain dead, two experienced doctors must confirm that the brain is no longer functioning and that the lack of brain function is permanent. This can be done by testing for reflexes that are controlled by the brain stem, the most primitive part of the brain, to make sure that all of the reflexes are absent and by making sure that there is no reversible cause for the lack of brain stem reflexes. Sometimes a scan of the brain showing no blood flow to the brain is performed instead. If the patient has been declared brain dead and the family of the deceased (dead person) has consented to organ donation, donation after brain death can occur. This is also known as DBD and has also been called heart-beating donation in the past.
Donation after circulatory death	Some patients with a severe brain injury (and occasionally in some other circumstances such as a high spinal cord injury) but who are not initially brain dead can become deceased (dead) donors if the breathing tube is removed and the heart stops. Once the heart has stopped beating and the doctor determines that it is not going to start again, the patient can be declared dead. If consent for organ donation has been obtained, the person who has been declared dead can then donate their organs. This is also known as DCD and has also been called donation after cardiac death and non-heart-beating donation in the past.
Fulminant hepatic failure	Acute liver failure (usually occurring in a person who was not known to have pre-existing liver disease). This can be due to viruses, drugs or the cause may be unknown.
Gastroschisis	A condition in which babies are born with most of their bowel outside the abdomen.
Graft survival	The proportion (often expressed as a percentage) of patients undergoing transplantation (liver transplantation in this case) who are still alive with the same graft (transplanted organ) at different time periods after the transplant. In this report, graft survival time is calculated from the date of transplantation to the date the patient has another liver transplant if this has occurred or until death for patients who die without being retransplanted, or date of last contact or end of the reporting year (31 December, 2022 for this report), whichever occurred first, for patients who have not been retransplanted or died by that date.

Graft number	The number of liver transplants the patient has previously undergone plus one. Thus, a patient's first liver transplant will be performed using graft 1, the second, with graft 2 and so on.
Hepatitis B virus	A blood-borne virus that can damage the liver and lead to cirrhosis and liver cancer or can occasionally cause acute liver failure. There is a vaccine available to prevent transmission of hepatitis B virus and drugs are available that slow down the multiplication of the virus. However, some patients still have cirrhosis (scarring of the liver) or liver cancer or they may present with acute liver failure. These conditions may require liver transplantation.
Hepatitis C virus	A blood-borne virus that can damage the liver and lead to cirrhosis (scarring of the liver) and liver cancer. There are now very effective drugs that can cure the virus but some patients still have cirrhosis or liver cancer which may require liver transplantation.
Hepatoblastoma	A rare liver cancer that occurs in childhood.
Hepatocellular carcinoma	A type of primary (not spread from another organ) liver cancer. It often occurs in a patient with cirrhosis (scarring of the liver) and sometimes requires liver transplantation.
Hirschsprung's disease	A condition in which the nervous system of the bowel is partly or completely absent resulting in the bowel not moving properly. This can lead to intestinal failure and require intestinal transplantation.
Hollow visceral myopathy	A rare condition affecting the muscles in the wall of the bowel and sometimes the urinary tract. This can lead to intestinal failure and require intestinal transplantation.
Hypothermic Oxygenated Perfusion (HOPE)	A process of supporting a liver on a machine that perfuses the organ with oxygenated blood at low temperature. This can enable assessment of liver function prior to transplantation, might improve early liver function after transplantation and can enable delay of transplantation for logistical reasons, such as when there are simultaneous donors.
Initial poor function	Sometimes the new liver does not work well which results in metabolic problems that the liver normally takes care of. This can require retransplantation.
Interquartile range	The central half of data points. A quarter of cases will be below the lower end of the interquartile range and a quarter of cases will be above the upper end of the interquartile range.
Kaplan-Meier survival curve	The survival rate (for example, patient or graft survival) of a group of patients over time (for example, after transplantation) can be displayed in a graph that has the proportion or percentage surviving on the Y (vertical) axis and time on the X (horizontal) axis. Each curve is a line that runs horizontally if there are no events (deaths for patient survival and deaths or retransplants for graft survival) and drops down vertically whenever an event occurs. Several curves representing different patient groups can be displayed on the same graph.
Kruskal-Wallis test	A statistical test that can determine whether it is likely that two or more groups of continuous data (data that can be represented as numbers) are significantly different.

