Australia & New Zealand
Liver and Intestinal Transplant Registry

Report on liver and intestinal transplantation activity to 31/12/2021

33rd
ANNUAL REPORT
ANZLITR

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1 Preface

We are pleased to present the 33rd 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 2021. 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 transplantation unit.

We thank the staff at all the liver 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.

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.

Mr Michael Fink, Registry Director
Ms Mandy Byrne, 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 4.9% in 2021. In 2021, two of 22 patients listed as category 1 and none of 15 patients listed as category 2 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. In 2021, 6.3% of donors were donation after circulatory death donors (DCD). Living donor liver transplantation accounted for 1.7% of transplants performed.

In 2021, 307 liver transplants were performed in 301 patients, a further reduction from 2020, due to reduced deceased donor numbers which is likely related to the COVID-19 pandemic. Between 1985 and 2021, 7,266 transplants were performed in 6,706 patients, including 1,247 transplants in 1,094 children and 6,019 transplants in 5,612 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 (48.6% in 2021) and whole liver transplantation is the dominant form of liver transplantation in adults (93.0% in 2021).

The commonest indication for transplantation in children is biliary atresia and in adults was hepatitis C virus cirrhosis until 2014, after which hepatocellular carcinoma 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 4.8% in 2021.

The 1-, 3-, 5- and 10-year patient survival in recent years for paediatric patients was 100%, 97%, 97% and 90%, 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%, 91%, 88% and 76%, respectively. Patient survival in adults reduced progressively with increasing recipient age ($P < 0.001$), varied significantly by primary disease ($P = 0.005$), with poorer outcomes for hepatitis C virus and alcohol-related cirrhosis. Patient survival has improved over time for hepatitis B ($P < 0.001$) and hepatitis C virus cirrhosis ($P = 0.003$).

The 1-, 3-, 5- and 10-year graft survival in recent years for paediatric patients was 99%, 89%, 86% and 80%, respectively. The 1-, 3-, 5- and 10-year graft survival in recent years for adult patients was 89%, 87%, 83% and 72%, respectively. Graft survival varied significantly by era of transplant (better outcome in more recent 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, $P < 0.001$), cold ischaemia time (better outcome with cold ischaemia time < 441 mins, $P < 0.001$) and recipient urgency category at transplant (poorer outcome for category 1 recipients, $P = 0.005$).

The commonest indications for retransplantation were vascular problems (28%), biliary complications (18%), rejection (18%), primary non-function or initial poor function (15%) and recurrent disease (13%). The commonest causes of death were malignancy (25%), graft-related causes (17%), sepsis (14%), multi-organ failure (9%) and cardiovascular disease (8%).

2.2 Intestinal Transplantation

Twenty-one patients have been listed for intestinal transplantation. Ten patients were transplanted, three died waiting, four were delisted and four were still waiting at the end of 2021.

The 1- and 3-year patient and graft survival are 88.9% and the 5- and 10-year patient and graft survival are 71.1%.

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 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 1985. Following formal Human Research and Ethics Committee (HREC) approval for the Registry in 2019, collection of identifying data on patients that 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 patient 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. Mr Michael Fink commenced as the Registry Director and Ms. Mandy Byrne as the Registry Manager. Formal Human Research and 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 that 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 hepatocellular carcinoma (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 is still hosted and managed at Royal Prince Alfred Hospital and they prepare the cancer report for the ANZLITR Annual Report.

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

Registry Manager Ms Mandy Byrne
c/o Victorian Liver Transplant Unit,
Austin Health,
145 Studley Road,
Heidelberg, Australia.
PO Box 5555, Victoria, 3084

Phone: (+61) 03 9496 6980
Email: mandy.byrne@austin.org.au

3.7 Registry Management Committee

Director	Mr Michael Fink, Austin Health
Manager	Ms Mandy Byrne, Austin Health
New South Wales	Professor Geoff McCaughan, 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
Victoria	Professor Robert Jones, Austin Health and The Royal Children's Hospital
Western Australia	Professor Bryon Jaques, 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 has 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 whilst 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 (6,495 listings)

Comprehensive waiting list data including listing and delisting date and delisting outcome are available from 1 January 2004. There are data on 6,495 listings from this date.

4.2.2 Intestinal Transplant Waiting List Dataset (22 listings)

Comprehensive waiting list data including listing and delisting date and delisting outcome are available from the first listing in 2007. There are 22 listings for 21 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 (6,706 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 (6,700 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.

4.3.3 Graft Survival Dataset (7,266 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.

4.4 Deceased and Living Liver Donor Datasets

4.4.1 Deceased Liver Donors (6596 deceased donors; 7,021 transplants)

The Australia and New Zealand Organ Donation (ANZOD) Registry provides the ANZLITR with deceased donor data for analysis. A total of 7,147 grafts were sourced from 6,722 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 6,596 donors. A total of 6,170 donated livers were allocated to a single recipient and 426 donated livers were split (one graft was not utilised as recipient found to be unsuitable at time of transplant), resulting in a total of 7,021 grafts with deceased donor data.

4.4.2 Living Liver Donors (119 living donors)

Data on 119 living liver donors (including four domino living donors) are collected in ANZLITR.

4.5 Intestinal Dataset (10 transplants)

The intestinal dataset includes data on all 21 wait-listed patients (the first listing was in 2007) and all ten 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 (ie. Graft 1). Patients are classified as either alive (censored as of 31 December 2021) 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 as of 31 December 2021) or failed (due to death or re-transplantation).

4.8 Statistical Analysis

Statistical analyses were undertaken using IBM SPSS Statistics 28.

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

The independent-samples Kruskal-Wallis test was used to determine if there is a significant difference in the distribution of age across the eras.

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.

Multivariable Cox regression using the backward stepwise method was used to determine independently significant variables that were associated with graft survival after living donor liver transplantation. Of a list of potentially significant variables, the following variables with a P value of < 0.1 on univariate analysis were included in the multivariable analysis: transplant era, age at listing, listing creatinine, listing bilirubin, listing weight, transplant albumin, transplant height, transplant weight, urgency at transplant.

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.

Chapter 15 (Liver Transplantation and Cancer) was produced by Pamela Dilworth, Liver Cancer Registry, Royal Prince Alfred Hospital, Sydney. Stata was used for statistical analyses in this chapter.

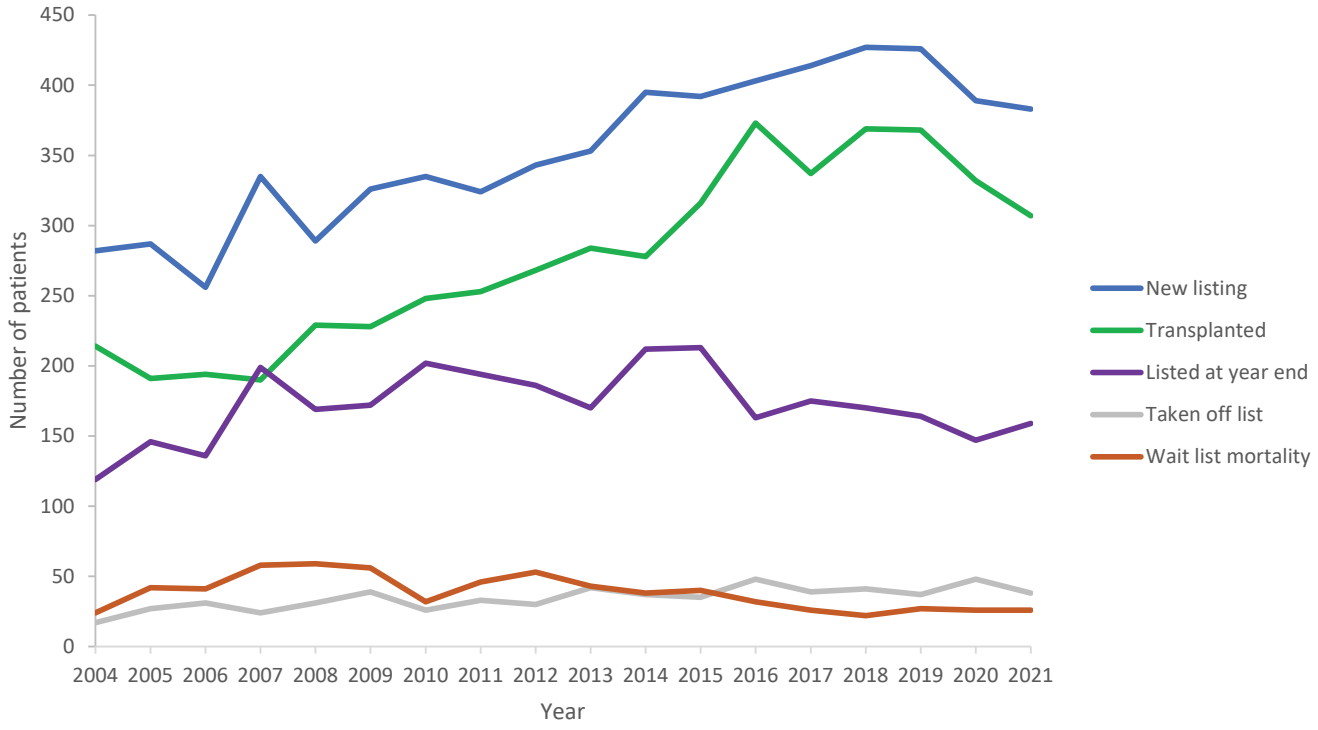
5 Liver Transplant Waiting List

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 51.1% from 2004 to 2019 (282 to 426, Figure 1). However, from 2019 to 2020, the number of patients listed for liver transplantation fell by 8.7% (426 to 389), then there was smaller 1.5% decrease to 383 in 2021. 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 performed in Australia and New Zealand. It is likely that the reduction in transplant activity over the last two years is at least partly related to the COVID-19 pandemic. There were 159 people on the waiting list for a liver transplant at the end of 2021.

The annual waiting list mortality rate progressively decreased from a peak of 12.3% in 2007 to 4.5% in 2017 and has remained stable since this time. The annual waiting list mortality was 4.9% in 2021.

Figure 1. Liver transplant waiting list activity – all patients

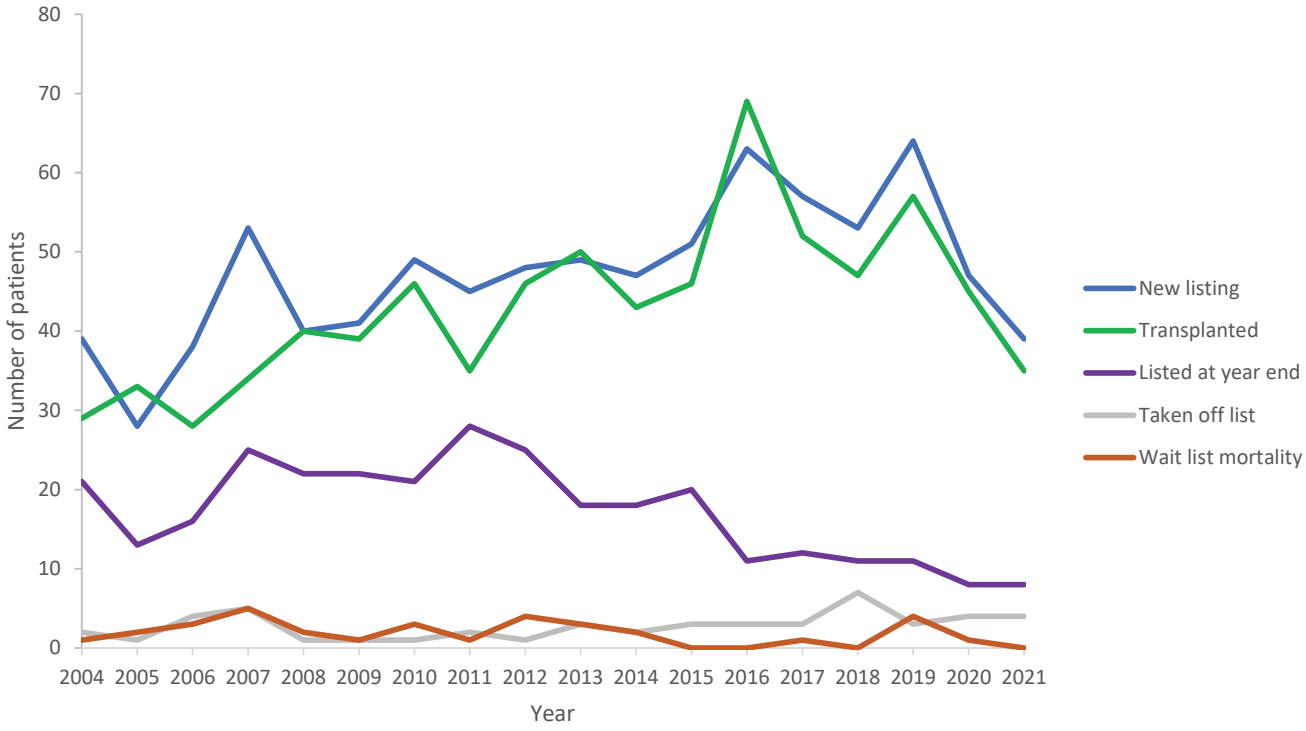


5.2 Paediatric Waiting List Activity

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. 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 in 2021 to 35 paediatric liver transplants performed in Australia and New Zealand. It is likely that the reduction in transplant activity over the last two 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 8 at the end of 2021.

The paediatric annual waiting list mortality rate has progressively decreased from a peak of 7.2% in 2007 to 0% in 2021.

Figure 2. Paediatric liver transplant waiting list activity

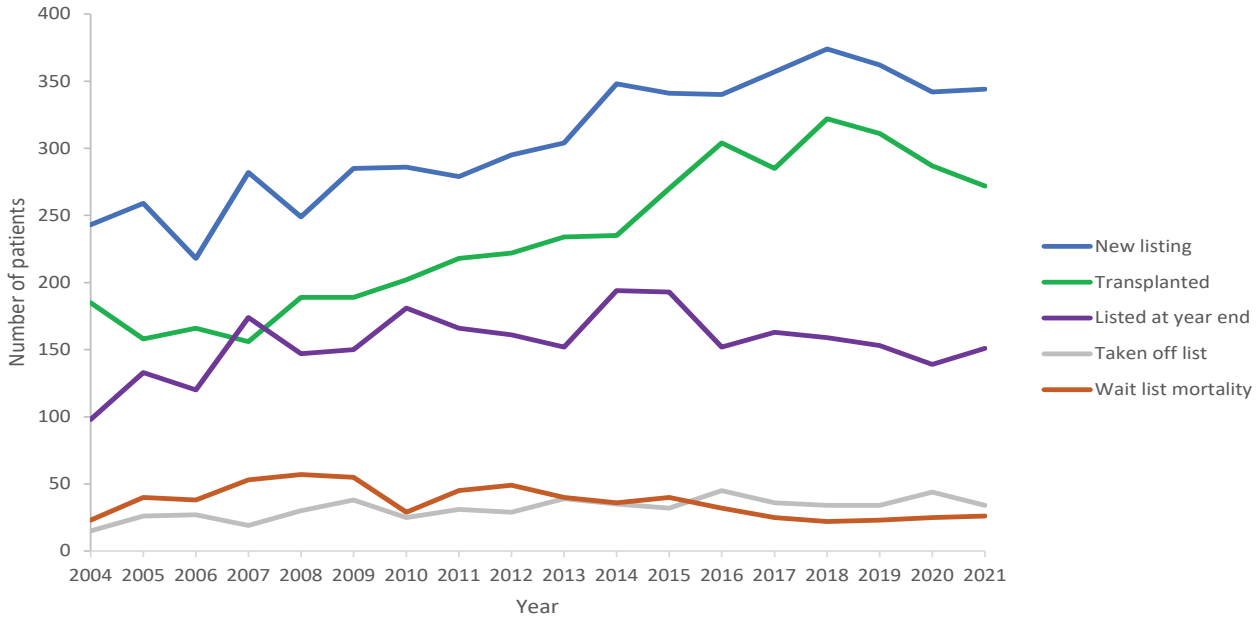


5.3 Adult Waiting List Activity

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 49.0% from 2004 to 2019 (243 to 362, Figure 3). However, from 2019 to 2020, the number of adults listed for liver transplantation fell by 5.5% (362 to 342), then there was a small 0.6% increase to 344 in 2021. 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 and another 5.2% decrease in 2021 to 272 liver transplants performed in Australia and New Zealand. It is likely that the reduction in transplant activity over the last two years is at least partly related to the COVID-19 pandemic. 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 139 in 2020 then increased to 151 in 2021.

The adult annual waiting list mortality rate peaked at 13.5% in 2008 and has fallen to 5.4% in 2021.

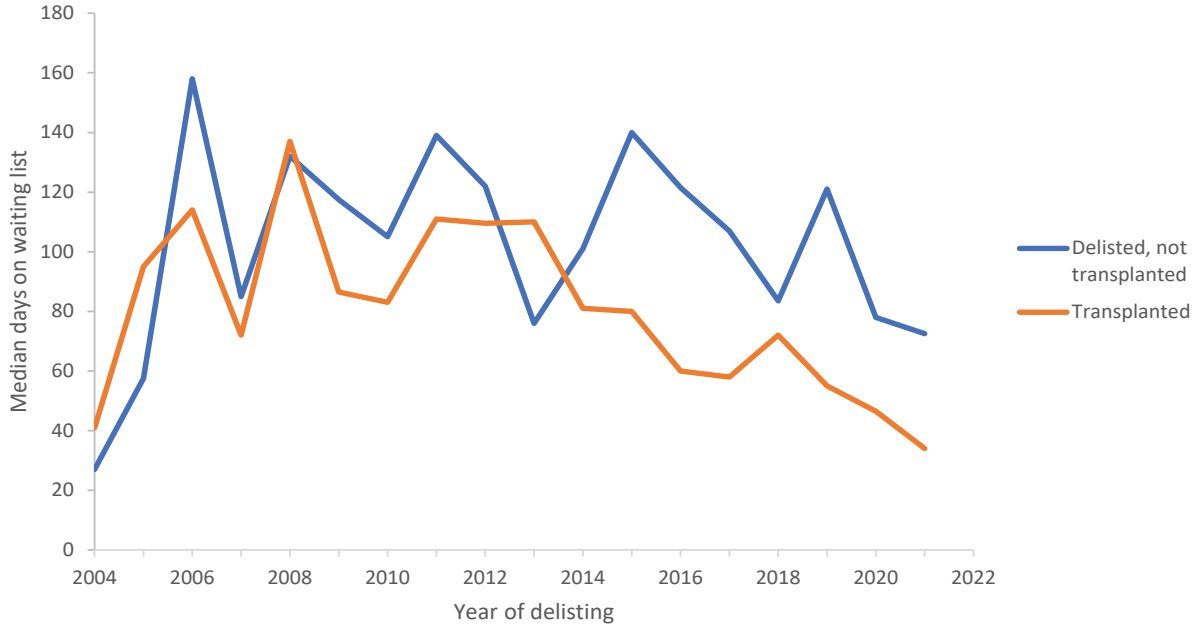
Figure 3. Adult liver transplant waiting list activity



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 34 days in 2021 (Figure 4). The median time from listing to delisting without transplant was 140 days in 2015 and has decreased to 73 days in 2021.

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.
- 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.

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

The urgent category 1 waiting list mortality rate for the last five years (2017 – 2021) was 10.3%. In 2021, two of the 22 patients on the category 1 waiting list died, resulting in a waiting list mortality rate of 9.1%.

The urgent category 2 waiting list mortality rate for the last five years (2017 – 2021) was 2.5%. There were no deaths out of 15 patients listed as category 2 in 2021.

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.

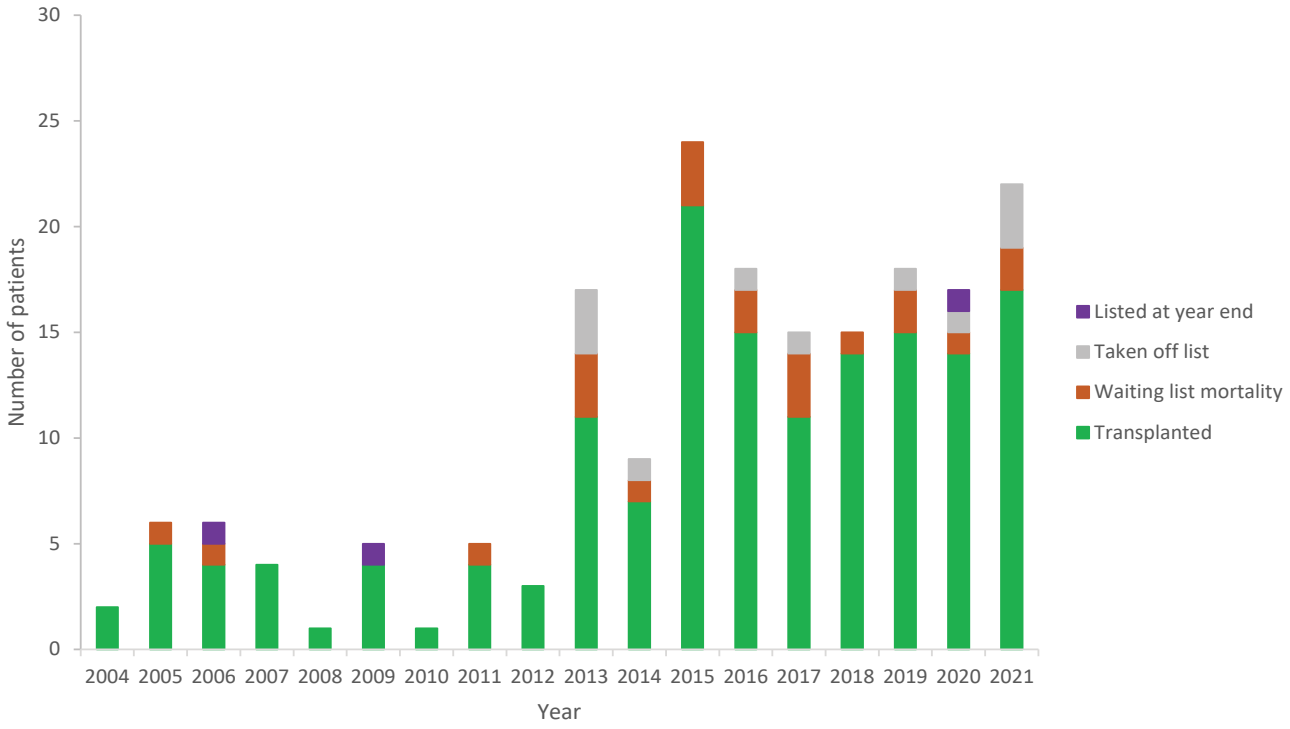
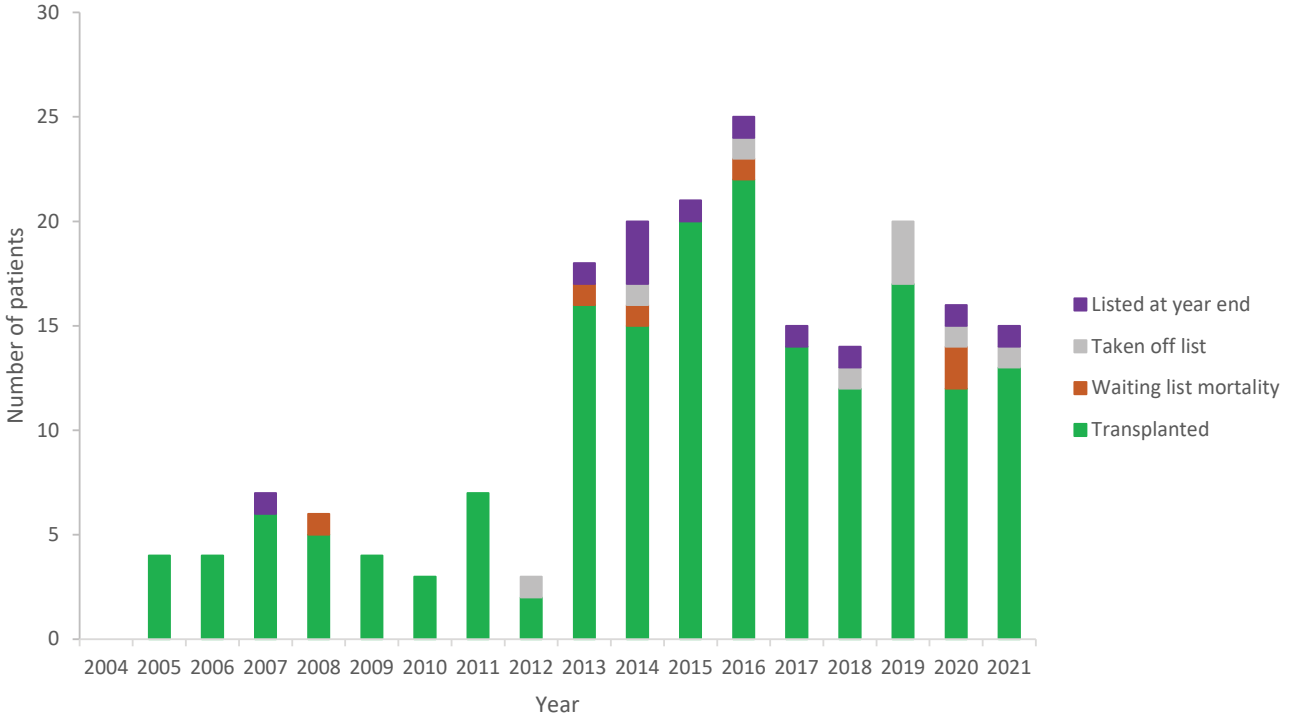


Figure 6. Urgent category 2 waiting list outcomes
Data show the outcome of urgent listings for each year. The outcomes of patients still listed at the end of the year are reported in the subsequent year.



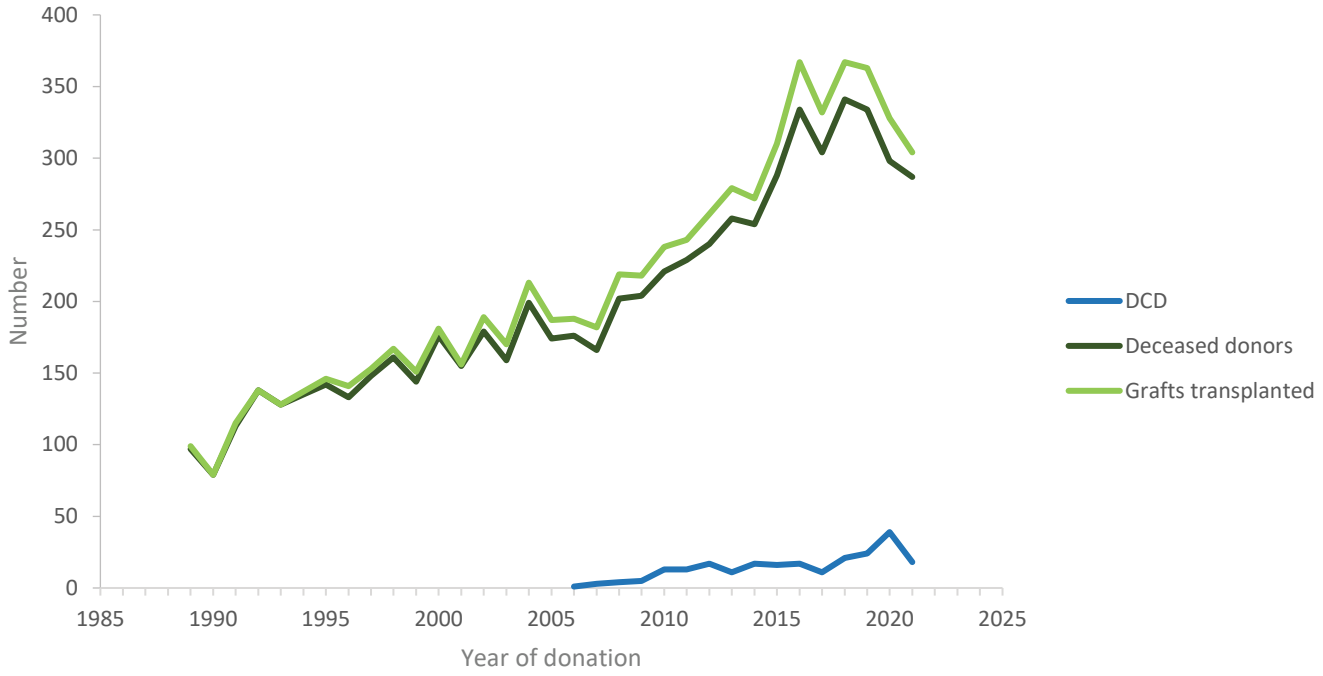
6 Deceased Liver Donors

Of 7,266 liver transplants, 7,147 (98.4%) were sourced from deceased donors, with only a small proportion from living donors (119, 1.6%). 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 to 6,596 deceased donors from 1989 onwards with donor data.

6.1 Deceased Donors and Grafts Transplanted Per Year

Of 6,596 deceased donors with donor data, 426 donated livers were split (one graft was not utilised from one split liver, so there were 851 split grafts transplanted), resulting in a total of 7,021 grafts. The number of deceased donors has grown steadily over the years until recently (Figure 7). Between 2019 and 2020, there was an 10.8% reduction (from 334 to 298) in deceased liver donors and a further 3.7% reduction (from 298 to 287) from 2020 to 2021, likely related to the COVID-19 pandemic. Of 287 deceased donors in 2021, 18 (6.3%) were donation after circulatory death donors, down from 39 (13.1%) in 2020.

Figure 7. Deceased donors and grafts transplanted by year



Abbreviation: DCD, donation after circulatory death

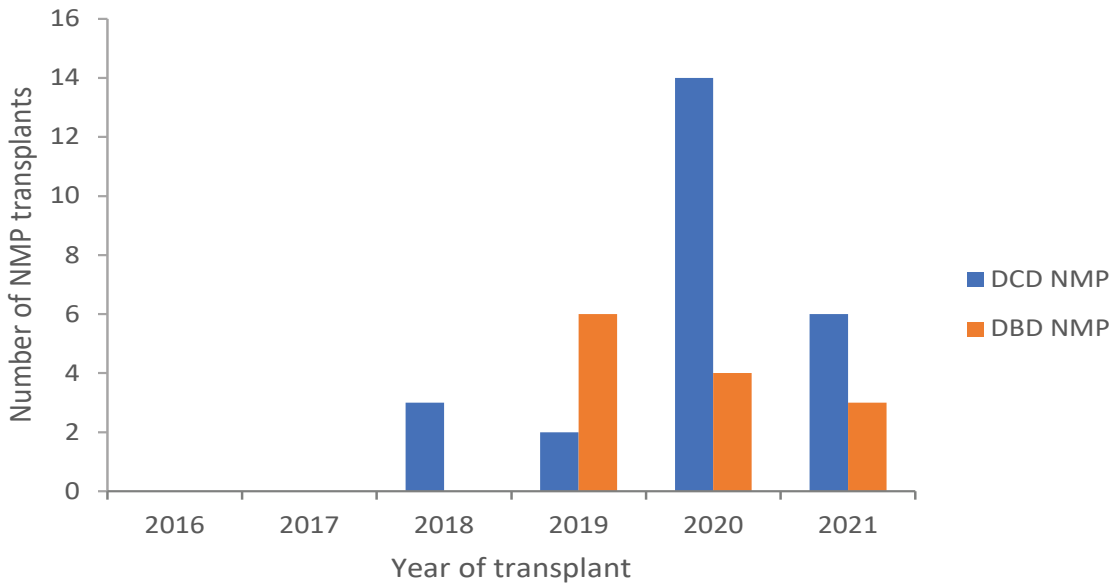
6.2 Normothermic Machine Perfusion of Deceased Donor Livers

Normothermic machine perfusion has been introduced as a preservation method in liver transplantation in recent years. The availability of normothermic machine perfusion has enabled greater utilisation of donation after circulatory death donor livers as donor liver viability/functionality can be assessed whilst being perfused and increases the time the liver can be held prior to transplant.

Queensland was the first liver transplant unit to utilise normothermic machine perfusion across Australia and New Zealand. They performed three liver transplants in 2018, seven in 2019, 12 in 2020 and three in 2021 using a normothermic machine perfused liver. Victoria's first transplant using a normothermic machine perfused liver occurred in December 2019. A further six were transplanted in 2020 and six in 2021.

In 2021, six (33%) of the 18 transplanted livers sourced from DCD donors were supported using normothermic machine perfusion (Figure 8, Table 1).

Figure 8. Transplants utilising normothermic machine perfusion with donor source type



Abbreviation: DCD, donation after circulatory death; DBD, donation after brain death; NMP, normothermic machine perfusion

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

	Donation after Circulatory Death				Donation after Brain Death			
Transplant Year	**DCD NMP**	**DCD no NMP**	**DCD Total**	***% DCD with NMP***	**DBD NMP**	**DBD no NMP**	**DBD Total**	***% DBD with NMP***
2016	0	17	**17**	*0%*	0	317	**317**	*0%*
2017	0	11	**11**	*0%*	0	293	**293**	*0%*
2018	3	18	**21**	*14%*	0	320	**320**	*0%*
2019	2	22	**24**	*8%*	6	304	**310**	*2%*
2020	14	25	**39**	*36%*	4	255	**259**	*2%*
2021	6	12	**18**	*33%*	3	283	**286**	*1%*

Abbreviation: DCD, donation after circulatory death; DBD, donation after brain death; NMP, normothermic 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 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

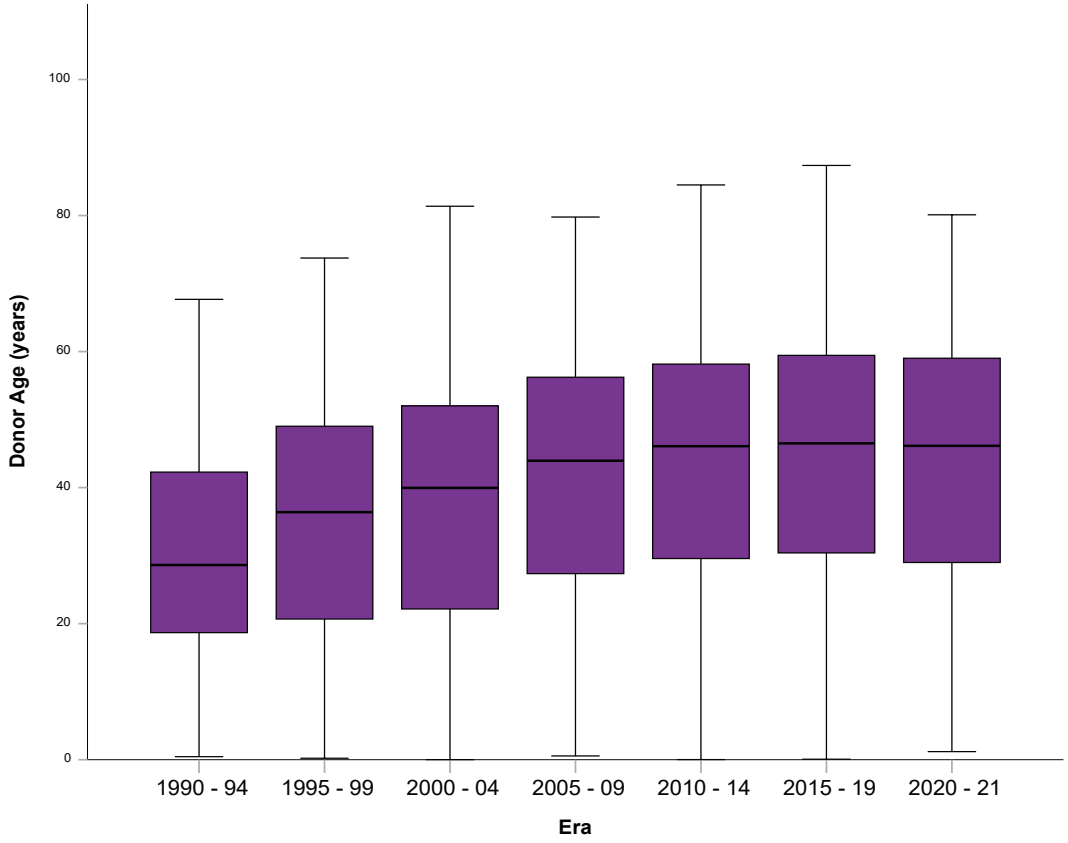
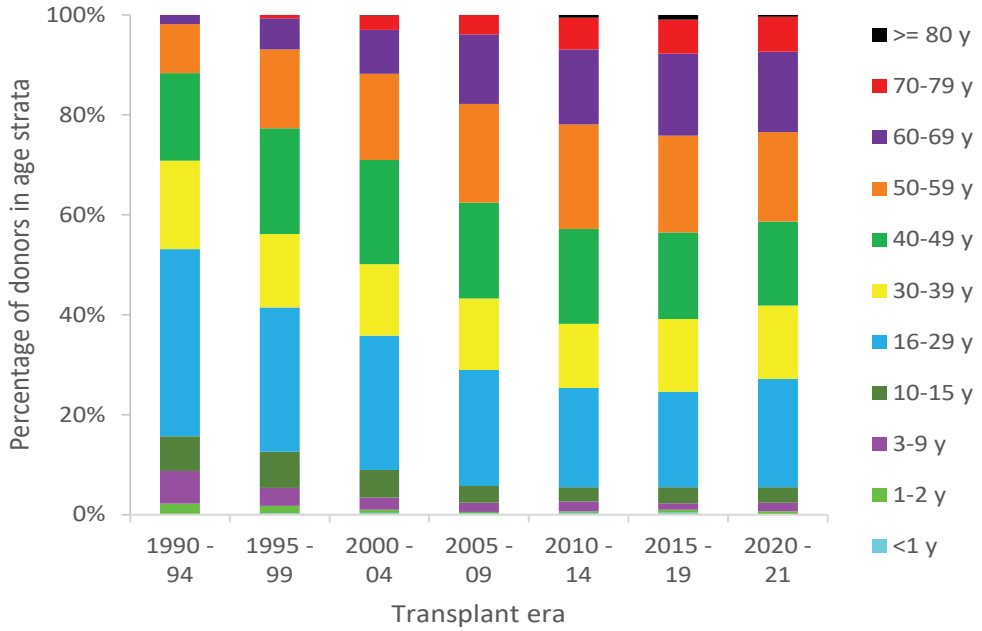


Figure 10 demonstrates the changing deceased donor age profile over the various transplant eras. There has been a progressive increase in the proportion of donors aged 50-59, 60-69, 70-79 and ≥ 80 years from 10%, 2% 0% and 0%, respectively in the 1990-94 era to 21%, 15%, 6% and 1%, respectively in the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

Figure 10. Deceased donor age by transplant era



7 Living Liver Donors

Of 7,266 liver transplants, 119 (1.7%) were sourced from living donors (including four domino livers). Paediatric recipients received the majority (82.4%) 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 % living donors	**98** 82.4%	**21** 17.6%	**119**
Gender of living donor			
Female *(% age category)*	46 *(46.9%)*	8 *(38.1%)*	**54 *(45.4%)***
Male *(% age category)*	52 *(53.1%)*	13 *(61.9%)*	**65 *(54.6%)***
Age of living donor (years)			
Median	34	33	**33**
Range	19 – 54	18 – 54	**18 – 54**
Living donor relationship			
Father	41	1	**42**
Mother	25	0	**25**
Aunt	11	0	**11**
Family friend	8	1	**9**
Brother	2	3	**5**
Son	0	5	**5**
Cousin	4	0	**4**
Domino whole liver	0	4	**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 2021

There were 307 liver transplants performed on 301 recipients in 2021. The number of liver transplants has fallen progressively since 2019 (332 in 2020, 368 in 2019). This is associated with a similar reduction in deceased donor activity. Unlike renal transplantation, there was no interruption to liver transplantation in Australia and New Zealand as a result of the COVID-19 pandemic but is likely that there were multiple factors related to the pandemic, such as reduced donor referrals and interruption to travel between states and between Australia and New Zealand, that impacted deceased donor numbers. The liver transplant rates in 2021 for Australia and New Zealand were 9.9 and 10.3 liver transplant recipients per million population, respectively (Australia population in 2021: 25.8 million; New Zealand population in 2021: 5.1 million).

8.1 Demographic Data for Patients Transplanted in 2021

Of the 301 patients receiving a transplant in 2021, 11.6% were children. Females represented 65.7% of paediatric patients transplanted but only 38.7% of the adult population (Table 3. Patient demographics by age group (2021).

Table 3. Patient demographics by age group (2021)

Patients Transplanted in ANZ in 2021	**Children** (<16 years)	**Adults** (≥16 years)	**Total Patients**
Number of patients *(% total patients)*	35 *(11.6%)*	266 *(88.4%)*	301
Gender			
Female *(% age category)*	23 *(65.7%)*	103 *(38.7%)*	126 *(41.9%)*
Male *(% age category)*	12 *(34.3%)*	163 *(61.3%)*	175 *(58.1%)*
Age at first ANZ transplant in 2021			
Mean ± SD (years)	4 ± 5	53 ± 12	47 ± 20
Median (years)	1	57	54
Range	3 m - 15 y	17 y - 70 y	3 m - 70 y
Interquartile range	7 m - 6 y	47 y - 63 y	38 y - 62 y
Status of patients at 31/12/2021			
Alive *(% age category)*	35 *(100.0%)*	253 *(95.1%)*	288 *(95.7%)*
Deceased *(% age category)*	0 *(0.0%)*	13 *(4.9%)*	13 *(4.3%)*

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

8.2 Transplants in 2021

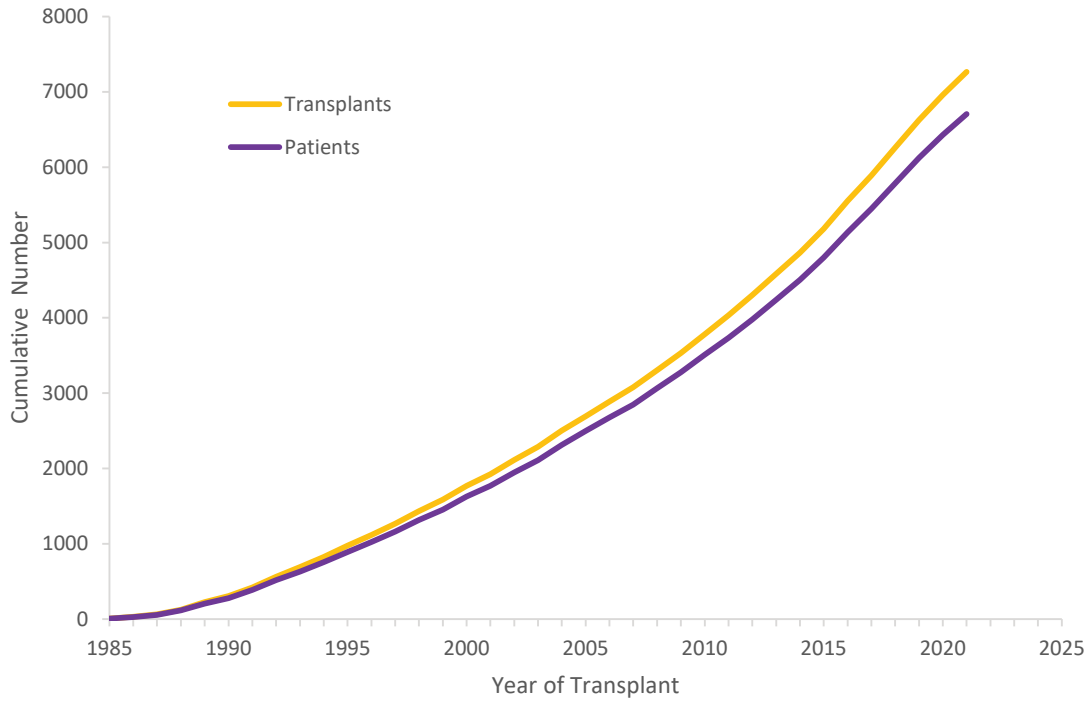
The majority of the 307 transplants were for adult patients (272, 88.6%), whilst 35 (11.4%) transplants were performed on children.

Of the 301 patients transplanted in 2021, 277 (92.0%) patients had their first transplant in 2021. Of these, five required retransplantation (i.e. two transplant operations in 2021). Twenty-one patients who had a single transplant prior to 2021 were retransplanted in 2021. One of these went on to have another (their third) transplant in 2021. Three patients who had two transplants prior to 2021 were retransplanted with their third graft in 2021.

9 Liver Transplantation from 1985 – 2021

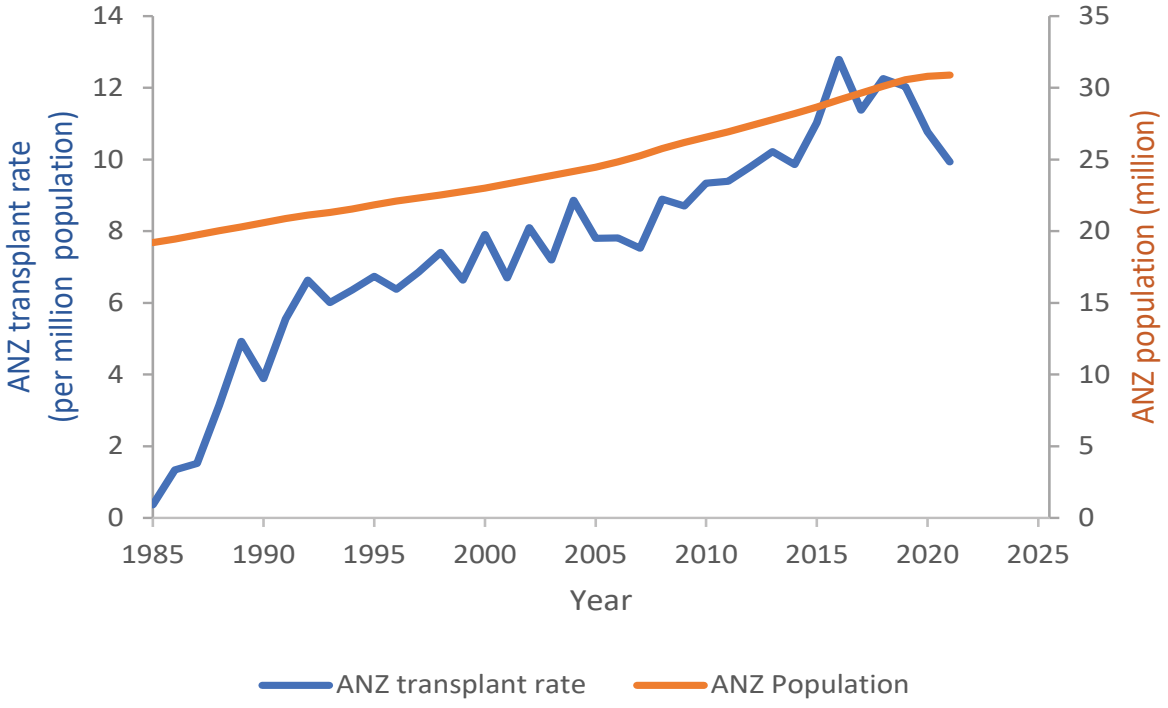
There have been 7,266 liver transplants undertaken on 6,706 patients between 1985 and 2021. Figure 11 shows the cumulative number of patients and transplants.

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



There has been an increase over time of the number of transplant recipients per million population from 5.6 in 1991, peaking at 12.8 in 2016 and then falling to 9.9 in 2021. (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 - 2021

Demographic data are based on the first liver transplant undertaken in Australia or New Zealand across all years. In five cases, this is the patient's second liver transplant as their first transplant was done outside Australia and New Zealand. One patient had two prior transplants outside Australia. (6,706 patients, 6,700 graft 1, 5 graft 2, 1 graft 3).

Of 6,706 patients receiving a transplant from 1985 to 2021, 16.3% were children. Females comprised 51.2% of paediatric patients but only 33.6% of adult patients (Table 4).

Table 4. Patient demographics by age group (1985 – 2021)

Patients Transplanted in ANZ from 1985 to 2021	**Children** (<16 years)	**Adults** (≥16 years)	**Total Patients**
Number of patients *(% total patients)*	1,094 *(16.3%)*	5,612 *(83.7%)*	6,706
Gender			
Female *(% age category)*	560 *(51.2%)*	1,885 *(33.6%)*	2,445 *(36.5%)*
Male *(% age category)*	534 *(48.8%)*	3,727 *(66.4%)*	4,261 *(63.5%)*
Age at first ANZ transplant			
Mean ± SD (years)	4 ± 4	50 ± 11	43 ± 20
Median (years)	2	52	50
Range	18 d - 15 y	16 y - 73 y	18 d - 73 y
Interquartile range	11 m- 6 y	44 y - 59 y	33 y - 58 y
Status of patient at 31/12/2021			
Alive *(% age category)*	908 *(83.0%)*	3,797 *(67.7%)*	4,705 *(70.2%)*
Deceased *(% age category)*	186 *(17.0%)*	1,815 *(32.3%)*	2,001 *(29.8%)*

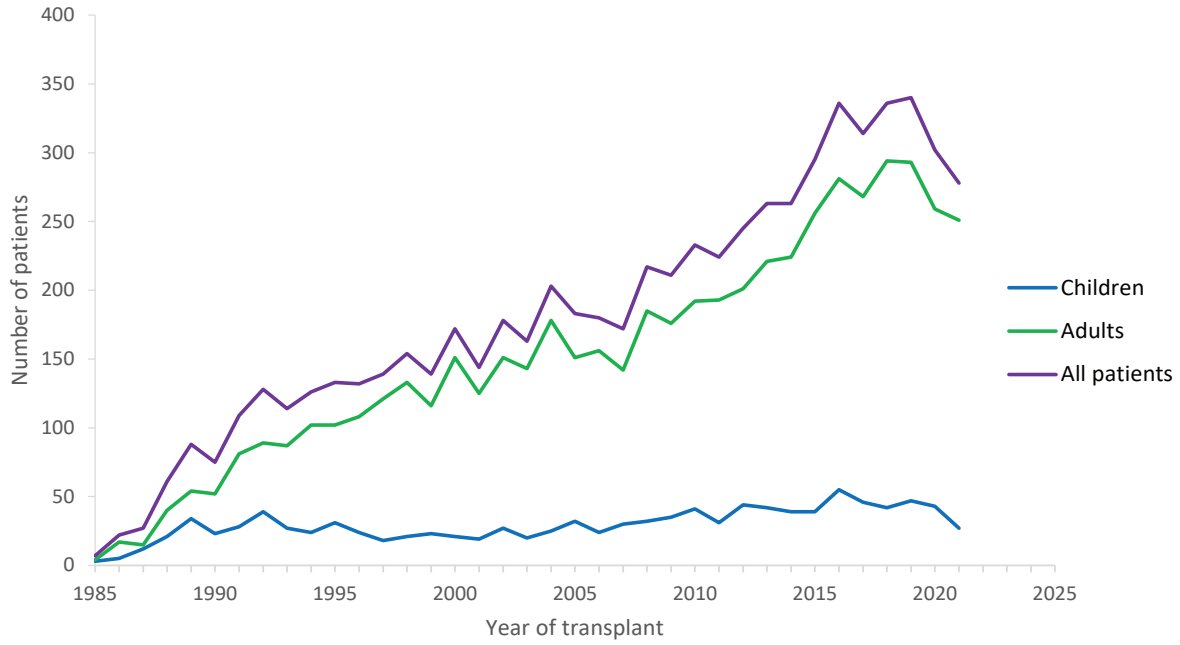
Abbreviation: ANZ, Australia or New Zealand; m, month; y, year

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).