Leiomyoma	A tumour affecting the muscle in the wall of the bowel.
Listing	Placing a patient on a liver or intestinal transplant waiting list while they wait for a suitable organ donor. This is also known as activation.
Liver transplantation	The process of replacing the liver of a patient who has end-stage liver disease, some forms of liver cancer or some forms of metabolic disease caused at least in part by the liver with a liver or part of a liver from a deceased or living donor.
Living donor liver transplantation	This is where a piece of liver from a healthy person is carefully removed for transplantation into a patient who needs liver transplantation. This is a common form of liver transplantation in some parts of the world, notably Asia, but is a relatively uncommon form of transplantation in places with a reasonable deceased donor rate, such as Australia and New Zealand. This form of transplantation can be performed in a child or an adult.
Log-rank test	A statistical test that can determine whether it is likely that there is a significant difference in survival between two or more groups of patients.
Mean	Average (the sum of the data points divided by the number of data points).
Median	The middle data point.
Metabolic disease	A disease where the biochemical processes in the liver are deranged.
Multiorgan failure	Failure of multiple organ systems. Because the liver is involved in many metabolic processes, if it functions poorly or not at all, this can lead to failure of other organ systems, such as the lungs, heart, circulation and kidneys.
Normothermic Machine Perfusion (NMP)	A process of supporting a liver on a machine that perfuses the organ with oxygenated blood at body temperature. This can enable assessment of liver function prior to transplantation, might improve early liver function after transplantation and can enable delay of transplantation for logistical reasons, such as when there are simultaneous donors.
Non-Alcoholic Fatty Liver Disease (NAFLD)	A condition in which fat accumulates in the liver in the absence of significant alcohol intake. This can lead to cirrhosis and liver failure.
P-value	The likelihood that a difference between sets of data occurred by chance. The lower the P-value, the less likely the difference occurred by chance alone and the more likely the difference is significant. P-values < 0.05 (that is 1 in 20) are generally considered to be statistically significant.
Patient survival	The proportion (often expressed as a percentage) of patients undergoing a particular treatment (liver transplantation in this case) who are alive at different time periods after the treatment. In this report, patient survival time is calculated from the date of first transplantation (that is, if the patient has another liver transplant, this is ignored for the purpose of calculation of patient survival) until the date of death for patients who die, or date of last contact or end of the reporting year (31 December 2022 for this report), whichever occurred first, for patient who were still alive at that time.

Porto-mesenteric thrombosis	Clotting of blood in the blood vessels leading from the bowel to the liver.
Primary biliary cirrhosis	Scarring in the liver associated with abnormalities in the small bile ducts inside the liver.
Primary non-function	This describes the fact that occasionally the liver fails to work after transplantation. This requires emergency retransplantation to prevent death.
Primary sclerosing cholangitis	A disease that results in narrowing of bile ducts inside and/or outside the liver.
Range	The lowest data point to the highest data point.
Recipient	A patient who undergoes a (liver and/or intestine in this case) transplant.
Recurrent malignancy	Cancer that was present before transplantation that comes back after transplantation.
Reduced liver transplantation	A transplant performed by cutting down a deceased donor liver to the appropriate size to fit inside a recipient. Usually the donor is an adult and the recipient is a child. The other part of the liver is not transplanted in this case (unlike split liver transplantation).
Registry	A database that stores information on patients with a similar disease process or method of treatment; in this case, liver transplantation. Patients give permission for their data to be stored on the database and for subsequent use in generating reports and research.
Rejection	When a transplant is performed, the patient's immune system sees the new organ as a foreign invader and tries to destroy it, just like it would try to destroy an infection or cancer. Patients are given medications to reduce this effect of the immune system. However, sometimes the immune system can still injure the organ. This is called rejection. It can be suspected because the blood tests become abnormal and confirmed with a biopsy (small piece of tissue obtained with a needle). Rejection can be treated by giving more powerful medications but occasionally the liver can be so damaged that it needs to be replaced by performing another transplant.
Sepsis	Severe infection.
Split liver transplantation	In some good quality liver donors (relatively young with good liver function and suitable anatomy), it is possible to divide the liver into two parts so that it can be transplanted into two patients. Usually the left part of the liver is transplanted into a child and right part of the liver is transplanted into an adult.
Stroke	A sudden vascular event (bleed or blockage to blood supply) in the brain.
Trauma	Injury (to the brain in this case, which can lead to brain death).
Vascular complications	When a liver transplant is performed, the donor's and recipient's (patient receiving the transplant) artery and veins that supply blood to and drain blood from the liver are joined together. Sometimes there can be problems after the transplant related to these blood vessels. Often these problems can be fixed but sometimes another transplant is required to fix the problem, for example, if the main artery to the liver is blocked.
Volvulus	A condition in which the bowel twists.