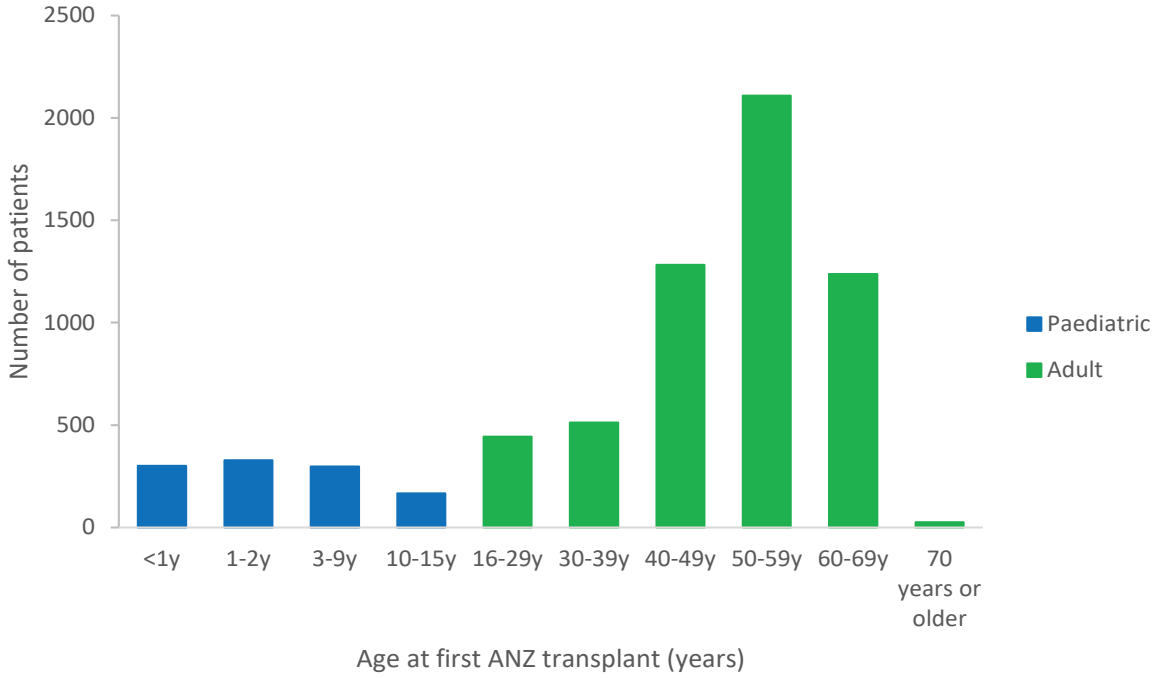
Figure 13. Number of patients transplanted by age group by year of first transplant



9.1.2 Recipient Age at First Transplant (1985 – 2021)

Of the 1,094 paediatric transplant recipients, 27.5% were infants less than one year old and 15.2% were adolescents 10 to 15 years old (Figure 14). Of the 5,612 adult recipients, 37.6% were in their 50s and only 0.5% were in their 70s.

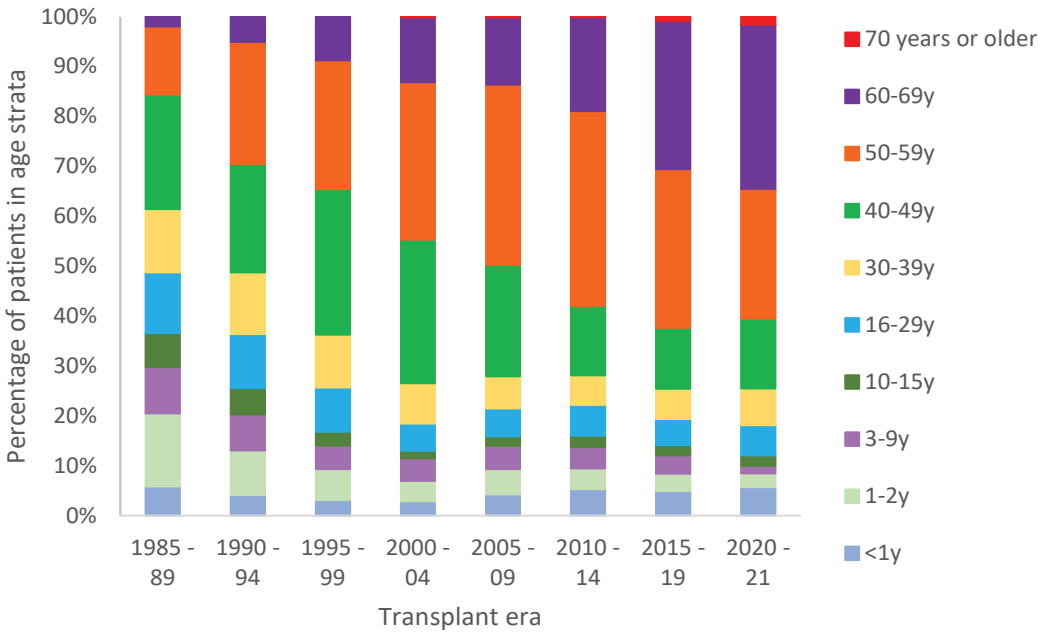
Figure 14. Recipient age strata at first Australian or New Zealand transplant (1985 – 2021)



9.1.3 Recipient Age at First Transplant by Era of Transplant

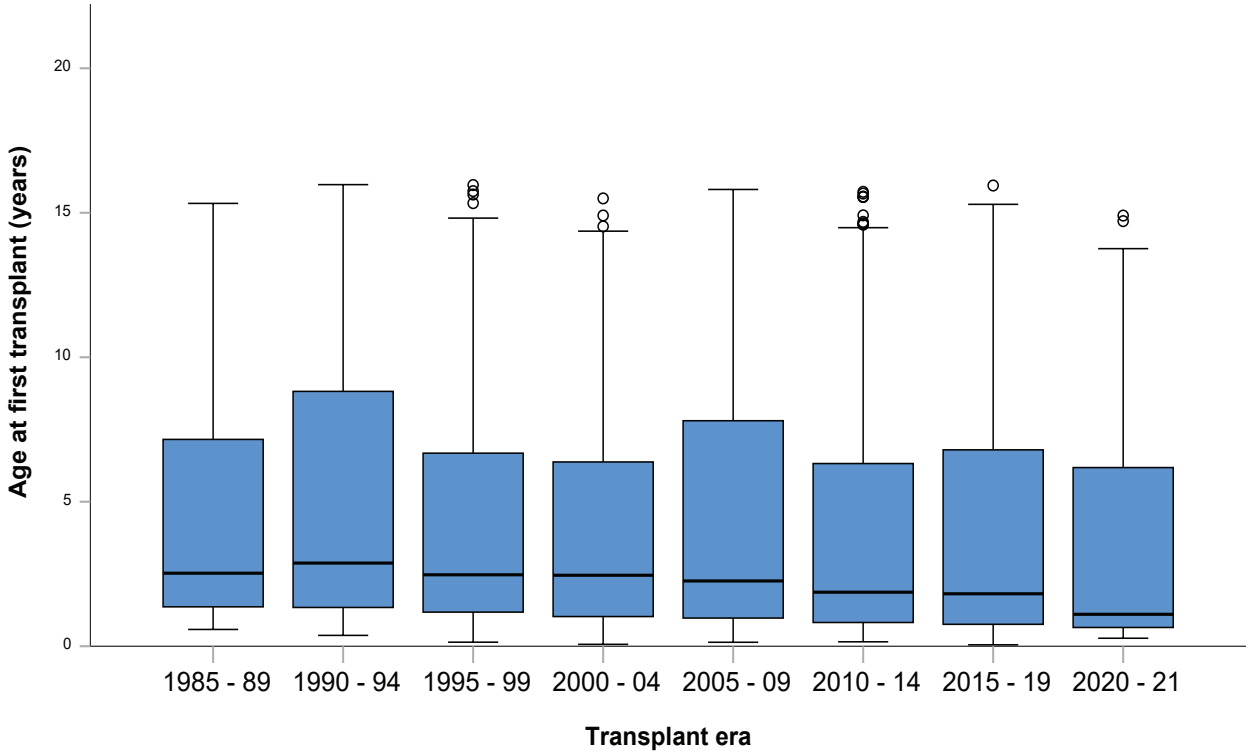
Figure 15 demonstrates the changing recipient age profile over the various transplant eras. There has been a progressive increase in the proportion of recipients aged 60-69 and ≥ 70 years from 2.0% and 0%, respectively in the 1985 - 89 era to 32.9% and 1.6%, respectively in the 2020 - 21 era. Whilst 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 26.0% in 2020 – 21 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



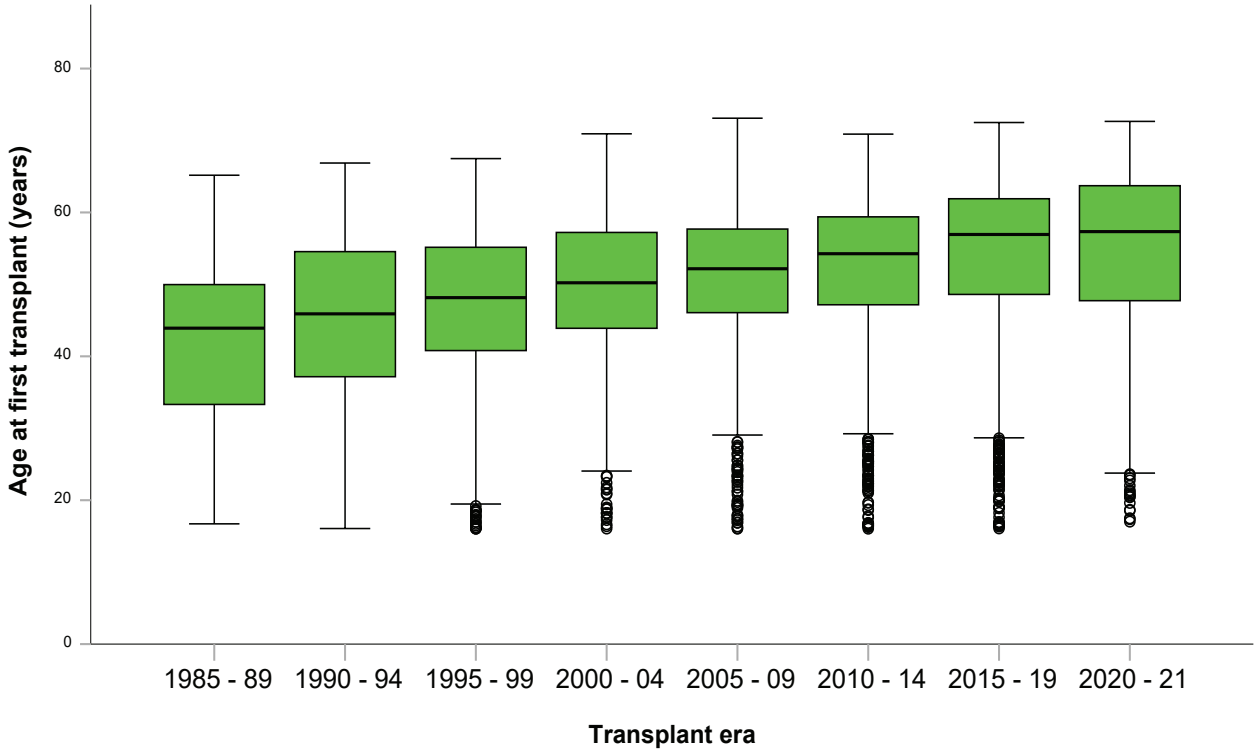
The median paediatric recipient age has been gradually decreasing over the transplant eras, from 2 years and 6 months in 1985-89 to 1 year and 1 month in 2020-21 (P=0.019, Figure 16).

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 2020-21 (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



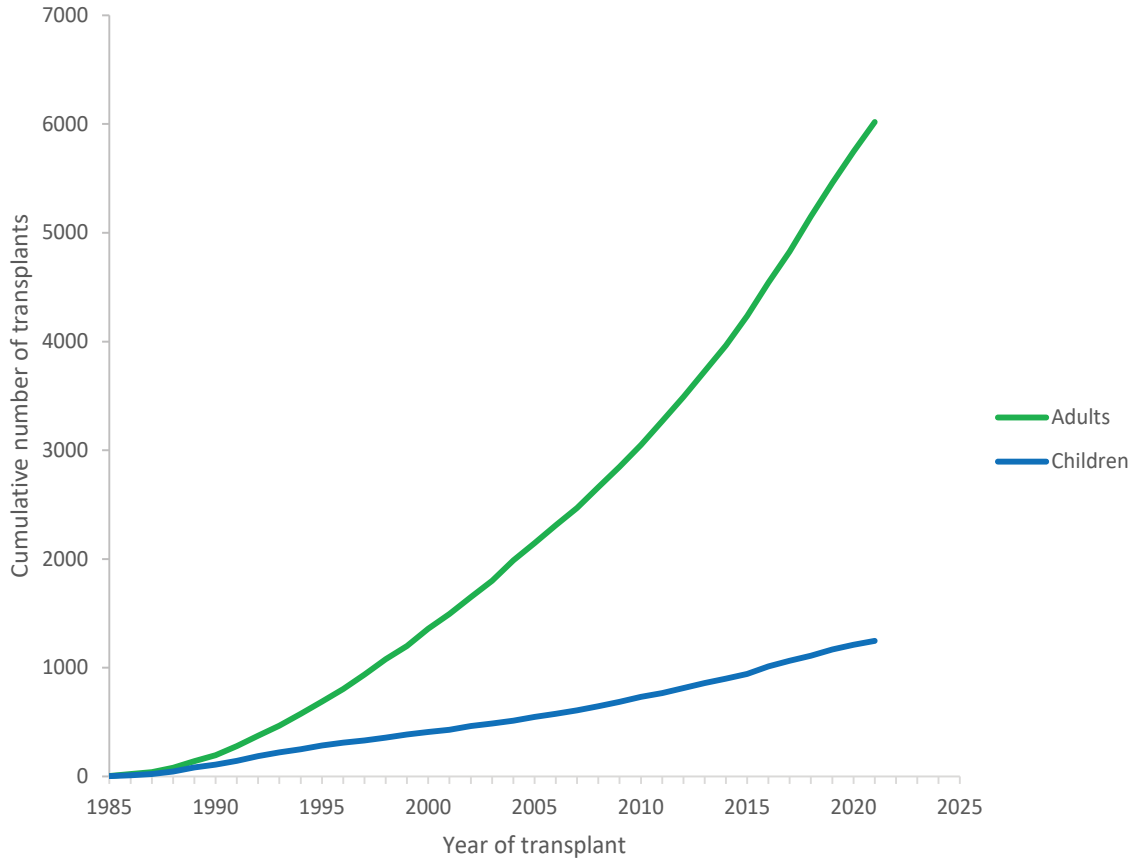
9.2 Transplants (1985 – 2021)

Of the 7,266 transplants, 6,019 (82.8%) were performed in adults and 1,247 (17.2%) in children (<16 years, Table 5, Figure 18). Since the first transplant in 1985, 500 (7.5%) recipients have undergone retransplantation. Of these, 442 patients had one retransplant, 56 patients have required two retransplants and two patients had three retransplants.

Table 5. Transplants by age group (1985 – 2021)

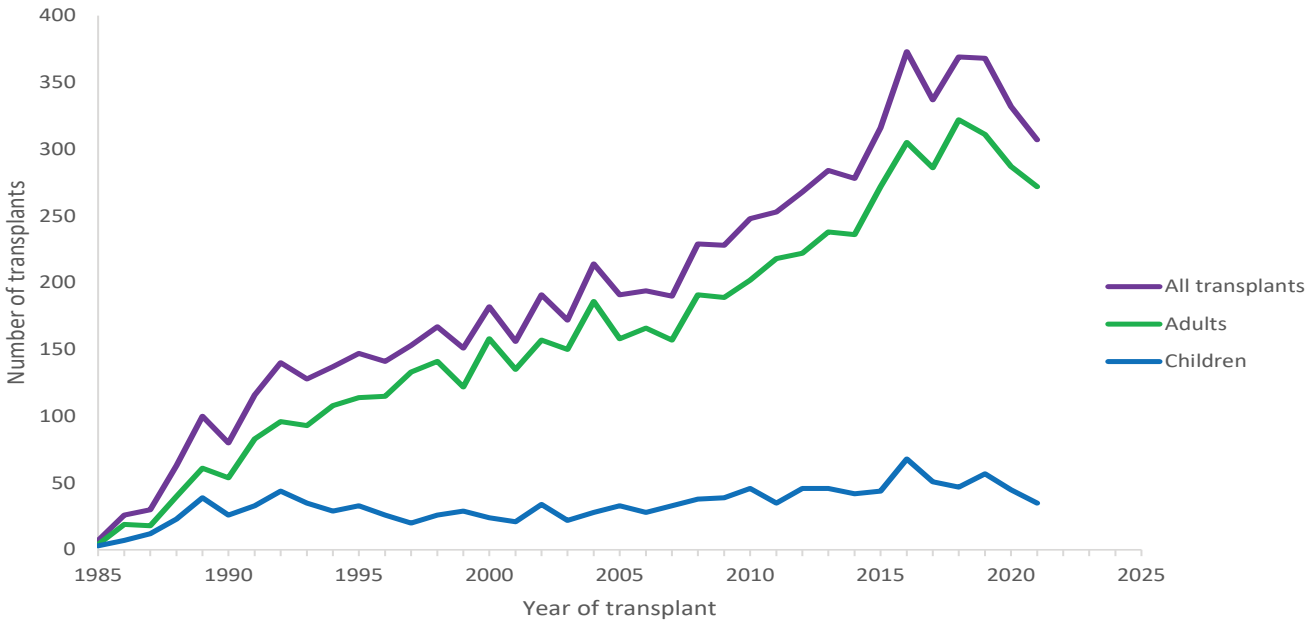
Transplants Transplanted in ANZ from 1985 to 2021	**Children** (<16 years)	**Adults** (≥16 years)	**Total**
Number of transplants *(% total transplants)*	1,247 *(17.2%)*	6,019 *(82.8%)*	**7,266**
Number of patients *(% total patients)*	1,094 *(16.3%)*	5,612 *(83.7%)*	**6,706**

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



There was a 7.5% reduction in the number of transplants from 2020 to 2021, following the 10% reduction in liver transplants in 2019 to 2020. The number of transplants performed fell from 332 in 2020 to 307 in 2021. The number of transplants in children fell from 45 to 35 and adults from 287 to 272 (Figure 19). This decrease in transplants per year is associated with a similar reduction in deceased donor activity. Unlike renal transplantation, there was no interruption to liver transplantation in Australia and New Zealand as a result of the COVID-19 pandemic but is likely that there were multiple factors related to the pandemic, such as reduced donor referrals and interruption to travel between states and between Australia and New Zealand, that impacted deceased donor numbers.

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



9.2.1 Type of Graft – Paediatric Recipients, All Years

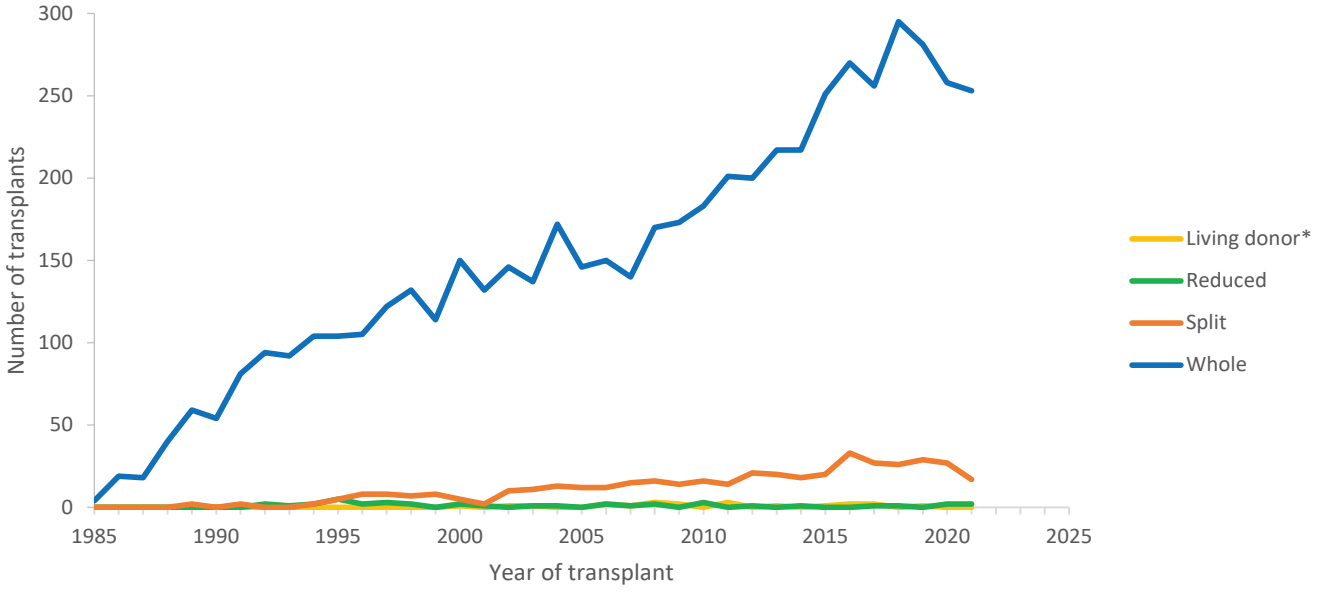
The first paediatric liver transplant (whole liver) was performed in 1985, the first reduced size liver transplant in 1986, the first split liver transplant in 1989 and the first successful living donor liver transplant in the world was performed by Professor Strong in Brisbane in July 1989. In the 1990s, 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 and decreasing to 48.6% in 2021 (Figure 20). The number of living donors peaked at 10 in 2010 and subsequently this has become an infrequent method of transplantation in children (three transplants in 2021).

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 (253 of 272 transplants, 93.0% in 2021, Figure 21). The number of deceased donor split liver transplants in adults has increased from 5 of 158 transplants (3.2%) in 2000 to 17 of 272 (6.3%) in 2021. There has been a total of 21 adult-to-adult living donor liver transplants performed, including four 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 1,092 children who underwent their first liver transplant in Australia or New Zealand, the most common primary diagnoses were biliary atresia (53.5%), metabolic disorders (14.9%) and fulminant hepatic failure (FHF, 10.8%, Table 6). The primary diagnosis and up to three additional diagnoses are collected in the ANZLITR. There were 27 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	584	53%	**585**	54%
Metabolic disorders*	163	15%	**166**	15%
Fulminant hepatic failure#	118	11%	**120**	11%
Alagille syndrome	41	4%	**42**	4%
Hepatoblastoma	34	3%	**35**	3%
Progressive familial intrahepatic cholestasis	33	3%	**33**	3%
Cryptogenic cirrhosis	24	2%	**24**	2%
Cystic fibrosis	18	2%	**18**	2%
Hepatocellular carcinoma	8	1%	**14**	1%
Autoimmune cirrhosis	12	1.1%	**13**	1%
Primary sclerosing cholangitis	8	0.7%	**11**	1%
Histiocytosis X	5	0.5%	**6**	0.5%
Neonatal hepatitis	6	0.5%	**6**	0.5%
Caroli's disease	4	0.4%	**4**	0.4%
Choledochal cyst	3	0.3%	**4**	0.4%
Cholangiocarcinoma	0	0.0%	**3**	0.3%
Congenital intrahepatic portosystemic shunt	3	0.3%	**3**	0.3%
Ductopenia	3	0.3%	**3**	0.3%
Intestinal failure associated liver disease	3	0.3%	**3**	0.3%
Secondary biliary cirrhosis	3	0.3%	**3**	0.3%
Chronic Budd Chiari	2	0.2%	**2**	0.2%
Common variable immune deficiency	2	0.2%	**2**	0.2%
Polycystic liver +/- kidney disease	2	0.2%	**2**	0.2%
Arterio-venous malformation	1	0.1%	**1**	0.1%
Autoimmune sclerosing cholangitis	1	0.1%	**1**	0.1%
Bile salt synthetic defect	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%
Gestational alloimmune liver disease	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%
Hepatopulmonary syndrome	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%
Nephronophthisis	0	0.0%	**1**	0.1%
Nodular regenerative hyperplasia	1	0.1%	**1**	0.1%
Parvovirus	1	0.1%	**1**	0.1%
Total	**1,092**	**100.0%**	**1,119**	**102.5%**

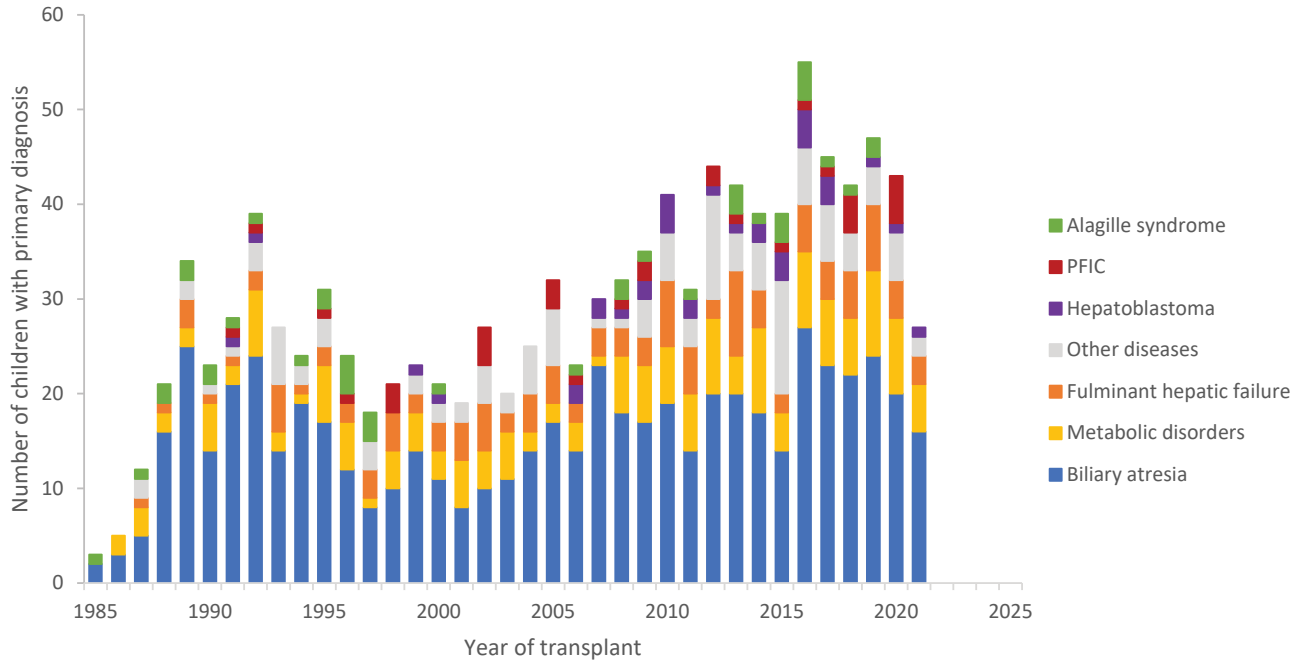
* See Table 9 for breakdown of metabolic disorders

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

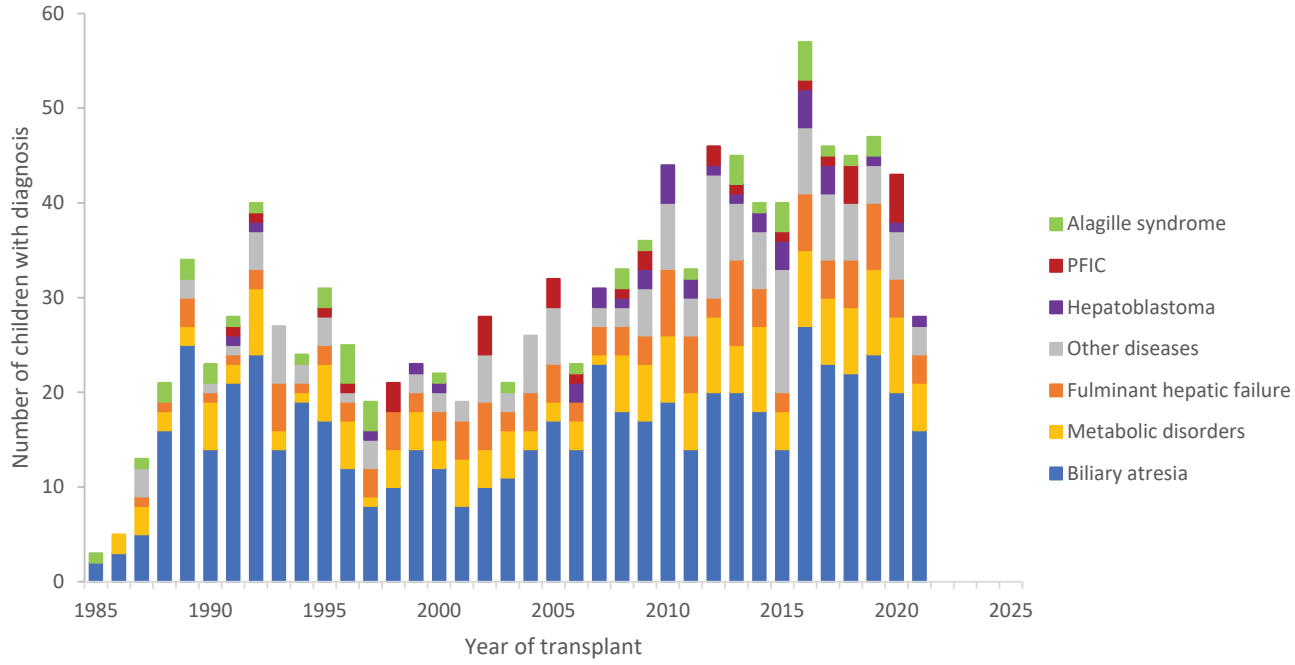


Abbreviation: PFIC, Progressive familial intrahepatic cholestasis

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 5,608 adults who underwent their first liver transplant in Australia or New Zealand, the most common primary diagnoses were hepatitis C virus cirrhosis (20.1%), alcohol-related cirrhosis (14.1%) and hepatocellular carcinoma (12.5%, Table 7).

The primary diagnosis and up to three additional diagnoses are collected in the ANZLITR. In addition to the 5,608 primary diagnoses, there were 2,429 additional diagnoses recorded for adults. The proportion of patients with hepatitis C virus cirrhosis increased from 20.1% as a primary diagnosis to 27.8% across all diagnoses. The proportion of patients with hepatocellular carcinoma as a primary diagnosis was 12.5% and increased to 26.4% across all diagnoses. The proportion of patients with alcohol-related cirrhosis as a primary diagnosis was 14.1% and increased to 24.5% 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	1126	20%	**1559**	28%
Hepatocellular carcinoma	701	13%	**1481**	26%
Alcohol-related cirrhosis	788	14%	**1376**	25%
NAFLD / Cryptogenic cirrhosis	523	9%	**681**	12%
Primary sclerosing cholangitis	561	10%	**581**	10%
Hepatitis B virus cirrhosis	321	6%	**527**	9%
Fulminant hepatic failure#	493	9%	**524**	9%
Metabolic disorder*	226	4%	**305**	5%
Primary biliary cirrhosis	287	5%	**291**	5%
Autoimmune cirrhosis	191	3%	**230**	4%
Polycystic liver +/- kidney disease	69	1%	**71**	1%
Biliary atresia	55	1%	**56**	1%
Cholangiocarcinoma	13	0.2%	**50**	0.9%
Chronic Budd Chiari	41	0.7%	**44**	0.8%
Cystic fibrosis	34	0.6%	**34**	0.6%
Secondary biliary cirrhosis	21	0.4%	**24**	0.4%
Caroli's disease	20	0.4%	**20**	0.4%
Granulomatous hepatitis / sarcoidosis	14	0.2%	**16**	0.3%
Hepatopulmonary syndrome	0	0%	**13**	0.2%
Epithelioid haemangioendothelioma	10	0.2%	**11**	0.2%
Hereditary haemorrhagic telangiectasia	10	0.2%	**11**	0.2%
Alagille syndrome	10	0.2%	**10**	0.2%
Adenomatosis	5	0.1%	**9**	0.2%
Metastatic neuroendocrine tumour	6	0.1%	**8**	0.1%
Nodular regenerative hyperplasia	7	0.1%	**8**	0.1%
Haemangioma	5	0.09%	**6**	0.1%
Portopulmonary hypertension	0	0%	**6**	0.1%
Progressive familial intrahepatic cholestasis	6	0.1%	**6**	0.1%
Congenital hepatic fibrosis	5	0.09%	**5**	0.09%
Drug hepatotoxicity	5	0.09%	**5**	0.09%
Haemolytic uraemic syndrome	5	0.09%	**5**	0.09%
Post hepatitic cirrhosis - Drug related	3	0.05%	**5**	0.09%
Secondary biliary cirrhosis - hepatolithiasis	4	0.07%	**5**	0.09%
Cholestatic cirrhosis / Secondary cholangitis	3	0.05%	**4**	0.07%
Cirrhosis - Virus related cirrhosis - Other viruses	1	0.02%	**4**	0.07%

(table continued on next page)

Diagnosis	Primary Diagnosis	% of Adults with Primary Diagnosis	All Diagnoses	% of Adults with Diagnosis
Ductopenia	4	0.07%	**4**	0.07%
Non-cirrhotic portal hypertension	4	0.07%	**4**	0.07%
Recurrent cholangitis	2	0.04%	**4**	0.07%
Chronic cholestatic liver disease	3	0.05%	**3**	0.05%
Intestinal failure associated liver disease	3	0.05%	**3**	0.05%
Oriental cholangiohepatitis	3	0.1%	**3**	0.05%
Angiosarcoma	1	0.02%	**2**	0.04%
Choledochal cyst	2	0.04%	**2**	0.04%
Congenital biliary fibrosis	2	0.04%	**2**	0.04%
Abernethy malformation	1	0.02%	**1**	0.02%
Acute alcohol-related hepatitis	0	0%	**1**	0.02%
Arterio-venous malformation	1	0.02%	**1**	0.02%
Benign liver tumours - Other	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%	**1**	0.02%
Congenital heart disease	1	0%	**1**	0.02%
Drug induced cholestasis	1	0.02%	**1**	0.02%
Fasciola	1	0%	**1**	0.02%
Focal nodular hyperplasia	0	0%	**1**	0.02%
Parasitic disease - Schistosomiasis (Bilharzia)	0	0%	**1**	0.02%
Graft vs host disease - bone marrow transplant	1	0%	**1**	0.02%
Hepatoblastoma	0	0%	**1**	0.02%
Histiocytosis X	1	0.02%	**1**	0.02%
Parasitic disease - Infected hydatid cysts	1	0.02%	**1**	0.02%
Portal biliopathy	1	0.02%	**1**	0.02%
Total	**5,608**	**100%**	**8,037**	**143%**

See Table 8 for breakdown of causes of fulminant hepatic failure

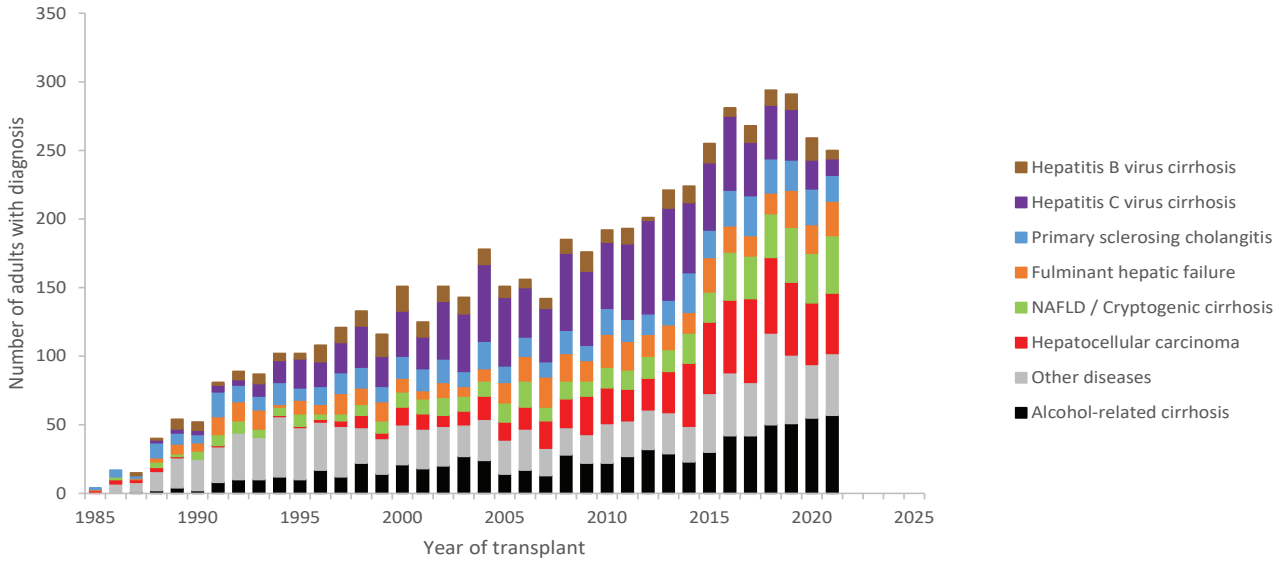
* See Table 9 for breakdown of metabolic disorders

Abbreviation: 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 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 4.8% in 2021 (Figure 24). The proportion of patients transplanted for alcohol-related cirrhosis has increased from 15.9% in 2012 to 22.8% in 2021 and hepatocellular carcinoma has increased from 11.4% in 2012 to 17.6% in 2021. Over the same time period, the proportion of patients transplanted for non-alcoholic fatty liver disease increased from 8.0% to 16.8%.

Figure 24. Primary diagnosis trend in adults

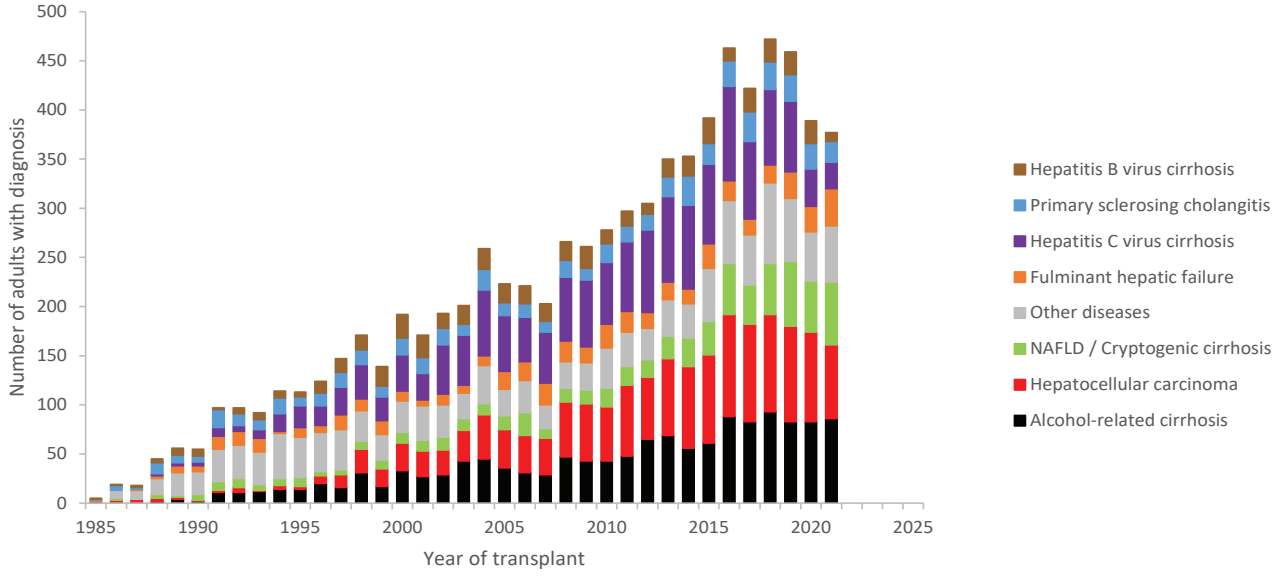


Abbreviation: NAFLD, non-alcoholic fatty liver disease

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 5.0% in 1988 to 34.4% in 2021. Hepatocellular carcinoma has increased from 1.1% in 1993 to 30.0% in 2021 and non-alcoholic fatty liver disease has increased from 3.7% in 1996 to 25.6% in 2021, 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 10.8% in 2021. 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 a primary diagnosis or 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	Adult	Total patients with FHF	% of all patients
Acute hepatic failure - Idiopathic	63	112	175	2.6%
Acute hepatic failure - Hepatitis B	0	96	96	1.4%
Acute hepatic failure - Hepatitis non A-G	19	25	44	0.7%
Acute hepatic failure - Other drugs	3	39	42	0.6%
Subacute hepatitis - Type unknown	5	30	35	0.5%
Acute hepatic failure - Wilson's	9	24	33	0.5%
Subacute hepatitis - Autoimmune hepatitis	2	30	32	0.5%
Acute hepatic failure - Paracetamol	4	27	31	0.5%
Subacute hepatitis - Hepatitis B	0	28	28	0.4%
Acute hepatic failure - Autoimmune hepatitis	1	20	21	0.3%
Subacute hepatitis - Drugs	1	19	20	0.3%
Subacute hepatitis - Hepatitis C	0	15	15	0.2%
Acute hepatic failure - Herbs / mushrooms	0	12	12	0.2%
Subacute hepatic failure - Wilson's	2	7	9	0.1%
Acute hepatic failure - Post-operative	2	6	8	0.1%
Subacute hepatitis - Non A-G	0	6	6	0.09%
Acute hepatic failure - Alpha-1-antitrypsin	2	3	5	0.07%
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	3	4	0.06%
Subacute hepatic failure - Budd Chiari	1	2	3	0.04%
Subacute hepatic failure - Post surgical resection	1	1	2	0.03%
Subacute hepatitis - Herbs	0	2	2	0.03%
Subacute hepatitis - Hepatitis A	0	2	2	0.03%
Acute hepatic failure - Acute alcohol-related hepatitis	0	1	1	0.01%
Acute hepatic failure - Epstein-Barr virus hepatitis	1	0	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 - Post traumatic	0	1	1	0.01%
Acute hepatic failure - Hepatitis D	0	1	1	0.01%
Acute hepatic failure - Hepatitis E	0	1	1	0.01%
Subacute hepatitis - Giant cell	1	0	1	0.01%
Subacute hepatitis - Ischaemic	0	1	1	0.01%
Total	**120**	**524**	**644**	9.6%
All patients	*1092*	*5608*	*6700*	

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	Adult	Total patients with a Metabolic Disorder	% of all patients
Alpha-1-antitrypsin deficiency	44	106	150	2%
Haemochromatosis	3	68	71	1%
Wilson's disease	8	42	50	0.7%
Familial amyloid polyneuropathy	0	46	46	0.7%
Urea cycle disorders	32	6	38	0.6%
- Ornithine transcarbamylase deficiency	*21*	*1*	*22*	*0.3%*
- Carbamyl phosphate synthetase 1 deficiency	*3*	*3*	*6*	*0.09%*
- Argininosuccinate lyase deficiency	*4*	*1*	*5*	*0.07%*
- Citrullinaemia, Argininosuccinate synthetase deficiency	*4*	*1*	*5*	*0.07%*
Primary hyperoxaluria	12	10	22	0.3%
Glycogen storage disease	5	14	19	0.3%
Crigler-Najjar	12	1	13	0.2%
Propionic acidaemia	10	0	10	0.1%
Homozygous hypercholesterolaemia	7	2	9	0.1%
Maple syrup urine disease	8	1	9	0.1%
Tyrosinaemia	8	1	9	0.1%
Protoporphyria	0	4	4	0.06%
Bile acid synthesis / transport disorder	3	0	3	0.04%
Methylmalonic acidaemia	3	0	3	0.04%
Protein C deficiency	1	2	3	0.04%
Carnitine acylcarnitine translocase deficiency	2	0	2	0.03%
Mitochondrial disease	2	0	2	0.03%
Acute intermittent porphyria	0	1	1	0.01%
Citrullinaemia	1	0	1	0.01%
Familial immunodeficiency syndrome	1	0	1	0.01%
Hereditary lysozyme amyloidosis	0	1	1	0.01%
Indian childhood cirrhosis	1	0	1	0.01%
Niemann-Pick Type C	1	0	1	0.01%
POLG mitochondrial disorder	1	0	1	0.01%
Pyridoxamine 5-phosphate oxidase deficiency	1	0	1	0.01%
Total	**166**	**305**	**471**	**7%**
All patients	*1,092*	*5,608*	*6,700*	

Abbreviation: POLG, polymerase gamma

11 Patient Survival

Patient 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.

11.1 All patients

6,700 patients had their first liver transplant in Australia or New Zealand (i.e. Graft 1, Figure 26 and Table 10). 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 75.5%. The median patient survival post-transplant was 23.7 years.

Figure 26. Patient survival curve

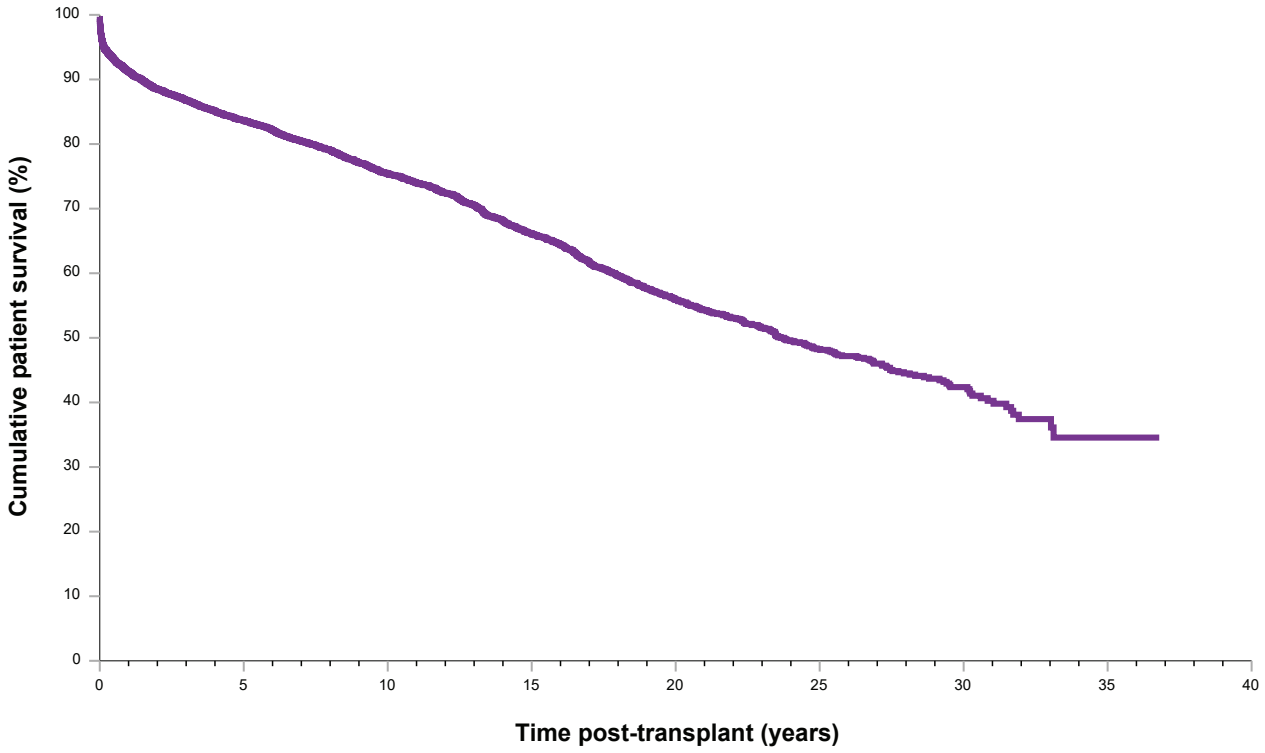


Table 10. Patient survival

Patient Survival	Time post-transplant (years)								
	0	1	3	5	10	20	30	35	40
No. at risk	6,700	5,856	4,985	4,238	2,705	881	137	5	0
Survival (%)		91%	87%	84%	76%	56%	42%	35%	

11.2 Patient Survival by Age Group

Paediatric cases are defined as less than 16 years at time of first transplant (n = 1,092). Adult cases are defined as greater than or equal to 16 years at time of first transplant (n = 5,608). Post-transplant survival was superior in the paediatric population compared to the adult population (P < 0.001, Figure 27, Table 11). Ten-year patient survival was 85.8% for children and 73.3% for adults. Median patient survival was not reached for children and was 20.4 years for adults.

Figure 27. Patient survival curve by age category

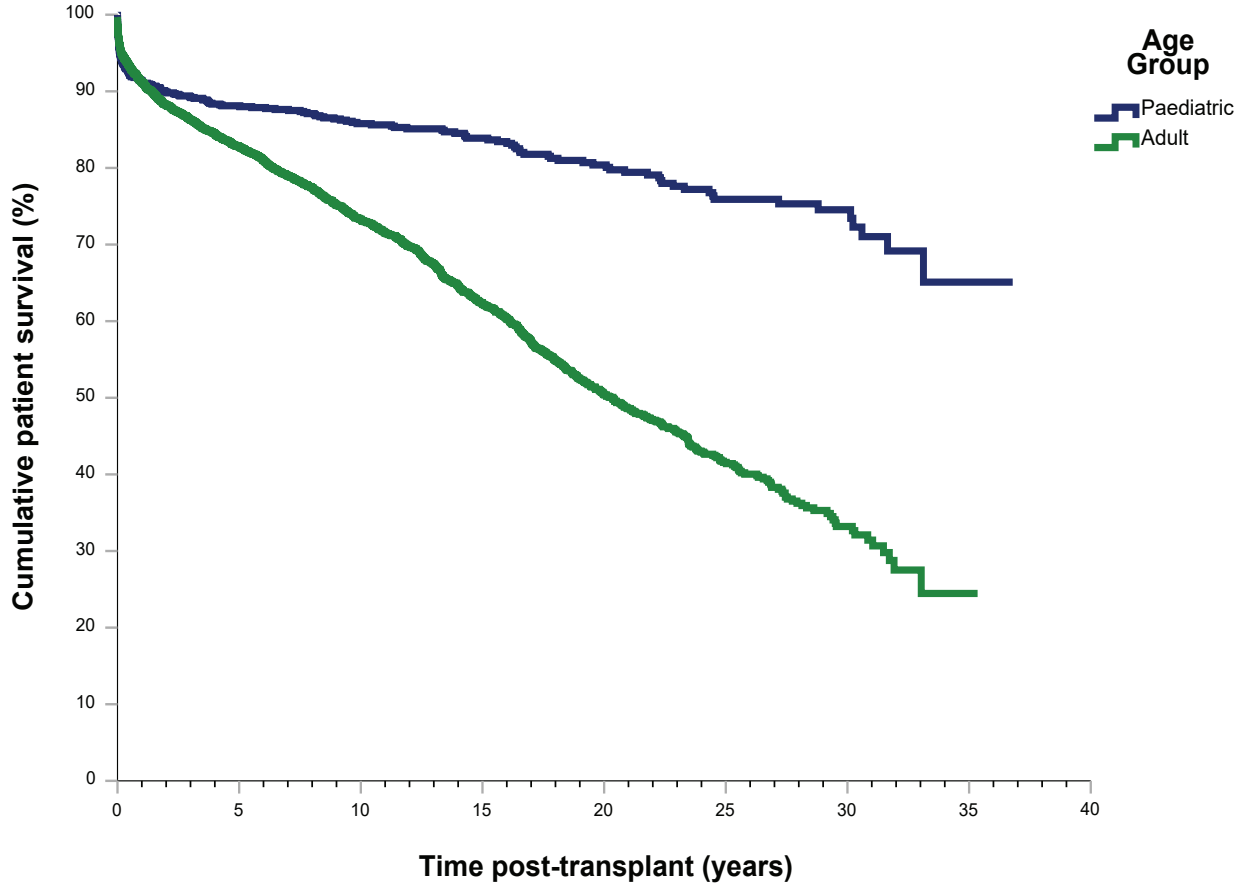


Table 11. Patient survival by age category

Age group	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Paediatric (<16y)	No. at risk	1,092	971	861	766	548	259	71	2	0
	Survival (%)		91%	89%	88%	86%	80%	75%	65%	
Adults (≥16y)	No. at risk	5,608	4,885	4,124	3,472	2,157	622	66	3	0
	Survival (%)		91%	86%	83%	73%	51%	33%	25%	

11.3 Paediatric Patient Survival by Age Strata

There was no significant difference in patient survival by paediatric age strata (P = 0.351, Figure 28, Table 12). Ten-year patient survival was 87.3% for children less than 1 year, 82.1% for 1 – 2-year-olds, 87.3% for 3 – 9-year-olds and 88.3% for 10 – 15-year-olds. Median patient survival was not reached for all paediatric age groups.