Waiting list mortality rate	The rate of patients dying waiting for a liver and/or intestinal transplant. Unfortunately, some patients' condition can deteriorate (for example, progression of liver failure or cancer) while they are waiting for a liver transplant. This includes patients who are taken off the waiting list and who subsequently die within 1 year. The waiting list mortality rate is the number of these patients divided by the number of patients on the waiting list (the number active at the start of the period under evaluation plus the number added to the waiting list during that period), usually expressed as a percentage.
Waiting time	Time from listing for transplantation to delisting (in the case of liver waiting time to transplantation, this the time from listing for liver transplantation to the liver transplant date.
Whole liver transplantation	Transplantation of the whole liver from a deceased (dead) donor to replace the liver of a patient who has been waiting for liver transplantation. This is the commonest form of liver transplantation in Australia and New Zealand.

20 Appendix II. Publications utilising ANZLITR data

20.1 Publications in 2023

External validation of the United Kingdom transplant benefit score in Australia and New Zealand.
Lee EG, Perini MV, Makalic E, Oniscu GC, Fink MA. Progress in Transplantation. 2023 Mar;33(1):25-33.

Long-term outcomes of liver transplantation for homozygous familial hypercholesterolaemia in Australia and New Zealand.
Page MM, Hardikar W, Alex G, Bates S, Srinivasan S, Stormon M, Hall K, Evans HM, Johnston P, Chen J, Wigg A, John L, Ekinci EI, O'Brien RC, Jones R, Watts GF. Atherosclerosis. 2023 Dec;387:117305

20.2 Publications in 2022

The Hidden Epidemic: The Prevalence and Impact of Concurrent Liver Diseases in Patients Undergoing Liver Transplantation in Australia and New Zealand.
Howell J, Majumdar A, Fink M, Byrne M, McCaughan G, Strasser SI, Crawford M, Hodgkinson P, Stuart KA, Tallis C, Chen J, Wigg A, Jones R, Jaques B, Jeffrey G, Adams L, Wallace MC, Gane E, Thompson A, Gow P. Transplantation Direct 2022 Aug; 8(8):p e1345.

Expansion of Liver Transplantation Criteria for Hepatocellular Carcinoma from Milan to UCSF in Australia and New Zealand and Justification for Metroticket 2.0
Barreto SG, Strasser SI, McCaughan GW, Fink MA, Jones R, McCall J, Munn S, Macdonald GA, Hodgkinson P, Jeffrey GP, Jaques B, Crawford M, Brooke-Smith ME and Chen JW. Cancers (Basel) 2022 Jun 3;14(11):2777. doi: 10.3390/cancers14112777.

Turning the Tide on Hepatitis C Virus-Related Liver Transplantation: The Return on Investment in Hepatitis C Virus Treatment in Australia and New Zealand.
Howell J, Majumdar A, Fink MA, Byrne M, McCaughan G, Strasser SI, Crawford M, Hodgkinson P, Stuart KA, Tallis C, Chen J, Wigg A, Jones R, Jaques B, Jeffrey G, Adams L, Wallace MC, Munn S, Gane E, Thompson AJ, Gow P. Liver Transpl. 2022 Feb;28(2):236-246. doi: 10.1002/lt.26329. Epub 2021 Nov 10.

20.3 Publications in 2021

Predicting recurrence of hepatocellular carcinoma after liver transplantation using a novel model that incorporates tumor and donor-related factors.
Orci LA, Combescure C, Fink M, Oldani G, Compagnon P, Andres A, Berney T, Toso C. Transpl Int 2021; 34: 2875–2886

Trends and Outcomes in Simultaneous Liver and Kidney Transplantation in Australia and New Zealand.
Drak D, Tangirala N, Fink M, Adams LA, Fawcett J, Jeffrey GP, Byrne M, McCaughan G, Chadban S, Wyburn K, Wong G, Lim WH, Gracey DM. Transplant Proc. Jan-Feb 2021;53(1):136-140.

20.4 Publications in 2020

Outcomes for children after second liver transplantations are similar to those after first transplantations: a binational registry analysis.
Jeffrey AW, Jeffrey GP, Stormon M, Thomas G, O'Loughlin E, Shun A, Hardikar W, Jones R, McCall J, Evans H, Starkey G, Hodgkinson P, Ee LC, Moore D, Mews C, McCaughan GW, Angus PW, Wigg AJ, Crawford M, Fawcett J. Med J Aust 2020; 213 (10): 464-470.

Paediatric liver transplantation in Australia and New Zealand: 1985-2018.
Stormon MO, Hardikar W, Evans HM, Hodgkinson P. 1985-2018. Journal Paediatrics and Child Health 2020 Nov;56(11):1739-1746.

20.5 Publications in 2019

Increasing incidence of nonalcoholic steatohepatitis as an indication for liver transplantation in Australia and New Zealand.
Calzadilla-Bertot L, Jeffrey GP, Jacques B, McCaughan G, Crawford M, Angus P, Jones R, Gane E, Munn S, Macdonald G, Fawcett J, Wigg A, Chen J, Fink M, Adams LA. Liver Transplantation, 25 (1):25-34, 2019.

Characteristics and outcomes of patients with acute liver failure admitted to Australian and New Zealand intensive care units.
Warrillow S, Bailey M, Pilcher D, Kazemi A, McArthur C, Young P, Bellomo R. Internal Medicine Journal. 49(7):874-885, 2019 07.

Excellent Contemporary Graft Survival for Adult Liver Retransplantation: An Australian and New Zealand Registry Analysis from 1986 to 2017.
Jeffrey AW, Delriviere L, McCaughan G, Crawford M, Angus P, Jones R, Macdonald GA, Fawcett J, Wigg A, Chen J, Gane E, Munn S and Jeffrey GP. Transplantation Direct 2019;5: e472; doi: 10.1097/TXD.0000000000000920.

Longitudinal immunosuppression data can minimize misclassification bias in solid organ transplantation cohorts.
Laaksonen MA, Webster AC, McCaughan GW, Keogh AM, Grulich AE, Vajdic CM. Clin Transplant. 2019 Feb;33(2):e13470.

20.6 Publications in 2018

Aortic Versus Dual Perfusion for Retrieval of the Liver After Brain Death: A National Registry Analysis.
Hameed AM, Pang T, Yoon P, Balderson G, De Roo R, Yuen L, Lam V, Laurence J, Crawford M, Allen RDM, Hawthorne WJ, Pleass HC. Liver Transplantation. 24(11):1536-1544, 2018 11.

20.7 Publications in 2016 and earlier

Additive impact of pre-liver transplant metabolic factors on survival post-liver transplant.
Adams LA, Arauz O, Angus PW, Sinclair M, MacDonald GA, Chelvaratnam U, Wigg AJ, Yeap S, Shackel N, Lin L, Raftopoulos S, McCaughan GW, Jeffrey GP, on behalf of the Australian New Zealand Liver Transplant Study Group. Journal of Gastroenterology and Hepatology. 31(2016) 1016–1024.

Good outcomes of liver transplantation for hepatitis C at a low volume centre.
Lau SY, Woodman RJ, Silva MF, Muller K, Libby L, Chen JW, Padbury R, Wigg AJ. Annals of Hepatology 2016; 15(2): 207-214.

The increasing burden of potentially preventable liver disease among adult liver transplant recipients: A comparative analysis of liver transplant indication by era in Australia and New Zealand.
Howell J, Balderson G, Hellard M, Gow P, Strasser S, Stuart K, Wigg A, Jeffrey G, Gane E, Angus PW. Journal of Gastroenterology & Hepatology. 31(2):434-41, 2016 Feb.

Liver transplantation in Australia and New Zealand.
McCaughan GW, Munn SR. Liver Transplantation. 22(6):830-8, 2016 06.

High azathioprine dose and lip cancer risk in liver, heart, and lung transplant recipients: A population-based cohort study.
Na R, Laaksonen MA, Grulich AE, Meagher NS, McCaughan GW, Keogh AM, Vajdic CM. J Am Acad Dermatol. 2016 Jun;74(6):1144-1152.e6.

Iatrogenic immunosuppression and risk of non-Hodgkin lymphoma in solid organ transplantation: A population-based cohort study in Australia.
Na R, Laaksonen MA, Grulich AE, Meagher NS, McCaughan GW, Keogh AM, Vajdic CM. Br J Haematol. 2016 Aug;174(4):550-62.

Longitudinal dose and type of immunosuppression in a national cohort of Australian liver, heart, and lung transplant recipients
Na R, Laaksonen MA, Grulich AE, Webster AC, Meagher NS, McCaughan GW, Keogh AM, Vajdic CM, 1984-2006. Clin Transplant. 2015 Nov;29(11):978-90.

Liver transplantation outcomes for Australian Aboriginal and Torres Strait Islanders.
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