Figure 28. Paediatric patient survival curve by age strata

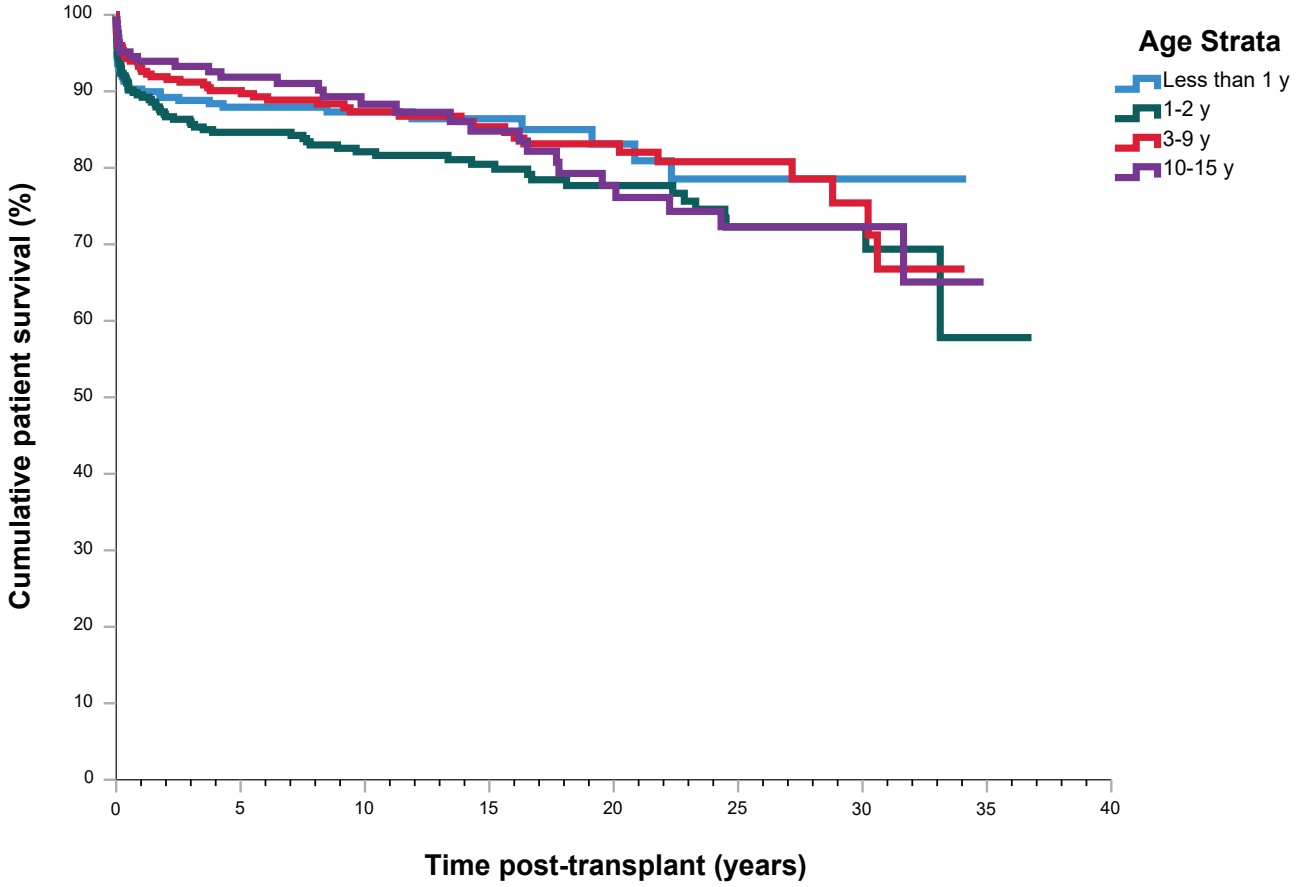


Table 12. Paediatric patient survival by age strata

Age strata	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
< 1 year	No. at risk	301	260	219	179	119	40	10	0	
	Survival (%)		90%	89%	88%	87%	83%	79%		
1 - 2 years	No. at risk	328	286	254	235	176	91	27	2	0
	Survival (%)		90%	86%	85%	82%	78%	72%	58%	
3 - 9 years	No. at risk	298	273	250	228	163	79	19	0	
	Survival (%)		93%	91%	90%	87%	83%	75%		
10 – 15 years	No. at risk	165	152	138	124	90	49	15	0	
	Survival (%)		94%	93%	92%	88%	78%	72%		

11.4 Adult Patient Survival by Age Strata

Post-transplant patient survival in adults was significantly worse with increasing patient age (P < 0.001, Figure 29, Table 13). 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 80.6%, 78.4%, 74.3%, 72.9%, 65.6% and 80.0%, 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, 31.0, 23.3, 17.9, 14.8 and 11.0 years, respectively.

Figure 29. Adult patient survival curve by age strata

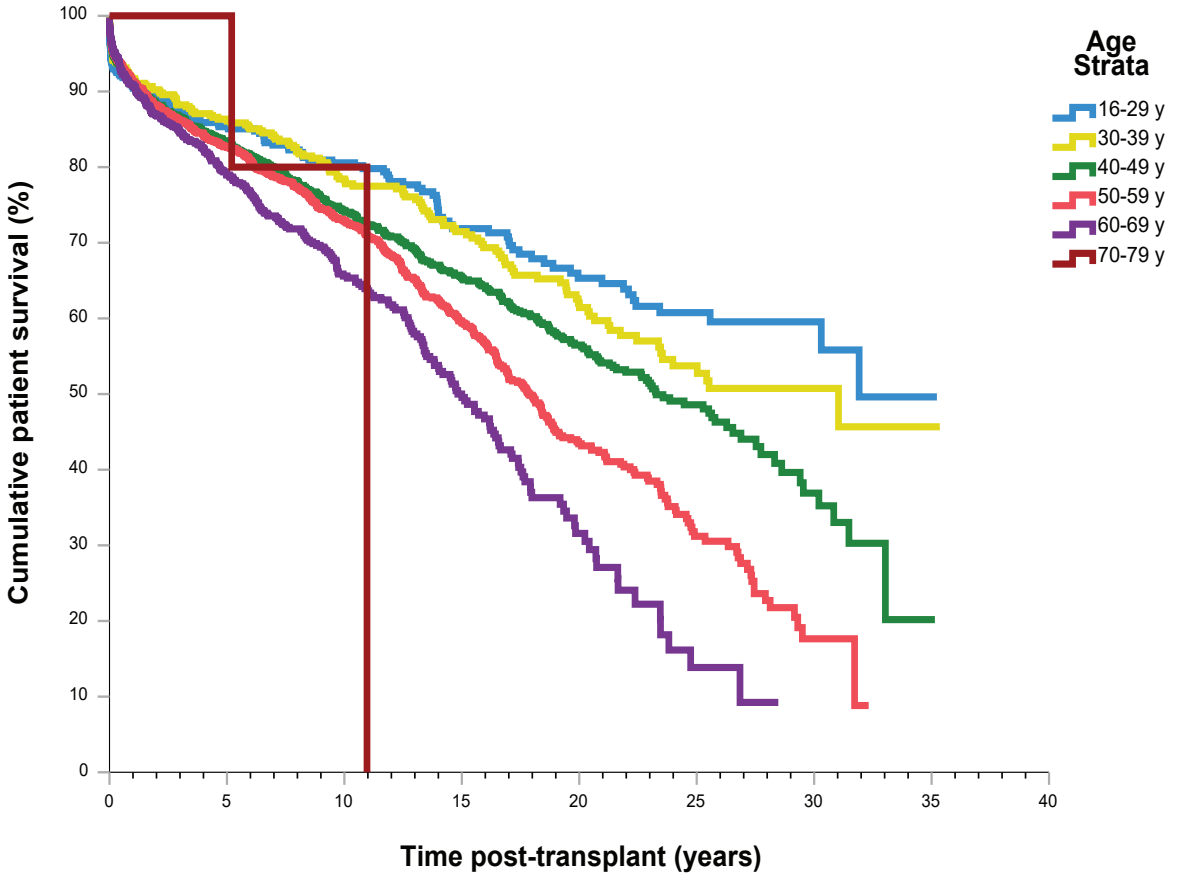


Table 13. Adult patient survival by age strata

Age strata	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
16-29 y	No. at risk	443	387	339	305	220	96	17	1	0
	Survival (%)		91%	88%	85%	81%	65%	60%	50%	
30-39 y	No. at risk	511	445	390	346	250	110	15	1	0
	Survival (%)		92%	88%	86%	78%	62%	51%	46%	
40-49 y	No. at risk	1,283	1,137	994	888	640	226	23	1	0
	Survival (%)		91%	87%	83%	74%	57%	37%	20%	
50-59 y	No. at risk	2,108	1,853	1,597	1,360	799	160	11	0	
	Survival (%)		91%	86%	83%	73%	43%	18%		
60-69 y	No. at risk	1,237	1,043	791	568	247	30	0		
	Survival (%)		91%	85%	79%	66%	32%			
70-79 y	No. at risk	26	20	13	5	1	0			
	Survival (%)		100%	100%	100%	80%				

11.5 Patient Survival by Era of Transplant

There has been a progressive improvement in patient survival over eras of transplantation (P < 0.001, Figure 30, Table 14). Patient survival in the most recent era was 94.1% at 1 year, 91.5% at 3 years, 89.0% at 5 years and 78.5% at 10 years. Median patient survival was not reached for recent eras since 2000 and was 20.5 years for 1995 – 99, 20.5 years for 1990 – 94 and 11.8 years for 1985 – 89.

Figure 30. Patient survival curve by era of transplant

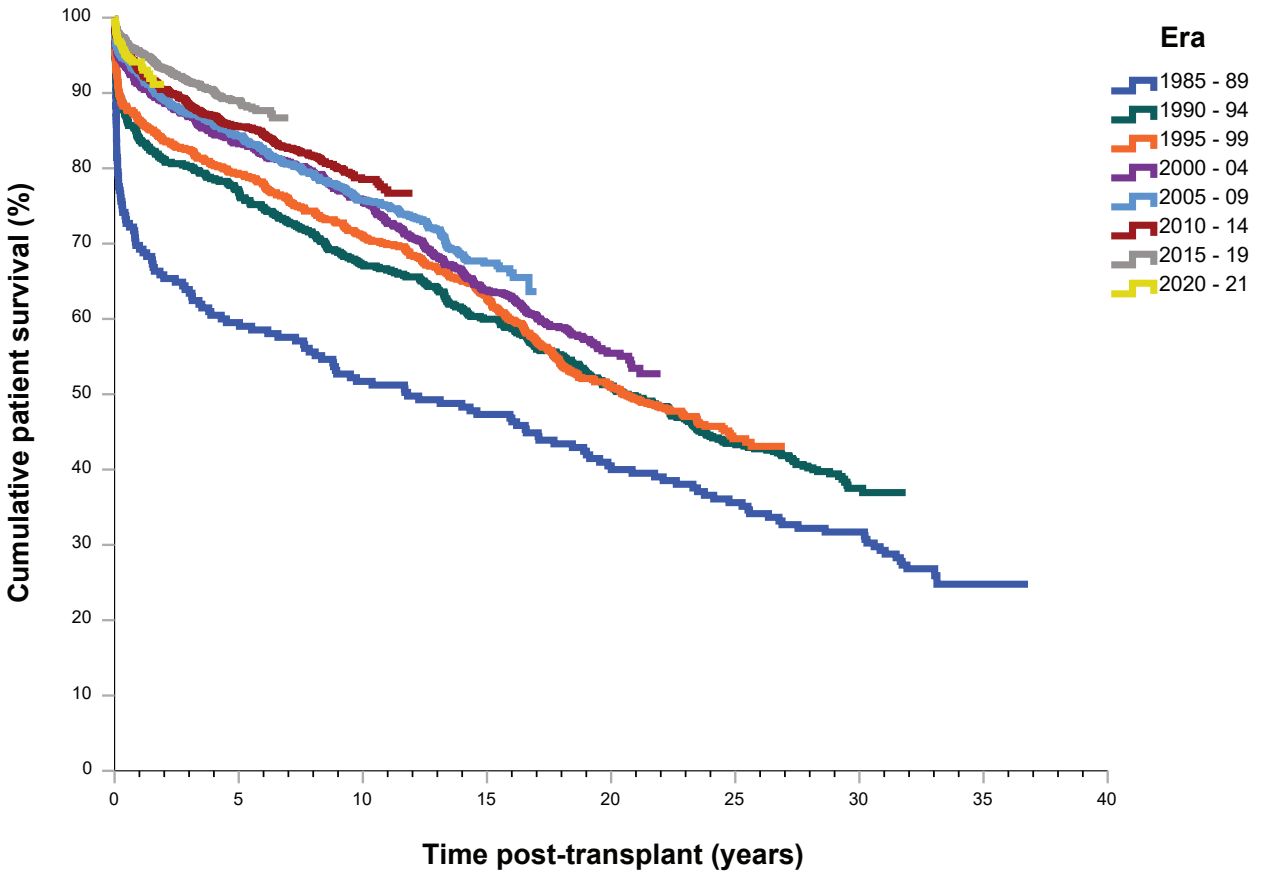


Table 14. Patient survival by transplant era

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	83	65	5	0
	Survival (%)		70%	64%	60%	52%	41%	32%	25%	
1990 - 94	No. at risk	552	463	443	425	371	282	72	0	
	Survival (%)		84%	80%	77%	67%	51%	38%		
1995 - 99	No. at risk	697	602	575	552	495	355	0		
	Survival (%)		86%	83%	79%	71%	51%			
2000 - 04	No. at risk	860	785	747	716	652	161	0		
	Survival (%)		91%	87%	83%	76%	55%			
2005 - 09	No. at risk	962	891	839	811	729	0			
	Survival (%)		93%	87%	84%	76%				
2010 - 14	No. at risk	1,228	1,143	1,085	1,050	352	0			
	Survival (%)		93%	88%	86%	79%				
2015 - 19	No. at risk	1,617	1,544	1,165	562	0				
	Survival (%)		96%	92%	89%					
2020 - 21	No. at risk	579	285	0						
	Survival (%)		94%							

11.6 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 31, Table 15). Paediatric patient survival in the most recent era was 100% at 1 year, 96.5% at 3 years, 96.5% at 5 years and 90.2% at 10 years. Median paediatric patient survival was not reached for all eras other than 1985 – 89 who had a median survival of 20.8 years.

Figure 31. Paediatric patient survival curve by era of transplant

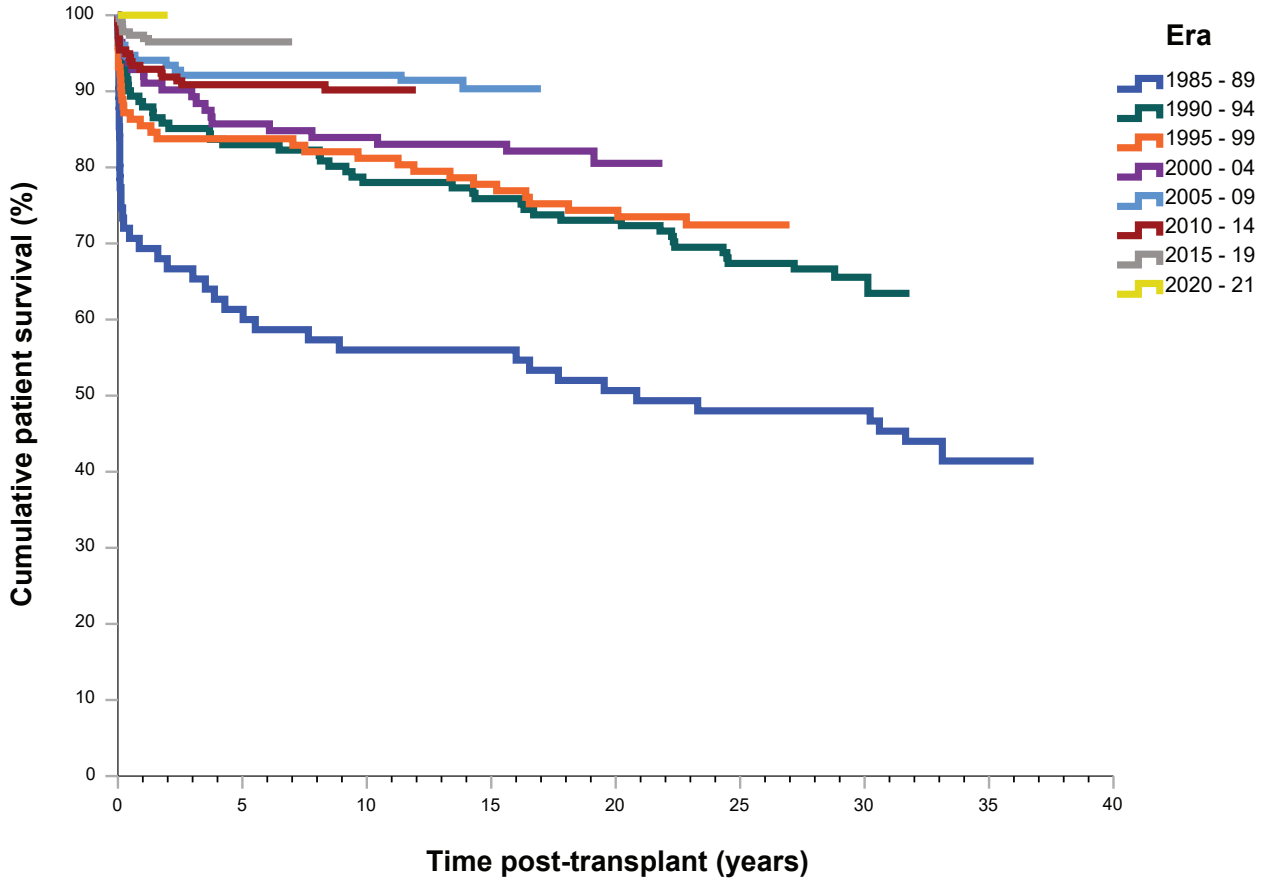


Table 15. Paediatric patient survival by transplant era

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	38	36	2	0
	Survival (%)		69%	67%	61%	56%	51%	48%	41%	
1990 - 94	No. at risk	141	124	120	117	110	103	35	0	
	Survival (%)		88%	85%	83%	78%	73%	66%		
1995 - 99	No. at risk	117	100	98	98	95	87	0		
	Survival (%)		86%	84%	84%	81%	74%			
2000 - 04	No. at risk	112	104	100	96	94	31	0		
	Survival (%)		93%	89%	86%	84%	81%			
2005 - 09	No. at risk	152	143	140	140	140	0			
	Survival (%)		94%	92%	92%	92%				
2010 - 14	No. at risk	197	183	179	179	67	0			
	Survival (%)		93%	91%	91%	90%				
2015 - 19	No. at risk	228	222	174	90	0				
	Survival (%)		97%	97%	97%					
2020 - 21	No. at risk	70	43	0						
	Survival (%)		100%							

11.7 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 32, Table 16). Patient survival in the most recent era was 93.3% at 1 year, 90.7% at 3 years, 87.7% at 5 years and 76.3% at 10 years. Median adult patient survival was not reached for recent eras since 2005 and was 20.8 years for 2000 – 04, 17.9 years for 1995 – 99, 17.0 years for 1990 – 94 and 9.5 years for 1985 – 89.

Figure 32. Adult patient survival curve by era of transplant

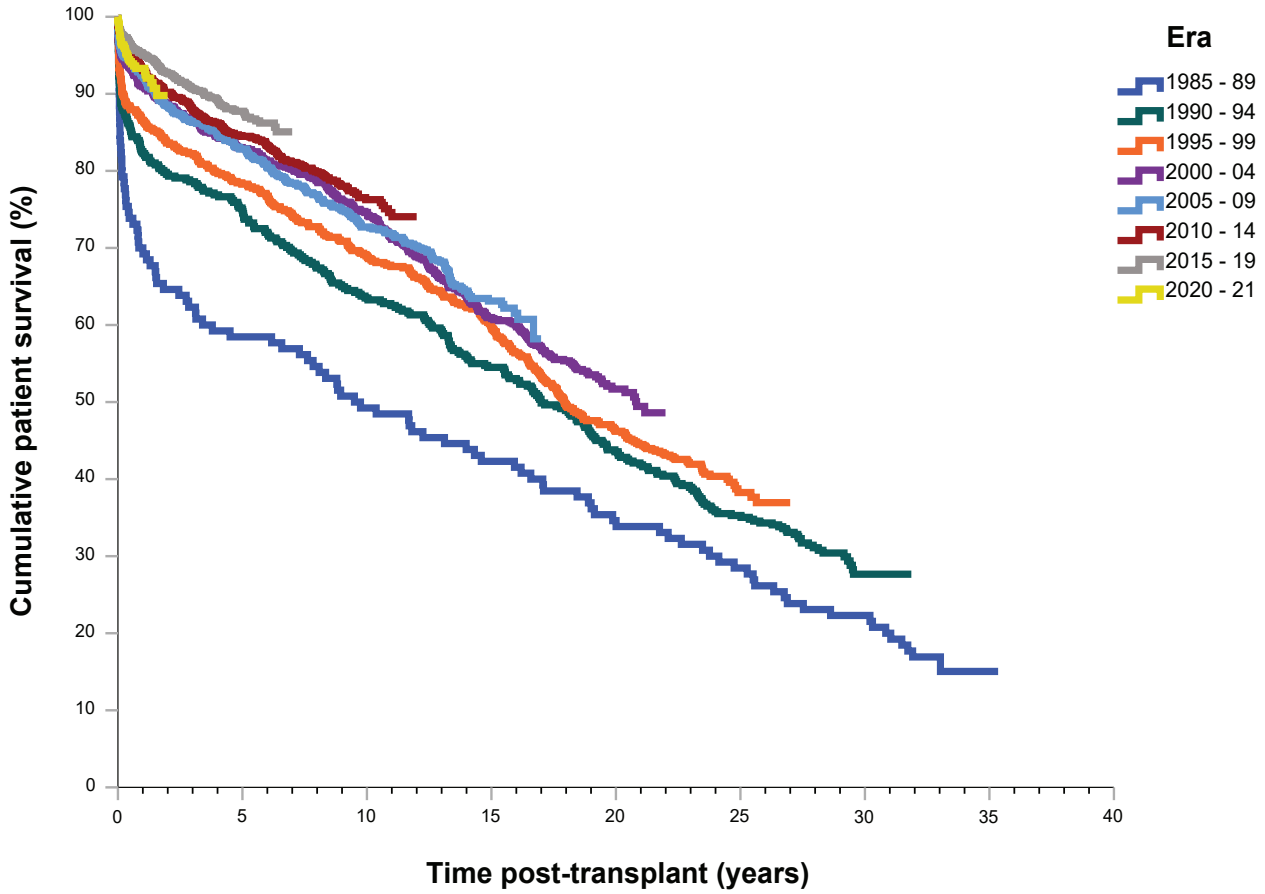


Table 16. Adult patient survival by transplant era

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	45	29	3	0
	Survival (%)		70%	62%	59%	49%	35%	22%	15%	
1990 - 94	No. at risk	411	339	323	308	261	179	37	0	
	Survival (%)		83%	79%	75%	64%	44%	28%		
1995 - 99	No. at risk	580	502	477	454	400	268	0		
	Survival (%)		87%	82%	78%	69%	46%			
2000 - 04	No. at risk	748	681	647	620	558	130	0		
	Survival (%)		91%	87%	83%	75%	52%			
2005 - 09	No. at risk	810	748	699	671	589	0			
	Survival (%)		92%	86%	83%	73%				
2010 - 14	No. at risk	1,031	960	906	871	285	0			
	Survival (%)		93%	88%	85%	76%				
2015 - 19	No. at risk	1,389	1,322	991	472	0				
	Survival (%)		95%	91%	88%					
2020 - 21	No. at risk	509	242	0						
	Survival (%)		93%							

11.8 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 33, Table 17). 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, 90.0% for living donor grafts, 86.3% for whole liver grafts and 76.9% for reduced grafts. Median paediatric patient survival was not reached for all graft types.

Figure 33. Paediatric patient survival curve by type of primary graft

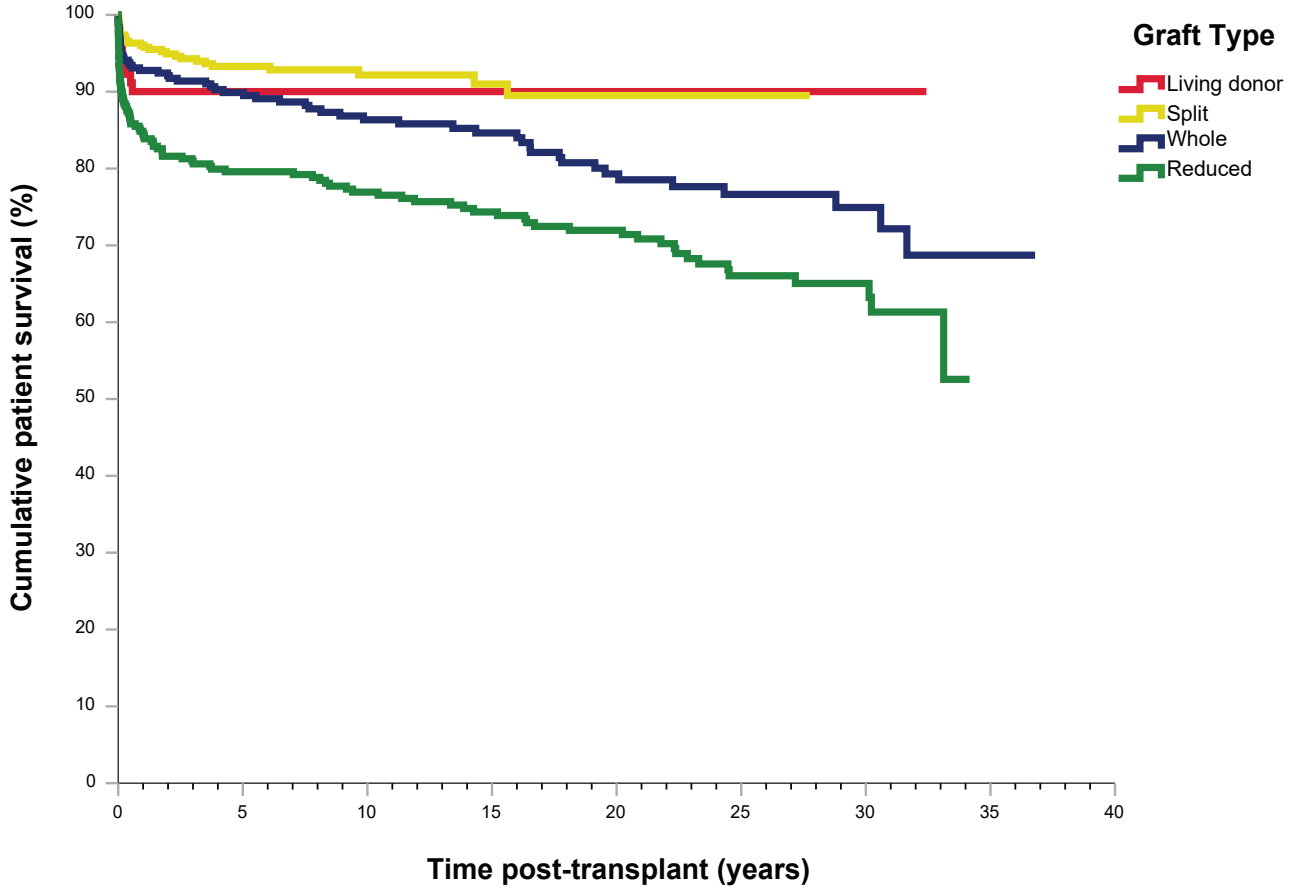


Table 17. Paediatric patient survival by type of primary graft

Graft Type Category	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Living donor	No. at risk	91	79	72	68	48	3	2	0	
	Survival (%)		90%	90%	90%	90%	90%	90%		
Split	No. at risk	383	355	292	240	132	18	0		
	Survival (%)		96%	94%	93%	92%	90%			
Whole	No. at risk	306	276	253	228	174	105	31	2	0
	Survival (%)		93%	91%	90%	86%	79%	75%	69%	
Reduced	No. at risk	311	260	243	229	193	133	38	0	
	Survival (%)		85%	81%	80%	77%	72%	65%		

11.9 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 = 0.305, Figure 34, Table 18). Ten-year patient survival was 79.8% for living donor grafts, 77.3% for split grafts, 73.1% for whole grafts, 55.3% for reduced grafts and 0 for domino grafts. Median adult patient survival was not reached for split, living and reduced donor grafts and was 20.0 years for whole grafts and 9.4 years for domino grafts.

Figure 34. Adult patient survival curve by type of primary graft

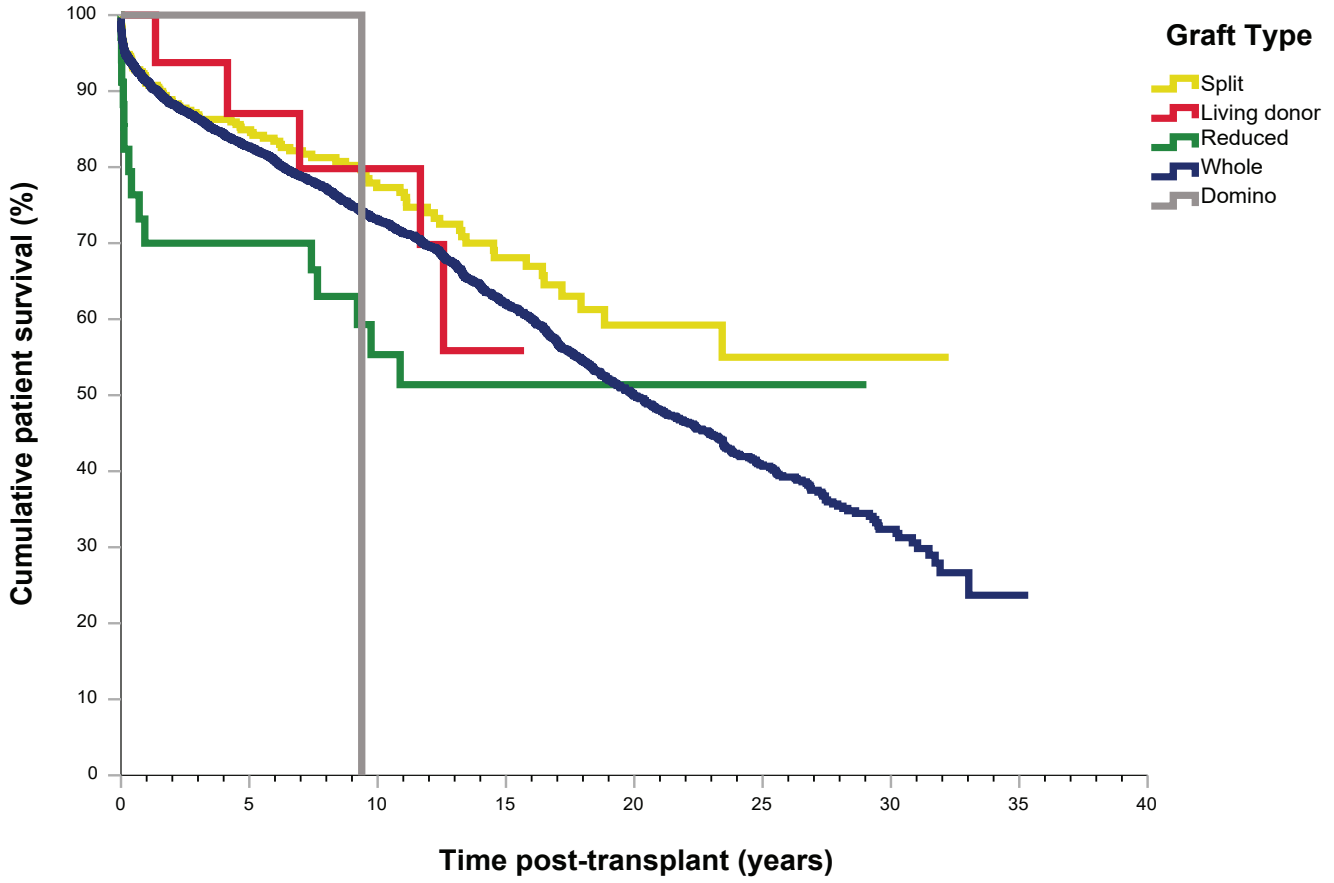


Table 18. Adult patient survival by type of primary graft

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	14	12	11	0			
	Survival (%)		100%	94%	87%	80%				
Split	No. at risk	407	354	289	238	129	21	2	0	
	Survival (%)		91%	87%	85%	77%	59%	55%		
Reduced	No. at risk	34	22	21	20	14	9	0		
	Survival (%)		70%	70%	70%	55%	51%			
Whole	No. at risk	5,147	4,489	3,796	3,198	2,003	592	64	3	0
	Survival (%)		91%	86%	83%	73%	50%	32%	24%	
Domino	No. at risk	4	4	4	4	0				
	Survival (%)		100%	100%	100%					

11.10 Paediatric Patient Survival by Weight

There was no significant difference in patient survival of children of different weights (P = 0.577, Figure 35 and Table 19). Ten-year paediatric patient survival was 89.1% for children over 20 kg, 85.4% for children weighing between 8.01 and 20 kg, 82.8% for children between 5 and 8 kg and 79.4% for children under 5 kg. Median paediatric patient survival was not reached for all weight categories.

Figure 35. Paediatric patient survival curve by transplant weight

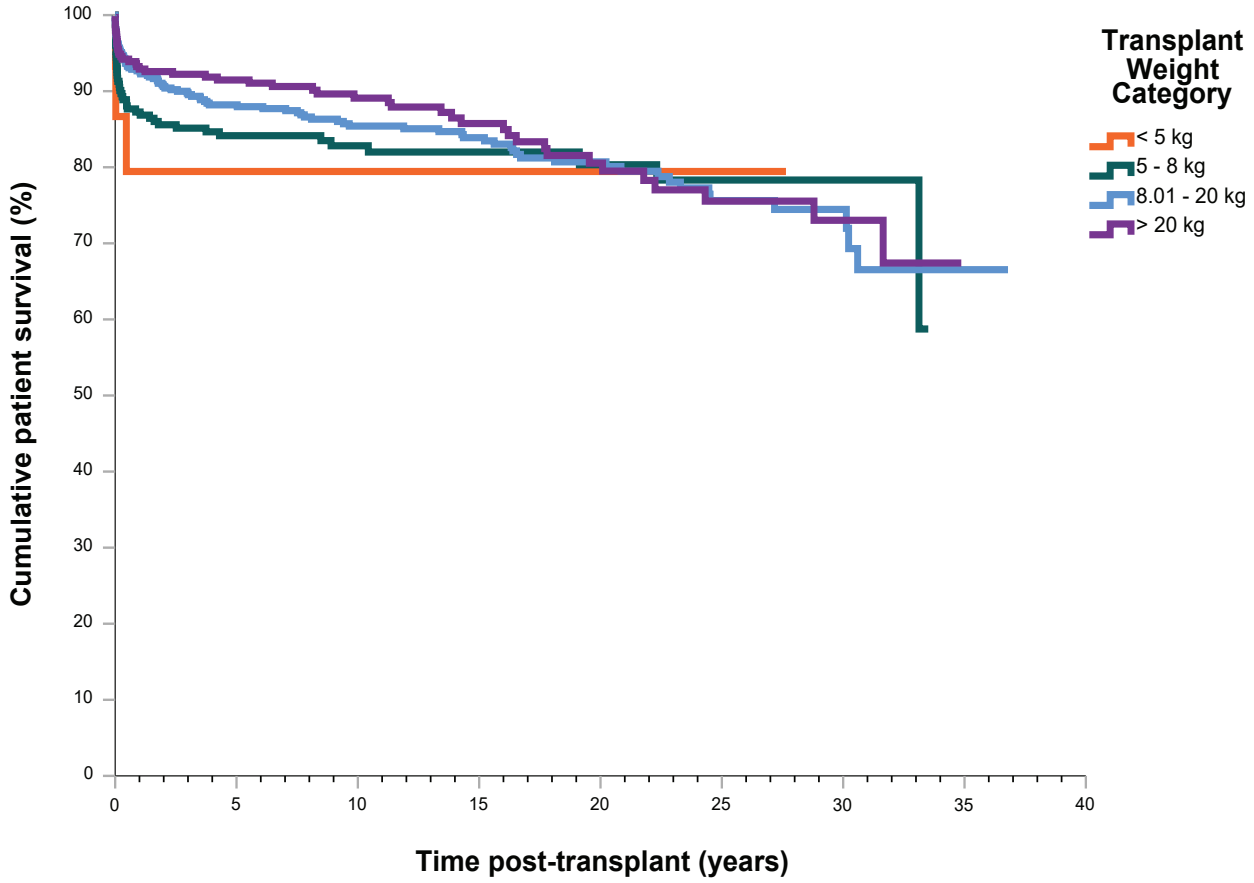


Table 19. Paediatric patient survival by transplant weight

Transplant weight	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
< 5 kg	No. at risk	15	11	10	7	5	2	0		
	Survival (%)		79%	79%	79%	79%	79%			
5 - 8 kg	No. at risk	253	214	187	156	106	44	17	0	
	Survival (%)		87%	85%	84%	83%	80%	78%		
8.01 - 20 kg	No. at risk	509	460	406	371	274	135	33	2	0
	Survival (%)		93%	90%	88%	85%	81%	75%	67%	
> 20 kg	No. at risk	311	283	256	231	163	78	21	0	
	Survival (%)		93%	92%	92%	89%	81%	73%		

11.11 Paediatric Patient Survival by Primary Disease

There was no significant difference in patient survival between different disease categories in children (P = 0.076, Figure 36, Table 20). Children with fulminant hepatic failure had the poorest ten-year survival of 77.3%. Children with hepatoblastoma had a ten-year survival of 81.4%. All other paediatric disease categories had an 86% or higher 10-year survival. Median patient survival was 31.6 years for children with other diseases, 27.2 years for children with progressive familial intrahepatic cholestasis and was not reached for all other disease groups.

Figure 36. Paediatric patient survival curve by primary disease

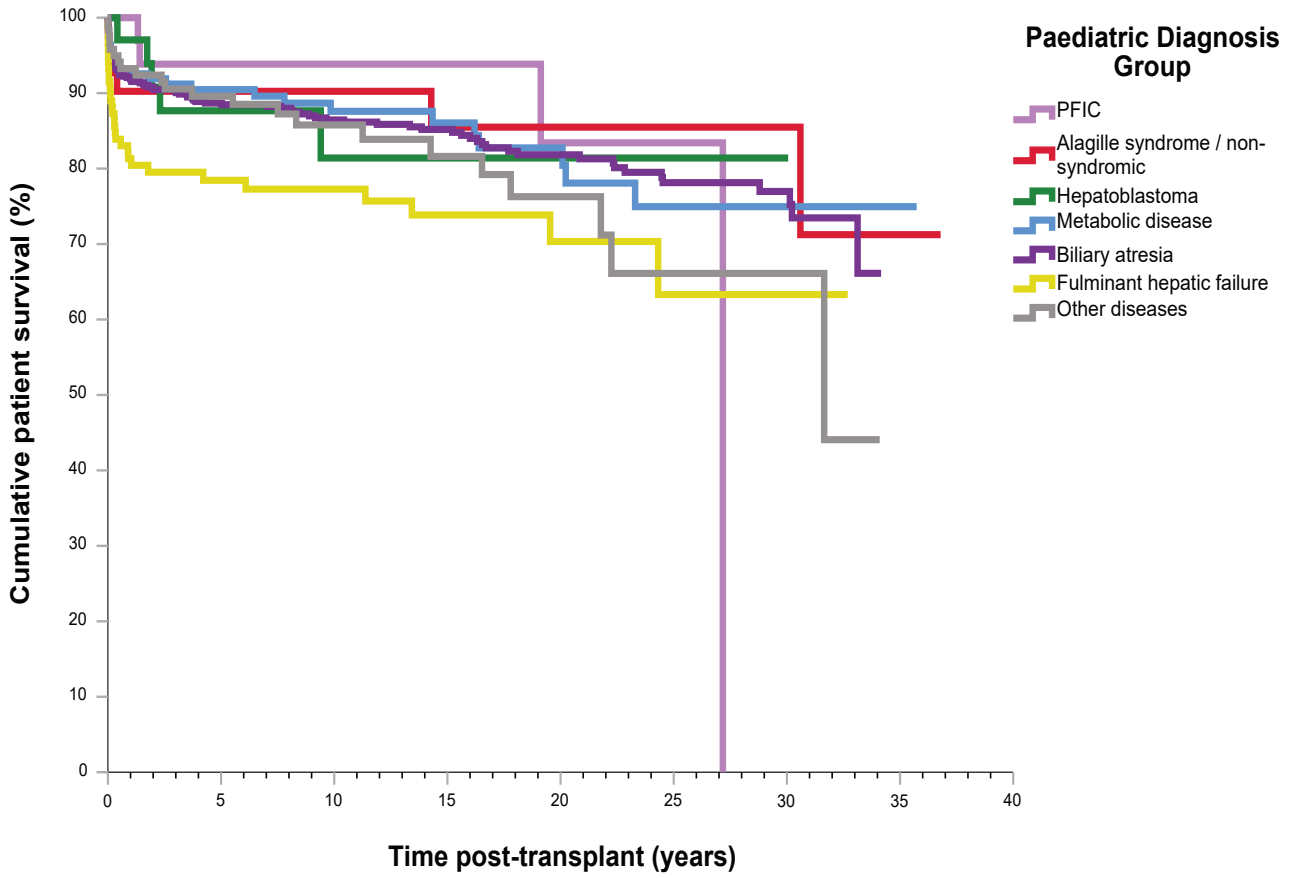


Table 20. Paediatric patient survival by primary disease

Primary Diagnosis	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
PFIC	No. at risk	33	33	26	20	16	5	0		
	Survival (%)		100%	94%	94%	94%	83%			
Alagille syndrome / non-syndromic	No. at risk	41	37	35	33	22	17	7	1	0
	Survival (%)		90%	90%	90%	90%	86%	86%	71%	
Hepatoblastoma	No. at risk	34	32	27	24	12	2	1	0	
	Survival (%)		97%	88%	88%	81%	81%	81%		
Metabolic Diseases	No. at risk	163	146	127	113	81	37	8	1	0
	Survival (%)		93%	91%	91%	88%	83%	75%	75%	
Biliary atresia	No. at risk	584	521	468	417	314	159	48	0	
	Survival (%)		92%	90%	89%	86%	82%	77%		
Fulminant hepatic failure	No. at risk	118	93	80	71	54	20	3	0	
	Survival (%)		81%	80%	78%	77%	70%	63%		
Other Diseases	No. at risk	119	109	98	88	49	19	4	0	
	Survival (%)		93%	91%	90%	86%	76%	66%		

Abbreviation: PFIC, Progressive familial intrahepatic cholestasis

11.12 Adult Patient Survival by Primary Disease

There was a significant difference in the survival between different disease categories in adults (P = 0.005, Figure 37, Table 21). Patients with hepatocellular carcinoma, hepatitis C virus cirrhosis and non-alcoholic fatty liver disease / cryptogenic cirrhosis had the poorest 10-year patient survival (67.6%, 70.2% and 72.3%, respectively), while those with alcohol-related cirrhosis, hepatitis C virus cirrhosis and NAFLD / cryptogenic cirrhosis had the poorest median survival (17.1 years, 18.3 years and 18.8 years, respectively). Patients with fulminant hepatic failure had poorer early survival than other diagnoses (1-year patient survival 83.7%), but long-term survival was similar to patients transplanted for other diagnoses.

Figure 37. Adult patient survival curve by primary disease

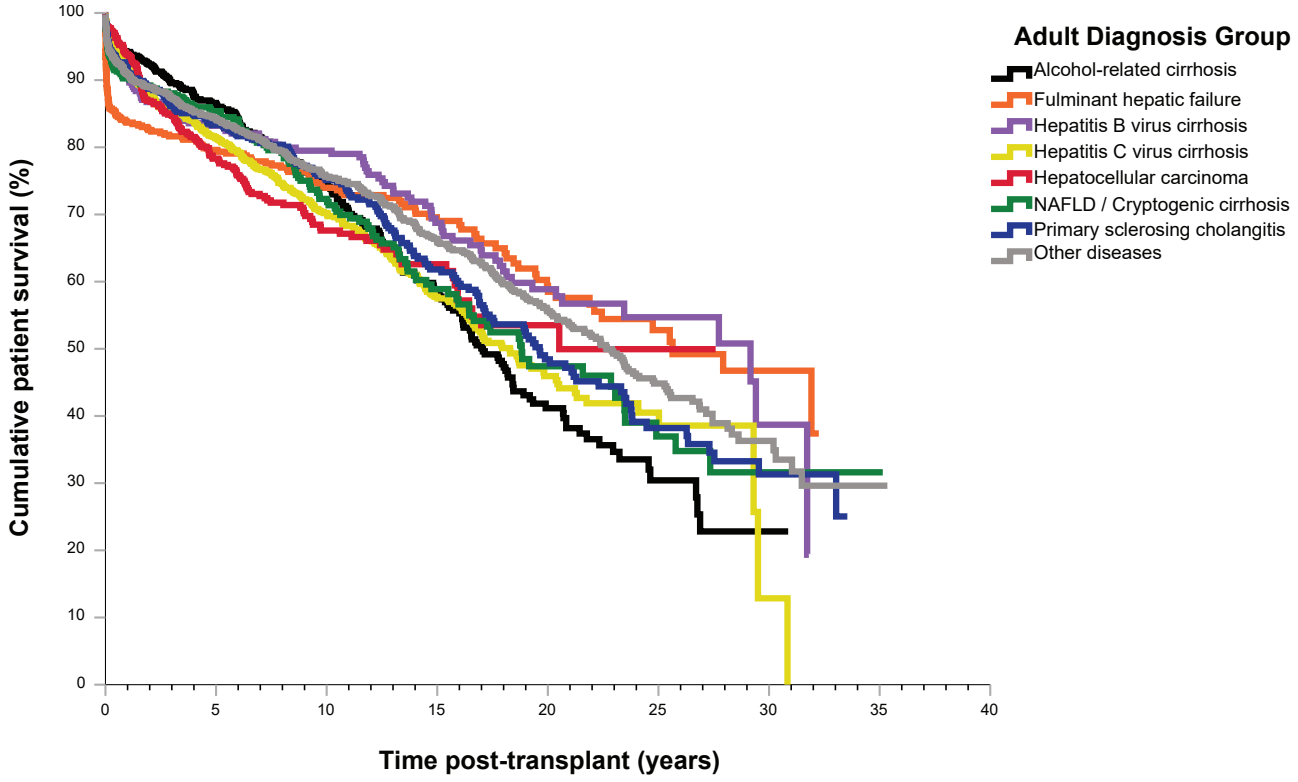


Table 21. Adult patient survival by primary disease

Primary Diagnosis	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Alcohol-related cirrhosis	No. at risk	788	689	559	457	270	60	1	0	
	Survival (%)		94%	90%	86%	75%	41%	23%		
Fulminant hepatic failure	No. at risk	493	390	336	303	212	67	10	0	
	Survival (%)		84%	82%	80%	74%	59%	47%		
Hepatocellular carcinoma	No. at risk	701	615	473	339	152	20	0		
	Survival (%)		94%	85%	78%	68%	54%			
Hepatitis B virus cirrhosis	No. at risk	321	285	244	217	168	57	4	0	
	Survival (%)		90%	85%	83%	80%	59%	39%		
Hepatitis C virus cirrhosis	No. at risk	1,126	1,022	903	792	458	80	1	0	
	Survival (%)		92%	86%	81%	70%	46%	13%		
NAFLD / Cryptogenic cirrhosis	No. at risk	523	434	355	289	154	40	6	1	0
	Survival (%)		90%	88%	85%	72%	47%	32%	32%	
Primary sclerosing cholangitis	No. at risk	561	496	423	365	245	80	16	1	0
	Survival (%)		92%	86%	83%	75%	48%	31%	25%	
Other diseases	No. at risk	1,095	954	831	710	498	218	28	2	0
	Survival (%)		91%	87%	84%	76%	56%	36%	30%	

Abbreviation: NAFLD, non-alcoholic fatty liver disease

11.13 Patient Survival by Age Group with Fulminant Hepatic Failure – All Diagnoses

There was no significant difference in the survival between adults and children with fulminant hepatic failure as a primary diagnosis or other diagnosis (P = 0.304, Figure 38 and Table 22). Ten-year patient survival was 77.8% for children and 74.4% for adults. Median patient survival was not reached for children and was 25.6 years for adults.

Figure 38. Patient survival curve by age group with fulminant hepatic failure – all diagnoses

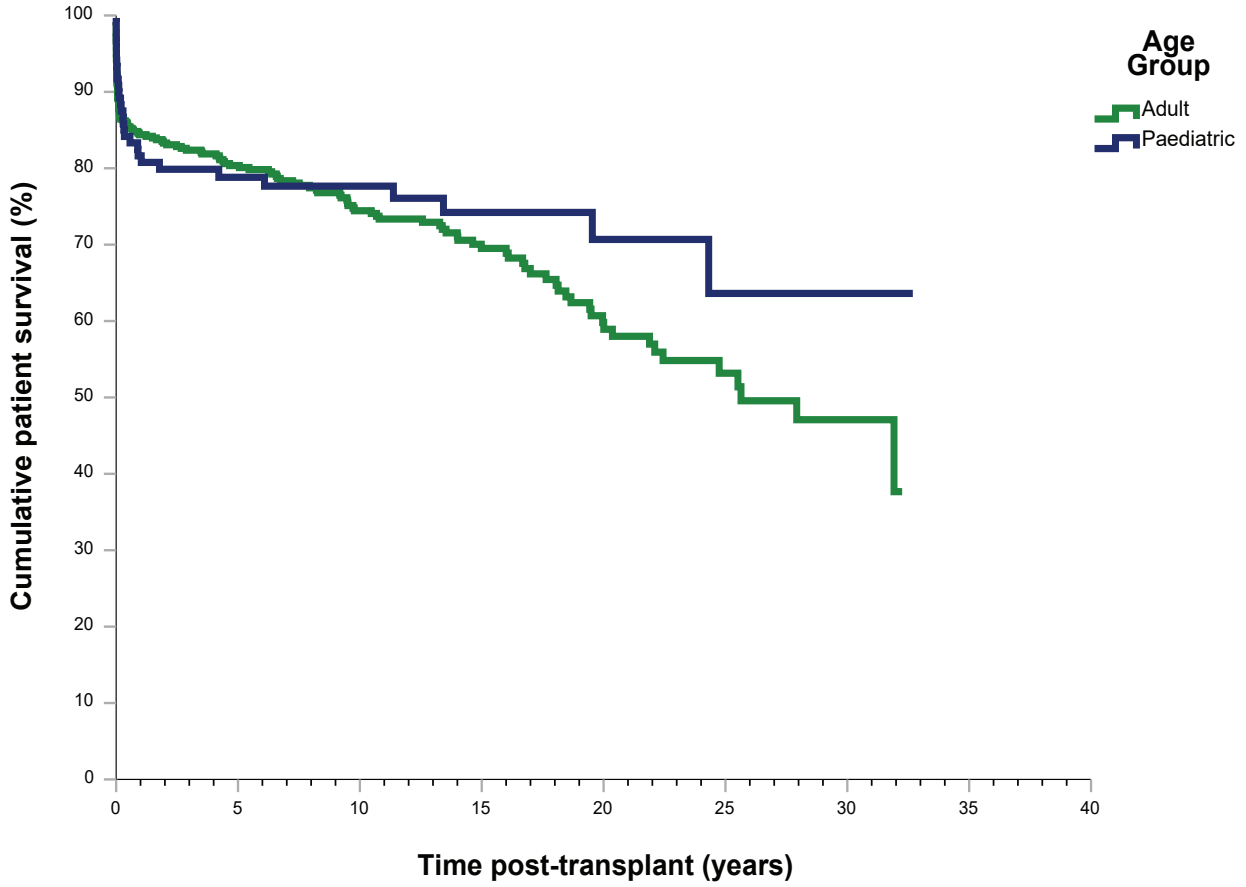


Table 22. Patient survival by age group with fulminant hepatic failure – all diagnoses

Primary Diagnosis	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Paediatric	No. at risk	120	95	82	73	55	20	3	0	
	Survival (%)		82%	80%	79%	78%	71%	64%		
Adult	No. at risk	517	401	342	307	214	67	10	0	
	Survival (%)		84%	82%	80%	74%	60%	47%		

11.14 Patient Survival by Transplant Era with Hepatitis B Virus Cirrhosis – All Diagnoses

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 39, Table 23). Patient survival in the most recent era was 93.8% at 1 year, 93.1% at 3 years, 87.5% at 5 years and 82.1% at 10 years. Median patient survival was not reached for the recent eras since 2000 and was 27.7 years for 1990 – 94, 20.4 years for 1995 – 99 and 0.6 years for 1985 – 89.

Figure 39. Patient survival curve by transplant era with hepatitis B virus cirrhosis – all diagnoses

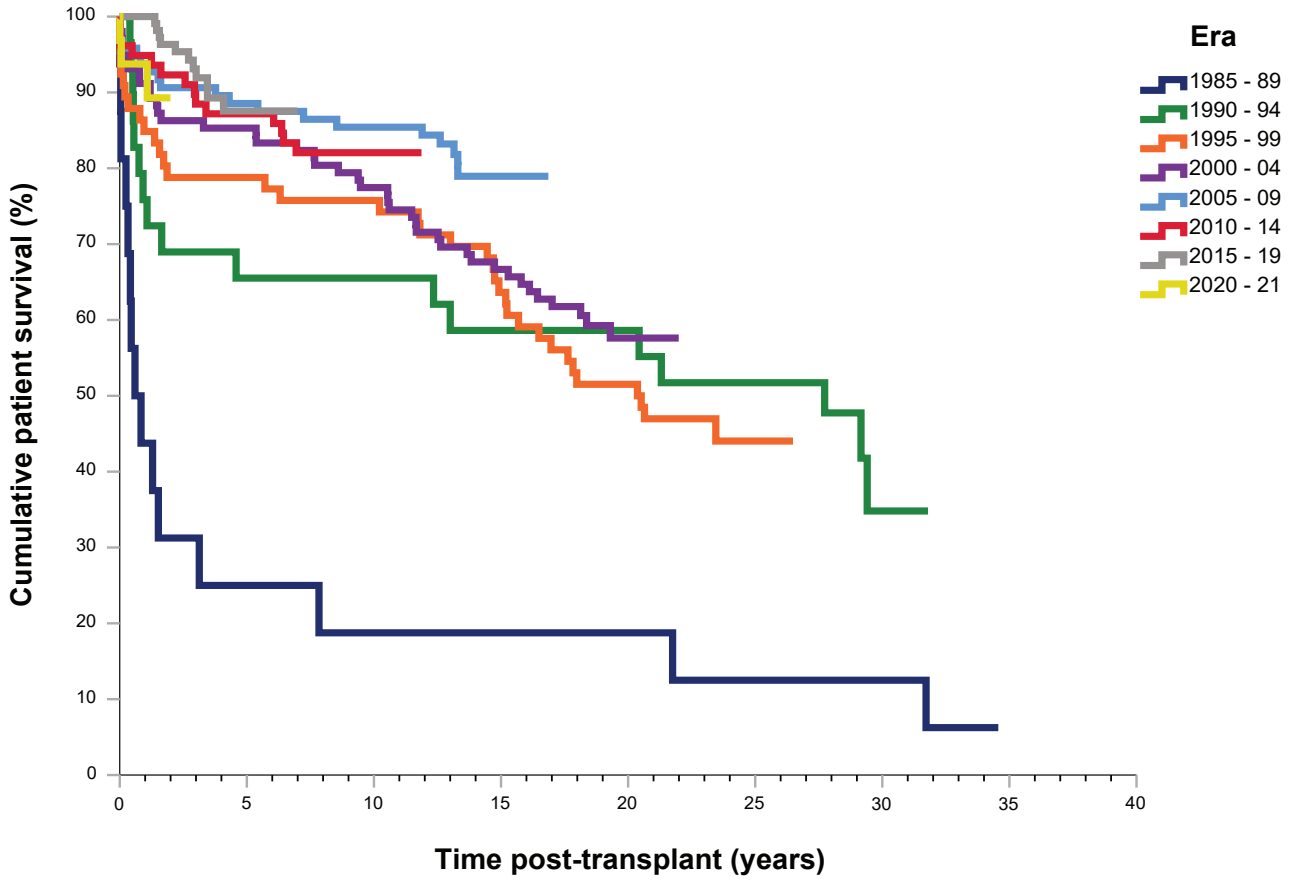


Table 23. Patient survival by transplant era with hepatitis B virus cirrhosis – all diagnoses

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	0	
	Survival (%)		44%	31%	25%	19%	19%	13%		
1990 - 94	No. at risk	29	22	20	19	19	17	3	0	
	Survival (%)		76%	69%	66%	66%	59%	35%		
1995 - 99	No. at risk	66	56	52	52	50	34	0		
	Survival (%)		85%	79%	79%	76%	52%			
2000 - 04	No. at risk	102	93	88	87	79	28	0		
	Survival (%)		91%	86%	85%	78%	58%			
2005 - 09	No. at risk	96	90	87	85	82	0			
	Survival (%)		94%	91%	89%	85%				
2010 - 14	No. at risk	78	74	69	68	27	0			
	Survival (%)		95%	89%	87%	82%				
2015 - 19	No. at risk	109	109	79	33	0				
	Survival (%)		100%	93%	88%					
2020 - 21	No. at risk	32	22	0						
	Survival (%)		94%							

11.15 Patient Survival by Transplant Era with Hepatitis C Virus Cirrhosis – All Diagnoses

Patient survival after transplantation for hepatitis C virus cirrhosis as a primary diagnosis or other diagnosis varied over transplant eras with the best 3-year survival (100%) in 1985 - 89 and the best 5-year survival (85.0%) in 2015 - 19 (P = 0.003, Figure 40 and Table 24). Median patient survival was not reached for the recent eras since 2010 and was 20.4 years for 2000 - 04, 17.1 years for 1985 – 89, 16.7 years for 2005 – 09, 14.5 years for 1995 – 99 and 12.9 years for 1990 – 94.

Figure 40. Patient survival curve by transplant era with hepatitis C virus cirrhosis – all diagnoses

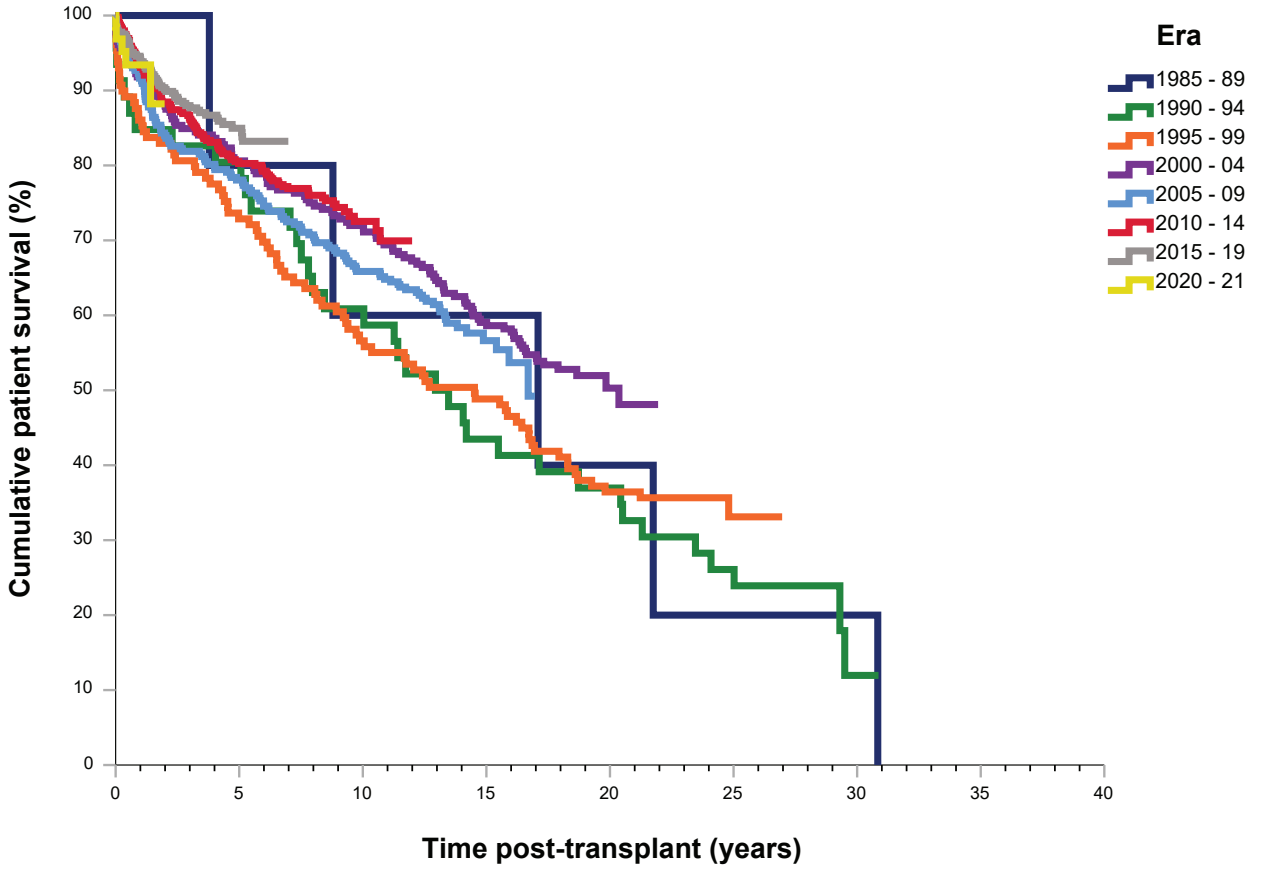


Table 24. Patient survival curve by transplant era with hepatitis C virus cirrhosis – all diagnoses

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	46	39	38	37	28	17	2	0	
	Survival (%)		85%	83%	80%	61%	37%	12%		
1995 - 99	No. at risk	129	111	104	94	73	47	0		
	Survival (%)		86%	81%	73%	57%	36%			
2000 - 04	No. at risk	232	213	197	187	167	27	0		
	Survival (%)		92%	85%	81%	72%	50%			
2005 - 09	No. at risk	287	263	235	224	189	0			
	Survival (%)		92%	82%	78%	66%				
2010 - 14	No. at risk	390	364	336	313	90	0			
	Survival (%)		93%	86%	80%	73%				
2015 - 19	No. at risk	405	382	295	153	0				
	Survival (%)		94%	88%	85%					
2020 - 21	No. at risk	65	35	0						
	Survival (%)		93%							

11.16 Patient Survival with Hepatocellular Carcinoma by Era of Transplant – All Diagnoses

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 41, Table 25). Patient survival in the most recent era was 92.7% at 1 year, 88.7% at 3 years, 84.5% at 5 years and 72.3% at 10 years. Median patient survival was not reached for the recent eras since 2005 and was 19.8 years for 2000 – 04, 14.5 years for 1995 – 99, 5.0 years for 1990 – 94 and 1.5 years for 1985 – 89.

Figure 41. Patient survival curve with a diagnosis of hepatocellular carcinoma by transplant era – all diagnoses

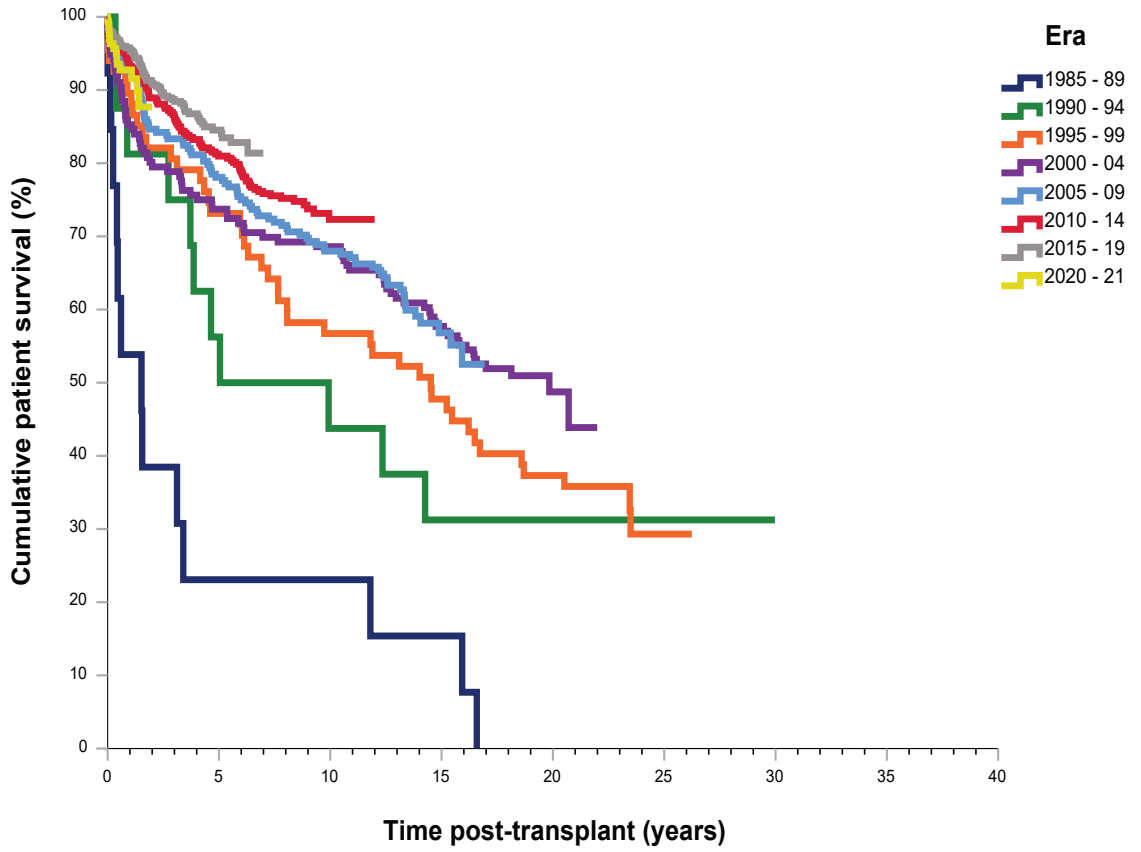


Table 25. Patient survival curve with a diagnosis of hepatocellular carcinoma by transplant era – all diagnoses

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	16	13	12	9	7	5	0		
	Survival (%)		81%	75%	56%	44%	31%			
1995 - 99	No. at risk	67	60	54	49	38	25	0		
	Survival (%)		90%	81%	73%	57%	37%			
2000 - 04	No. at risk	156	133	123	115	107	22	0		
	Survival (%)		85%	79%	74%	69%	49%			
2005 - 09	No. at risk	228	211	190	178	155	0			
	Survival (%)		93%	83%	78%	68%				
2010 - 14	No. at risk	352	329	303	285	88	0			
	Survival (%)		94%	86%	81%	72%				
2015 - 19	No. at risk	495	474	355	169	0				
	Survival (%)		96%	89%	85%					
2020 - 21	No. at risk	168	83							
	Survival (%)		93%							

11.17 Paediatric Patient Survival with Diagnosis of Malignancy – All Diagnoses

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 = 0.048, Figure 42 and Table 26). Ten-year paediatric patient survival was 100% for cholangiocarcinoma and histiocytosis X, 82.2% for hepatoblastoma and 64.7% 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 42. Paediatric patient survival curve with a malignancy diagnosis – all diagnoses

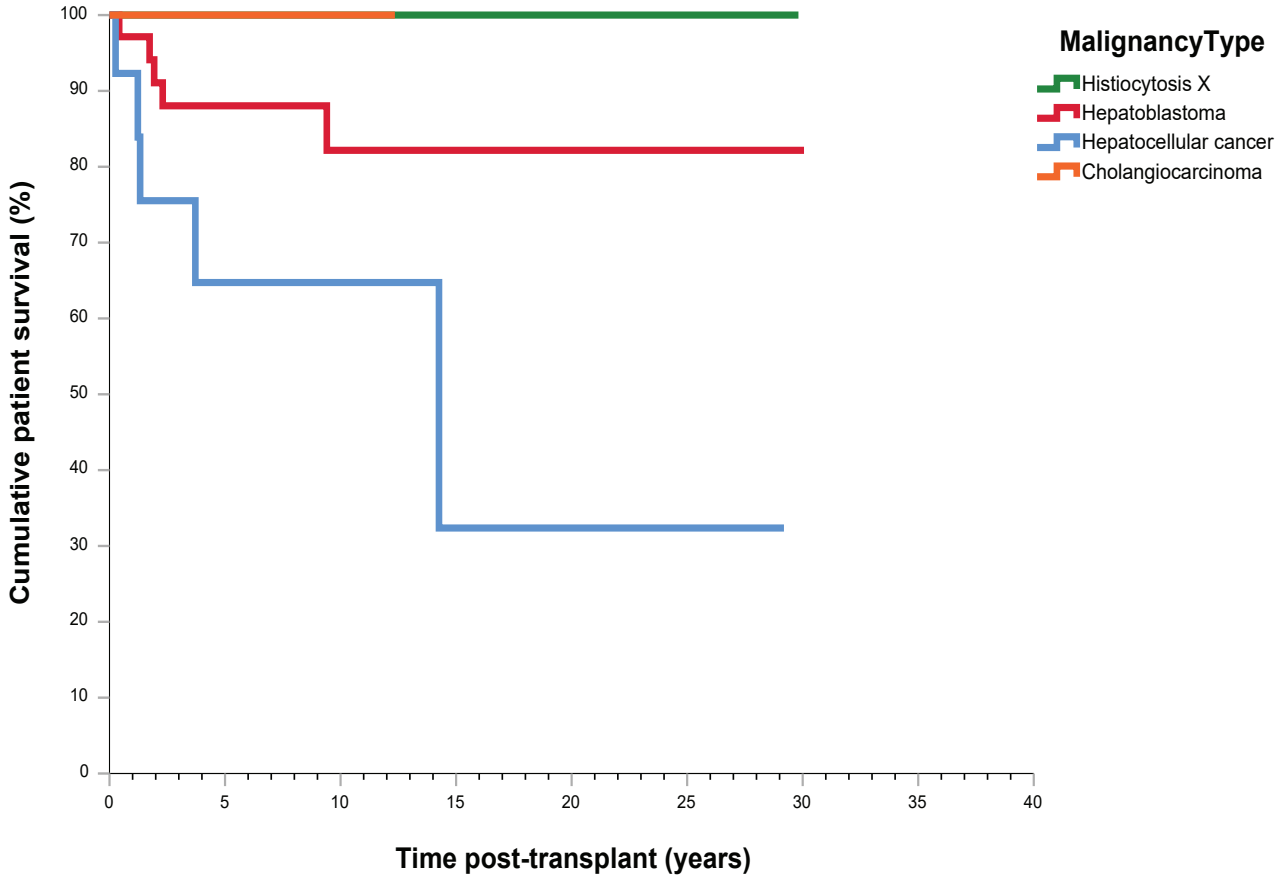


Table 26. Paediatric patient survival with malignancy diagnosis – all diagnoses

Primary Diagnosis	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Cholangio-carcinoma	No. at risk	3	3	3	2	2	0			
	Survival (%)		100%	100%	100%	100%				
Histiocytosis X	No. at risk	6	6	6	6	4	2	0		
	Survival (%)		100%	100%	100%	100%	100%			
Hepatoblastoma	No. at risk	35	33	28	25	13	3	1	0	
	Survival (%)		97%	88%	88%	82%	82%	82%		
Hepatocellular carcinoma	No. at risk	14	11	9	6	2	1	0		
	Survival (%)		92%	76%	65%	65%	32%			

11.18 Adult Patient Survival with a Diagnosis of Malignancy – All Diagnoses

Adult patient survival after transplantation for malignancy as a primary or other diagnosis varied by diagnosis (P <0.001, Figure 43 and Table 27). Ten-year patient survival was 100% for hepatoblastoma and histiocytosis X (only one patient each), 70.3% for hepatocellular carcinoma, 69.3% for epithelioid haemangio-endothelioma, 29.6% for cholangiocarcinoma, 0 for angiosarcoma and not reached for metastatic neuroendocrine tumours. Median adult patient survival was 18.7 years for hepatocellular carcinoma, 16.7 years for hepatoblastoma, 14.2 years for epithelioid haemangio-endothelioma, 3.2 years for cholangiocarcinoma, 3.1 years for metastatic neuroendocrine tumours and 0.8 years for angiosarcoma.

Figure 43. Adult patient survival curve with a malignancy diagnosis – all diagnoses

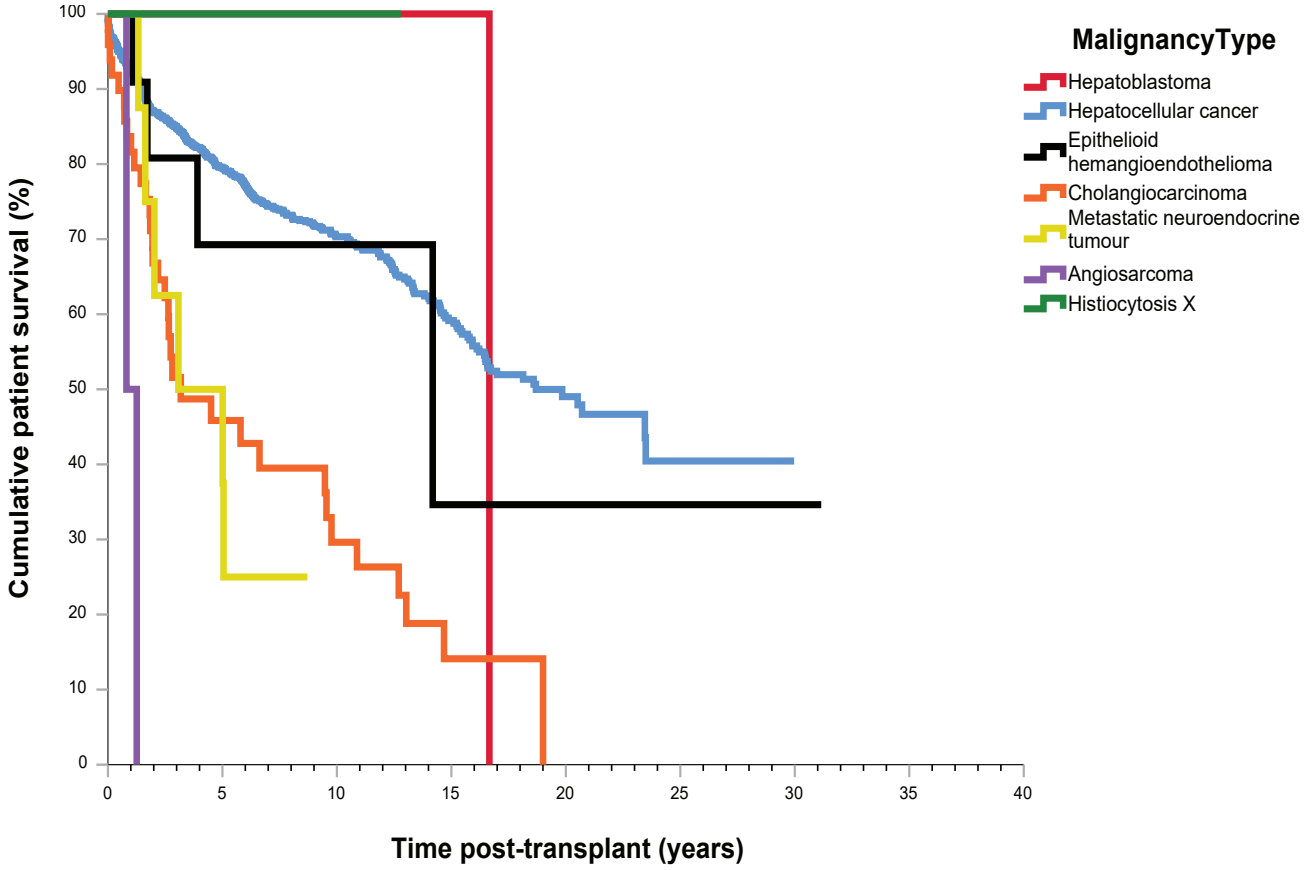


Table 27. Adult patient survival curve with a malignancy diagnosis - all diagnosis

Primary Diagnosis	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Histiocytosis X	No. at risk	1	1	1	1	1	0			
	Survival (%)		100%	100%	100%	100%				
Hepatoblastoma	No. at risk	1	1	1	1	1	0			
	Survival (%)		100%	100%	100%	100%				
Hepatocellular carcinoma	No. at risk	1,481	1,299	1,033	802	396	51	0		
	Survival (%)		92%	85%	80%	70%	49%			
Epithelioid haemangio-endothelioma	No. at risk	11	11	7	5	3	1	1	0	
	Survival (%)		100%	81%	69%	69%	35%	35%		
Cholangio-carcinoma	No. at risk	49	40	19	16	9	0			
	Survival (%)		84%	52%	46%	30%				
Metastatic neuroendocrine tumour	No. at risk	8	8	5	4	0				
	Survival (%)		100%	63%	50%					
Angiosarcoma	No. at risk	2	1	0						
	Survival (%)		50%							

12 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).

12.1 All Grafts Outcome

There were 7,266 grafts in 6,706 patients (Figure 44 and Table 28). Ten-year graft survival was 69.5% across all grafts. The median graft survival was 19.8 years.

Figure 44. Graft survival curve for all grafts

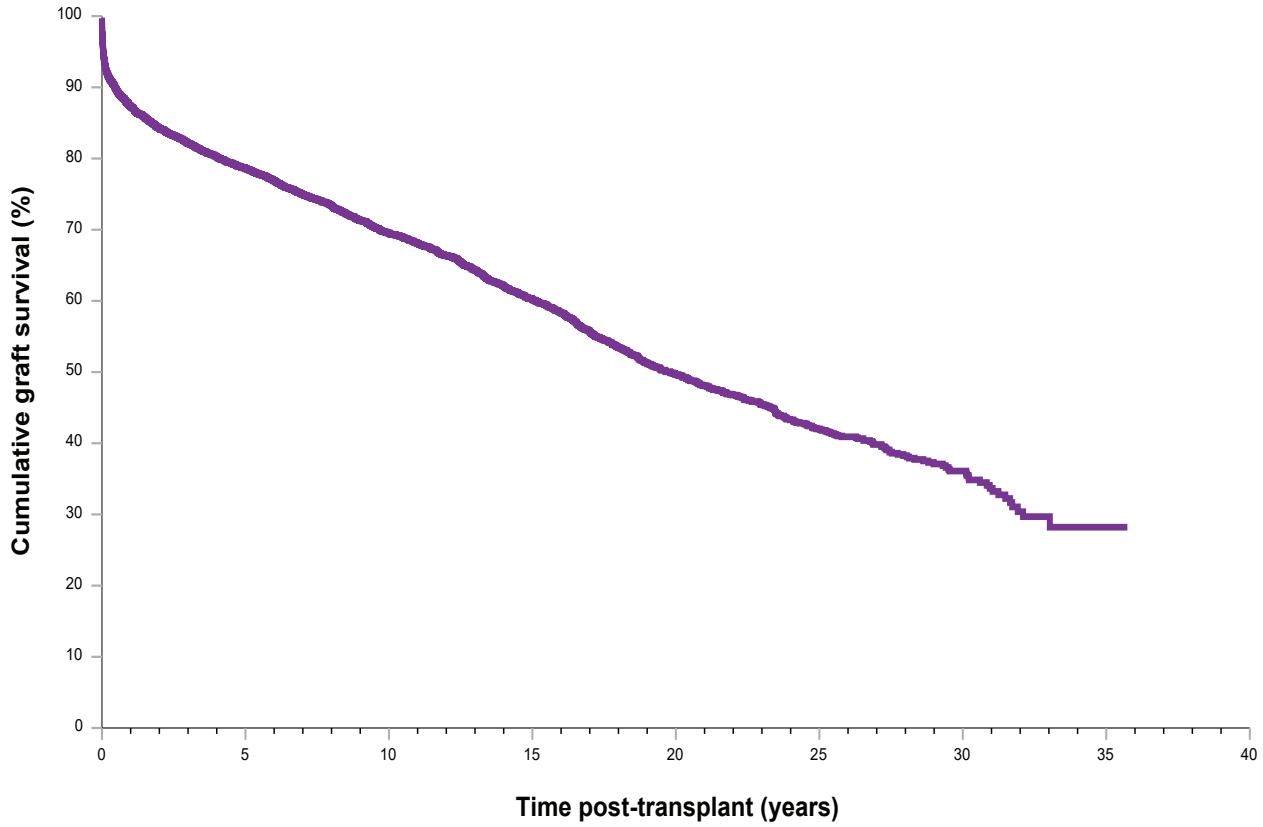


Table 28. Graft survival - all grafts

Graft Survival	Time post-transplant (years)								
	0	1	3	5	10	20	30	35	40
No. at risk	7,266	6,068	5,094	4,296	2,676	836	124	4	0
Survival (%)		87%	82%	79%	70%	50%	36%	28%	

12.2 Outcome of All Grafts by Age Group

A total of 1,247 transplants were performed in children and 6,019 in adults. Post-transplant graft survival was superior in the paediatric population (P < 0.001, Figure 45, Table 29). Ten-year graft survival was 73.6% for children and 68.6% for adults. Median graft survival was 31.6 years in children and 18.2 years in adults. Although 1-year survival was slightly worse in children (85.2% children versus 87.8% adults), the survival curve for children was subsequently flatter. However, there were several late graft losses occurring over 30 years after paediatric transplantation.

Figure 45. Graft survival curve for all grafts by age group

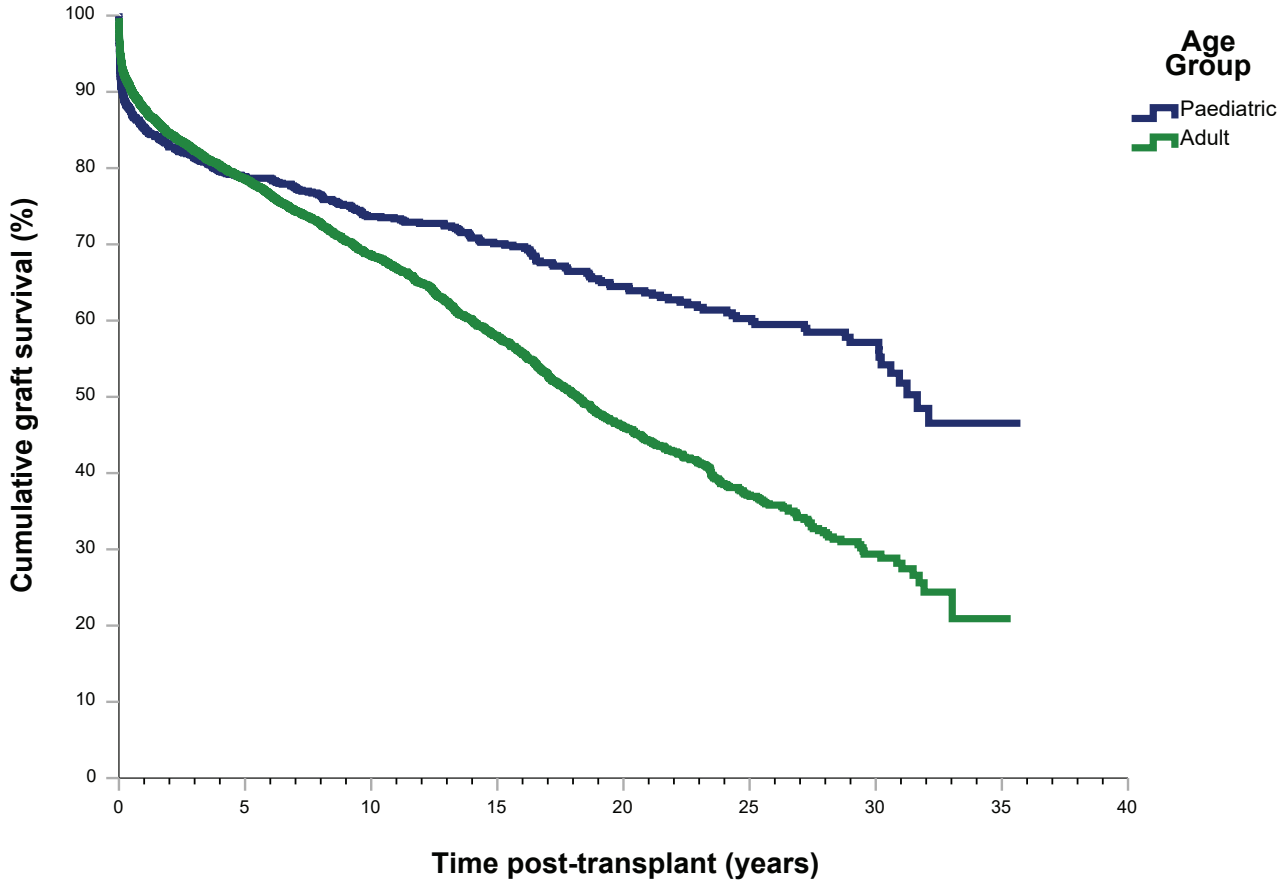


Table 29. Graft survival by age group - all grafts

Age Group	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Paediatric <16 years	No. at risk	1,247	1,029	888	776	531	238	63	1	0
	Survival (%)		85%	81%	79%	74%	65%	57%	47%	
Adult ≥16 years	No. at risk	6,019	5,039	4,206	3,502	2,145	598	61	3	0
	Survival (%)		88%	82%	79%	69%	46%	29%	21%	

12.3 Outcome by Graft Number

There was a significant difference in graft survival by graft number (P < 0.001, Figure 46 and Table 30). Ten-year graft survival was 70.5% for the first graft, 57.5% for the second graft, 64.0% for the third graft and not reached for the fourth graft. Median graft survival was 20.4 years for the first graft, 13.2 years for the second graft, 21.1 years for the third graft and 4.3 years for the fourth graft.

Figure 46. Graft survival curve for all grafts by graft number

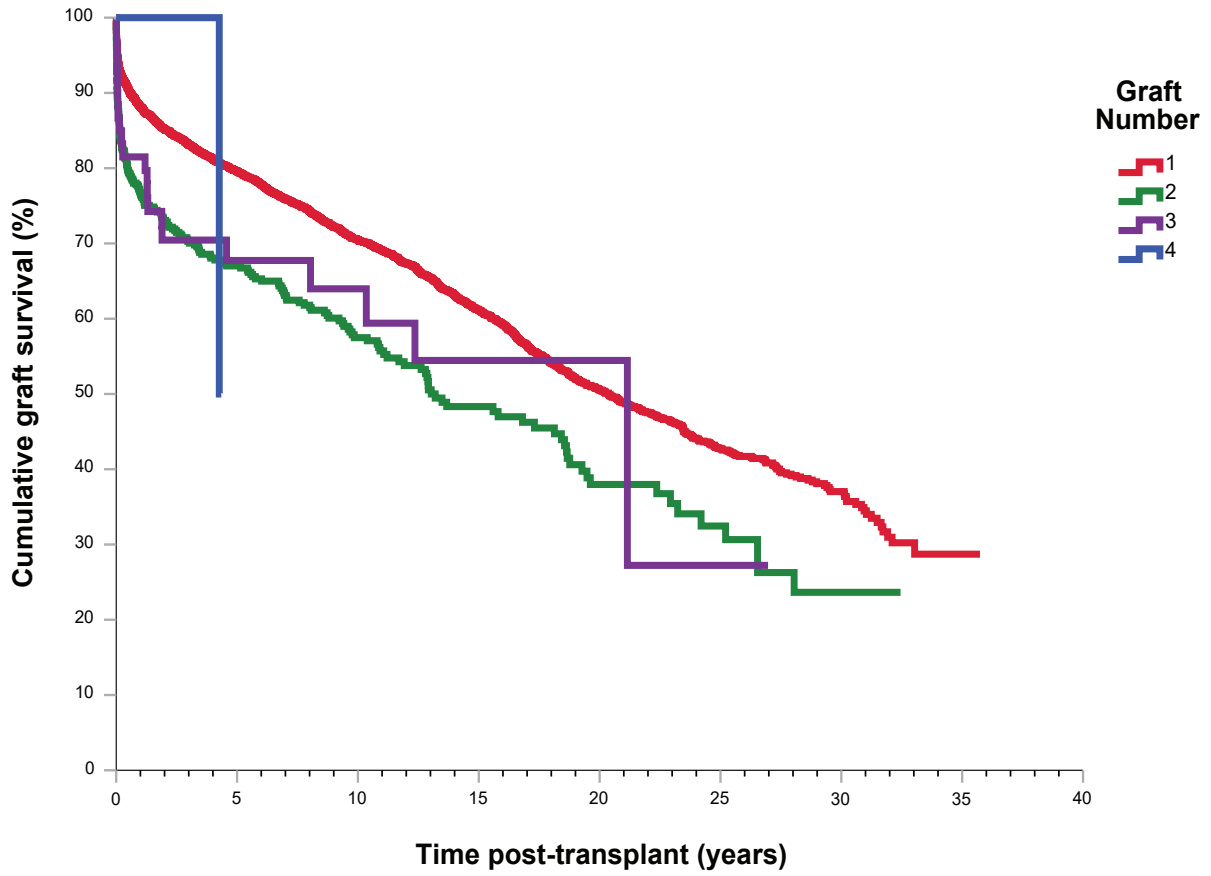


Table 30. Graft survival - all grafts

Graft Number	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1	No. at risk	6,700	5,658	4,767	4,024	2,513	793	121	4	0
	Survival (%)		88%	83%	80%	71%	51%	37%	29%	
2	No. at risk	504	363	293	247	149	41	3	0	
	Survival (%)		77%	70%	67%	58%	38%	24%		
3	No. at risk	60	45	32	22	14	2	0		
	Survival (%)		82%	70%	66%	64%	55%			
4	No. at risk	2	2	2	0					
	Survival (%)		100%	100						

12.4 Paediatric Outcome by Graft Number

There was a significant difference in graft survival by graft number in children (P < 0.001, Figure 47 and Table 31). Ten-year graft survival was 76.4% for the first graft, 52.6% for the second graft and 61.3% for the third graft. Median graft survival was 32.1 years for the first graft, 10.9 years for the second graft and 21.2 years for the third graft.

Figure 47. Graft survival curve for paediatric recipients by graft number

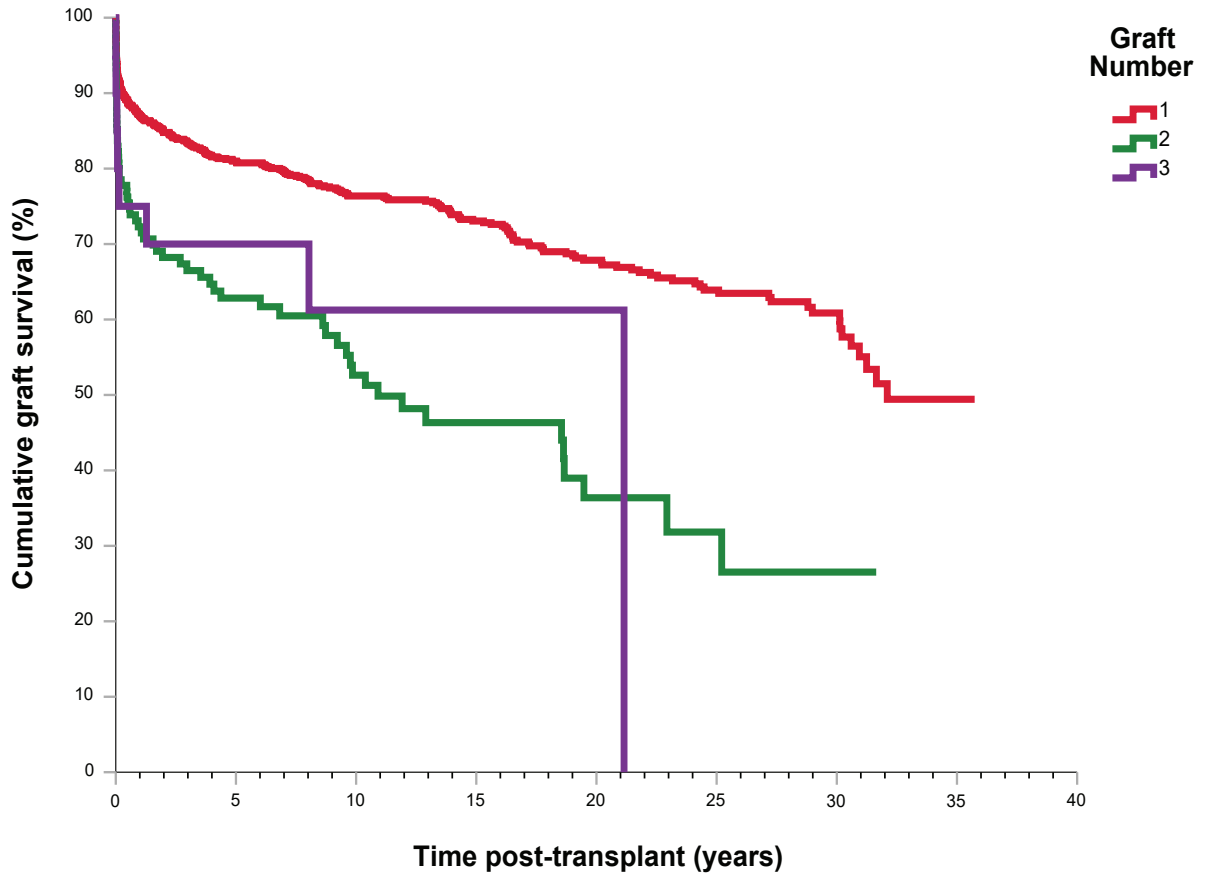


Table 31. Graft survival - paediatric by graft number

Graft Number	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1	No. at risk	1,092	925	801	702	484	223	62	1	0
	Survival (%)		87%	83%	81%	76%	68%	61%	49%	
2	No. at risk	135	90	75	64	40	14	1	0	
	Survival (%)		72%	66%	63%	53%	36%	27%		
3	No. at risk	20	15	12	10	7	1	0		
	Survival (%)		75%	70%	70%	61%	61%			

12.5 Adult Outcome by Graft Number

There was a significant difference in graft survival by graft number in adults (P < 0.001, Figure 48 and Table 32). Ten-year graft survival 69.3% for the first graft, 59.4% for the second graft, 65.8% for the third graft and not reached for the fourth graft. Median graft survival was 18.3 years for the first graft, 13.5 years for the second graft, 12.4 years for the third graft and 4.3 years for the fourth graft.

Figure 48. Graft survival curve for adults by graft number

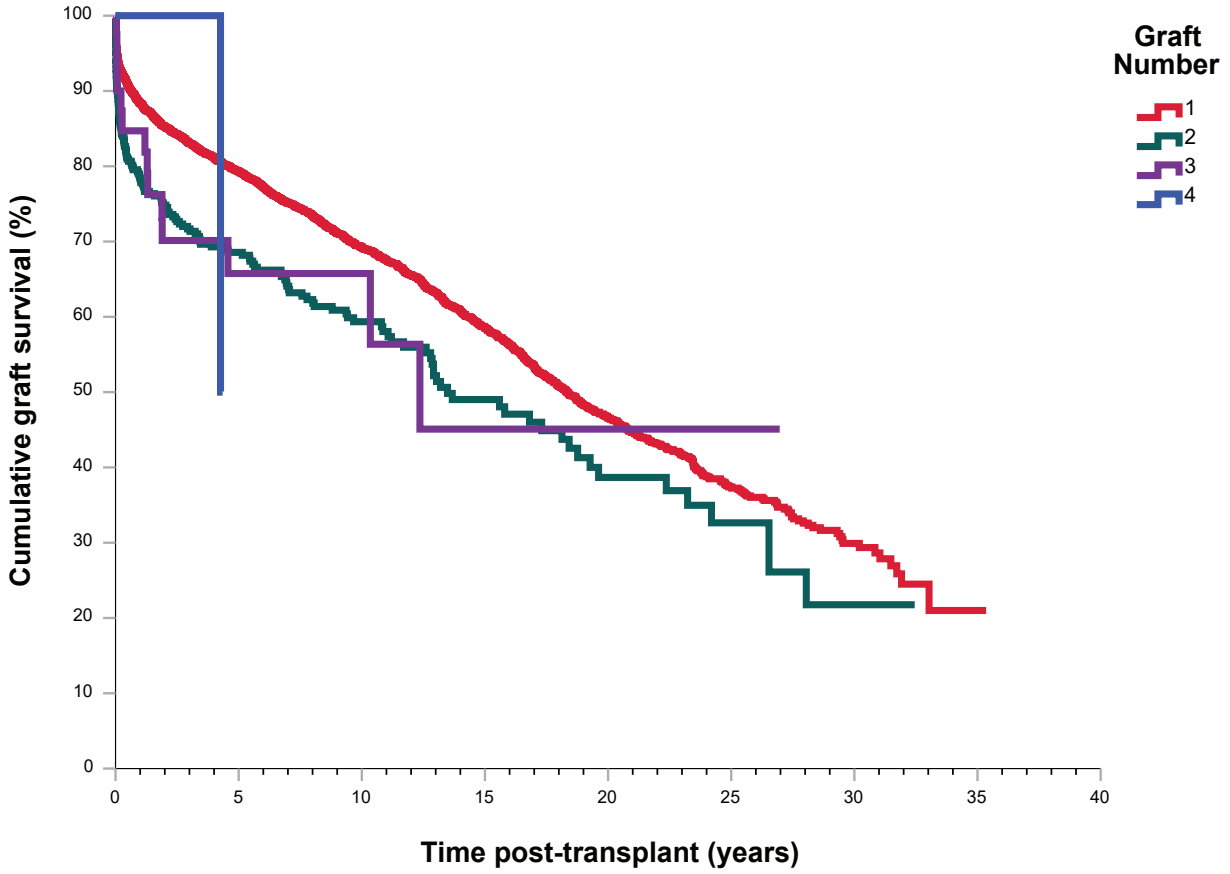


Table 32. Graft survival – adults by graft number

Graft Number	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1	No. at risk	5,608	4,734	3,966	3,322	2,029	570	59	3	0
	Survival (%)		88%	83%	79%	69%	47%	30%	21%	
2	No. at risk	369	273	218	183	109	27	2	0	
	Survival (%)		78%	72%	69%	59%	39%	22%		
3	No. at risk	40	30	20	15	7	1	0		
	Survival (%)		85%	70%	66%	66%	45%			
4	No. at risk	2	2	2	0					
	Survival (%)		100%	100%						

12.6 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 = 0.025, Figure 49 and Table 33). Ten-year graft survival was 78.9% for living donor grafts, 72.9% for split grafts, 69.5% for whole grafts, 60.6% for reduced grafts and 0 for domino grafts. Median graft survival was not reached for split and living donor grafts, 25.1 years for reduced grafts, 18.8 years for whole grafts and 9.4 years for domino grafts.

Figure 49. Graft survival curve for type of graft

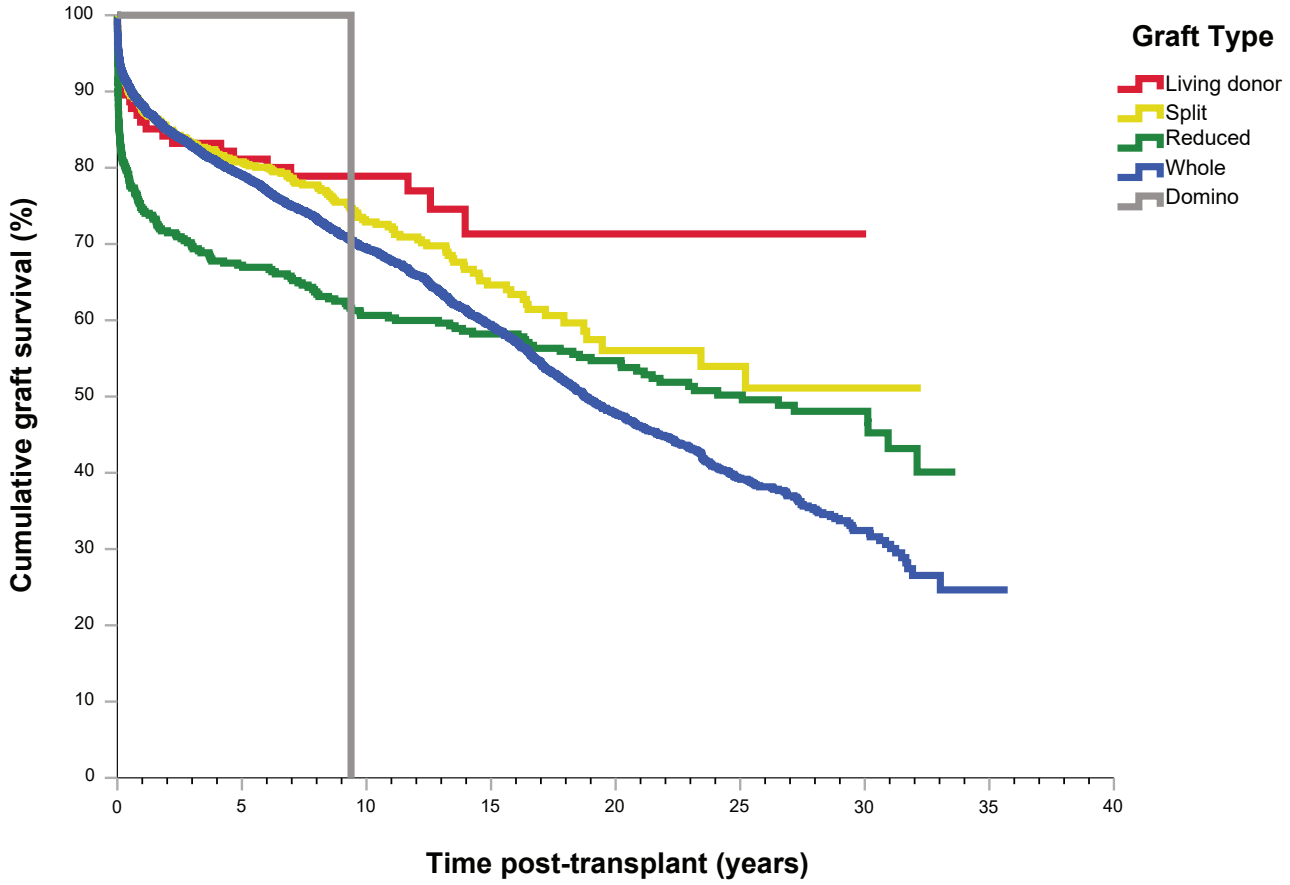


Table 33. Graft survival by type of graft - all grafts

Graft Type	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Domino	No. at risk	4	4	4	4	0				
	Survival (%)		100%	100%	100%					
Living donor	No. at risk	115	96	84	77	56	2	1	0	
	Survival (%)		86%	83%	81%	79%	71%	71%		
Split	No. at risk	851	714	575	466	241	36	2	0	
	Survival (%)		88%	83%	81%	73%	56%	51%		
Reduced	No. at risk	398	292	264	244	191	125	36	0	
	Survival (%)		75%	70%	67%	61%	55%	48%		
Whole	No. at risk	5,897	4,961	4,167	3,505	2,188	673	85	4	0
	Survival (%)		88%	83%	79%	70%	48%	32%	25%	

12.7 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 50 and Table 34). Ten-year graft survival was 81.0% for living donor liver transplantation, 78.7% for whole liver transplantation, 77.9% for split liver transplantation and 61.9% for reduced liver transplantation. Median graft survival was not reached for living donor and split grafts and was 31.6 years for whole grafts and 27.2 years for reduced grafts.

Figure 50. Paediatric graft survival curve for type of graft

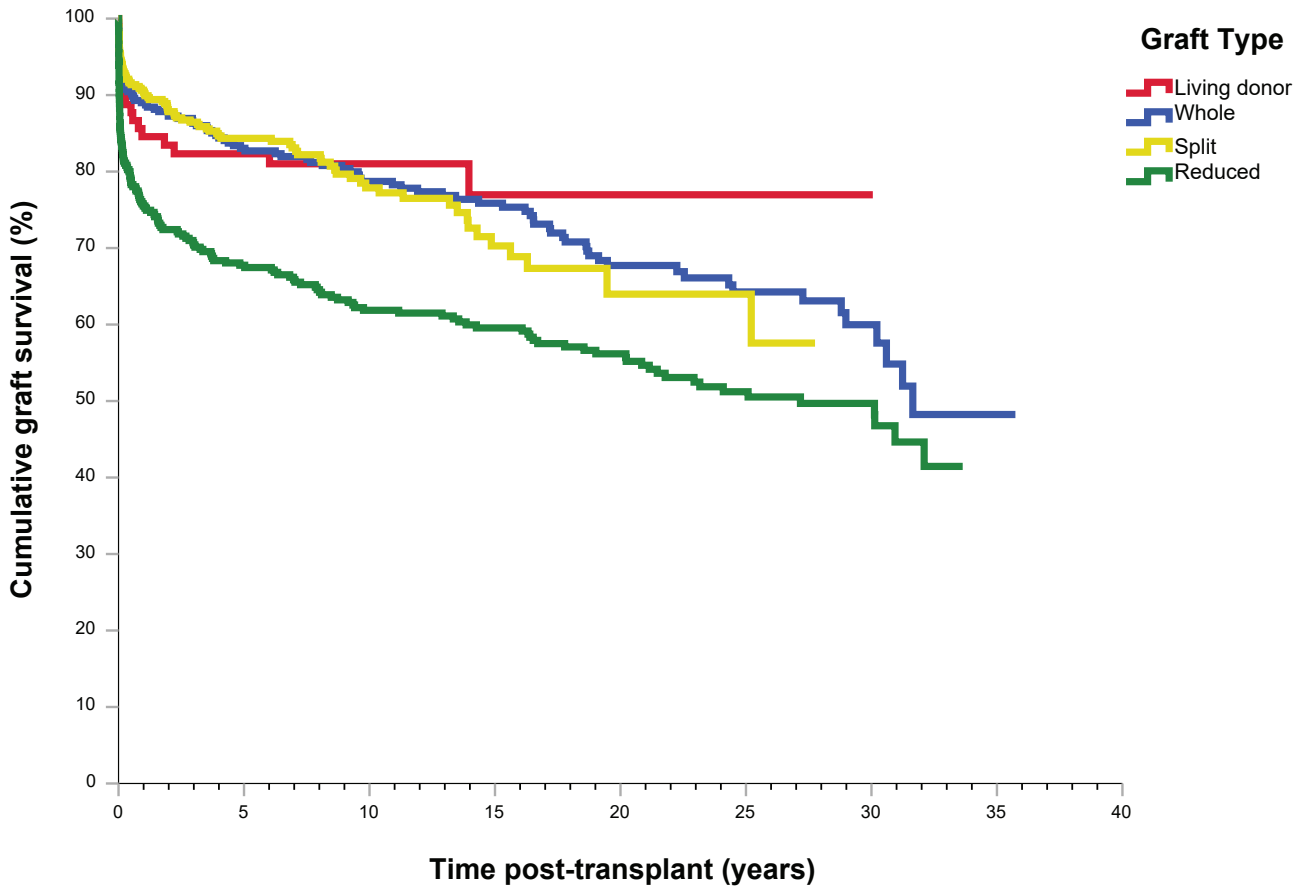


Table 34. Paediatric recipient graft survival by type of graft - all grafts

Graft Type	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Living donor	No. at risk	98	80	70	66	46	2	1	0	
	Survival (%)		85%	82%	82%	81%	77%	77%		
Whole	No. at risk	357	306	275	242	184	102	26	1	0
	Survival (%)		89%	86%	83%	79%	68%	60%	48%	
Split	No. at risk	431	373	300	243	123	17	0		
	Survival (%)		90%	87%	84%	78%	64%			
Reduced	No. at risk	360	269	243	225	178	117	36	0	
	Survival (%)		76%	70%	68%	62%	56%	50%		

12.8 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 = 0.576, Figure 51 and Table 35). Ten-year graft survival was 68.8% for whole liver transplantation, 67.9% for split liver transplantation, 68.3% for living donor liver transplantation, 48.5% for reduced liver transplantation and 0 for domino liver transplantation. Median graft survival was 18.8 years for split transplantation, 18.1 years for whole liver transplantation, 9.7 years for reduced liver transplantation, 9.4 years for domino liver transplantation and was not reached for living donor transplantation.

Figure 51. Adult graft survival curve for type of graft, all grafts

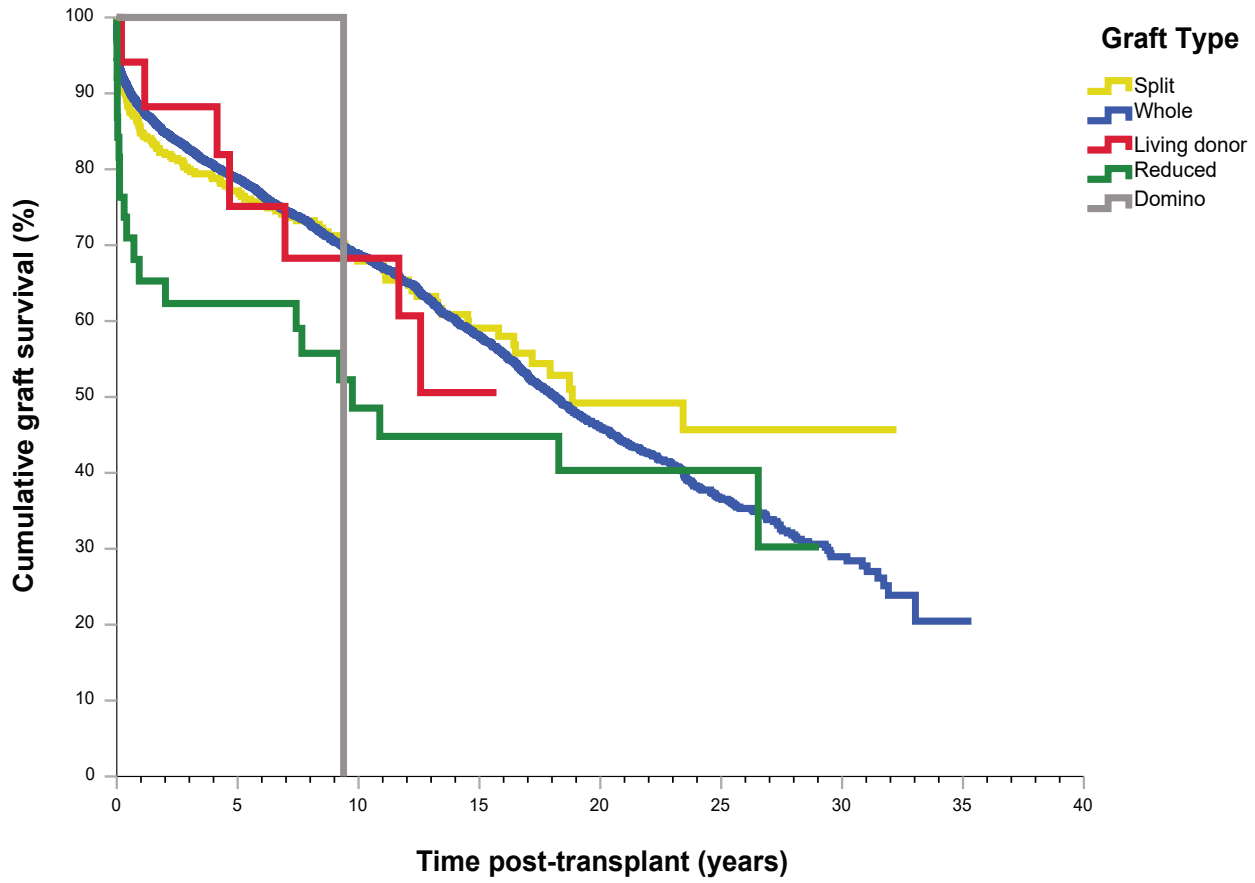


Table 35. Adult graft survival for type of graft, all grafts

Graft Type	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Split	No. at risk	420	341	275	223	118	19	2	0	
	Survival (%)		85%	80%	77%	68%	49%	46%		
Whole	No. at risk	5,540	4,655	3,892	3,263	2,004	571	59	3	0
	Survival (%)		88%	83%	79%	69%	46%	29%	21%	
Living donor	No. at risk	17	16	14	11	10	0			
	Survival (%)		94%	88%	75%	68%				
Reduced	No. at risk	38	23	21	19	13	8	0		
	Survival (%)		65%	62%	62%	49%	40%			
Domino	No. at risk	4	4	4	4	0				
	Survival (%)		100%	100%	100%					

12.9 Graft Survival by Era of Transplant

There has been a progressive improvement in graft survival over eras of transplantation (P < 0.001, Figure 52, Table 36). Graft survival in the most recent era was 90.3% at 1 year, 87.1% at 3 years, 83.8% at 5 years and 73.6% at 10 years. Median graft survival was not reached for recent eras since 2005 and was 19.6 years for 2000 – 04, 17.0 years for 1995 – 99, 16.9 years for 1990 – 94 and 7.7 years for 1985 – 89.

Figure 52. Graft (deceased and living donors) survival curve by era of transplant

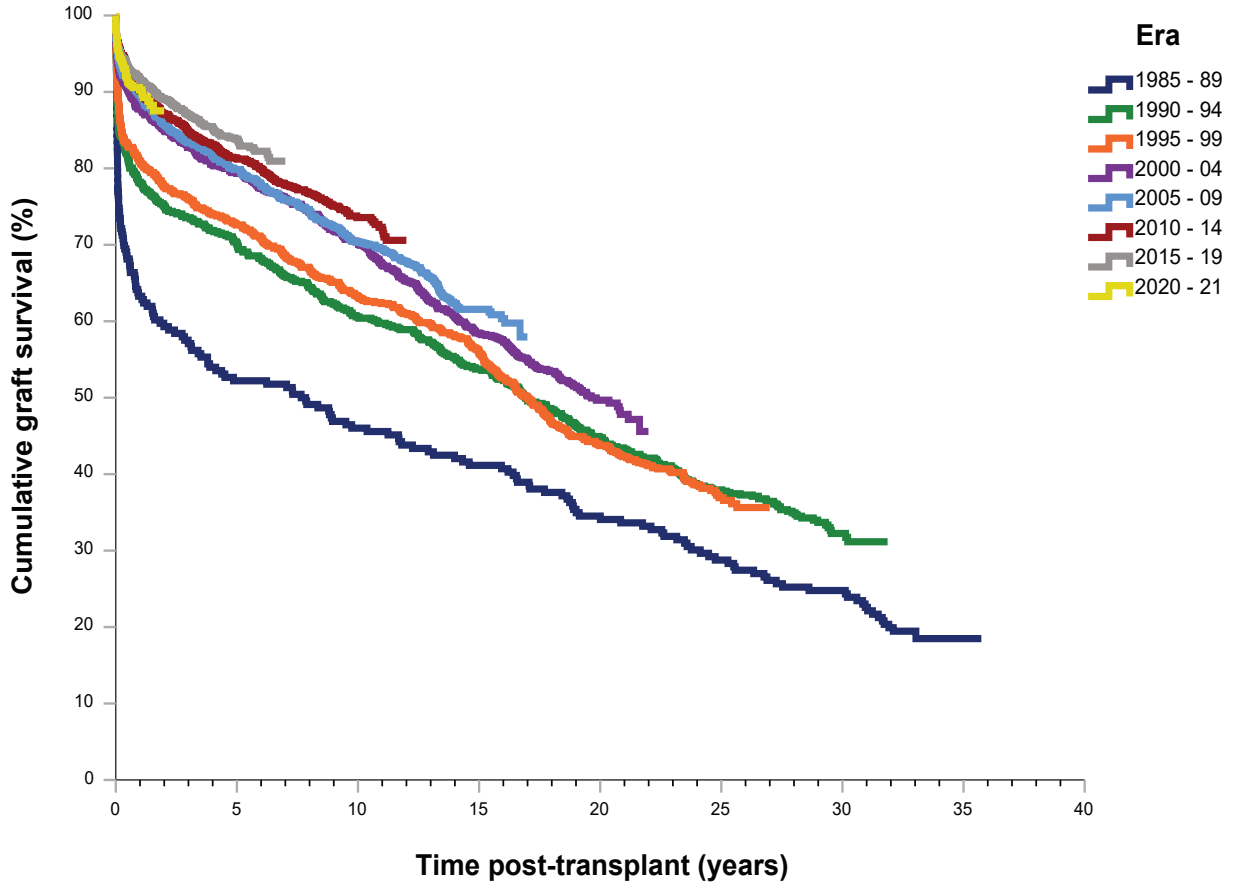


Table 36. Graft (deceased and living donors) survival by era of transplant

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	78	56	4	0
	Survival (%)		63%	57%	52%	46%	35%	25%	19%	
1990 - 94	No. at risk	601	470	442	422	364	269	68	0	
	Survival (%)		78%	74%	70%	61%	45%	32%		
1995 - 99	No. at risk	759	614	577	551	480	332	0		
	Survival (%)		81%	76%	73%	63%	44%			
2000 - 04	No. at risk	915	803	757	726	644	157	0		
	Survival (%)		88%	83%	79%	70%	50%			
2005 - 09	No. at risk	1,032	925	860	824	726	0			
	Survival (%)		90%	83%	80%	70%				
2010 - 14	No. at risk	1,331	1,201	1,128	1,082	358	0			
	Survival (%)		90%	85%	81%	74%				
2015 - 19	No. at risk	1,763	1,616	1,201	573	0				
	Survival (%)		92%	87%	84%					
2020 - 21	No. at risk	639	296	0						
	Survival (%)		90%							

12.10 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 53, Table 37). Graft survival in the most recent era was 98.7% at 1 year, 88.7% at 3 years, 86.0% at 5 years and 80.1% at 10 years. Median paediatric graft survival was not reached for transplant eras since 1995 and was 30.1 years for 1990 – 94 and 7.7 years for 1985 – 89.

Figure 53. Paediatric graft (deceased and living donors) survival curve by era of transplant

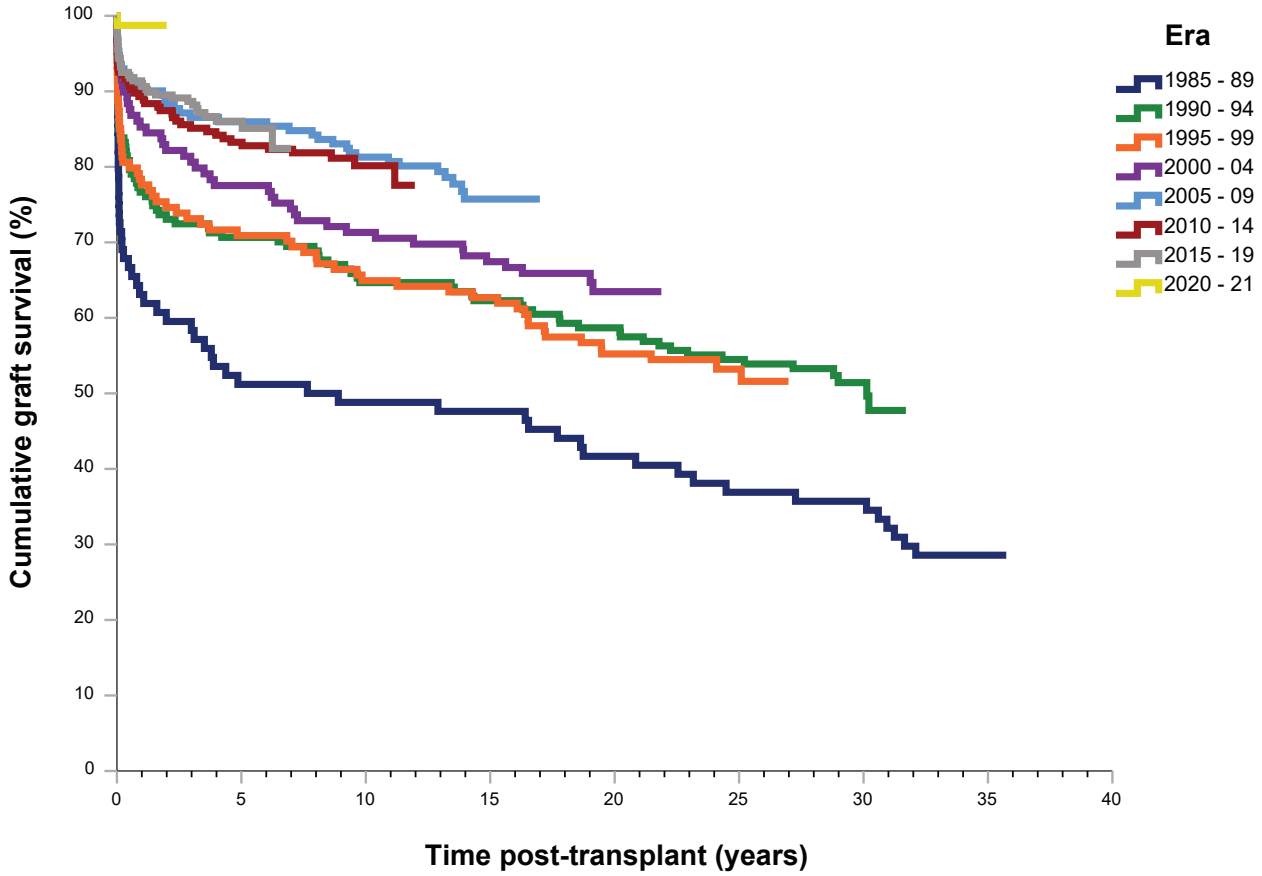


Table 37. Paediatric graft (deceased and living donors) survival by era of transplant

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	35	30	1	0
	Survival (%)		63%	58%	51%	49%	42%	36%	29%	
1990 - 94	No. at risk	167	128	121	118	108	98	33	0	
	Survival (%)		77%	73%	71%	65%	59%	51%		
1995 - 99	No. at risk	134	104	98	95	87	74	0		
	Survival (%)		78%	73%	71%	65%	55%			
2000 - 04	No. at risk	129	110	104	100	92	31	0		
	Survival (%)		85%	81%	78%	71%	64%			
2005 - 09	No. at risk	171	155	148	147	139	0			
	Survival (%)		91%	87%	86%	81%				
2010 - 14	No. at risk	215	192	183	179	64	0			
	Survival (%)		89%	85%	83%	80%				
2015 - 19	No. at risk	267	243	185	94	0				
	Survival (%)		91%	89%	86%					
2020 - 21	No. at risk	80	44	0						
	Survival (%)		99%							

12.11 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 54, Table 38). Graft survival in the most recent era was 89.1% at 1 year, 86.8% at 3 years, 83.4% at 5 years and 72.3% at 10 years. Median adult graft survival was not reached for transplant eras since 2005 and was 18.4 years for 2000 – 04, 16.4 years for 1995 – 99, 15.5 years for 1990 – 94 and 7.3 years for 1985 – 89.

Figure 54. Adult graft (deceased and living donors) survival curve by era of transplant

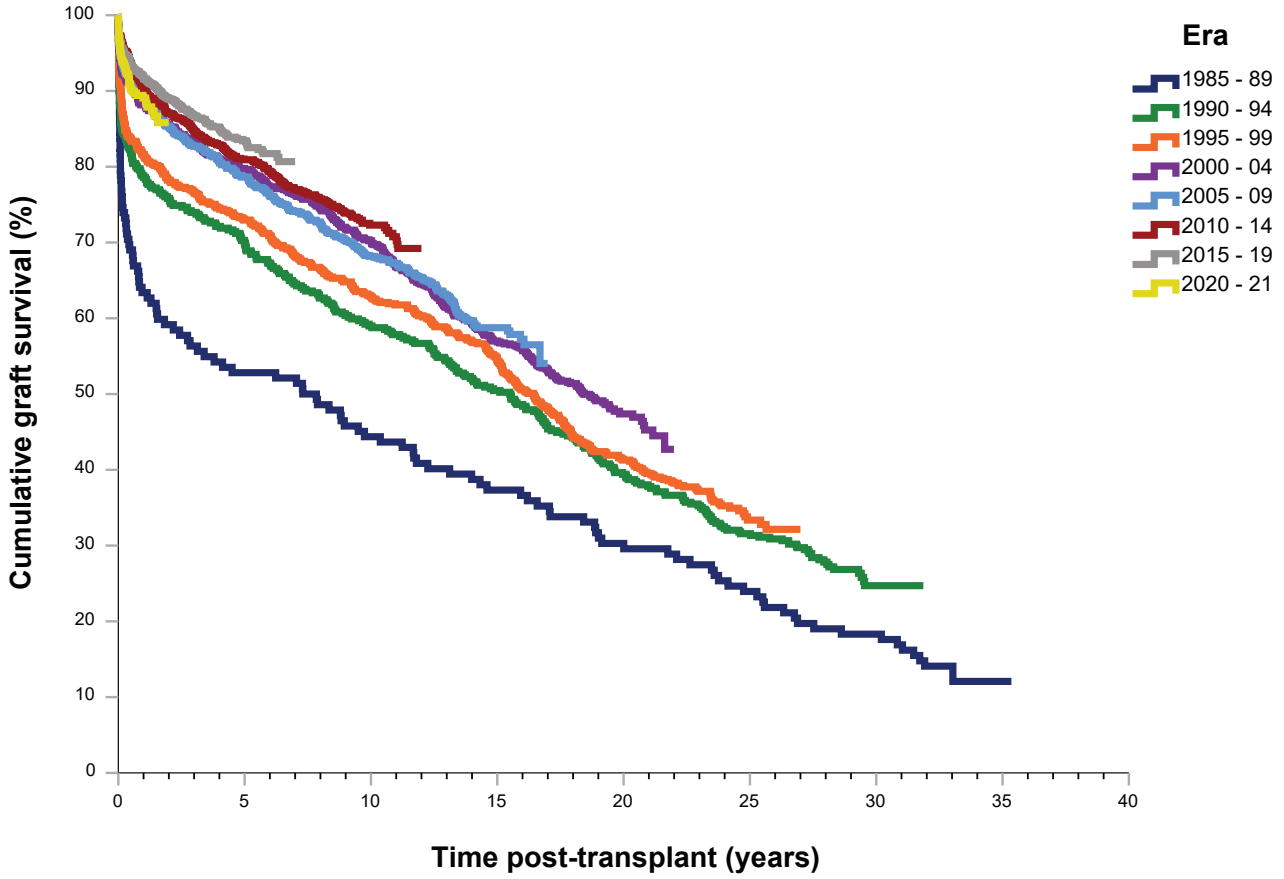


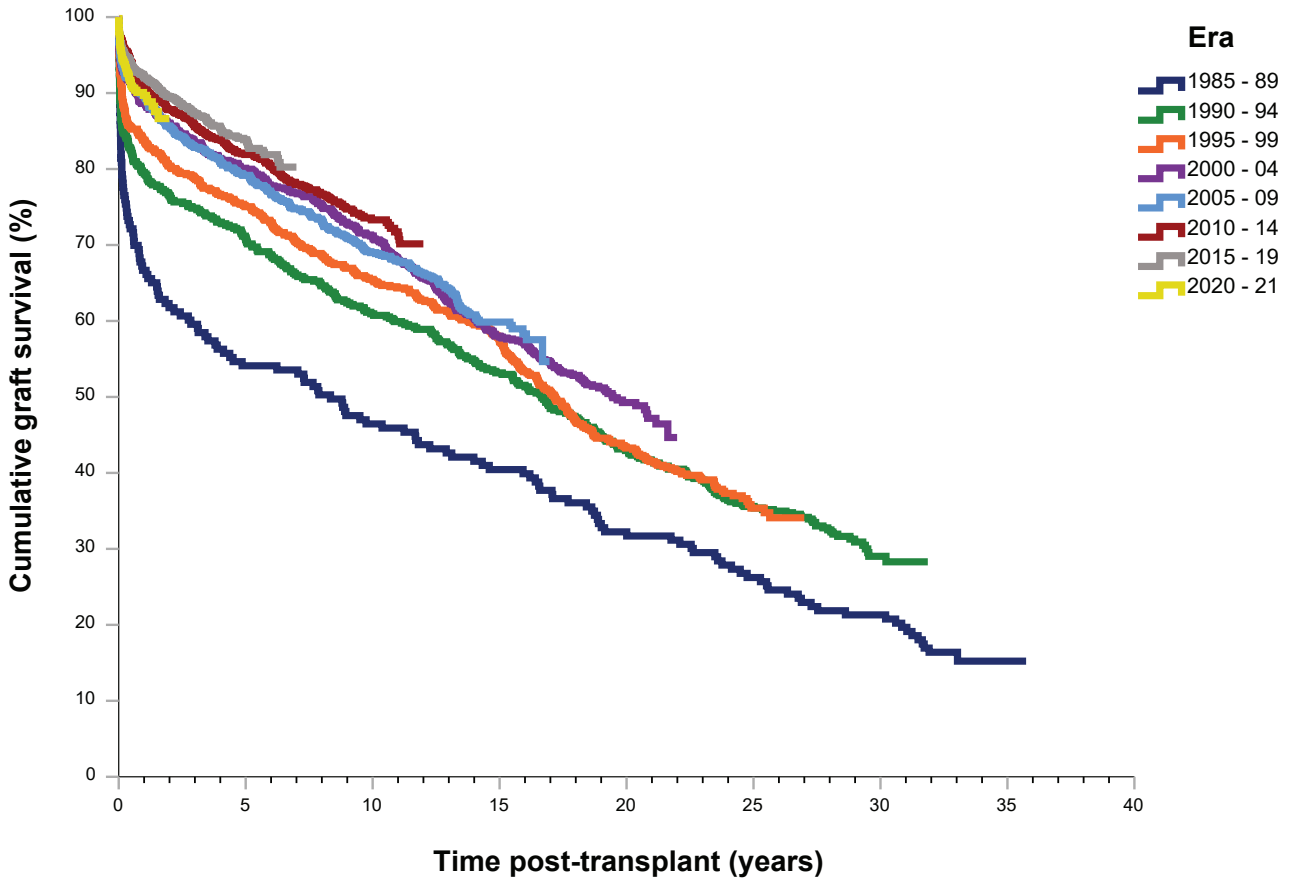
Table 38. Adult graft (deceased and living donors) survival by era of transplant

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	43	26	3	0
	Survival (%)		63%	56%	53%	44%	30%	18%	12%	
1990 - 94	No. at risk	434	342	321	304	256	171	35	0	
	Survival (%)		79%	74%	70%	59%	39%	25%		
1995 - 99	No. at risk	625	510	479	456	393	258	0		
	Survival (%)		82%	77%	73%	63%	41%			
2000 - 04	No. at risk	786	693	653	626	552	126	0		
	Survival (%)		88%	83%	80%	70%	47%			
2005 - 09	No. at risk	861	770	712	677	587	0			
	Survival (%)		89%	83%	79%	68%				
2010 - 14	No. at risk	1,116	1,009	945	903	294	0			
	Survival (%)		90%	85%	81%	72%				
2015 - 19	No. at risk	1,496	1,373	1,016	479	0				
	Survival (%)		92%	87%	83%					
2020 - 21	No. at risk	559	252	0						
	Survival (%)		89%							

12.12 Whole Graft Survival by Era of Transplant

There has been a progressive improvement in graft survival after whole liver transplantation over eras of transplantation, albeit relatively modest since 2000 (P < 0.001, Figure 55,Table 39). Graft survival in the most recent era was 89.7% at 1 year, 87.4% at 3 years, 83.9% at 5 years and 73.3% at 10 years. Median graft survival was not reached for eras since 2005 and was 19.5 years for 2000 – 04, 17.2 years for 1995 – 99, 16.7 years for 1990 – 94 and 8.3 years for 1985 – 89.

Figure 55. Whole graft survival curve by era of transplant



TTable 39. 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	59	39	4	0
	Survival (%)		67%	60%	54%	46%	32%	21%	15%	
1990 - 94	No. at risk	489	389	366	347	298	210	46	0	
	Survival (%)		80%	75%	71%	61%	43%	29%		
1995 - 99	No. at risk	617	517	486	463	404	267	0		
	Survival (%)		84%	79%	75%	66%	43%			
2000 - 04	No. at risk	774	686	646	619	551	137	0		
	Survival (%)		89%	84%	80%	71%	49%			
2005 - 09	No. at risk	816	732	676	646	563	0			
	Survival (%)		90%	83%	79%	69%				
2010 - 14	No. at risk	1,067	970	913	874	287	0			
	Survival (%)		91%	86%	82%	73%				
2015 - 19	No. at risk	1,421	1,310	971	457	0				
	Survival (%)		92%	87%	84%					
2020 - 21	No. at risk	530	235	0						
	Survival (%)		90%							

12.13 Reduced Graft Survival by Era of Transplant

Graft survival after reduced liver transplantation varied over transplant eras without a clear trend (P = 0.028, Figure 56, Table 40). Graft survival in the most recent era was 87.5% at 1 year, 85.4% at 3 years, 79.2% at 5 years and 63.6% at 10 years. Median graft survival was not reached for eras since 2015 and between 2000 and 2009. It was 21.1 years for 1990 – 94, 11.2 years for 2010 – 14, 9.2 years for 1995 – 99 and 3.0 years for 1985 – 89.

Figure 56. Reduced graft survival curve by era of transplant

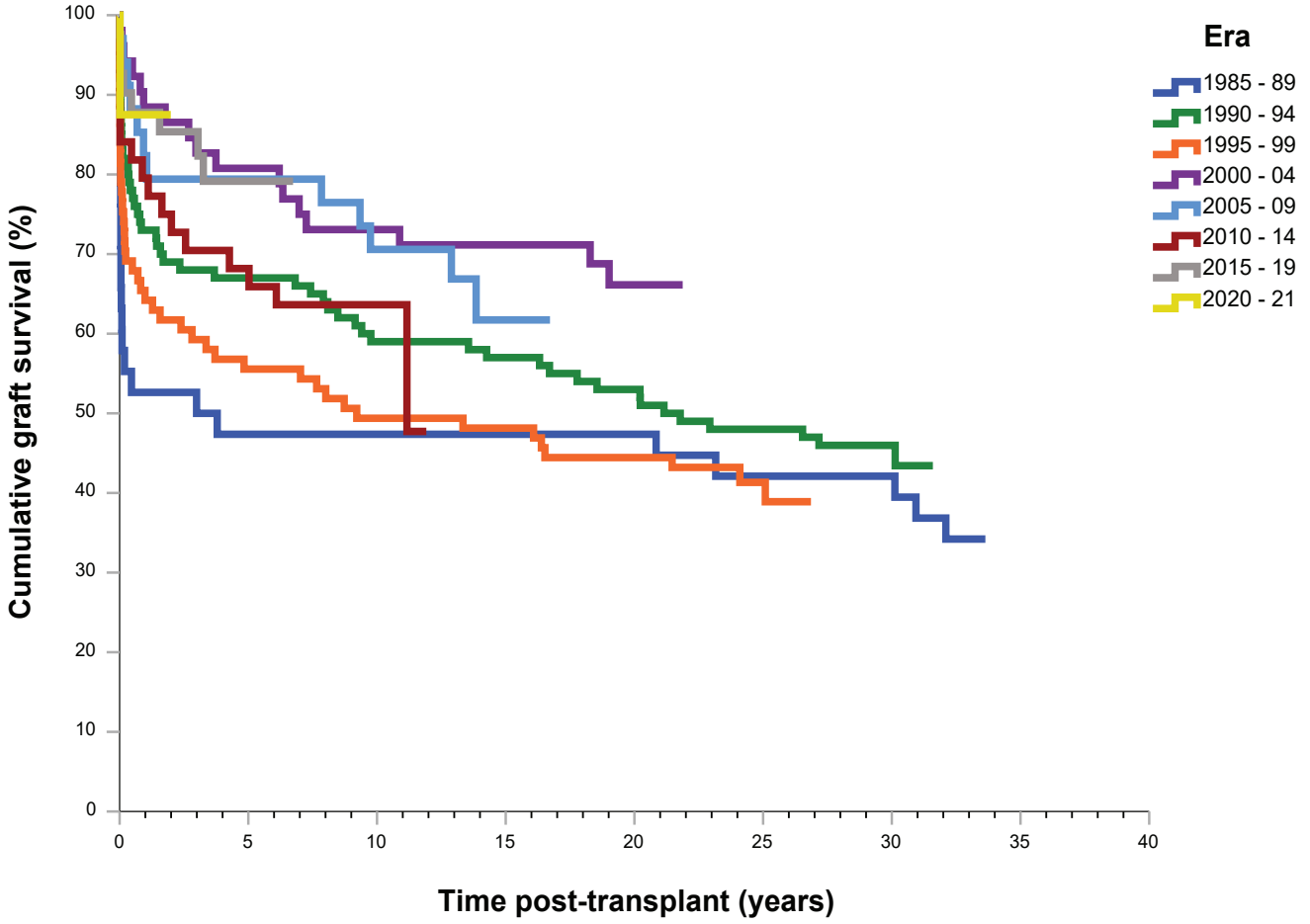


Table 40. Reduced graft (deceased donor) survival by era of transplant

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	18	16	0	
	Survival (%)		53%	50%	47%	47%	47%	42%		
1990 - 94	No. at risk	100	73	68	67	59	53	20	0	
	Survival (%)		73%	68%	67%	59%	53%	46%		
1995 - 99	No. at risk	81	52	48	45	40	36	0		
	Survival (%)		64%	59%	56%	49%	44%			
2000 - 04	No. at risk	52	46	43	42	38	18	0		
	Survival (%)		89%	83%	81%	73%	66%			
2005 - 09	No. at risk	34	28	27	27	24	0			
	Survival (%)		82%	79%	79%	71%				
2010 - 14	No. at risk	44	35	31	30	12	0			
	Survival (%)		80%	71%	68%	64%				
2015 - 19	No. at risk	41	36	28	15	0				
	Survival (%)		88%	85%	79%					
2020 - 21	No. at risk	8	2	0						
	Survival (%)		88%							

12.14 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 57, Table 41). Graft survival in the most recent era was 93.0% at 1 year, 86.5% at 3 years, 85.3% at 5 years and 75.8% at 10 years. Median graft survival was not reached for transplant eras since 2005 and was 17.9 years for 1995 – 99, 16.5 years for 2000 – 04 and 5.0 years for 1985 – 94.

Figure 57. Split graft (deceased donor) survival curve by era of transplant

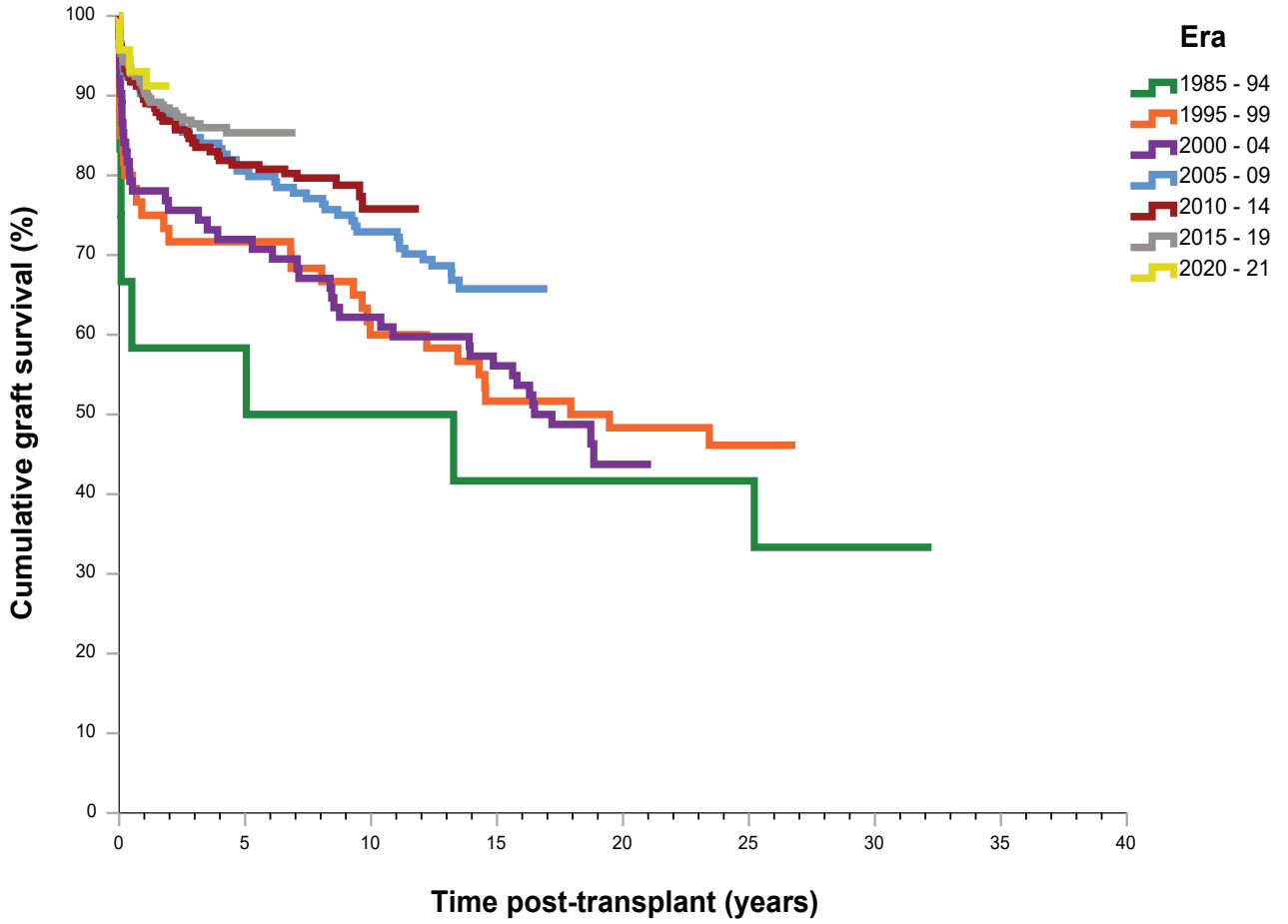


Table 41. Split graft (deceased donor) survival by era of transplant

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	5	2	0	
	Survival (%)		58%	58%	58%	50%	42%	33%		
1995 - 99	No. at risk	60	45	43	43	36	29	0		
	Survival (%)		75%	72%	72%	60%	48%			
2000 - 04	No. at risk	82	64	62	59	51	2	0		
	Survival (%)		78%	76%	72%	62%	44%			
2005 - 09	No. at risk	144	129	122	116	105	0			
	Survival (%)		90%	85%	81%	73%				
2010 - 14	No. at risk	182	163	153	148	43	0			
	Survival (%)		90%	84%	81%	76%				
2015 - 19	No. at risk	277	251	188	93	0				
	Survival (%)		91%	87%	85%					
2020 - 21	No. at risk	94	55	0						
	Survival (%)		93%							

12.15 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 - 21 (P = 0.021, Figure 58 and Table 42). Graft survival in the most recent era was 100% at 1 year, 77.3% at 3 years, 68.7% 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. Multivariable analysis determined that transplant era was not independently associated with graft survival following living donor transplantation.

Figure 58. Living donor (excluding domino) graft survival curve by era of transplant

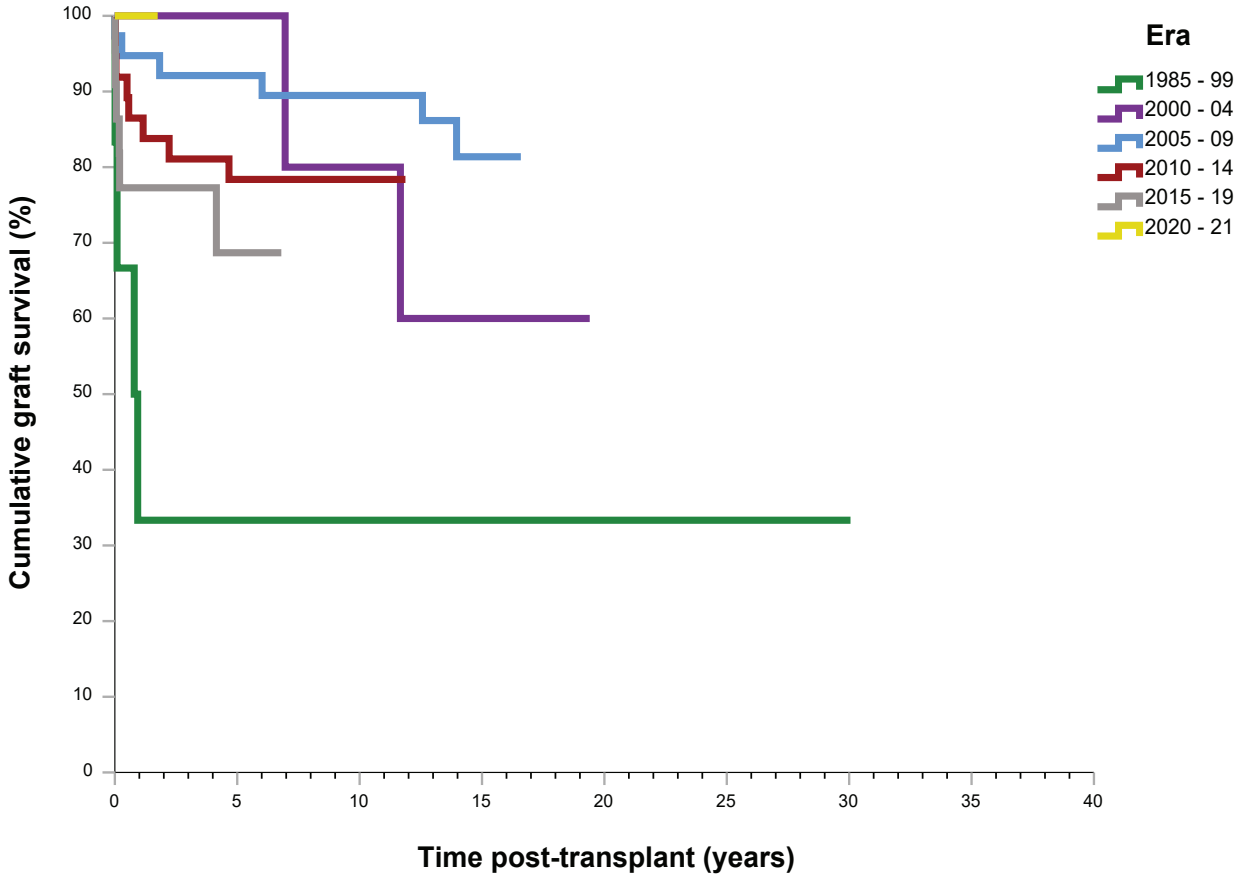


Table 42. Living donor (excluding domino) graft survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
1985 - 99	No. at risk	6	2	2	2	2	2	1	0	
	Survival (%)		33%	33%	33%	33%	33%	33%		
2000 - 04	No. at risk	5	5	5	5	4	0			
	Survival (%)		100%	100%	100%	80%				
2005 - 09	No. at risk	38	36	35	35	34	0			
	Survival (%)		95%	92%	92%	90%				
2010 - 14	No. at risk	37	32	30	29	16	0			
	Survival (%)		87%	81%	78%	78%				
2015 - 19	No. at risk	22	17	12	6	0				
	Survival (%)		77%	77%	69%					
2020 - 21	No. at risk	7	4	0						
	Survival (%)		100%							

12.16 Graft Survival by Deceased Donor Age

A total of 7,147 grafts were sourced from 6,722 deceased donors, however there is no deceased donor information on 126 grafts from 1985 to 1988. This survival analysis is limited to 7,021 grafts (from 6,596 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 59 and Table 43). Ten-year graft survival was 80.6% for donors aged 10 – 15 years, 77.6% for donors aged 0 – 9 years, 72.3% for donors aged 16 – 29 years, 69.1% for donors aged 70 years and older, 68.6% for donors aged 40 – 49 years, 68.2% for donors aged 30 – 39 years, 67.6% for donors aged 60 – 69 years and 65.2% 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, 23.0 years for donors aged 16 – 29 years, 18.3 years for donors aged 40 – 49 years, 18.0 years for donors aged 30 – 39 years, 17.1 years for donors aged 60 – 69 years, 17.0 years for donors aged 70 years and older and 16.1 years for donors aged 50 - 59 years.

Figure 59. Graft survival curve by deceased donor age

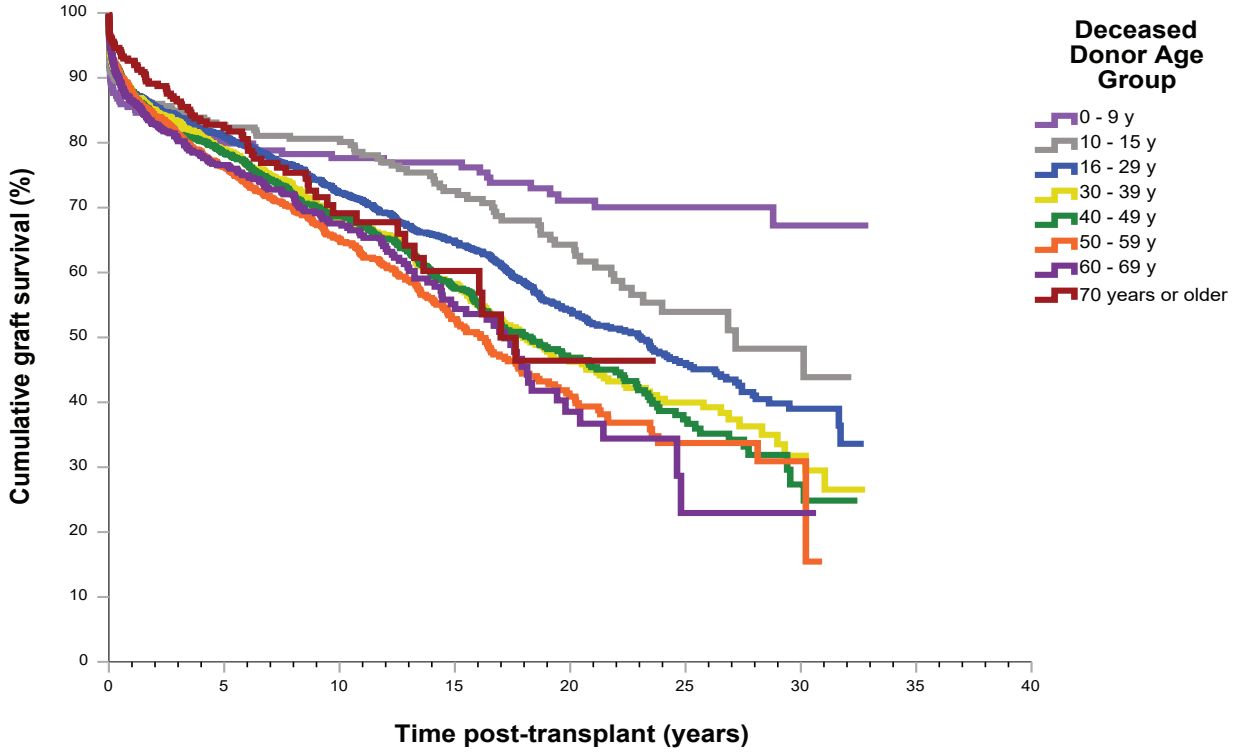


Table 43. Graft survival by deceased donor age

Donor Age	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
0 – 9 y	No. at risk	236	194	176	158	125	73	15	0	
	Survival (%)		86%	83%	80%	78%	71%	67%		
10 – 15 y	No. at risk	317	267	239	213	163	77	12	0	
	Survival (%)		87%	85%	83%	81%	64%	48%		
16 – 29 y	No. at risk	1,797	1,506	1,309	1,146	756	277	37	0	
	Survival (%)		88%	84%	81%	72%	54%	39%		
30 – 39 y	No. at risk	1,039	881	736	602	385	119	15	0	
	Survival (%)		88%	83%	79%	68%	46%	32%		
40 – 49 y	No. at risk	1,316	1,113	920	781	498	135	11	0	
	Survival (%)		88%	81%	79%	69%	47%	27%		
50 – 59 y	No. at risk	1,199	999	823	680	383	83	3	0	
	Survival (%)		88%	81%	76%	65%	41%	31%		
60 – 69 y	No. at risk	800	655	521	412	202	21	3	0	
	Survival (%)		87%	80%	77%	68%	39%	23%		
70 years and older	No. at risk	317	270	210	157	52	10	0		
	Survival (%)		93%	86%	82%	69%	46%			

12.17 Graft Survival by Donor Type

Although it appeared that 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, there was no difference in graft survival between these donor types (P = 0.062, Figure 60 and Table 44). Ten-year graft survival was 78.3% for transplantation from living donors, 69.5% for transplantation from donation after brain death donors and 65.9% for transplantation from donation after circulatory death donors. Median survival was not reached for transplantation from living donors and was 19.7 years for transplantation from donation after brain death donors and was 13.4 years for donation after circulatory death donors.

Figure 60. Graft survival curve by donor type – all grafts

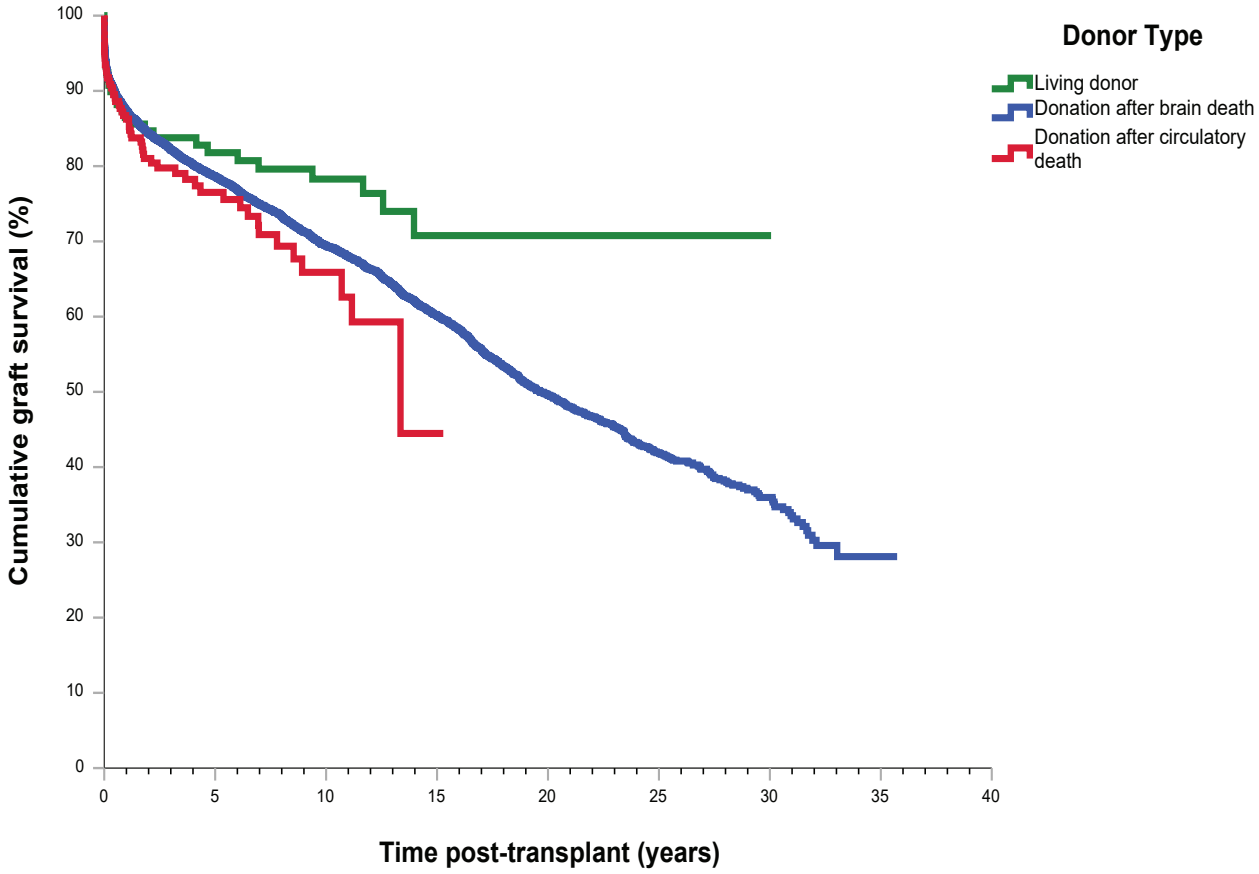


Table 44. Graft survival by donor type – all grafts

Donor Type	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Living donor	No. at risk	119	100	88	81	56	2	1	0	
	Survival (%)		87%	84%	82%	78%	71%	71%		
DBD	No. at risk	6,917	5,787	4,893	4,131	2,594	834	123	4	0
	Survival (%)		87%	82%	79%	70%	50%	36%	28%	
DCD	No. at risk	230	181	113	84	26	0			
	Survival (%)		86%	80%	77%	66%				

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

12.18 Graft Survival by Donor Cause of Death

Graft survival varied significantly by donor cause of death (P < 0.001, Figure 61, Table 45). Ten-year graft survival was 76.0% for other cause, 71.5% for anoxia, 71.0% for trauma and 67.6% for stroke. Median survival was 26.5 years for other cause, 22.2 years for trauma, 20.2 years for anoxia and 18.1 years for stroke.

Figure 61. Graft survival curve by donor cause of death

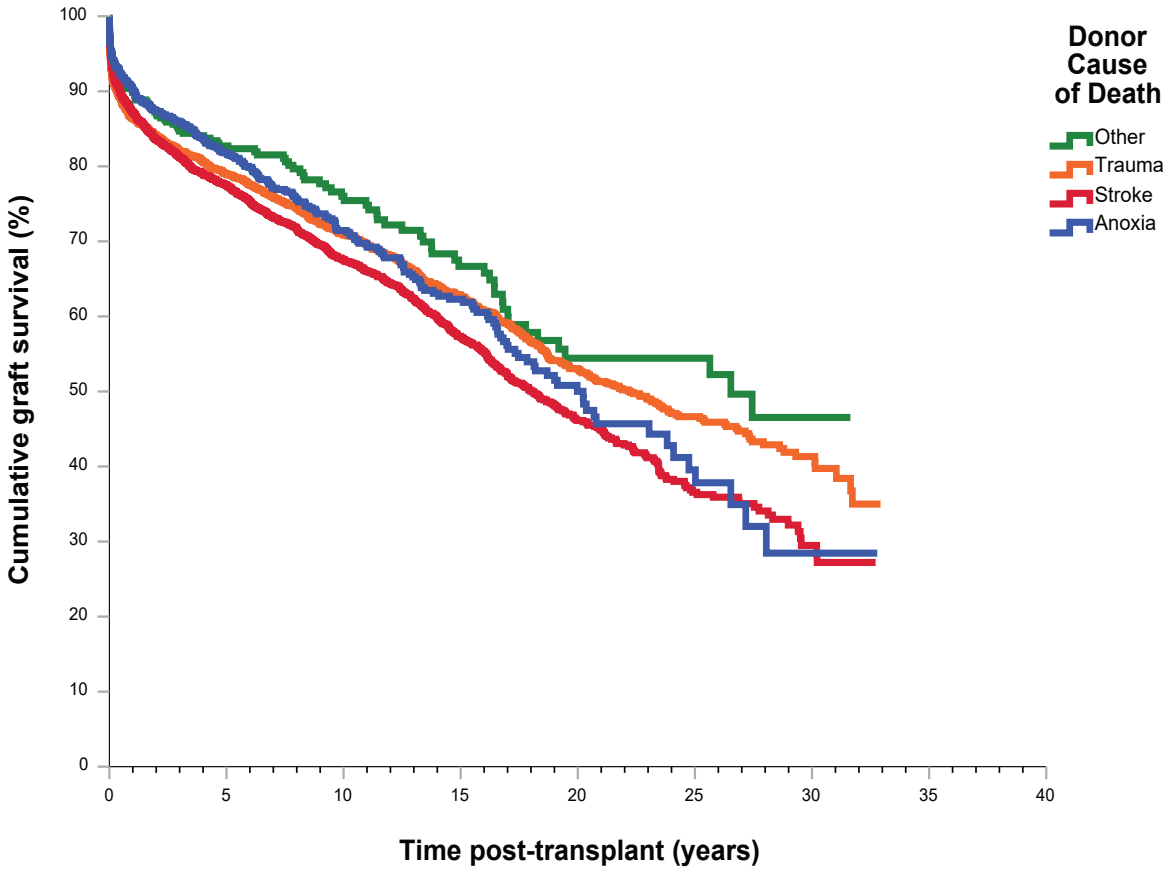


Table 45. Graft survival by donor cause of death

Donor cause of death	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Other	No. at risk	409	354	281	232	131	44	7	0	
	Survival (%)		90%	85%	83%	76%	54%	47%		
Trauma	No. at risk	2,009	1,690	1,488	1,341	956	380	55	0	
	Survival (%)		86%	82%	79%	71%	53%	41%		
Stroke	No. at risk	3,229	2,686	2,267	1,908	1,167	309	30	0	
	Survival (%)		87%	81%	78%	68%	46%	30%		
Anoxia	No. at risk	1,374	1,155	898	668	310	62	4	0	
	Survival (%)		90%	86%	82%	72%	50%	29%		

All deceased donors since 1989 (n=7,021)

12.19 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 < 0.001, Figure 62, Table 46). Ten-year graft survival was 71.3% for transplants performed with a non-shipped liver and 65.8% for a liver shipped from another unit. Median graft survival was 20.4 years for transplants performed with a donor liver from the unit's donor region and 18.9 years for a liver shipped from another unit.

Figure 62. Graft survival curve by organ shipping

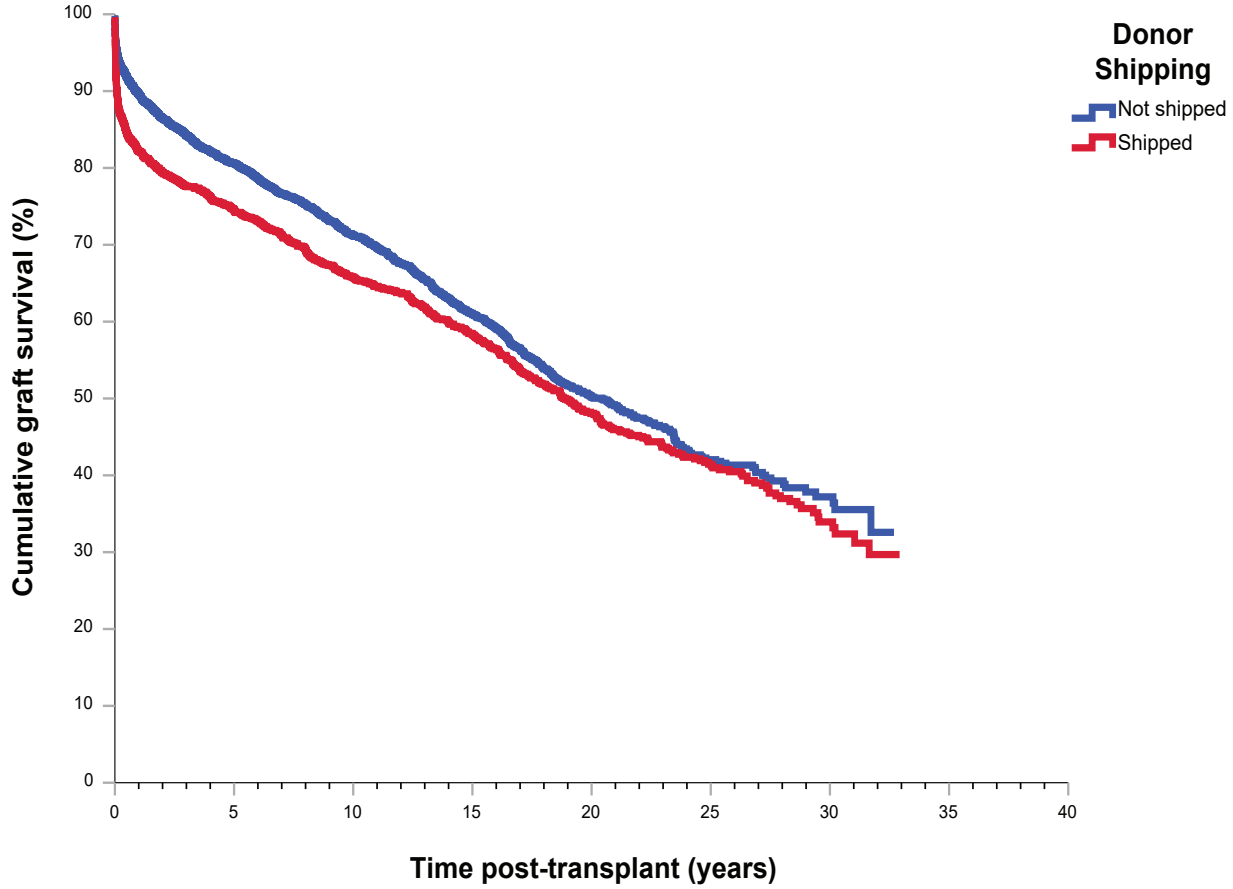


Table 46. Graft survival by organ shipping

Organ Shipping	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Not shipped	No. at risk	5,241	4,469	3,702	3,050	1,780	444	49	0	
	Survival (%)		90%	84%	81%	71%	50%	37%		
Shipped	No. at risk	1,780	1,416	1,232	1,099	784	351	47	0	
	Survival (%)		82%	78%	75%	66%	48%	34%		

All deceased donors since 1989 (n=7,021)

12.20 Graft Survival by Cold Ischaemia Time

Graft survival was significantly better for transplants performed with a cold ischaemia time less than 441 minutes compared to transplants performed with a cold ischaemia time 441 minutes or greater (P < 0.001, see Figure 63 and Table 47). Ten-year graft survival was 74.6% for transplants with a cold ischaemia time less than 441 minutes and 67.5% for transplants with a cold ischaemia time greater than or equal to 441 minutes. Median survival was 21.4 years for transplants with a cold ischaemia time less than 441 minutes and 17.0 years for transplants with a cold ischaemia time greater than or equal to 441 minutes.

Figure 63. Graft survival curve by cold ischaemia time

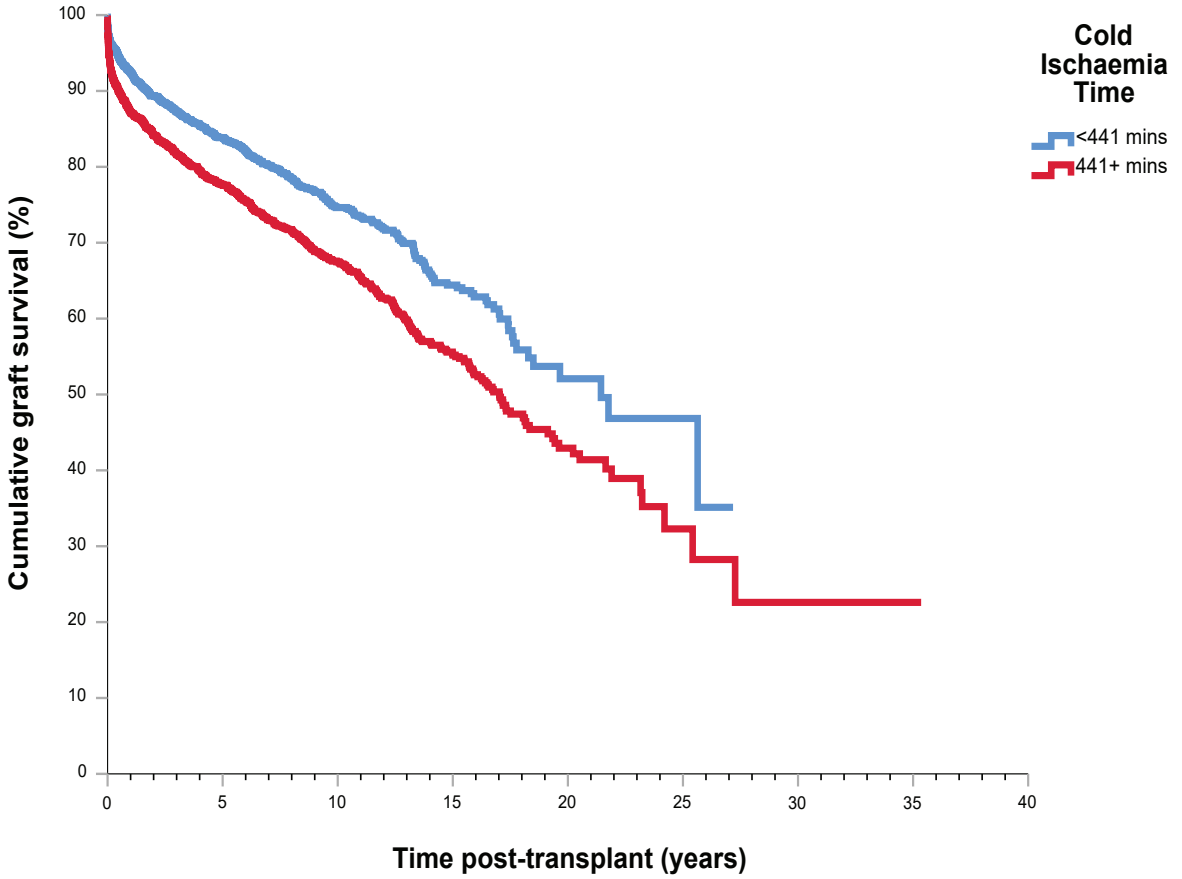


Table 47. Graft survival by cold ischaemia time

Cold Ischaemia Time	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
<441 min	No. at risk	3,231	2,757	2,136	1,616	661	30	0		
	Survival (%)		93%	87%	84%	75%	52%			
441+ min	No. at risk	1,936	1,645	1,399	1,191	714	62	2	2	0
	Survival (%)		87%	82%	78%	68%	43%	23%	23%	

2,099 cases missing

12.21 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=0.958, Figure 64 and Table 48). Ten-year graft survival was 72.4% 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), 71.7% for blood group incompatible transplants (excluding A2 donors), 70.2% for blood group-compatible transplants and 69.8% for blood group-identical transplants. Median graft survival was not reached for blood group incompatible transplants, 21.2 years for incompatible "A2" transplants, 20.8 years for transplants in which the donor and recipient blood groups were compatible and 19.5 years for transplants between identical blood groups.

Figure 64. Graft survival curve by blood group compatibility

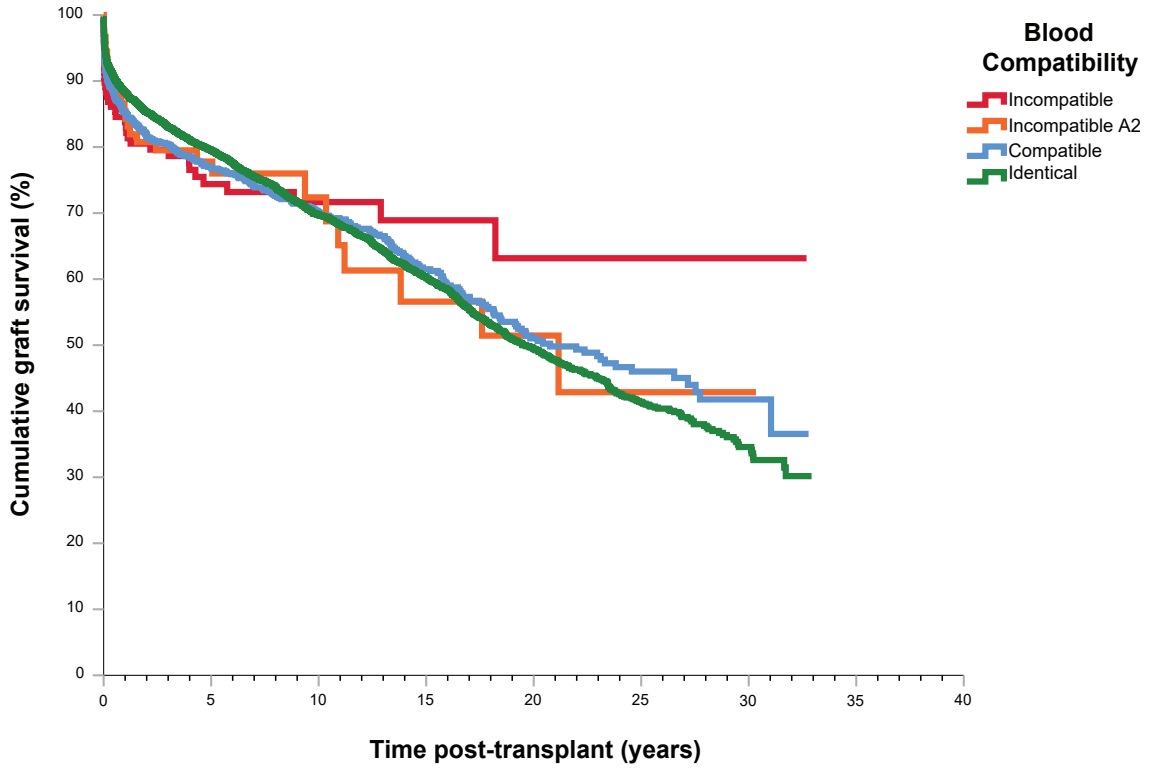


Table 48. Graft survival by blood group compatibility

Compatibility	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Incompatible	No. at risk	137	104	82	65	37	7	3	0	
	Survival (%)		84%	80%	74%	72%	63%	63%		
Incompatible A2	No. at risk	90	74	59	43	20	9	1	0	
	Survival (%)		85%	80%	78%	72%	51%	43%		
Compatible	No. at risk	968	794	676	570	381	133	17	0	
	Survival (%)		85%	80%	77%	70%	51%	42%		
Identical	No. at risk	5,813	4,906	4,117	3,471	2,126	646	75	0	
	Survival (%)		88%	83%	80%	70%	50%	35%		

All deceased donors since 1989, 12 deceased donor blood types missing from 1989 onwards

12.22 Graft Survival by Recipient Urgency at Transplant

Graft survival varied significantly by recipient urgency at transplant (P = 0.005, Figure 65 and Table 49). Ten-year graft survival was 81.2% for category 2, 69.5% for non-urgent and 61.0% for category 1 patients. Median graft survival was 25.6 years for category 2, 19.6 years for non-urgent patients and 15.9 years for category 1.

Figure 65. Graft survival curve by recipient urgency at transplant

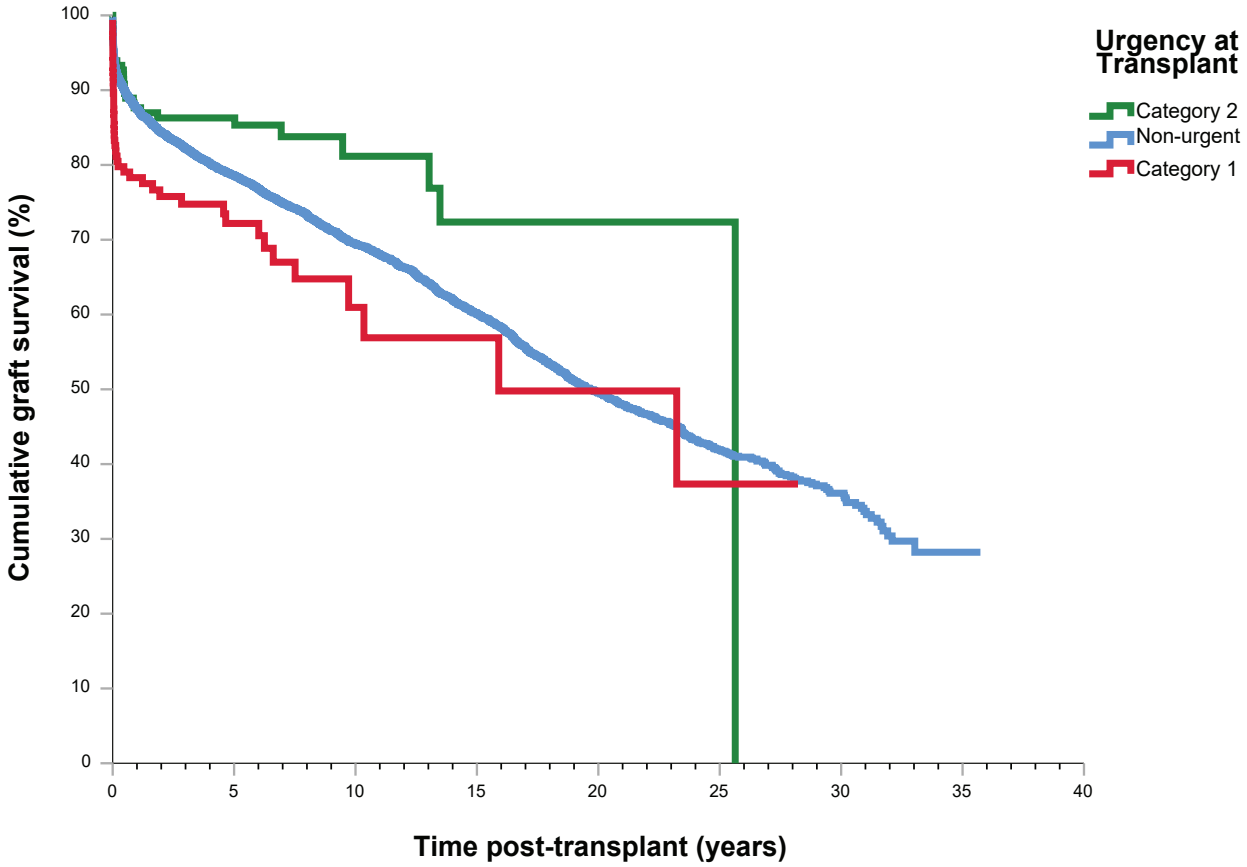


Table 49. Graft survival by recipient urgency at transplant

Urgency at Transplant	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	20	30	35	40
Category 2	No. at risk	165	134	109	90	30	3	0		
	Survival (%)		87%	86%	86%	81%	72%			
Non-urgent	No. at risk	6,957	5,835	4,913	4,150	2,630	828	124	4	0
	Survival (%)		88%	82%	79%	70%	50%	36%	28%	
Category 1	No. at risk	144	99	72	56	16	5	0		
	Survival (%)		78%	75%	72%	61%	50%			

13 Indication for Retransplantation

13.1 All Retransplants

There were 560 retransplants after the previous graft failed. There have been 499 second grafts, 59 third grafts and two fourth grafts. The commonest indications for retransplantation were vascular complications (27.9%), biliary complications (18.2%), rejection (18.2%), primary non-function or initial poor function (14.6%) and recurrent disease (13.4%, Table 50).

Table 50. Reason for retransplantation

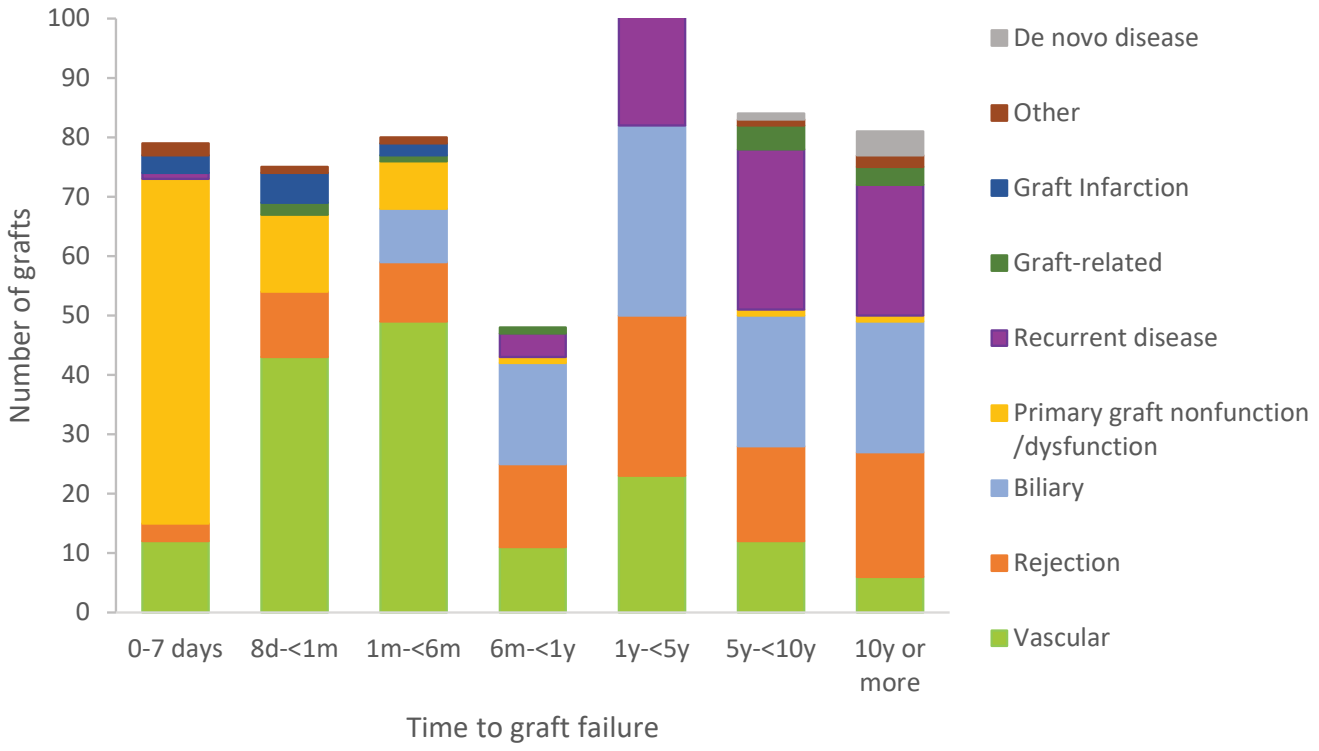
Reason for retransplantation	Graft 2	Graft 3	Graft 4	Total grafts	% Total
Vascular	**139**	**17**	**0**	**156**	**28%**
Hepatic artery thrombosis	*105*	*12*	*0*	*117*	*21%*
Portal vein thrombosis / Budd Chiari	*11*	*0*	*0*	*11*	*2%*
Hepatic vein thrombosis	*6*	*1*	*0*	*7*	*1%*
Unspecified	*5*	*0*	*0*	*5*	*0.9%*
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*	*0.4%*
Arterio-portal vein fistula	*1*	*0*	*0*	*1*	*0.2%*
Hepatic artery injury	*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	**95**	**7**	**0**	**102**	**18%**
Cholangiopathy	*67*	*3*	*0*	*70*	*13%*
Cholangitis	*8*	*2*	*0*	*10*	*2%*
Biliary cirrhosis / fibrosis	*7*	*0*	*0*	*7*	*1%*
Anastomotic	*6*	*0*	*0*	*6*	*1%*
Cholestatic disease	*4*	*0*	*0*	*4*	*0.7%*
Biliary necrosis	*0*	*2*	*0*	*2*	*0.4%*
Ductopenia	*2*	*0*	*0*	*2*	*0.4%*
Biliopathy caused by ABO incompatible transplant	*1*	*0*	*0*	*1*	*0.2%*
Rejection	**89**	**12**	**1**	**102**	**18%**
Chronic rejection	*65*	*11*	*0*	*76*	*14%*
Acute rejection	*16*	*1*	*1*	*18*	*3%*
ABO incompatible	*4*	*0*	*0*	*4*	*0.7%*
Donor antibody mediated	*2*	*0*	*0*	*2*	*0.4%*
Hyperacute rejection	*2*	*0*	*0*	*2*	*0.4%*
Primary graft nonfunction /dysfunction	**71**	**11**	**0**	**82**	**15%**
Primary nonfunction (ReTx <= 7 days)	*54*	*9*	*0*	*63*	*11%*
Primary dysfunction (ReTx > 7 days)	*17*	*2*	*0*	*19*	*3%*
Recurrent disease	**68**	**7**	**0**	**75**	**13%**
Primary sclerosing cholangitis	*26*	*5*	*0*	*31*	*6%*
Hepatitis C	*22*	*0*	*0*	*22*	*4%*
Autoimmune hepatitis	*8*	*1*	*0*	*9*	*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%*
Graft-related	**14**	**3**	**0**	**17**	**3%**
Post necrotic cirrhosis	*5*	*3*	*0*	*8*	*1%*
Graft infection	*4*	*0*	*0*	*4*	*0.7%*
Nodular regenerative hyperplasia	*3*	*0*	*0*	*3*	*0.5%*
Immune/nonviral hepatitis	*2*	*0*	*0*	*2*	*0.4%*

(table continued on next page)

Reason for retransplantation	Graft 2	Graft 3	Graft 4	Total grafts	% Total
Graft Infarction	**11**	**0**	**1**	**12**	**2%**
Non thrombotic	*5*	*0*	*1*	*6*	*1%*
Thrombotic	*6*	*0*	*0*	*6*	*1%*
Other	**6**	**2**	**0**	**8**	**1%**
Donor derived malignancy	*3*	*1*	*0*	*4*	*0.7%*
Cryptogenic cirrhosis	*2*	*1*	*0*	*3*	*0.5%*
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*	*0.4%*
Hepatocellular cancer	*2*	*0*	*0*	*2*	*0.4%*
Hepatitis B	*1*	*0*	*0*	*1*	*0.2%*
Hepatitis D	*1*	*0*	*0*	*1*	*0.2%*
Total	**499**	**59**	**2**	**560**	

Forty-two percent of graft failures occurred within the first six months post-transplant (14.1% 0 – 7 days, 13.4% day 8 to less than 1 month, 14.3% 1 month to less than 6 months). Primary graft non-function (73.4%) was the main reason for retransplantation in the first 7 days post-transplant whilst vascular causes were the main type for 8 days to less than 1 month (57.3%) and 1 month to less than 6 months (61.3% Figure 66). Recurrent disease was the leading cause of graft failure after five years post-transplant.

Figure 66. Time to graft failure by reason for retransplantation



13.2 Paediatric Retransplantation

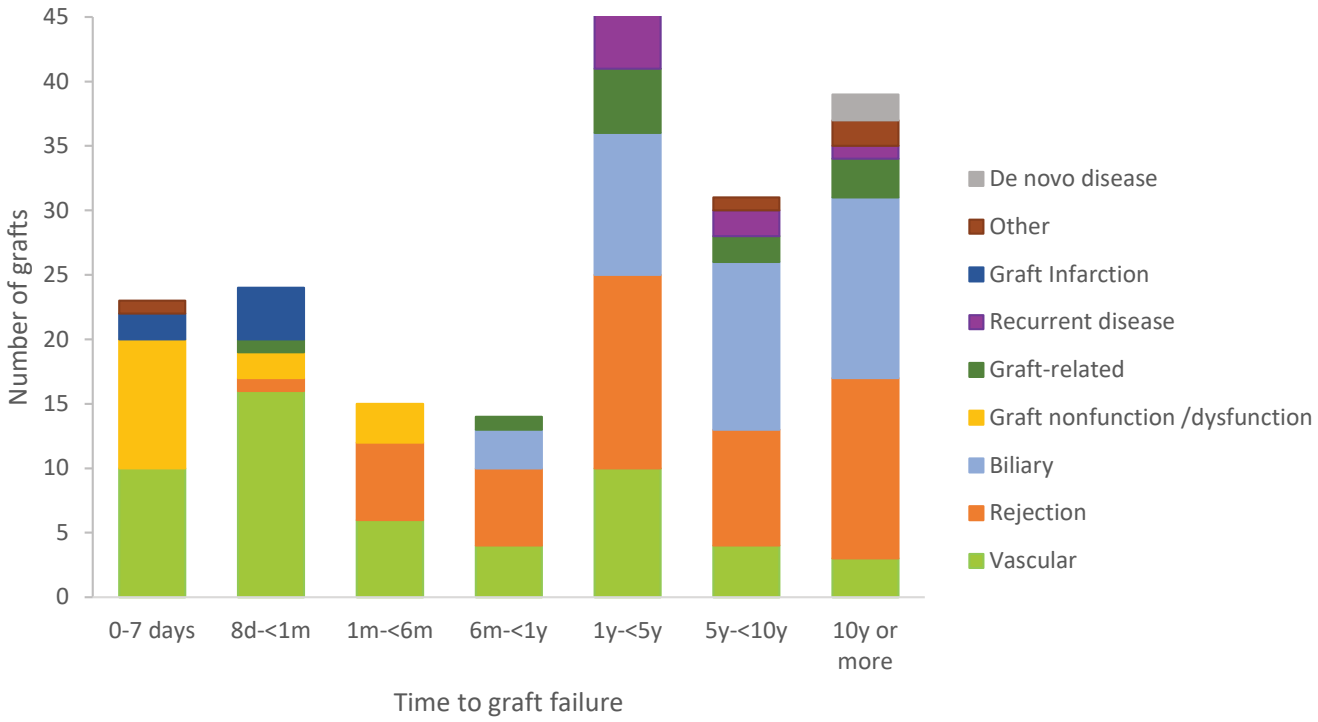
There were 192 retransplants following paediatric graft failure. There have been 164 second grafts and 28 third grafts. The commonest indications for retransplantation were vascular complications (27.6%), rejection (26.6%) and biliary complications (21.4%, Table 51).

Table 51. Reason for retransplantation following paediatric graft failure

Reason for retransplantation	Graft 2	Graft 3	Total grafts	% Total
Vascular	**44**	**9**	**53**	**28%**
Hepatic artery thrombosis	*28*	*6*	*34*	*18%*
Portal vein thrombosis / Budd Chiari	*8*	*0*	*8*	*4%*
Hepatic vein thrombosis	*2*	*1*	*3*	*2%*
Unspecified	*3*	*0*	*3*	*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	**41**	**10**	**51**	**27%**
Chronic rejection	*40*	*9*	*49*	*26%*
Acute rejection	*1*	*1*	*2*	*1%*
Biliary	**39**	**2**	**41**	**21%**
Cholangiopathy	*21*	*1*	*22*	*11%*
Biliary cirrhosis / fibrosis	*5*	*0*	*5*	*3%*
Cholangitis	*5*	*0*	*5*	*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**	**3**	**15**	**8%**
Primary nonfunction (ReTx <= 7 days)	*7*	*3*	*10*	*5%*
Primary dysfunction (ReTx > 7 days)	*5*	*0*	*5*	*3%*
Graft-related	**11**	**1**	**12**	**6%**
Post necrotic cirrhosis	*5*	*1*	*6*	*3%*
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*	*2%*
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**	**2**	**4**	**2%**
Cryptogenic cirrhosis	*2*	*1*	*3*	*2%*
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	**164**	**28**	**192**	**100%**

Thirty-two percent of graft failures occurred within the first six months post-transplant (12.0% 0 – 7 days, 12.5% day 8 to less than 1 month, 7.8% 1 month to less than 6 months). Vascular causes were the main reason for retransplantation in the first month post-transplant (Figure 67). Rejection, biliary and vascular causes were the leading causes of graft failure after one-year post-transplant.

Figure 67. Paediatric time to graft failure by reason for retransplantation



13.3 Adult Retransplantation

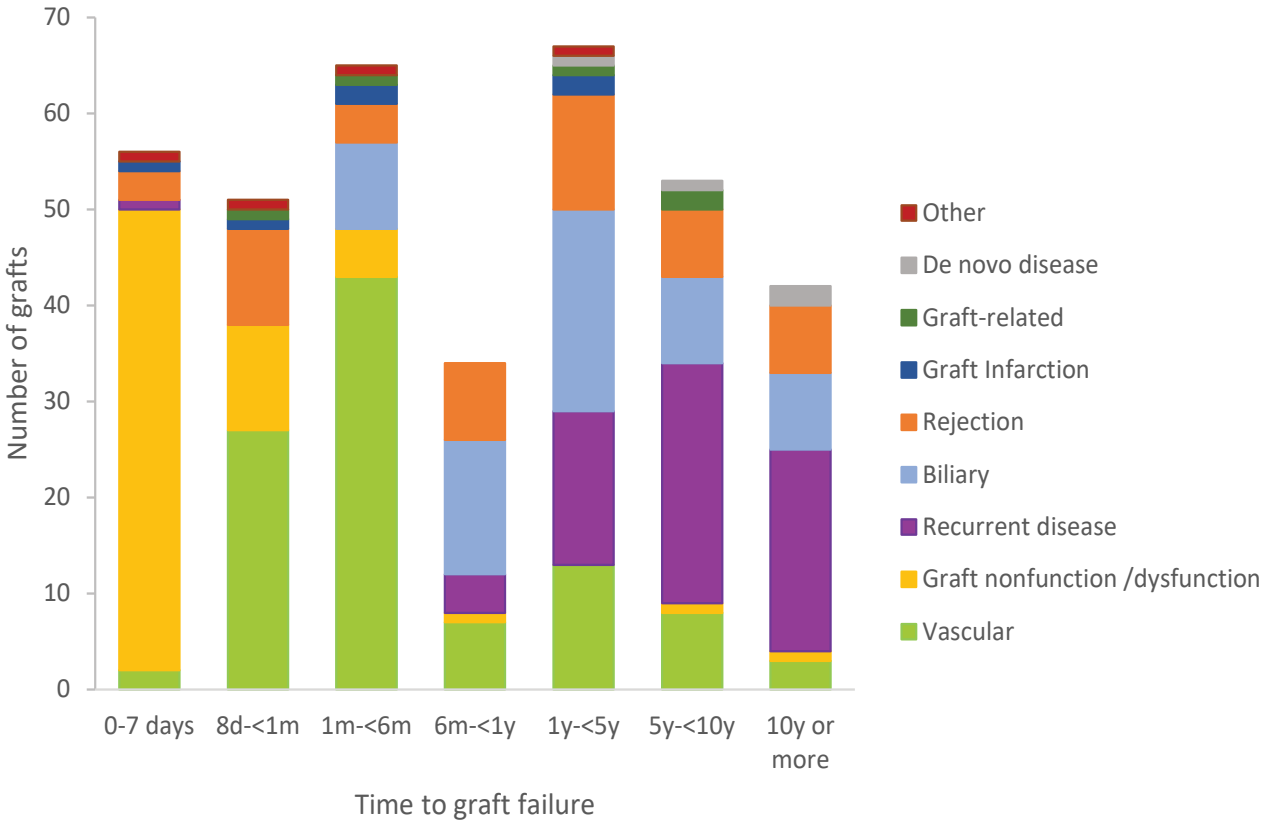
There were 368 retransplants following adult graft failure. There have been 335 second grafts, 31 third grafts and two fourth grafts. The commonest indications for retransplantation were vascular (28.0%), disease recurrence (18.2%) and primary non-function or initial poor function (18.2%, Table 52).

Table 52. Reason for retransplantation following adult graft failure

Reason for retransplantation	Graft 2	Graft 3	Graft 4	Total grafts	% Total
Vascular	**95**	**8**	**0**	**103**	**28%**
Hepatic artery thrombosis	*77*	*6*	*0*	*83*	*23%*
Haemorrhage (hepatic artery)	*4*	*0*	*0*	*4*	*1%*
Hepatic vein thrombosis	*4*	*0*	*0*	*4*	*1%*
Portal vein thrombosis	*3*	*0*	*0*	*3*	*0.8%*
Hepatic artery pseudoaneurysm	*2*	*0*	*0*	*2*	*0.5%*
Hepatic artery stenosis	*2*	*0*	*0*	*2*	*0.5%*
Unspecified	*2*	*0*	*0*	*2*	*0.5%*
Hepatic artery injury	*1*	*0*	*0*	*1*	*0.3%*
Hepatic vein stenosis	*0*	*1*	*0*	*1*	*0.3%*
Ruptured hepatic artery anastomosis	*0*	*1*	*0*	*1*	*0.3%*
Recurrent disease	**61**	**6**	**0**	**67**	**18%**
Primary sclerosing cholangitis	*24*	*5*	*0*	*29*	*8%*
Hepatitis C	*22*	*0*	*0*	*22*	*6%*
Autoimmune hepatitis	*6*	*0*	*0*	*6*	*2%*
Primary biliary cirrhosis	*4*	*1*	*0*	*5*	*1%*
Hepatitis B	*4*	*0*	*0*	*4*	*1%*
Erythropoietic protoporphyria	*1*	*0*	*0*	*1*	*0.3%*
Primary graft nonfunction /dysfunction	**59**	**8**	**0**	**67**	**18%**
Primary nonfunction (ReTx <= 7 days)	*47*	*6*	*0*	*53*	*14%*
Primary dysfunction (ReTx > 7 days)	*12*	*2*	*0*	*14*	*4%*
Biliary	**56**	**5**	**0**	**61**	**17%**
Cholangiopathy	*46*	*2*	*0*	*48*	*13%*
Cholangitis	*3*	*2*	*0*	*5*	*1%*
Cholestatic disease	*3*	*0*	*0*	*3*	*0.8%*
Anastomotic	*2*	*0*	*0*	*2*	*0.5%*
Biliary cirrhosis / fibrosis	*2*	*0*	*0*	*2*	*0.5%*
Biliary necrosis	*0*	*1*	*0*	*1*	*0.3%*
Rejection	**48**	**2**	**1**	**51**	**14%**
Chronic rejection	*25*	*2*	*0*	*27*	*7%*
Acute rejection	*15*	*0*	*1*	*16*	*4%*
ABO incompatible	*4*	*0*	*0*	*4*	*1.1%*
Donor antibody mediated	*2*	*0*	*0*	*2*	*0.5%*
Hyperacute rejection	*2*	*0*	*0*	*2*	*1%*
Graft Infarction	**5**	**0**	**1**	**6**	**2%**
Non thrombotic	*3*	*0*	*1*	*4*	*1%*
Thrombotic	*2*	*0*	*0*	*2*	*0.5%*
Graft-related	**3**	**2**	**0**	**5**	**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*	*0.3%*
De novo disease	**4**	**0**	0	**4**	**1%**
Hepatitis B	*1*	*0*	*0*	*1*	*0.3%*
Hepatitis C	*1*	*0*	*0*	*1*	*0.3%*
Hepatitis D	*1*	*0*	*0*	*1*	*0.3%*
Hepatocellular cancer	*1*	*0*	*0*	*1*	*0.3%*
Other	**4**	**0**	0	**4**	**1%**
Donor derived malignancy	*3*	*0*	*0*	*3*	*0.8%*
Acute hepatic failure - Drug related: interferon	*1*	*0*	*0*	*1*	*0.3%*
Total	**335**	**31**	**2**	**368**	**100%**

Forty-seven percent of graft failures occurred within the first six months' post-transplant (15.2% 0 – 7 days, 13.9% day 8 to less than 1 month, 17.7% 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 68). Recurrent disease was the leading cause of graft failure after five years post-transplant.

Figure 68. Adult time to graft failure by reason for retransplantation

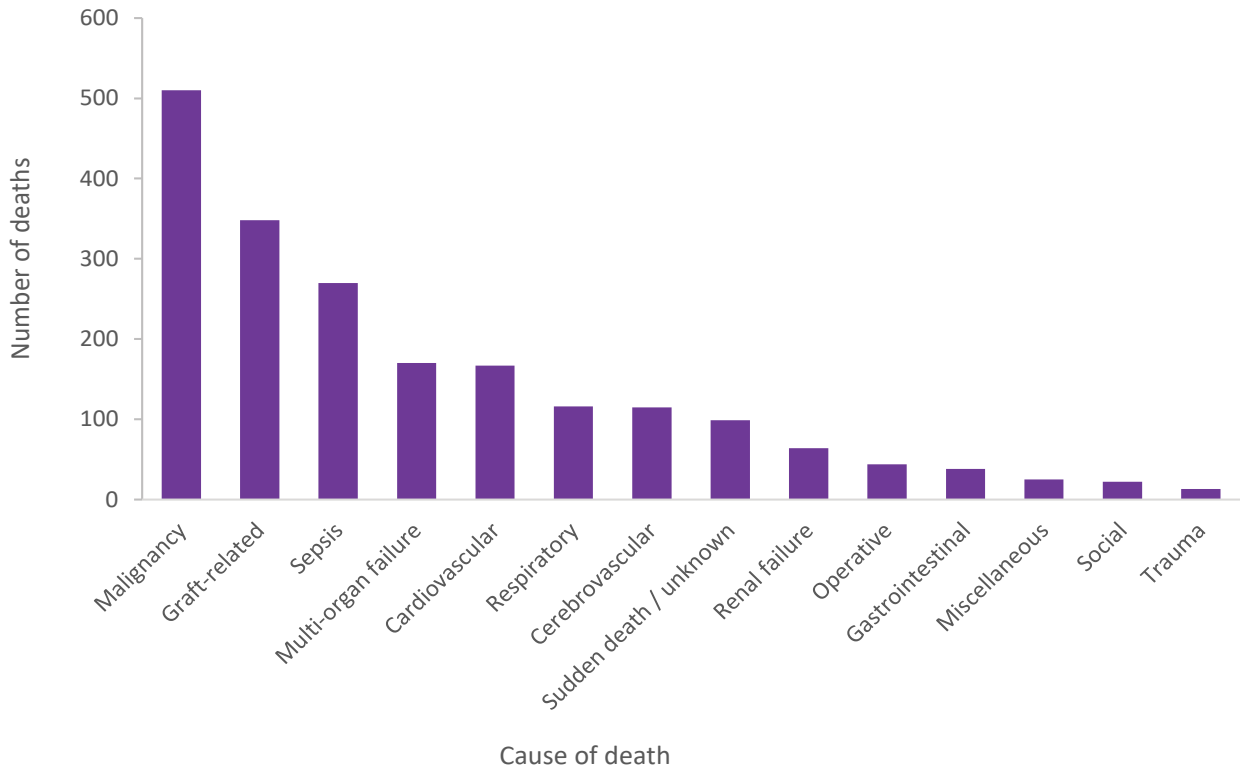


14 Cause of Patient Death

14.1 Cause of Death – All Patients

2,001 liver transplant patients (186 children and 1,815 adults based on age at first transplant) have died. The commonest causes of death were malignancy (25.5%), graft-related causes (17.4%), sepsis (13.5%), multi-organ failure (8.5%) and cardiovascular disease (8.3%, Figure 69, Table 53).

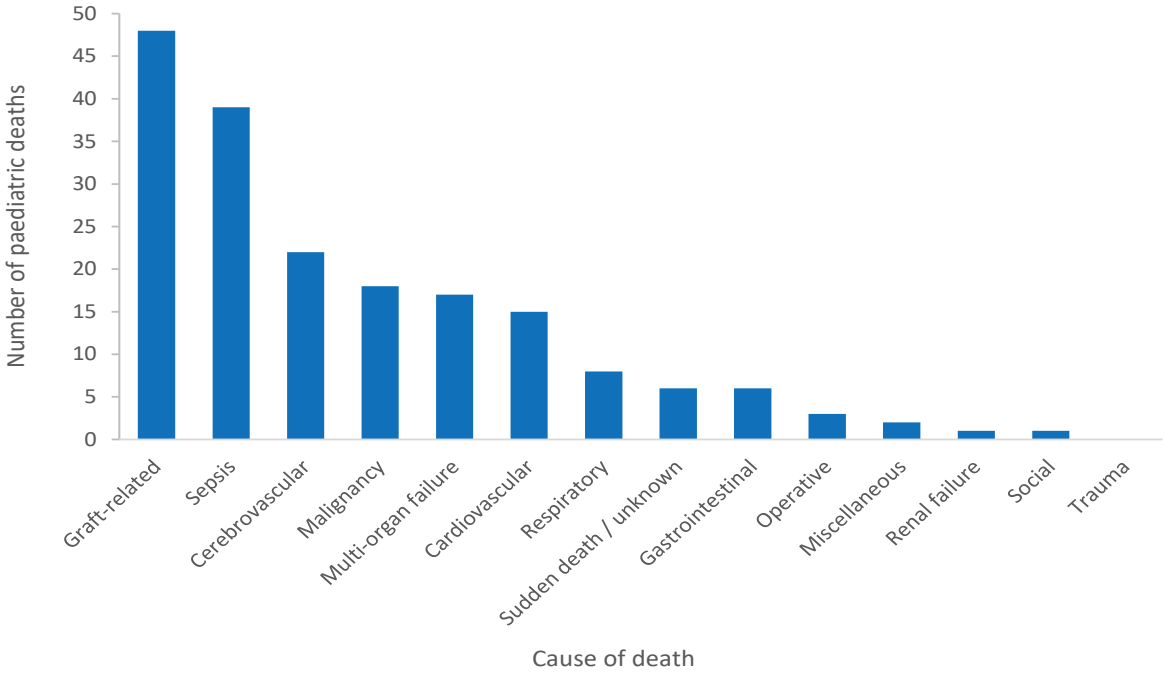
Figure 69. Cause of death by categories



14.2 Paediatric Patients - Cause of Death

Graft-related causes (25.8%) are the leading cause of death in children, with sepsis being the cause of death in a further 21.0% of paediatric patients (Figure 70, Table 53).

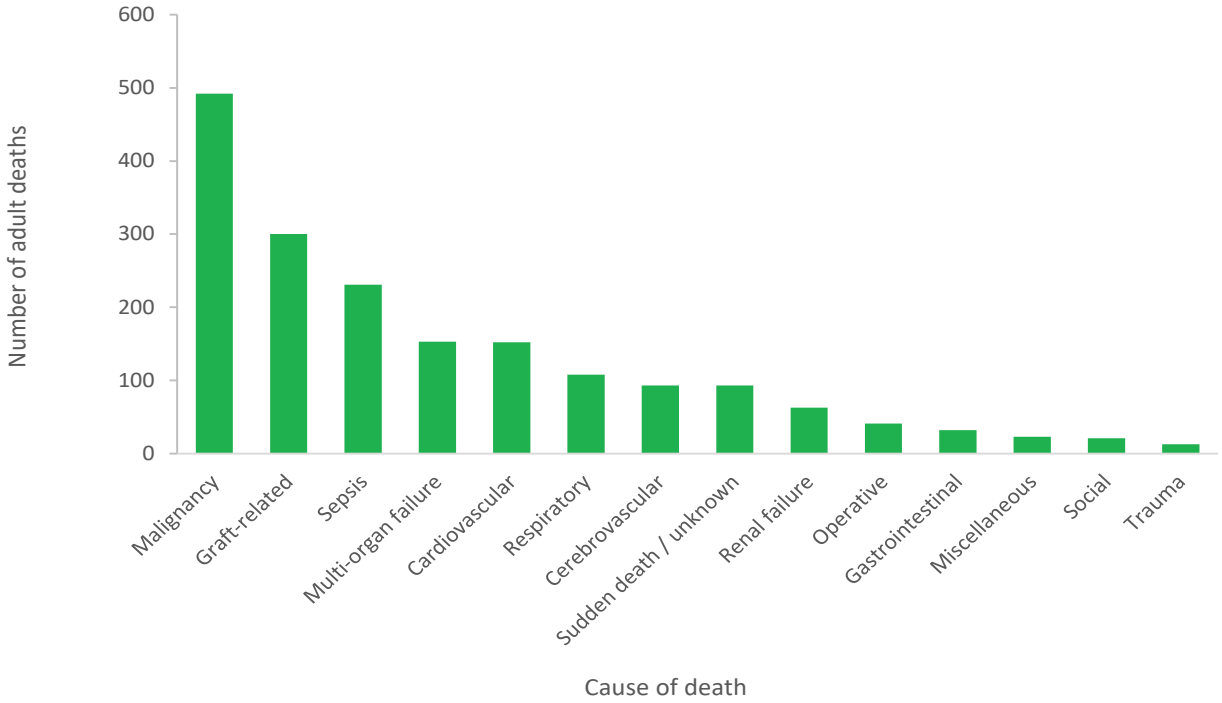
Figure 70. Paediatric cause of death



14.3 Adult Patients – Cause of Death

Malignancy (27.1% total: de novo malignancy 14.8%; recurrent malignancy 12.2%; donor transmitted malignancy 0.2%) is the most frequent cause of death in adult patients. Graft-related causes (16.5%) and sepsis (12.7%) are the next largest categories of adult deaths (Figure 71, Table 53).

Figure 71. Adult cause of death



14.4 Cause of Death Types by Age Group

Table 53. Cause of death by age group

Cause of death	Children	Adults	Total deaths	% of all deaths
Malignancy	**18**	**492**	**510**	**25%**
De novo malignancy	11	268	279	14%
Recurrent malignancy	7	221	228	11%
Donor transmitted malignancy	0	3	3	0.1%
Graft-related	**48**	**300**	**348**	**17%**
Other graft-related	39	136	175	9%
- Rejection	*17*	*73*	*90*	*4%*
- Primary non-function / dysfunction	*5*	*21*	*26*	*1%*
- Biliary complications	*3*	*17*	*20*	*1%*
- Graft vs host disease	*0*	*10*	*10*	*0.5%*
- Late graft failure	*0*	*8*	*8*	*0.4%*
- Hepatitis	*4*	*0*	*4*	*0.2%*
- Massive haemorrhagic necrosis	*4*	*0*	*4*	*0.2%*
- Non-thrombotic infarction	*3*	*1*	*4*	*0.2%*
- Unspecified	*2*	*2*	*4*	*0.2%*
- De novo hepatitis C	*0*	*2*	*2*	*0.1%*
- Hepato-renal syndrome	*0*	*1*	*1*	*0.05%*
- Portopulmonary hypertension	*0*	*1*	*1*	*0.05%*
- Post necrotic cirrhosis	*1*	*0*	*1*	*0.05%*
Disease recurrence	0	145	145	7%
- Hepatitis C	*0*	*95*	*95*	*5%*
- Hepatitis B	*0*	*18*	*18*	*0.9%*
- Alcohol-related cirrhosis	*0*	*12*	*12*	*0.6%*
- Primary sclerosing cholangitis	*0*	*8*	*8*	*0.4%*
- Autoimmune hepatitis	*0*	*4*	*4*	*0.2%*
- Primary biliary cirrhosis	*0*	*3*	*3*	*0.1%*
- NASH	*0*	*2*	*2*	*0.1%*
- Progressive familial amyloid polyneuropathy	*0*	*2*	*2*	*0.1%*
- Erythropoietic protoporphyria	*0*	*1*	*1*	*0.05%*
Vascular complications	9	19	28	1%
- Hepatic artery thrombosis	*4*	*9*	*13*	*0.6%*
- Portal vein thrombosis	*2*	*10*	*12*	*0.6%*
- Hepatic vein thrombosis	*2*	*0*	*2*	*0.1%*
- Inferior vena cava thrombosis	*1*	*0*	*1*	*0.05%*
Sepsis	**39**	**230**	**269**	**13%**
Bacterial	15	89	104	5%
Fungal	7	47	54	3%
Unspecified infection	6	46	52	3%
Mixed	5	28	33	2%
Viral	6	21	27	1%
Multi-organ failure	**17**	**153**	**170**	**8%**
Cardiovascular	**15**	**152**	**167**	**8%**
Respiratory	**8**	**108**	**116**	**6%**
Cerebrovascular	**22**	**93**	**115**	**6%**
Sudden death / unknown	**6**	**93**	**99**	**5%**
Renal failure	**1**	**63**	**64**	**3%**
Operative	**3**	**41**	**44**	**2%**
Gastrointestinal	**6**	**32**	**38**	**2%**
Miscellaneous	**2**	**24**	**26**	**1%**
Neurological	0	6	6	0.3%
Haematological	1	4	5	0.2%
Dementia	0	4	4	0.2%
Old age	0	4	4	0.2%

(table continued on next page)

Cause of death	Children	Adults	Total deaths	% of all deaths
Metabolic	1	2	3	0.1%
Allergy	0	1	1	0.05%
Donor transferred OTC deficiency	0	1	1	0.05%
Veno-occlusive disease	0	1	1	0.05%
Social	**1**	**21**	**22**	**1%**
Treatment withdrawal	0	9	9	0.4%
Suicide	0	7	7	0.3%
Overdose / Substance abuse	0	3	3	0.1%
Non-compliance immunosupportive therapy	1	2	3	0.1%
Trauma	**0**	**13**	**13**	**1%**
Motor vehicle accident	0	7	7	0.3%
Other accident excluding MVA	0	4	4	0.2%
Homicide	0	2	2	0.1%
Total	**186**	**1815**	**2001**	

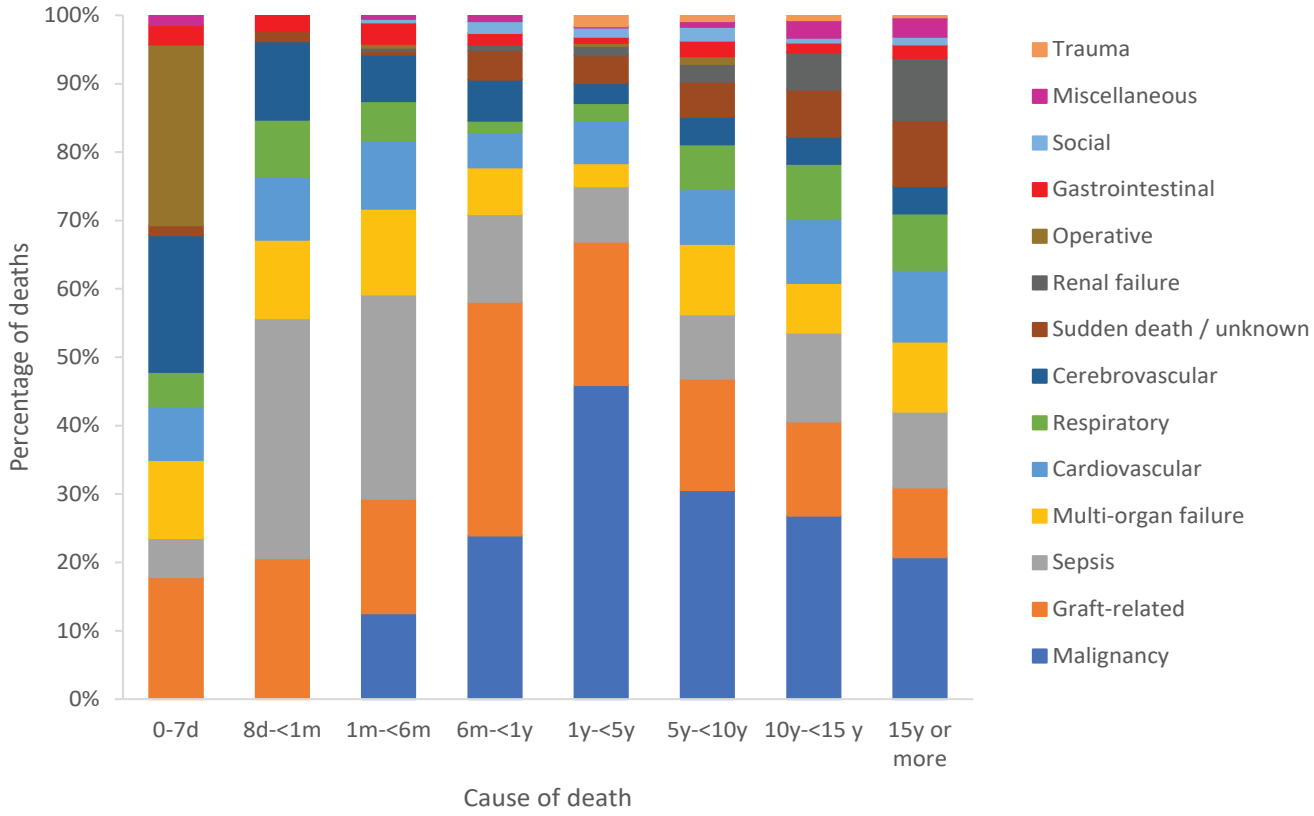
Abbreviation: MVA, motor vehicle accident; NASH, non-alcoholic steatohepatitis; OTC, Ornithine transcarbamylase

14.5 Cause of Death by Time to Death

Just under one third of post-transplant deaths occurred within the first year of transplant (7.0% in the first 7 days, 6.5% from day 8 to the end of the first month and 15.4% after the first month and before the end of the first year), a little more than one third between 1 and 10 years (22.2% between years 1 and 5 and 17.5% between years 5 and 10) and just under one third (31.4%) after 10 years.

The cause of death profile changes over the different post-transplant time periods (Figure 72). 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 72. Cause of death by time to death post-transplant – all patients

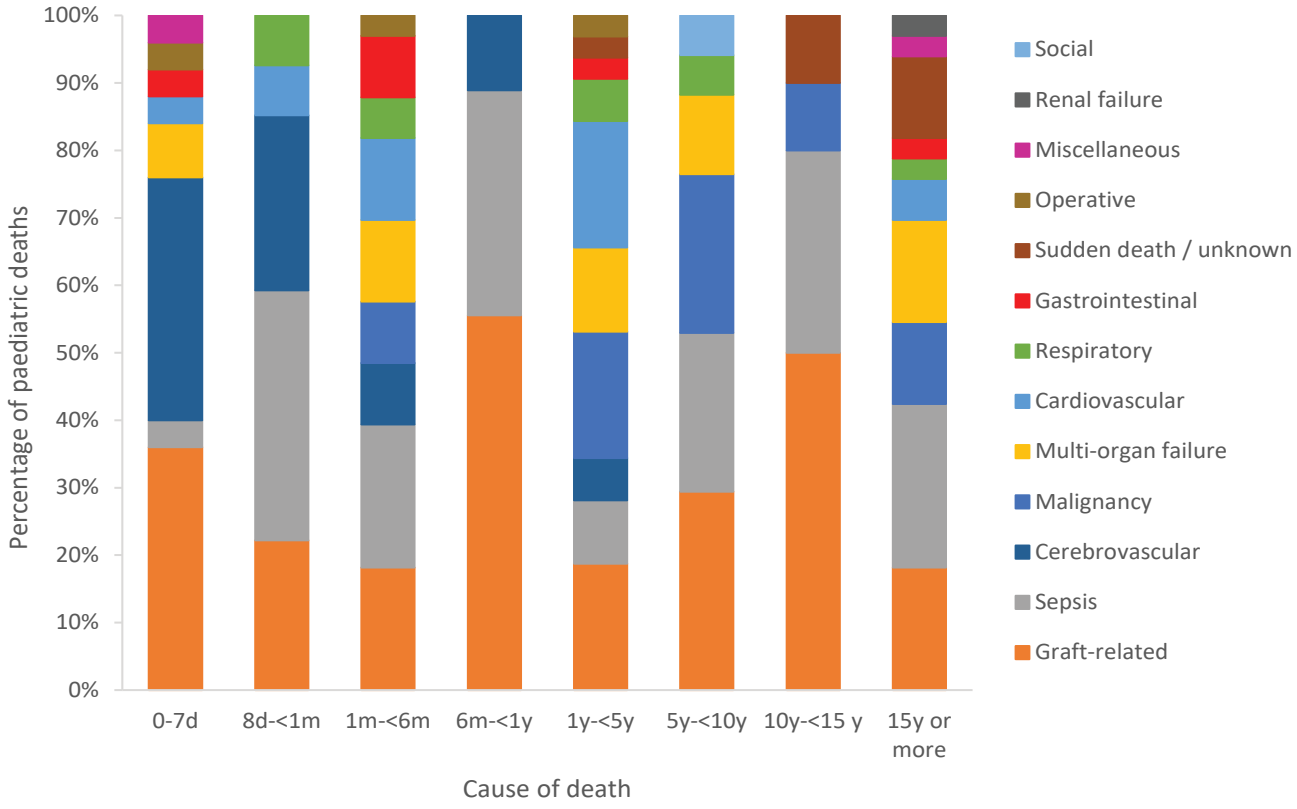


14.6 Paediatric Cause of Death by Time to Death

In children, 50.5% of deaths occurred within the first year of transplant (13.4% in the first 7 days, 14.5% 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), 17.2% between years 1 and 5, 9.1% between years 5 and 10 and 23.1% after 10 years.

Cerebrovascular and graft-related causes of death predominated in the first week post-transplant (Figure 73). 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 73. Paediatric cause of death by time to death post-transplant

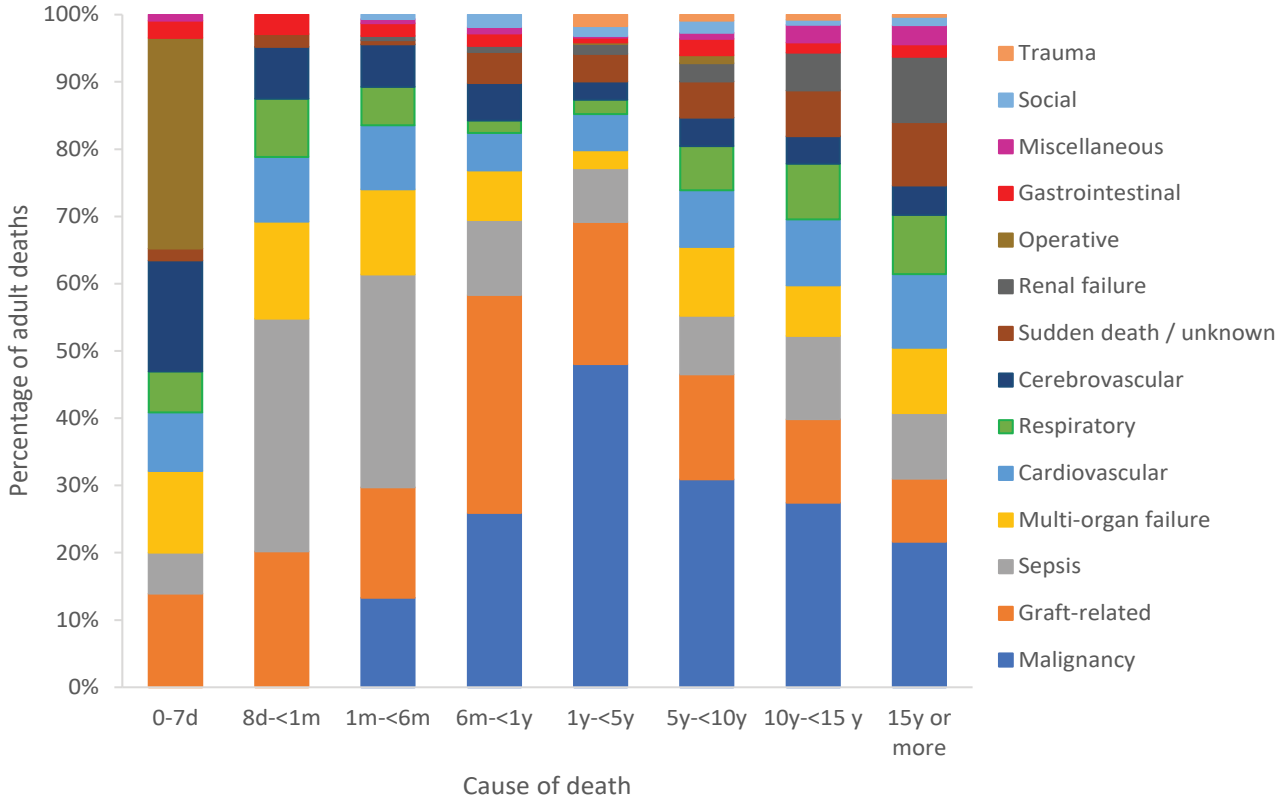


14.7 Adult Cause of Death by Time to Death

In adults, 26.7% of deaths occurred within the first year of transplant (6.3% in the first 7 days, 5.7% from day 8 to the end of the first month and 14.7% after the first month and before the end of the first year), 22.7% between years 1 and 5, 18.3% between years 5 and 10 and 32.2% after 10 years.

Operative, cerebrovascular and graft-related causes and multi-organ failure were prominent in the first week post-transplant (Figure 74). Sepsis was the predominant cause from 8 days to 6 months and malignancy and graft-related causes from 6 months.

Figure 74. Adult cause of death by time to death post-transplant



15 Liver Transplantation and Cancer

The Liver Transplantation and Cancer Report is produced by Pamela Dilworth, Liver Cancer Registry, Royal Prince Alfred Hospital, Sydney.

Cancer in liver transplant recipients was analysed from two perspectives. Firstly, those who had a liver cancer diagnosis at the time of transplantation (as primary diagnosis, secondary diagnosis or incidental finding at transplant) and secondly those who developed a cancer post transplantation (de novo skin and de novo non-skin cancer).

15.1 Cancer in Liver Transplant Recipients

Overall, 1,704 (25.4%) patients were transplanted with a liver malignancy, 706 (10.5%) as a primary diagnosis and 1,001 (14.9%) as a secondary diagnosis or incidental tumour (Table 54). Three patients had a primary liver cancer diagnosis and a different secondary liver cancer diagnosis. Another five patients had two secondary or incidental liver cancer types.

Table 54. Cancer in liver transplant recipients

	Number patients		% all transplant patients (n = 6,706)
At Transplant			
Liver cancer as indication for transplant	706		11%
Liver cancer as a secondary/incidental diagnosis#	1,001	(1,006 cancers)	15%
Total unique liver cancer patients*	**1,704**		**25%**
Post-transplant			
Recurrent liver cancer	198		3%
De novo non-skin cancer	540	(586 cancers)	8%
Skin cancer	1,019	(5,679 cancers)	15%
Total	**1,757**		**26%**
Multiple non-skin cancers	**150**		**2%**
Developed non-skin cancer < 90 days	**10**		**0.1%**

5 patients had 2 cancer types

*3 patients had liver cancers as both primary and secondary diagnosis

Post-transplant 198 (11.6%) patients with a primary, secondary, or incidental diagnosis of liver cancer developed a recurrent cancer and in 187 of these (11.0% of liver cancer patients and 94.4% of patients with recurrent liver cancer), death was related to their initial cancer. There were 540 patients (8.1% of all transplant recipients) who developed one or more de novo non-skin cancer types (586 cancer types). A total of 150 (2.2%) patients had more than one non-skin cancer type post-transplant. Ten patients developed a non-skin cancer within 90 days of their transplant (6 non-hodgkins lymphoma, 3 genitourinary, 1 Kaposi sarcoma).

15.2 Liver Cancer as a Primary Diagnosis

15.2.1 Types of Liver Cancer as a Primary Diagnosis

The primary indication for liver transplantation due to a liver cancer occurred in 706 (10.5%) liver transplant recipients. Ninety of these (12.7%) developed a recurrence of their primary tumour causing death.

Hepatocellular cancer was the most common type of liver cancer as a primary diagnosis (90.2%, Table 55). Whilst 21.5% of patients with hepatocellular carcinoma as a primary diagnosis have died, only 11.3% have died as a result of this cancer.

Table 55. Type of liver cancers as a primary diagnosis

Type of cancer as a primary diagnosis	Number cancers	% liver cancer patients	Deaths	% deaths for this cancer type	Died of this cancer	% patients died of this cancer
Hepatocellular cancer	637	90.2%	137	22%	72	11%
Hepatoblastoma	35	5.0%	5	14%	4	11%
Cholangiocarcinoma	12	1.7%	3	25%	2	17%
Fibrolamellar	5	0.7%	5	100%	2	40%
Epithelioid haemangioendothelioma	8	1.1%	2	25%	2	25%
Carcinoid	4	0.6%	4	100%	4	100%
Hepatocellular malignant neoplasm	2	0.3%	1	50%	1	50%
Angiosarcoma	1	0.1%	1	100%	1	100%
Gastrinoma	1	0.1%	1	100%	1	100%
Pancreatic islet cell	1	0.1%	1	100%	1	100%
Total primary liver cancers	706		160		90	
Percentage all liver transplant patients (n = 6,706)	11%		2%		1%	
Percentage primary liver cancer patients (n = 706)			23%		13%	

15.2.2 Patient Survival for Patients with Liver Cancer as a Primary Diagnosis

Ten-year patient survival for patients with a primary diagnosis of liver cancer was 71% (Figure 75, Table 56).

Figure 75. Patient survival curve for patients with a primary diagnosis of liver cancer

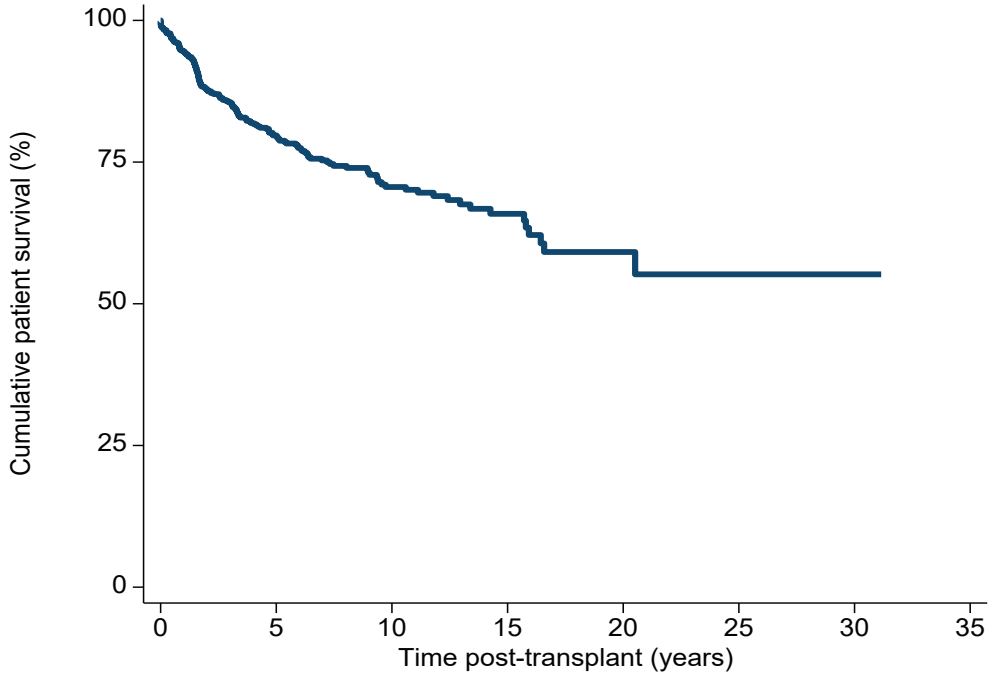
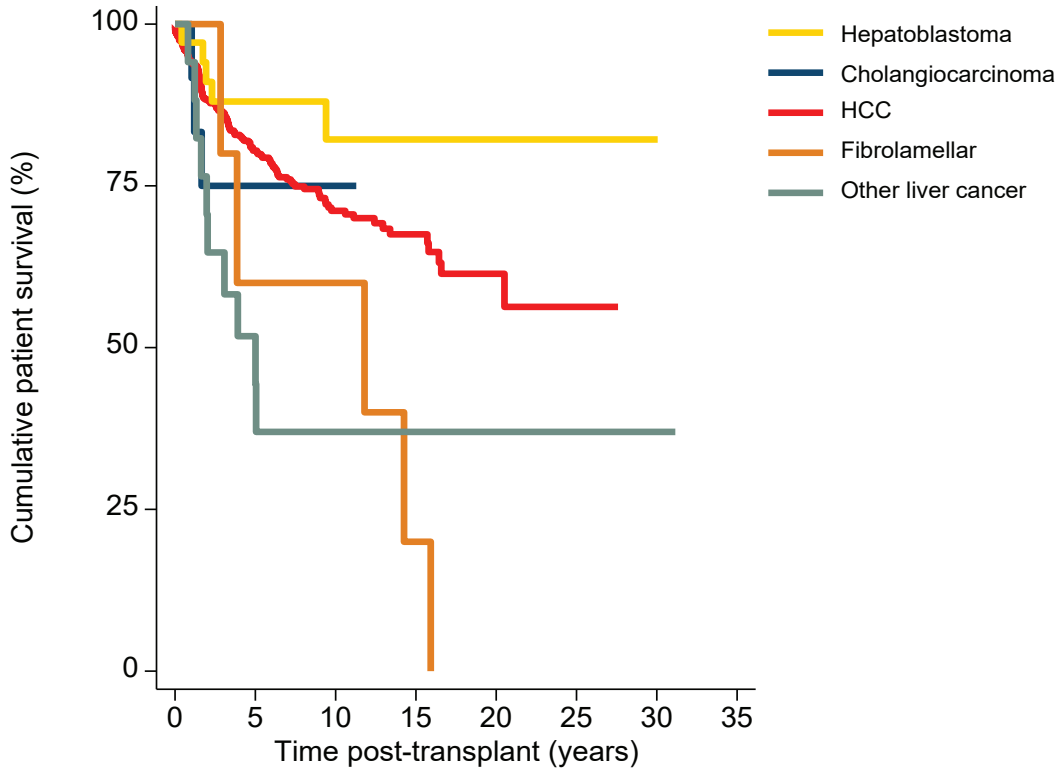


Table 56. Patient survival for patients with a primary diagnosis of liver cancer

Patient Survival	Time post-transplant (years)								
	0	1	5	10	15	20	25	30	35
No. at risk	706	622	342	160	68	19	5	3	1
Survival (%)		95%	80%	71%	66%	59%	55%	55%	

There was a significant difference in patient survival between patients with different liver cancers as a primary diagnosis (p<0.01). Ten-year patient survival for those with hepatoblastoma, cholangiocarcinoma, hepatocellular carcinoma, fibrolamellar variant and other liver cancers 82%, 75%, 72%, 60% and 37% respectively (Figure 76, Table 57).

Figure 76. Patient survival curve for patients with a primary diagnosis of liver cancer by type of cancer



Note: 3 patients had two primary liver cancer types

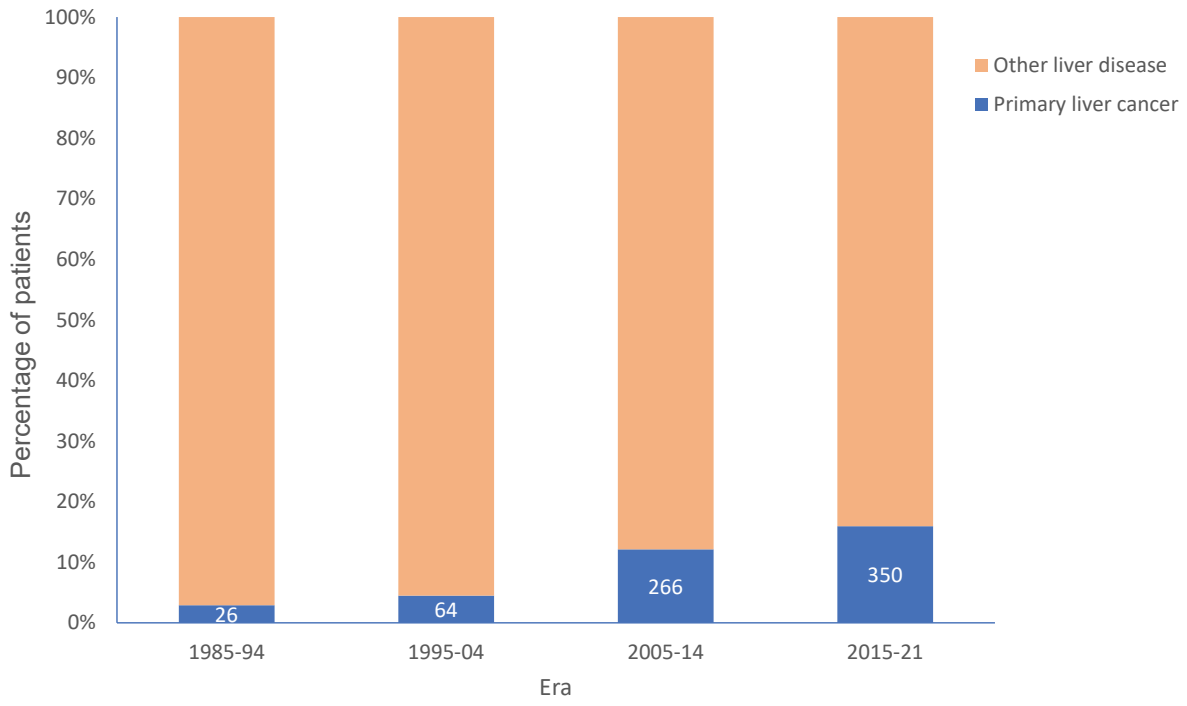
Table 57. Patient survival for patients with a primary diagnosis of liver cancer by type of cancer

Cancer type	Patient Survival	Time post-transplant (years)								
		0	1	5	10	15	20	25	30	35
Hepatoblastoma	No. at risk	35	34	26	14	4	3	2	2	1
	Survival (%)		97%	88%	82%	82%	82%	82%	82%	
Cholangiocarcinoma	No. at risk	12	12	3	2	1				
	Survival (%)		100%	75%	75%					
Hepatocellular carcinoma	No. at risk	637	557	305	141	63	16	3	1	
	Survival (%)		94%	81%	72%	68%	62%	57%		
Fibrolamellar	No. at risk	5	5	4	4	2	1			
	Survival (%)		100%	60%	60%	20%				
Other liver cancer	No. at risk	17	17	8	3	2	2	2	2	1
	Survival (%)		94%	52%	37%	37%	37%	37%	33%	

15.2.3 Incidence of Patients with Liver Cancer as a Primary Diagnosis by Era

The number of patients being transplanted with a primary liver cancer diagnosis increased over time from 26 in the 1985 – 94 era to 350 in the 2015 – 21 era. There has been a substantial increase in the proportion of transplant procedures for patients with primary liver cancer, from 3% in the 1985 – 94 era, 4% in the 1995 – 2004 era, 12% in the 2005 -14 era to 16% in the 2021 – 21 era (Figure 77).

Figure 77. Incidence of patients with liver cancer as a primary diagnosis by era



Text in blue boxes: number of patients transplanted with a primary liver cancer diagnosis

15.3 Liver Cancer as a Secondary / Incidental Diagnosis

1,001 patients with 1,006 liver cancers as a secondary / incidental diagnosis were transplanted. Five patients had two liver cancer types as their secondary diagnosis.

15.3.1 Types of Liver Cancer as a Secondary / Incidental Diagnosis

Hepatocellular carcinoma was the most common type of liver cancer as a secondary / incidental diagnosis (93.7%, Table 58). Whilst 25% of patients with hepatocellular carcinoma as a secondary / incidental diagnosis have died, only 8% died as a result of this cancer.

Table 58. Type of liver cancers as a secondary / incidental diagnosis

Type of cancer as a secondary diagnosis	Number patients	% of liver cancer patients	Deaths	% deaths for this cancer type	Died of this cancer	% patients died of this cancer
Hepatocellular cancer*	943	93.7%	236	25%	72	8%
Cholangiocarcinoma*	50	5.0%	35	70%	23	46%
Adenocarcinoma	4	0.4%	3	75%	0	0%
Fibrolamellar	4	0.4%	0	0%	0	0%
Hepatoblastoma*	2	0.2%	1	50%	0	0%
Epithelioid haemangioendothelioma	2	0.2%	1	50%	1	50%
Angiosarcoma	1	0.1%	1	100%	1	100%
Total liver cancers as a secondary / incidental diagnosis	1,006		277		97	
Percentage all liver transplant patients (n = 6,706)		16%		4%		2%
Percentage liver cancer patients as a secondary / incidental diagnosis (n = 1,001)				29%		10%

*Five patients had two liver cancer types as their secondary diagnosis.

15.3.2 Patient Survival for Patients with a Secondary / Incidental Liver Cancer Diagnosis

Ten-year patient survival for patients with a secondary diagnosis of liver cancer was 71% (Figure 78, Table 59). The median survival was 19 years.

Figure 78. Patient survival curve for patients with a secondary / incidental diagnosis of liver cancer

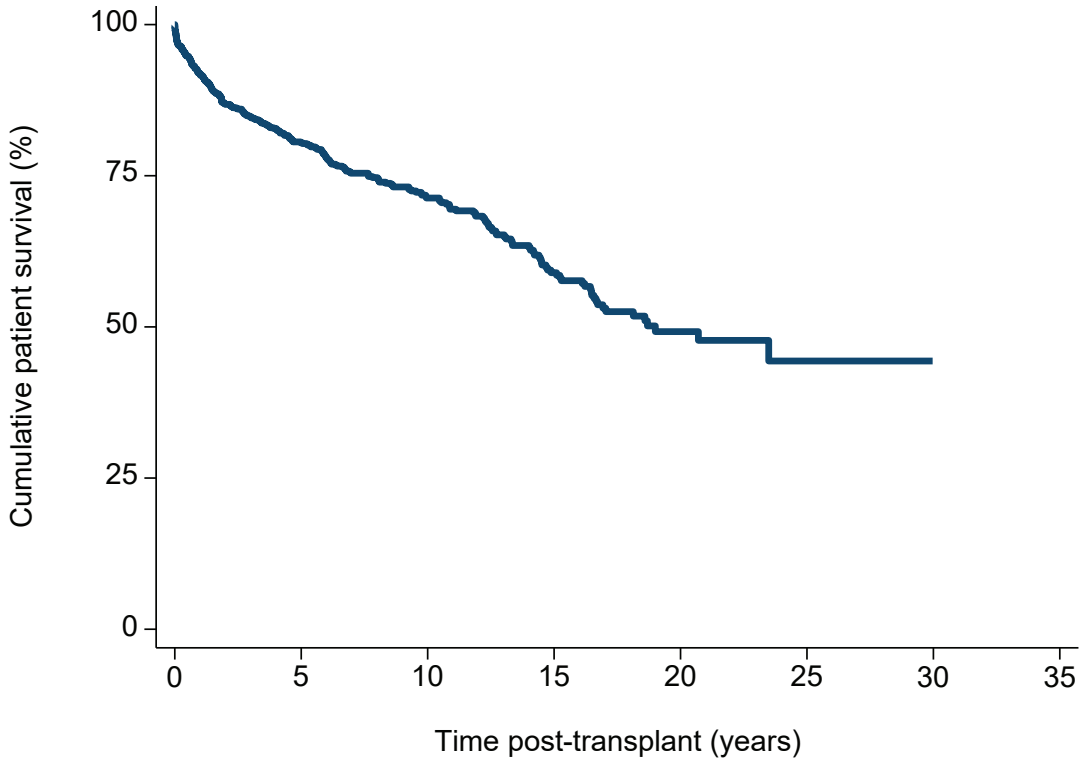
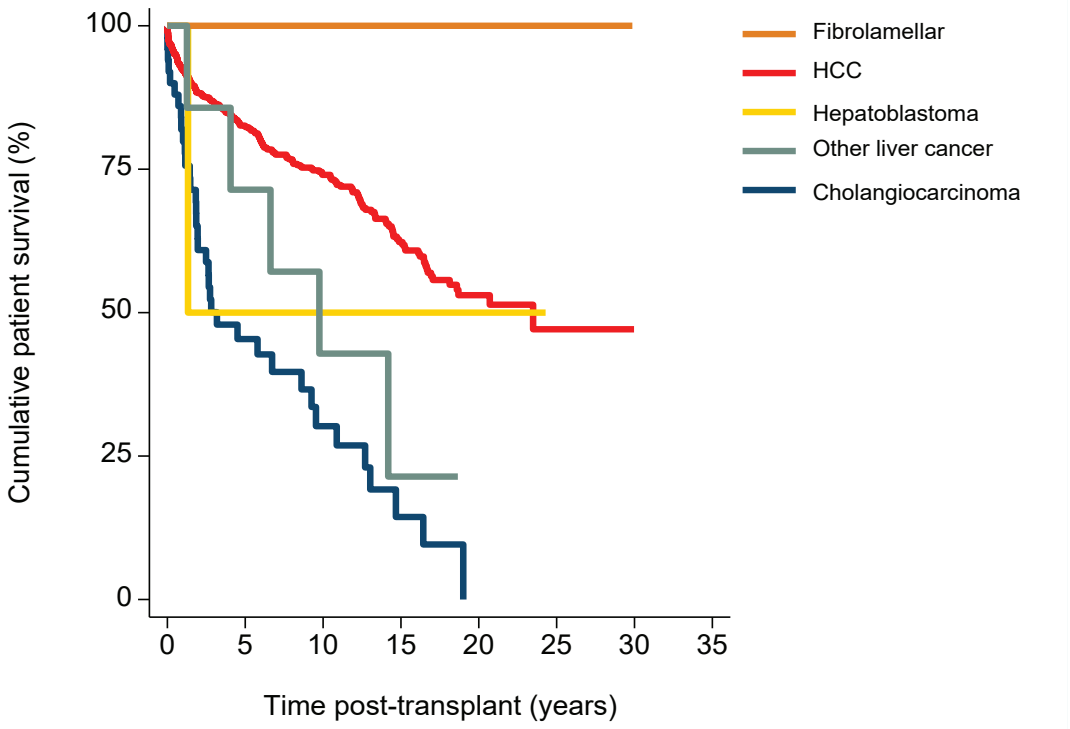


Table 59. Patient survival for patients with a secondary / incidental diagnosis of liver cancer

Patient Survival	Time post-transplant (years)								
	0	1	5	10	15	20	25	30	35
No. at risk	1,001	893	596	302	136	43	7	1	
Survival (%)		92%	80%	71%	59%	49%	44%		

There was a significant difference in survival between different liver cancers as a secondary / incidental diagnosis (p<0.0001, Figure 79, Table 60). Ten-year patient survival for those with a secondary diagnosis of fibrolamellar variant, hepatocellular carcinoma, hepatoblastoma, other liver cancers and cholangiocarcinoma were 100%, 74%, 50%, 43% and 30% respectively.

Figure 79. Patient survival curve for patients with secondary / incidental diagnosis of liver cancer by type of cancer



Note: 5 patients had two secondary / incidental liver cancer types

Table 60. Patient survival for patients with secondary / incidental diagnosis of liver cancer by type of cancer

Cancer type	Patient Survival	Time post-transplant (years)								
		0	1	5	10	15	20	25	30	35
Fibrolamellar	No at risk	4	4	4	4	2	2	2	1	
	Survival %		100%	100%	100%	100%	100%	100%		
Hepatocellular carcinoma	No at risk	943	841	569	285	130	41	6	1	
	Survival %		92%	82%	74%	62%	53%	47%		
Hepatoblastoma	No at risk	2	2	2	2	2	2	1		
	Survival %		100%	50%	50%	50%	50%			
Other liver cancer	No at risk	7	7	6	4	2	1			
	Survival %		100%	71%	43%	21%				
Cholangiocarcinoma	No at risk	50	40	18	10	4	1			
	Survival %		82%	45%	30%	14%				

15.4 Any Liver Cancer (Primary or Secondary / Incidental Diagnosis)

Of 6,706 transplanted patients, 1,704 (25.4%) patients had 1,712 liver cancers as a primary or secondary / incidental diagnosis (Table 61). Three patients had a primary liver cancer diagnosis and a different secondary liver cancer diagnosis. Five patients had two liver cancers as secondary / incidental diagnoses.

Table 61. Types of liver cancer (primary or secondary / incidental diagnosis)

Type of liver cancer as a diagnosis	Number cancers	% liver cancer patients	Deaths	% deaths for this cancer type	Died of this cancer	% patients died of this cancer
Hepatocellular cancer*	1,580	92.3%	373	24%	144	9%
Cholangiocarcinoma*	62	3.6%	38	61%	25	40%
Hepatoblastoma*	37	2.2%	6	16%	4	11%
Fibrolamellar	9	0.5%	5	56%	2	22%
Epithelioid haemangioendothelioma	10	0.6%	3	30%	3	30%
Adenocarcinoma	4	0.2%	3	75%	0	0%
Carcinoid	4	0.2%	4	100%	4	100%
Hepatocellular malignant neoplasm (nos)	2	0.1%	1	50%	1	50%
Angiosarcoma	2	0.1%	2	100%	2	100%
Gastrinoma	1	0.1%	1	100%	1	100%
Pancreatic islet cell	1	0.1%	1	100%	1	100%
Total liver cancers*	**1,712**		**430**		**187**	
Percentage all liver transplant patients (n=6,706)		25%		9%		4%
Percentage all liver cancer patients (n=1,704)				26%		11%

*Three patients had liver cancers as both primary and secondary diagnosis.

Five patients had two liver cancer types as their secondary diagnosis.

15.5 Patient Survival – Pretransplant Benign Disease Versus Pretransplant Liver Malignancy

Of patients transplanted, 5,000 had benign liver disease and 1,706 had pretransplant liver malignancy.

Post-transplant survival was superior in patients who were transplanted for benign disease (p<0.0001). Ten year and median survival for those with benign disease was 79% and 30 years, compared to 71% and 23 years for those with liver malignancy (Figure 80, Table 62).

Figure 80. Patient survival – pretransplant benign disease versus pretransplant liver malignancy

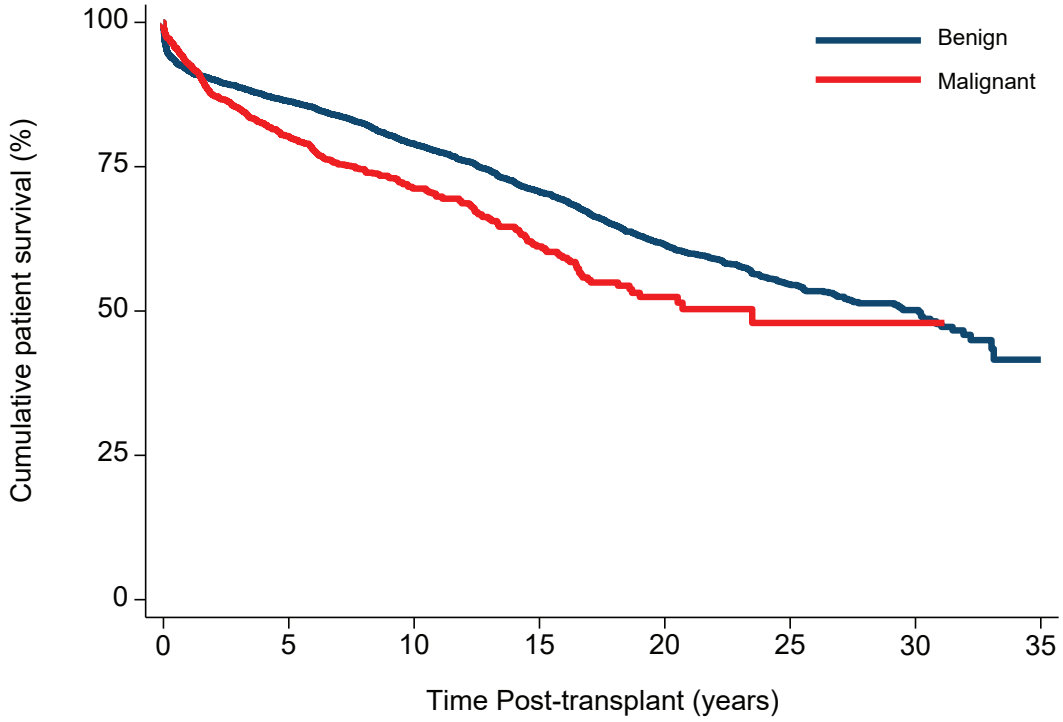


Table 62. Patient survival – pretransplant benign disease versus pretransplant liver malignancy

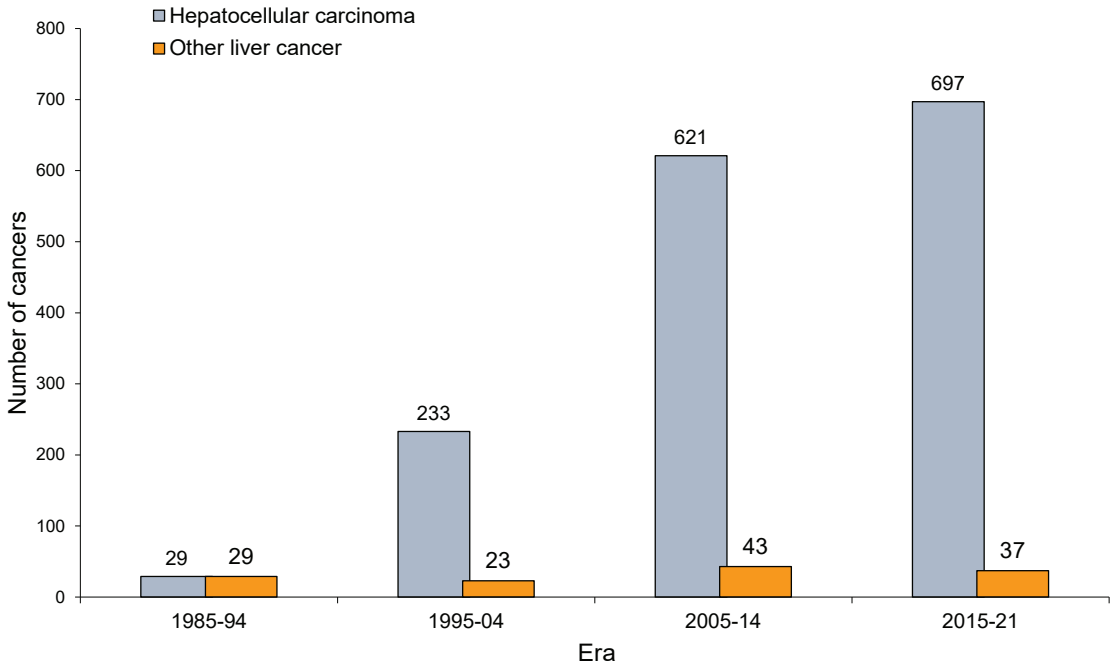
Cancer type	Patient Survival	Time post-transplant (years)								
		0	1	5	10	15	20	25	30	35
Benign	No at risk	5,000	4,359	3,313	2,260	1,460	843	437	143	6
	Survival %		92%	86%	79%	71%	62%	55%	50%	42%
Malignant	No at risk	1,706	1,505	932	459	202	61	11	3	1
	Survival %		93%	80%	71%	61%	52%	48%	48%	

15.6 Hepatocellular Carcinoma Diagnosis Versus Other Liver Cancers at Transplantation

15.6.1 Hepatocellular Carcinoma Versus Other Liver Cancers at Transplantation by Era

1,580 (24%) patients were transplanted with hepatocellular carcinoma either as a primary, secondary, or incidental diagnosis. The incidence of hepatocellular carcinoma has increased over the years (Figure 81).

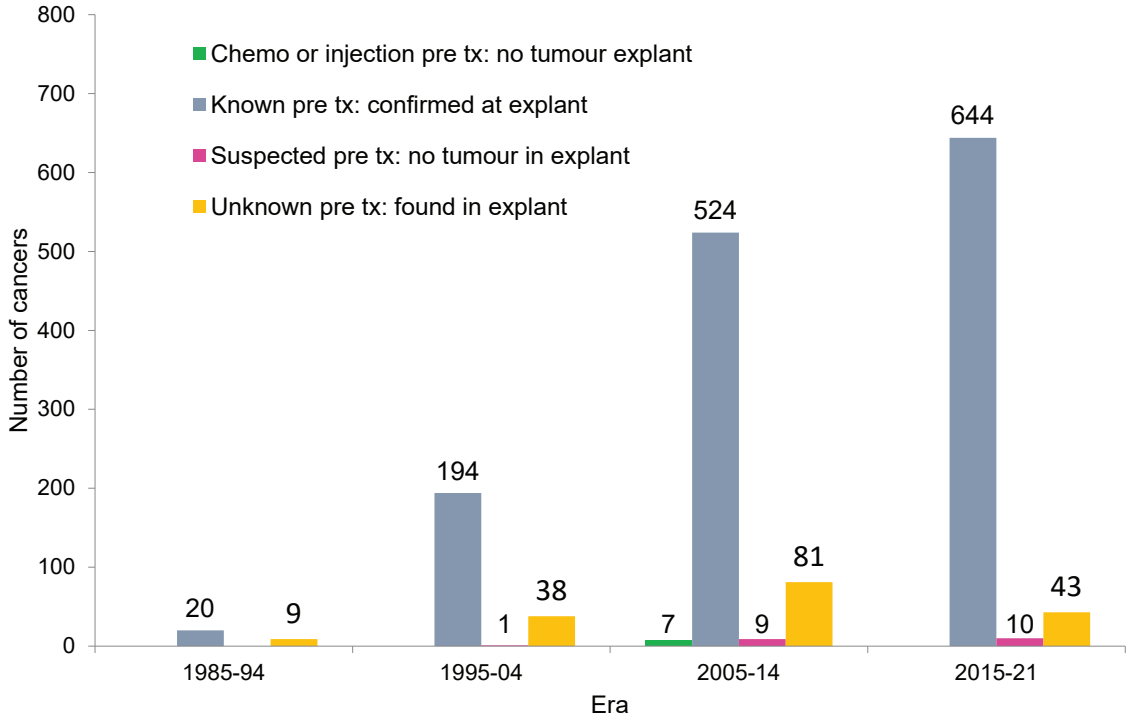
Figure 81. Hepatocellular carcinoma versus other liver cancers at transplantation by era



15.6.2 Hepatocellular Carcinoma Status at Transplant by Era

Most patients had hepatocellular carcinoma (HCC) known prior to transplant. Seven patients with treatment prior to transplant (transarterial chemoembolisation or ablation) had no HCC detected at explant. Twenty patients were suspected to have HCC, but no HCC was detected at explant. HCC was detected incidentally at explant in 171 patients. The number of patients transplanted with known HCC has increased over the eras (Figure 82).

Figure 82. Hepatocellular carcinoma status at transplant by era



15.6.3 Survival of Patients with Hepatocellular Carcinoma by Era

There has been improvement in patient survival over time for those transplanted with hepatocellular carcinoma. Ten-year survival for the 2005 - 14 era was 71%, 1995 - 2004 era was 66% and 1985 - 94 era was 38% (Figure 83, Table 63). Median survival between 1985 - 94 and 1995 - 2004 was 3 years and 17 years respectively and not reached in the 2005 - 14 and 2015 - 21 eras.

Figure 83. Survival of patients with hepatocellular carcinoma by era

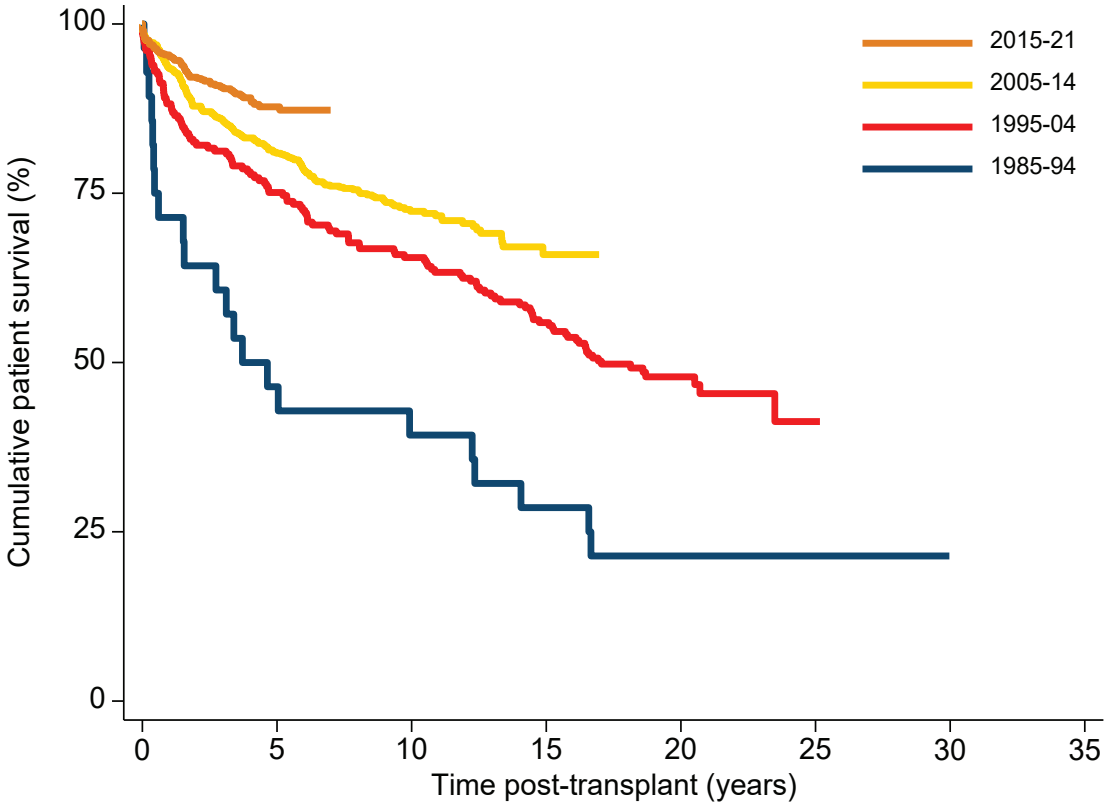


Table 63. Survival of patients with hepatocellular carcinoma by era

Era of Transplant	Patient Survival	Time post-transplant (years)								
		0	1	5	10	15	20	25	30	35
1985 - 1994	No at risk	29	19	13	11	8	6	6	1	
	Survival %		69%	46%	38%	27%	19%	19%		
1995 - 2004	No at risk	233	202	173	151	129	35	1		
	Survival %		89%	76%	66%	56%	48%			
2005 - 2014	No at risk	621	577	499	204	29	1			
	Survival %		94%	81%	71%	64%				
2015- 2021	No at risk	697	502	89	1					
	Survival %		95%	86%						

15.6.4 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 patients in whom it was not diagnosed prior to transplant and only detected in the explant (P=0.291, Figure 84, Table 64). Ten-year patient survival was 73% when there was known hepatocellular carcinoma and 70% when the hepatocellular carcinoma was not known pretransplant. Median survival for patients with hepatocellular carcinoma unknown pretransplant was 18 years and not reached where known pretransplant.

Figure 84. Survival of patients by hepatocellular carcinoma status at transplant

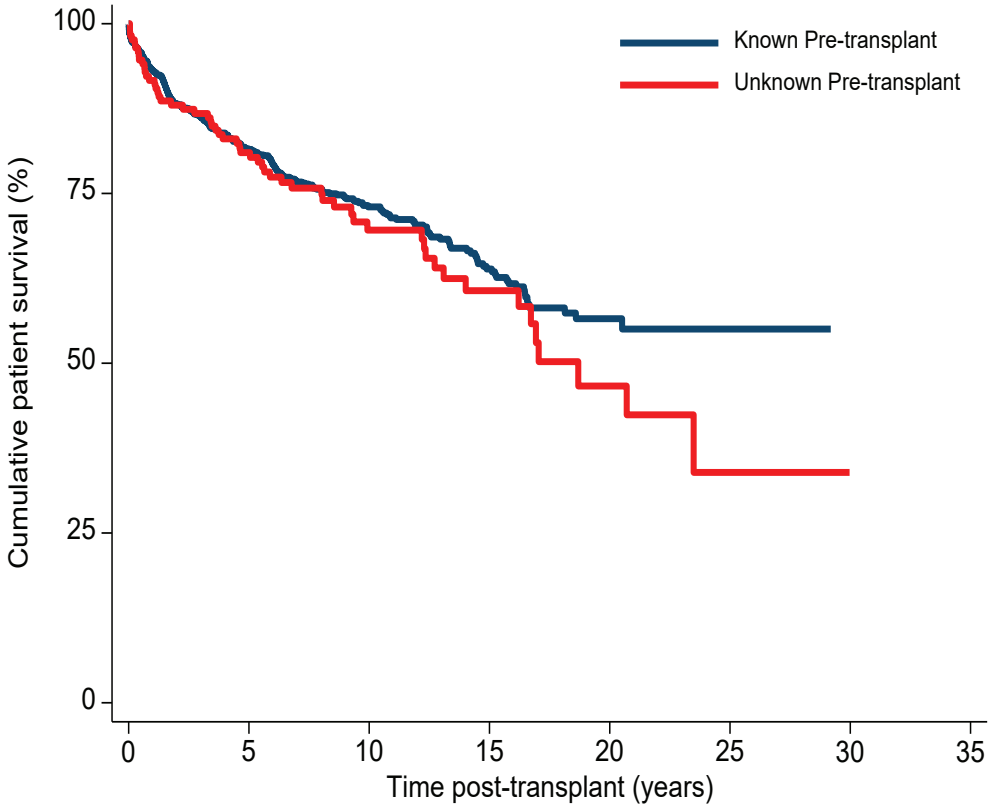


Table 64. Survival of patients by hepatocellular carcinoma status at transplant

HCC Category	Patient Survival	Time post-transplant (years)								
		0	1	5	10	15	20	25	30	35
Known pretransplant	No at risk	1,382	1,216	735	355	160	44	6	1	
	Survival %		93%	81%	73%	64%	57%	55%		
Unknown pretransplant	No at risk	171	153	118	59	29	13	3	1	
	Survival %		92%	81%	70%	61%	47%	34%		

Note: 27 patients were excluded from this analysis as they were treated HCC or suspected HCC that was not confirmed HCC on explant

15.7 De Novo Non-Skin Cancer

15.7.1 De Novo Non-Skin Cancer Types

Five hundred and forty patients (8%) developed 586 de novo non-skin cancers post-transplant with 41 patients developing more than one non-skin cancer type (Table 65). Of the 540 patients, 244 (45%) died of a de novo non-skin cancer. Median time from first transplant to development of a non-skin cancer post-transplant ranged from 17 to 113 months.

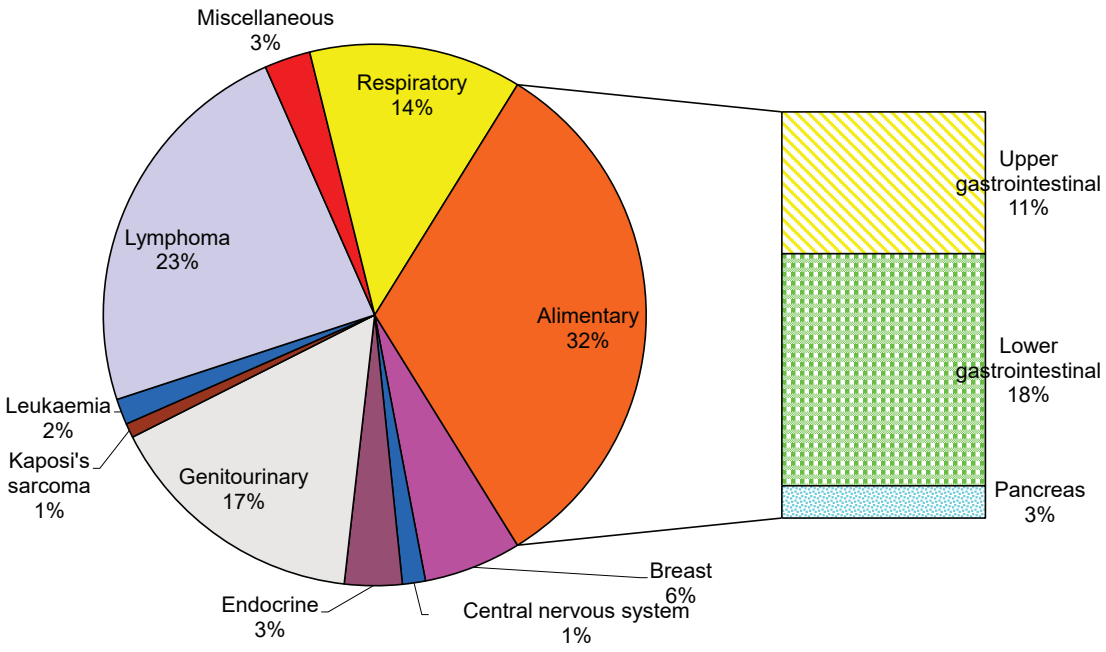
The three most common types of cancers were cancers of the alimentary tract (191, 32%), lymphoma (137, 23%) and genitourinary tract (92, 17%, Table 65, Figure 85). Lower gastrointestinal cancers account for 57% of alimentary tract cancers and 18% of all de novo non-skin cancers.

Table 65. De novo non-skin cancer types

	Number of patients	Male	Female	Age of patients (years)	Median age	Time to diagnosis (months)	Median time to diagnosis (months)	Died of this cancer	
Alimentary*	191	136	55	5 – 84	61	1 – 376	91	94	49%
Lymphoma*	137	79	58	1 – 82	50	1 – 283	67	56	41%
Genitourinary*	92	60	32	21 – 82	63	2 – 363	113	10	11%
Respiratory*	74	55	19	29 – 80	62	7 – 284	103	51	69%
Breast*	34	1	33	30 – 74	58	11 – 291	95	14	41%
Endocrine	20	10	10	28 – 77	56	6 – 346	82	3	15%
Miscellaneous*	16	10	6	49 – 82	65	6 – 301	99	7	44%
Leukaemia*	9	7	2	16 – 75	66	14 – 212	82	3	33%
Central nervous system*	8	6	2	3 – 66	59	15 – 190	44	6	75%
Kaposi's	5	4	1	31 – 76	49	2 – 254	17	0	0%
Total cancers	**586**	**368**	**218**	**1 – 84**	**60**	**1 – 376**	**87**	**244**	**42%**
Total patients	**540**	**343**	**197**					**244**	**45%**

*41 patients developed more than 1 non-skin cancer post-transplant.

Figure 85. De novo non-skin cancer types



Three hundred and forty-three males (8% males transplanted) developed 368 non-skin cancers. One hundred and ninety-seven females (8% of females transplanted) developed 218 non-skin cancers. Of the 244 patients who died from their non-skin cancer, 70% were male. Males were more likely to die from their cancer than women for alimentary tract cancers, lymphoma, endocrine, respiratory, CNS cancers and leukaemia and less likely to die than women for genitourinary, breast and miscellaneous cancers (Table 66).

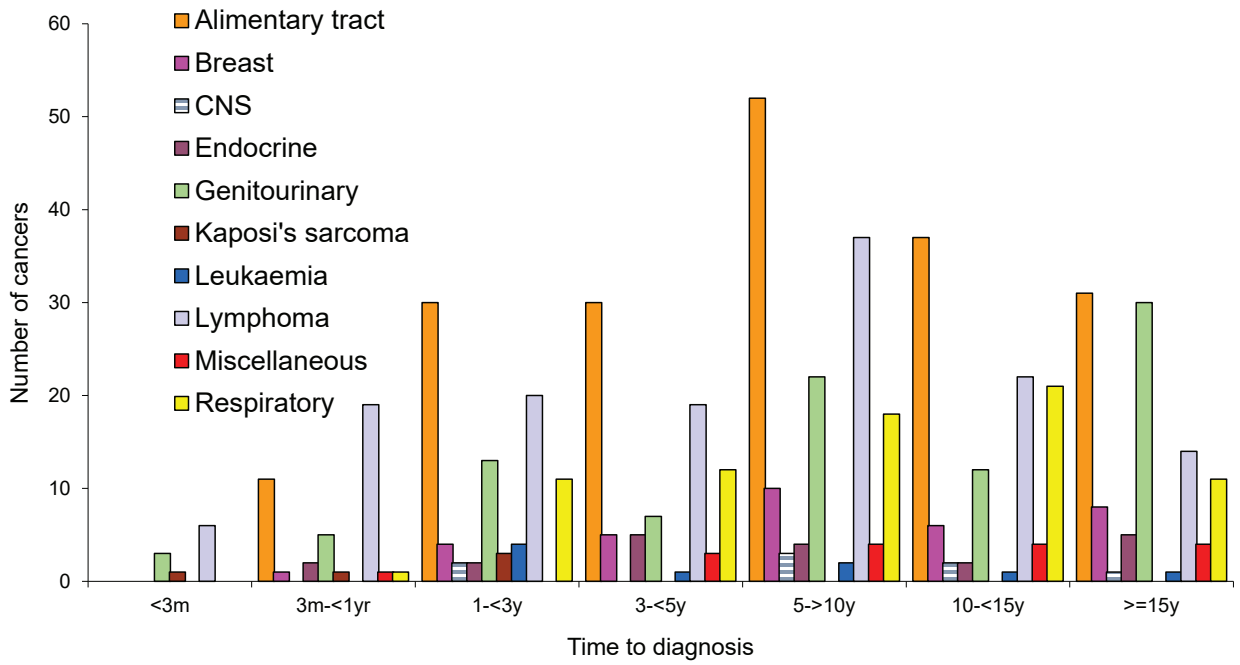
Table 66. De novo non-skin cancer types – gender versus death outcome

	Male			Female		
	No of cancers	Died of this cancer	% died of this cancer	No of cancers	Died of this cancer	% died of this cancer
Alimentary tract	136	75	55%	55	19	35%
Lymphoma	79	34	43%	58	22	38%
Genitourinary	60	6	10%	32	4	13%
Breast	1	0	0%	33	14	42%
Endocrine	10	3	30%	10	0	0%
Respiratory	55	40	73%	19	11	58%
Miscellaneous	10	4	40%	6	3	50%
Central nervous system	6	5	83%	2	1	50%
Leukaemia	7	3	43%	1	0	0%
Kaposi's sarcoma	4	0	0%	2	0	0%
Total cancers	**368**	**170**	**46%**	**218**	**74**	**34%**

15.7.2 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 86).

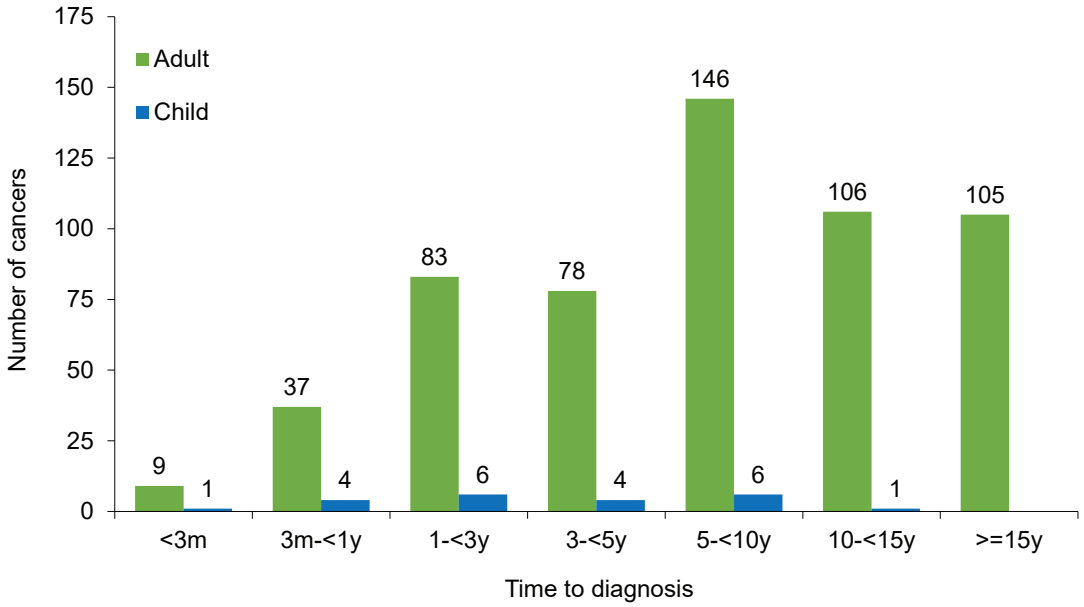
Figure 86. Time to diagnosis of de novo non-skin cancer



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

The majority of de novo non-skin cancers in children were diagnosed within the first 5 years post-transplant whilst, in adults, there were 207 in the first 5 years, 146 from five to ten years post-transplant and 211 cases ten years or more post-transplant (Figure 87).

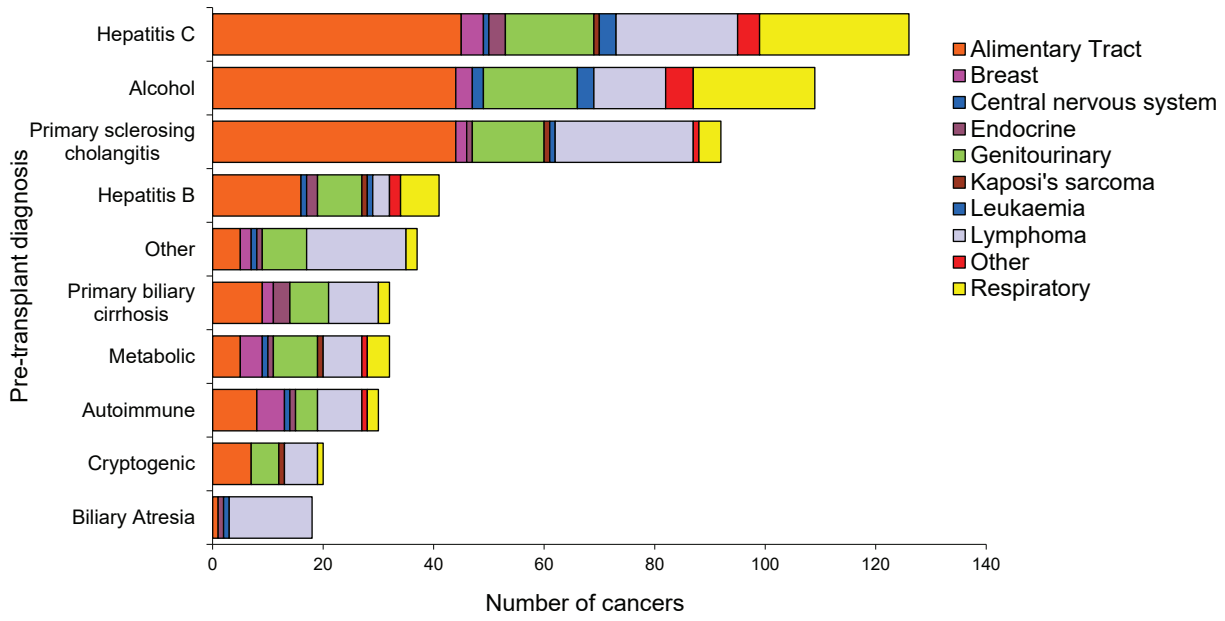
Figure 87. Time to diagnosis of any non-skin cancer by age category



15.7.4 Pretransplant Diagnosis and De Novo Non-Skin Cancer Types

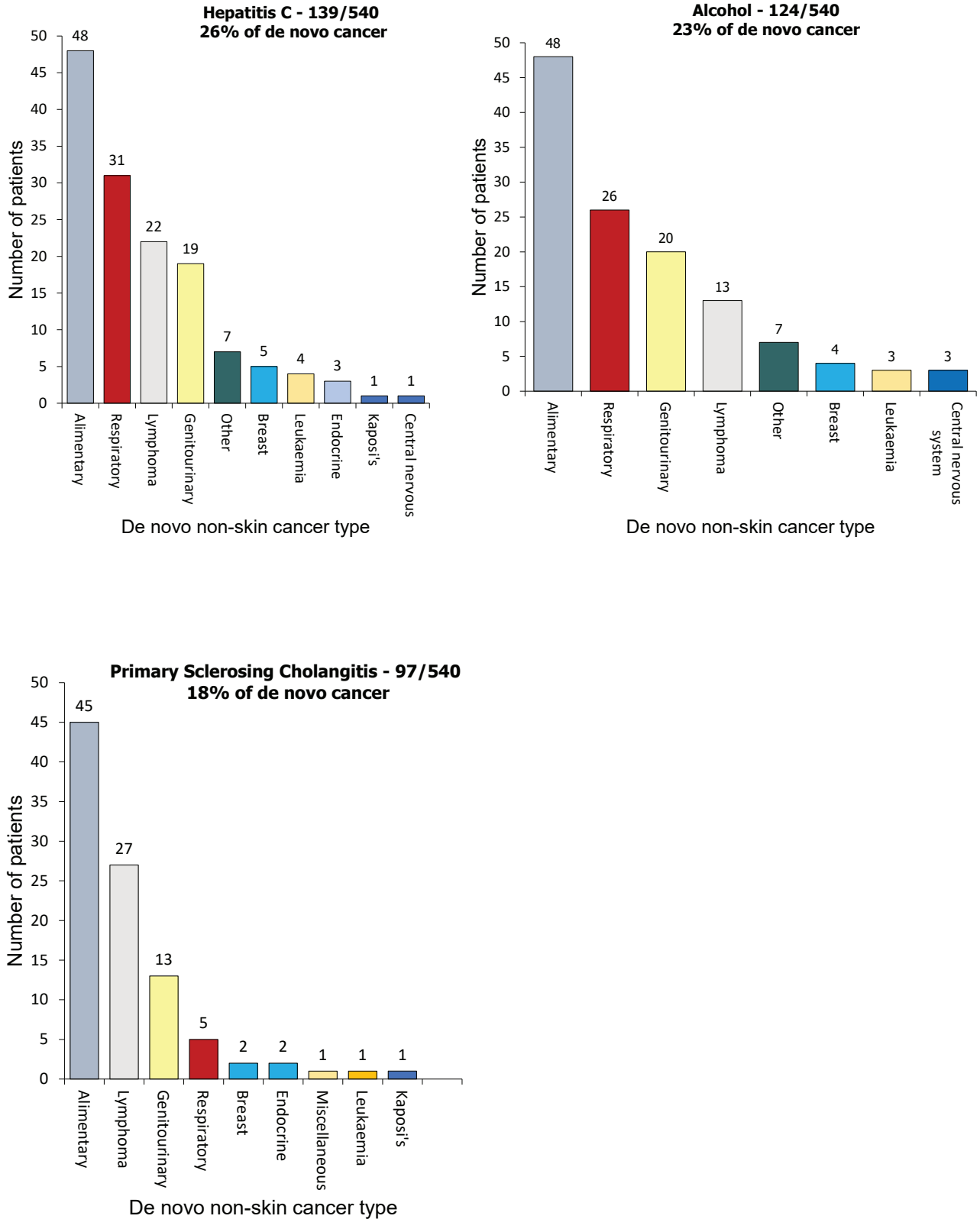
The incidence of de novo non-skin cancers appears to be related to the type of pretransplant underlying disease. Most notable is the incidence of de novo non-skin cancers in patients with underlying hepatitis C virus, alcohol and primary sclerosing cholangitis, being statistically significant ($p<0.0001$, Figure 88).

Figure 88. Pretransplant diagnosis and de novo non-skin cancer types



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 89). Pretransplant hepatitis C infection and alcohol-related liver disease were the dominant underlying disease for those who developed respiratory cancers.

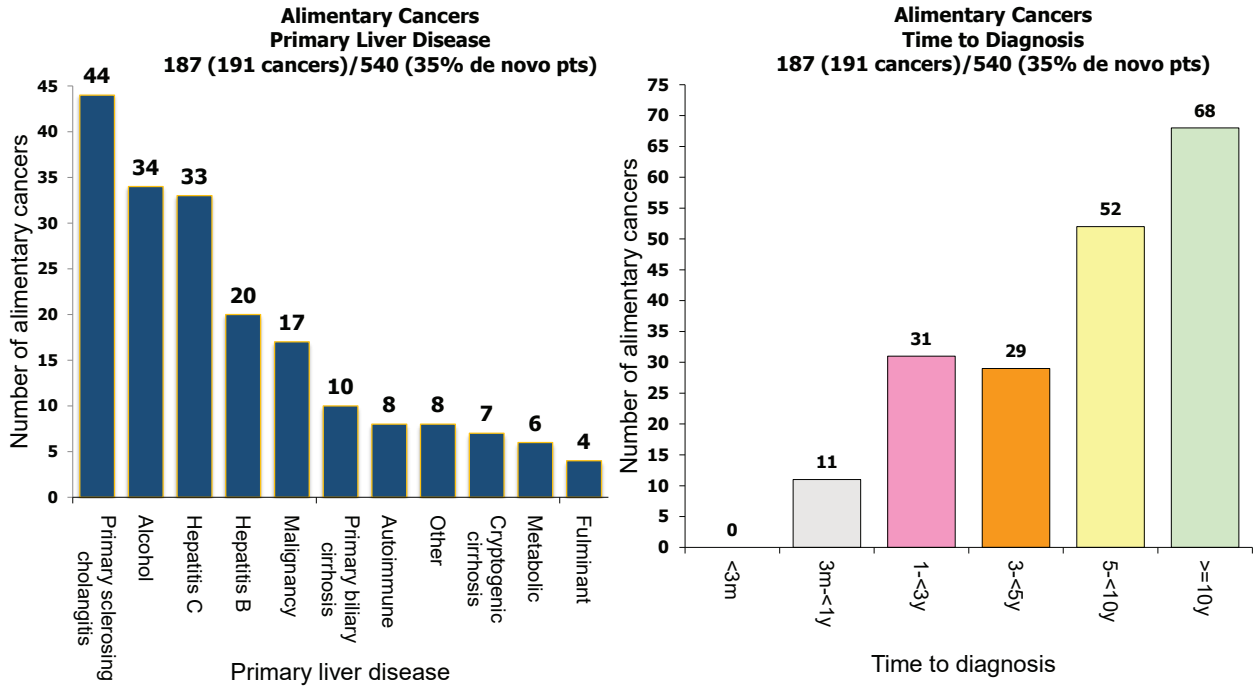
Figure 89. Hepatitis C virus, alcohol diagnosis and primary sclerosing cholangitis and types of de novo skin cancer



15.7.5 De Novo Alimentary Cancers

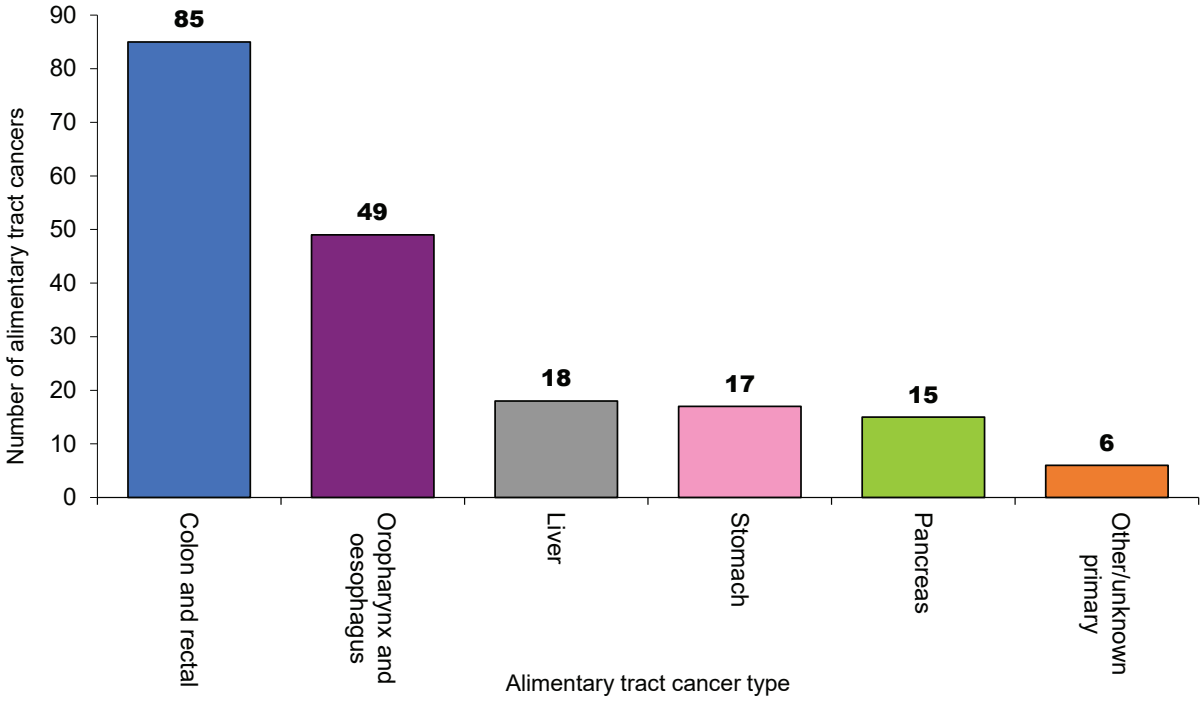
Cancer of the alimentary tract was the most prevalent non-skin cancer to develop post-transplant affecting 187 patients (191 cancers). Time to development ranged from 3 months to greater than 10 years with 63% being diagnosed after 5 years (Figure 90). Median time to diagnosis was 91 months. Pretransplant liver disease was predominantly primary sclerosing cholangitis, hepatitis C infection and alcohol-related liver disease.

Figure 90. Pretransplant diagnosis and de novo alimentary cancers



45% of alimentary cancers were of the colon and rectum; 26% were oropharynx and oesophagus (Figure 91).

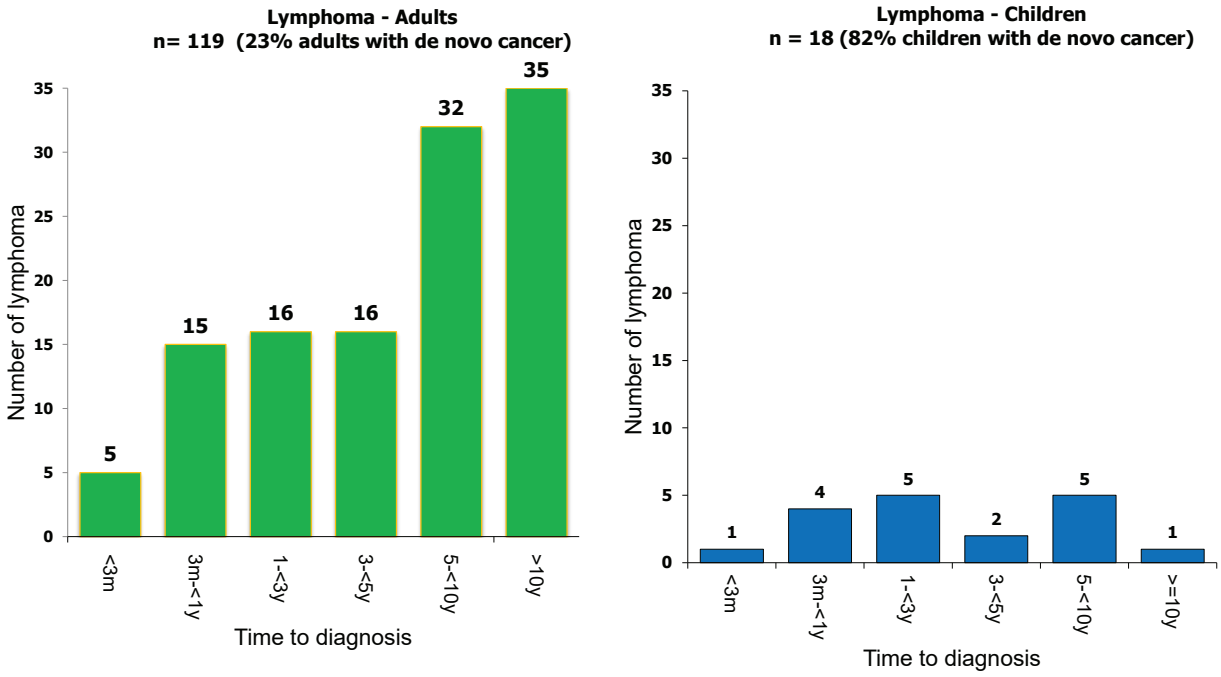
Figure 91. Incidence of de novo alimentary tract cancers by type



15.7.6 De Novo Lymphoma

Lymphoma was the second most prevalent non-skin cancer to develop post-transplant affecting 119 adults and 18 children. Time to development ranged from 1 month to greater than 10 years with 56% developing after 5 years in adults and 33% after 5 years in children (Figure 92). Median time to diagnosis in adults and children was 69 and 34 months respectively.

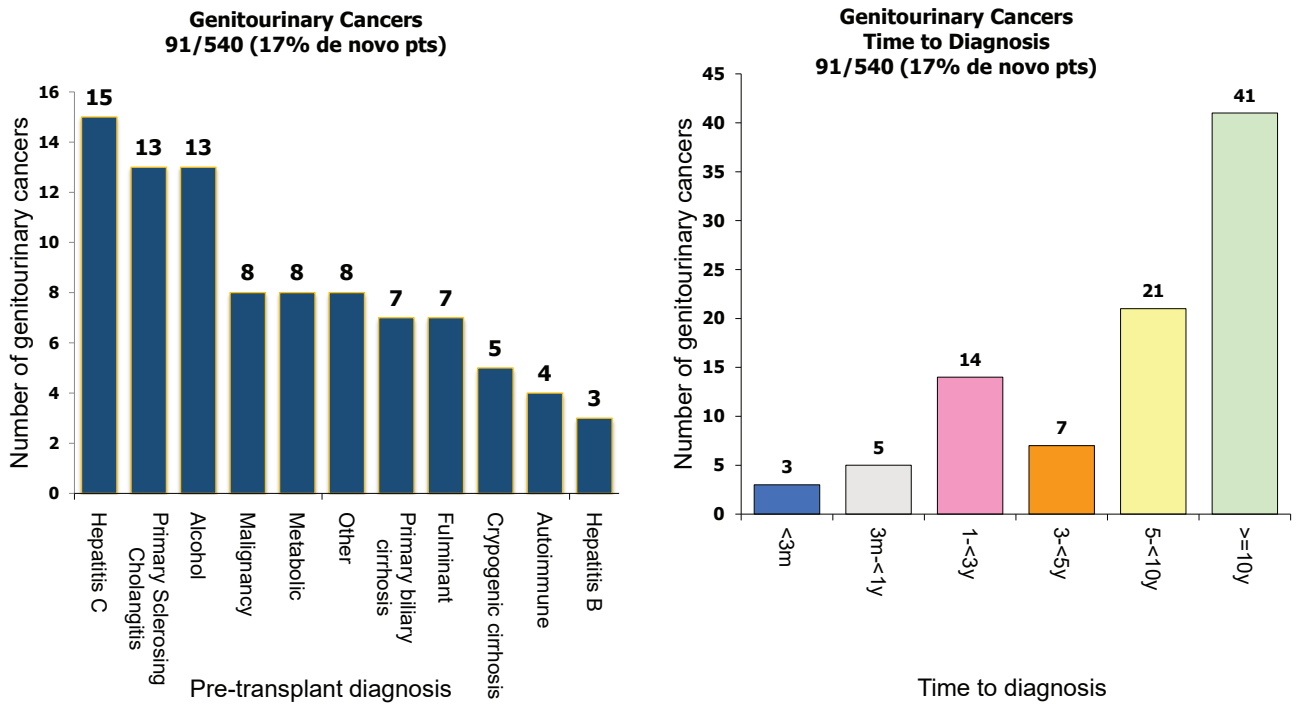
Figure 92. Time to diagnosis of de novo lymphoma by age category



15.7.7 De Novo Genitourinary Cancers

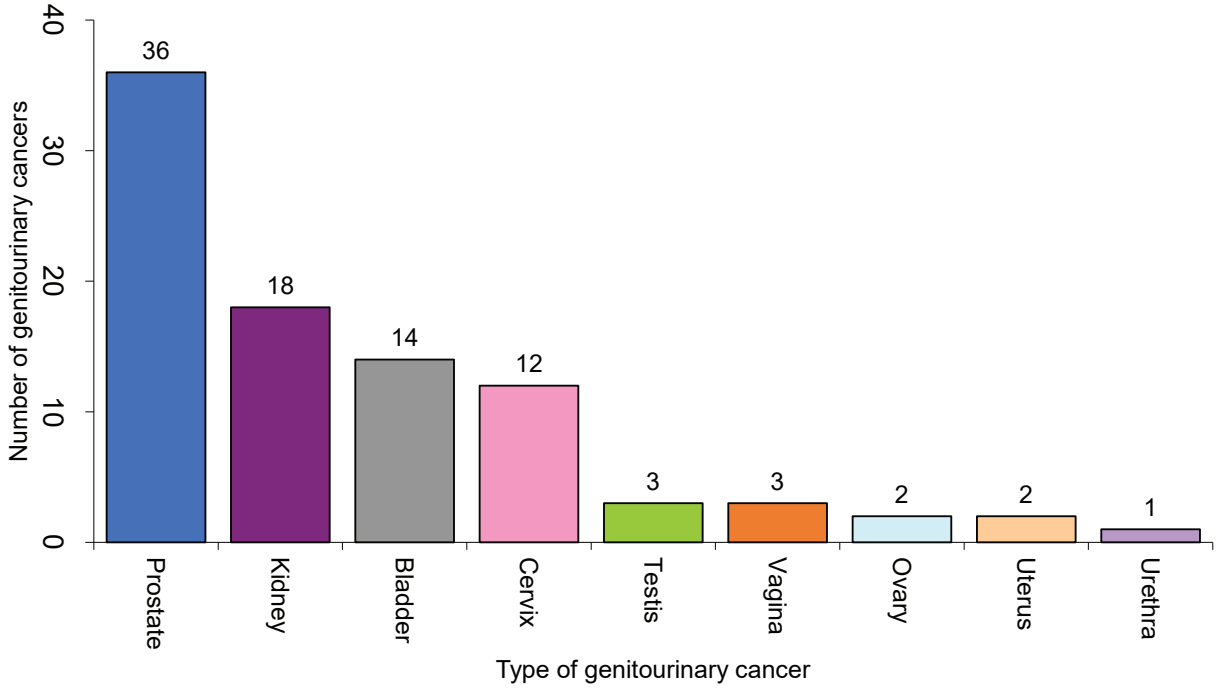
Cancers of the genitourinary tract consisted of 17% of all de novo non-skin cancers. Forty-one (45%) of these patients were transplanted for primary sclerosing cholangitis, hepatitis C infection or alcohol-related liver disease (Figure 93). Time to development ranged from less than 3 months to greater than 10 years with 68% developing after 5 years. Median time to diagnosis was 113 months.

Figure 93. Pretransplant diagnosis and de novo genitourinary cancers



Thirty-six (40%) of genitourinary tract cancers were cancers of the prostate (Figure 94).

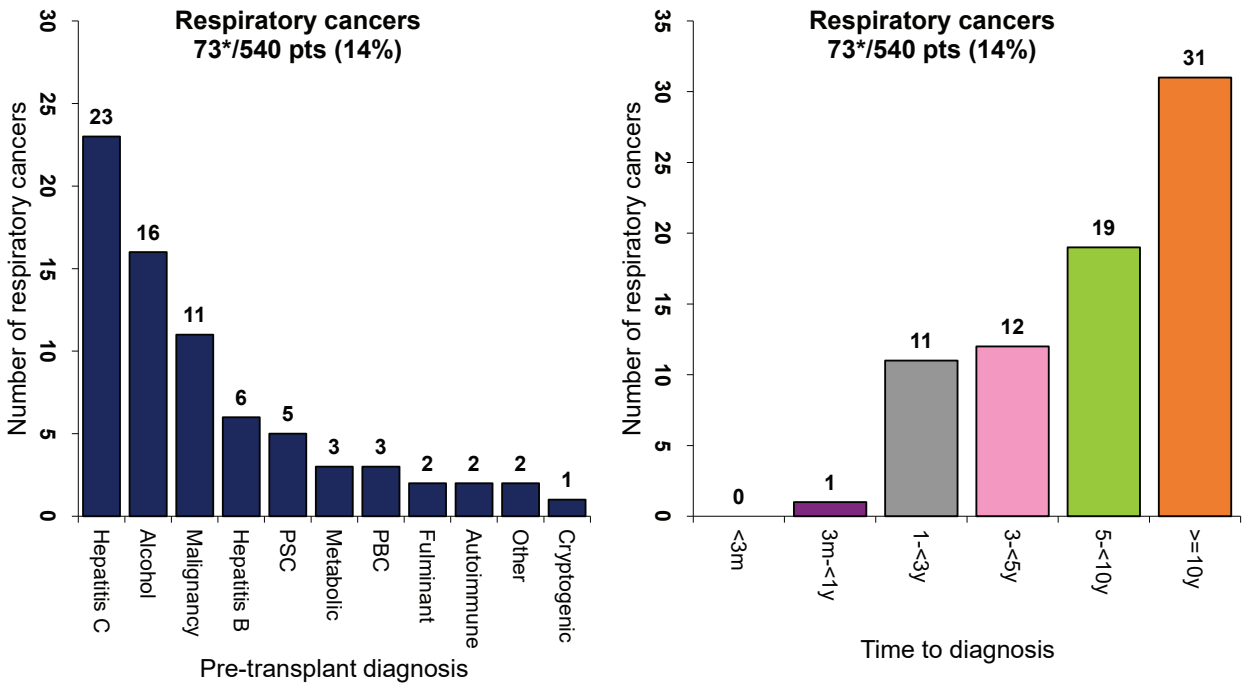
Figure 94. Incidence of de novo genitourinary tract cancers by type



15.7.8 De Novo Respiratory Cancers

Respiratory cancers consisted of 14% of all de novo non-skin cancers. Fifty (68%) of these patients were transplanted for hepatitis C infection, alcohol-related liver disease or pretransplant liver cancer (Figure 95). Time to development ranged from 3 months to greater than 10 years with 68% developing after 5 years. Median time to diagnosis was 103 months. 95% of respiratory cancers were of the lung (Figure 96).

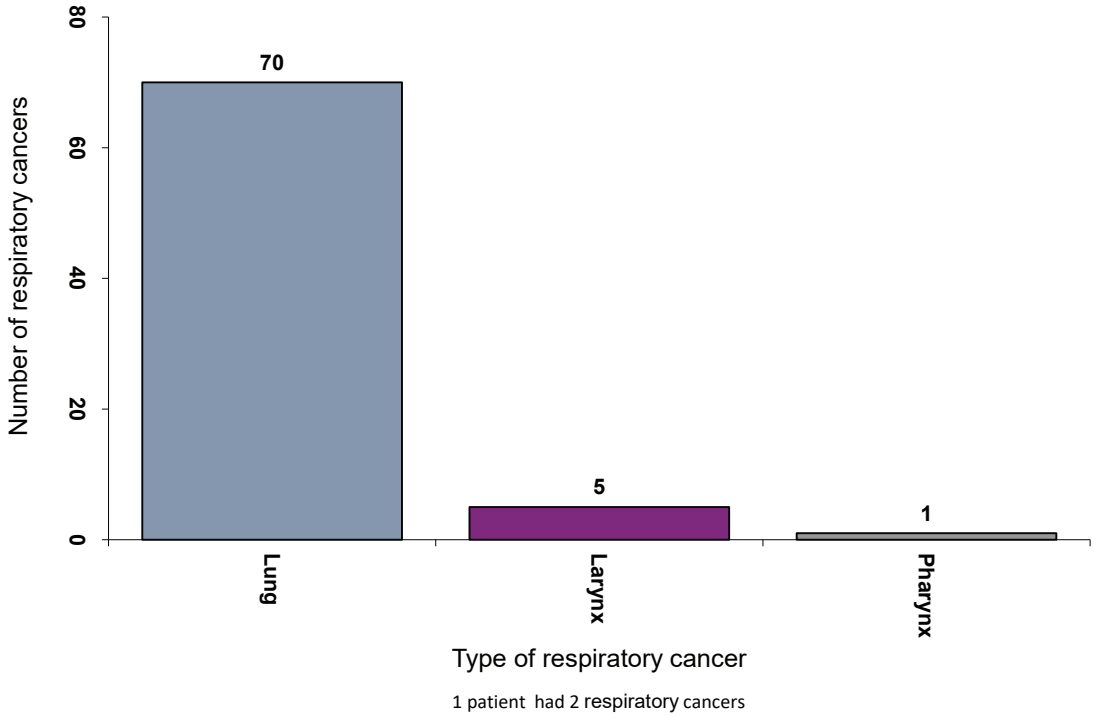
Figure 95. Pretransplant diagnosis and de novo respiratory cancers



*1 patient had 2 respiratory cancers

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

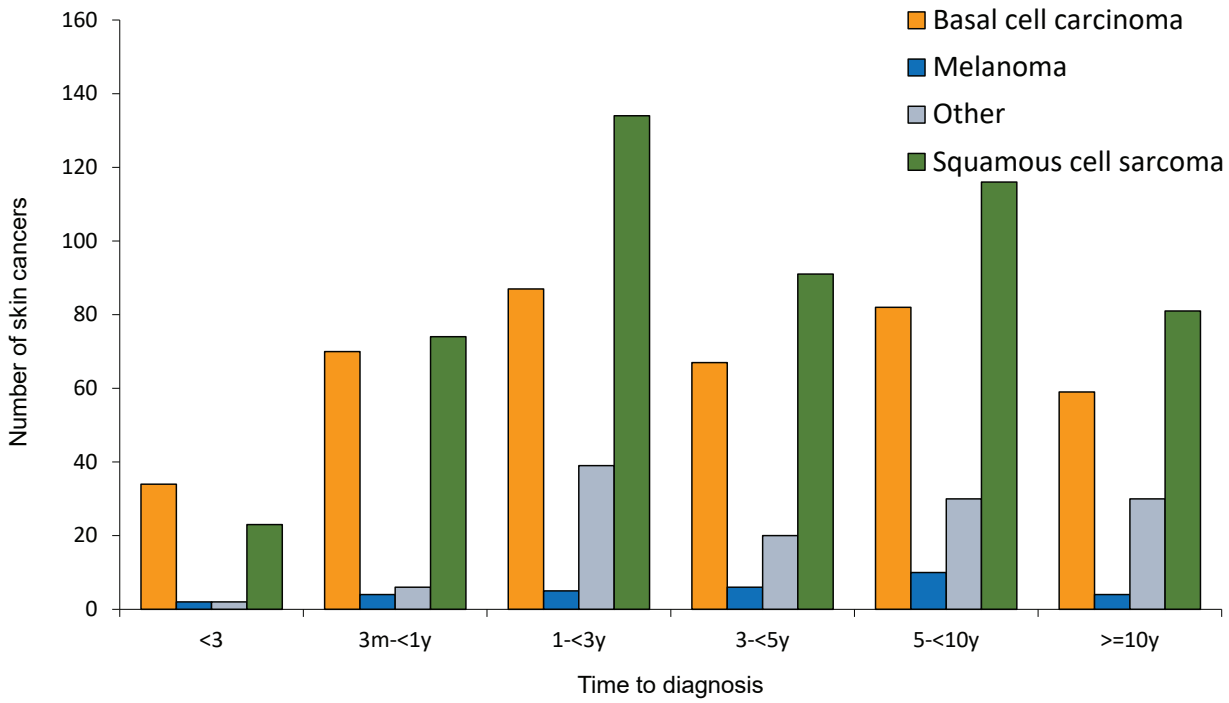
Figure 96. Incidence of de novo respiratory tract cancers by type



15.8 Skin Cancer Development Post-Transplant

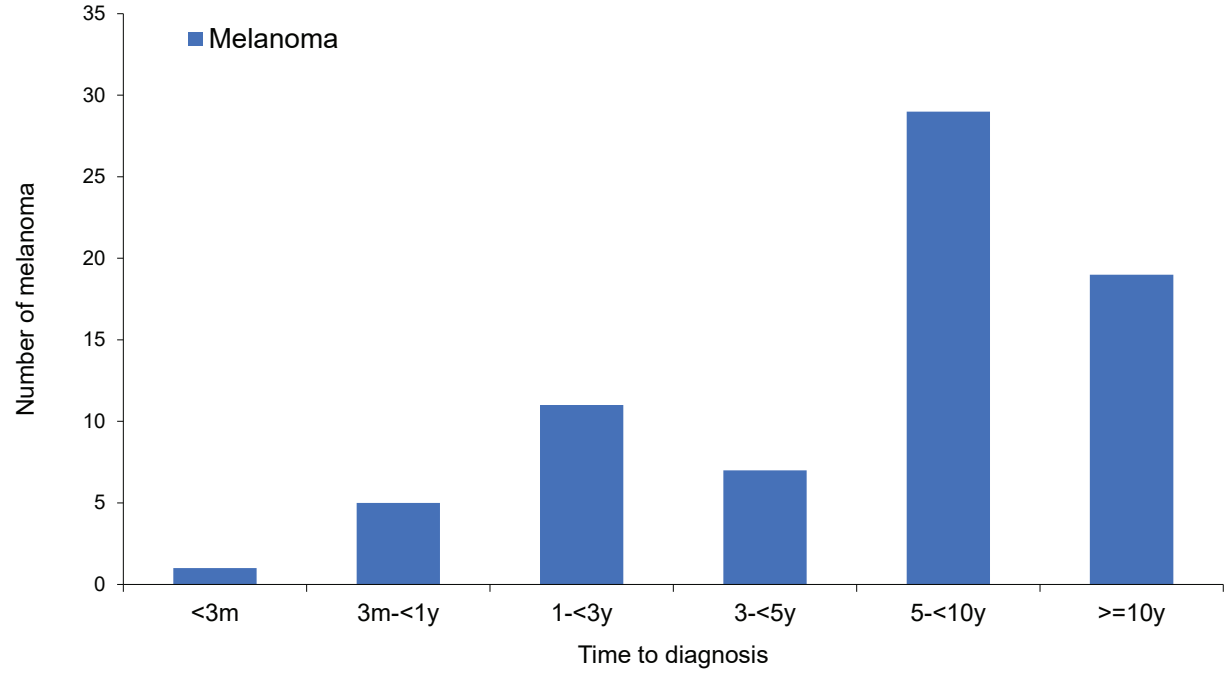
One thousand and nineteen patients (16%) developed a first skin cancer post-transplant with 489 going on to develop multiple skin cancer types (Figure 97).

Figure 97. Time to first skin cancer development post-transplant by type of skin cancer



Sixty-nine (1% of all patients) developed 72 melanomas (Figure 98).

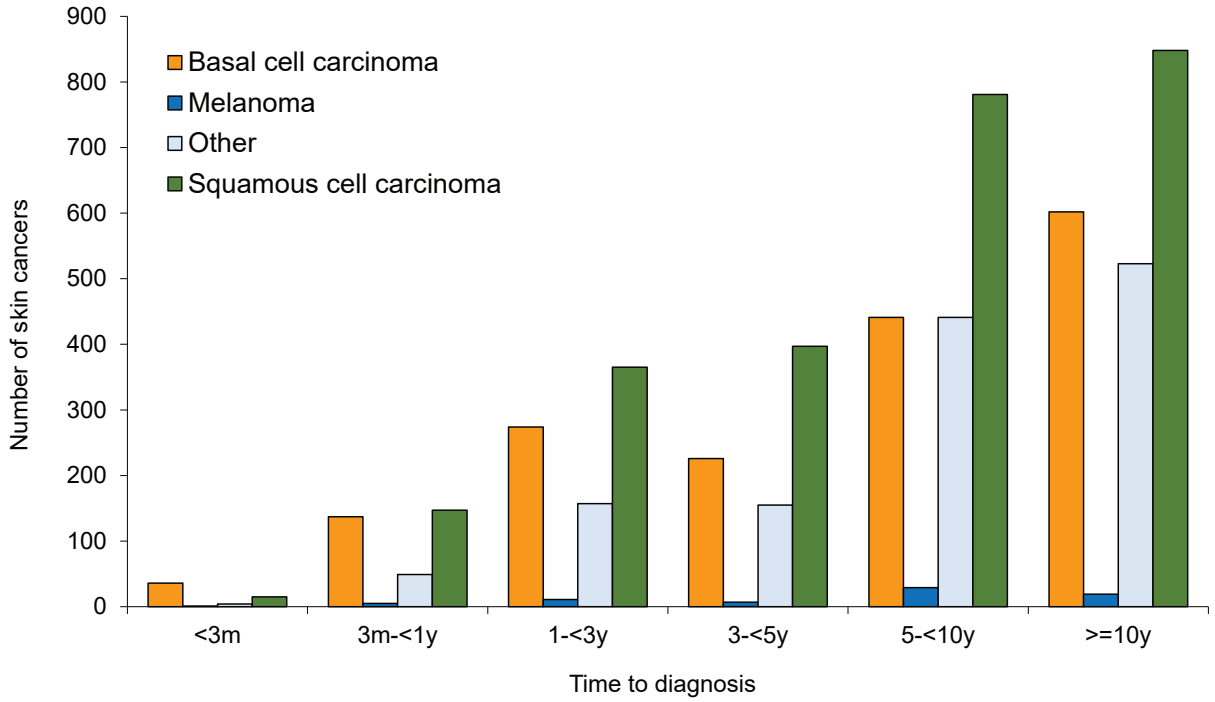
Figure 98. Time to first melanoma development post-transplant
Note: This includes patients who developed melanoma after a non-melanoma skin cancer (first skin cancer)



* 2 patients developed 2 melanoma

Skin cancers increased over time (Figure 99).

Figure 99. Time to any skin cancer development post-transplant



Males were more likely to develop skin cancer post-transplant than females (16% versus 13%). Males were more likely to die from squamous cell cancer but less likely than females to die of melanoma (Table 67).

Table 67. Skin Cancer Development Post-Transplant

		Male				Female			
	Number of recipients with new 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	719	508	12%	17	3%	211	9%	3	1%
Basal Cell	586	425	10%	0	0%	161	7%	0	0%
Bowen's disease	290	189	4%	0	0%	101	4%	0	0%
Miscellaneous	80	52	1%	0	0%	28	1%	0	0%
Melanoma	69	47	1%	9	19%	22	1%	14	64%
Merkel Cell	5	5	0.1%	1	20%	0	0%	-	-
Total skin cancer patients*	**1,019**	**705**	**16%**	**27**	**4%**	**314**	**13%**	**17**	**5%**
Total transplant recipients	**6,706**	**4,289**				**2,417**			

* Note: Some patients developed more than one skin cancer type. 1,019 patients developed 5,679 skin cancers. 498 patients developed more than one skin cancer type.

15.9 Cumulative Risk of Diagnosis of Skin or Non-Skin Cancer Following Liver Transplant

The cumulative risk of diagnosis of a de novo non-skin cancer post-transplant is approaching 20% by 20 years (Figure 100, Table 68). Cumulative risk of developing any cancer, skin cancer or non-skin cancer at 10 years post-transplant is 26%, 20% and 8% respectively.

Figure 100. Cumulative risk of diagnosis of skin or non-skin cancer following liver transplantation

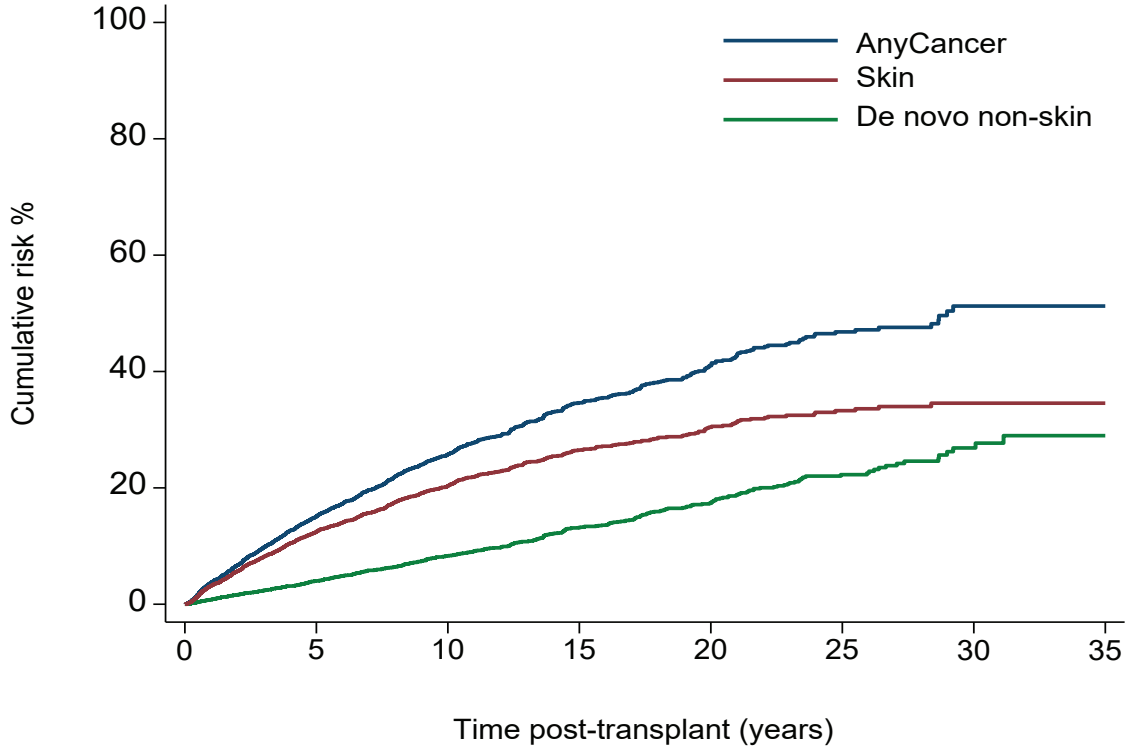


Table 68. Cumulative risk of diagnosis of cancer following liver transplantation

Cancer type	Patient Survival	Time post-transplant (years)								
		0	1	5	10	15	20	25	30	35
Any cancer	No at risk	6,706	5,655	3,664	2,106	1,209	647	307	92	2
	Cumulative risk	0%	4%	15%	26%	35%	41%	47%	51%	51%
Skin cancer	No at risk	6,706	5,677	3,733	2,182	1,271	686	331	104	3
	Cumulative risk	0%	3%	12%	20%	27%	30%	33%	35%	35%
De novo (non-skin) cancer	No at risk	6,706	5,835	4,145	2,591	1,545	836	406	125	5
	Cumulative risk	0%	1%	4%	8%	13%	17%	22%	27%	29%

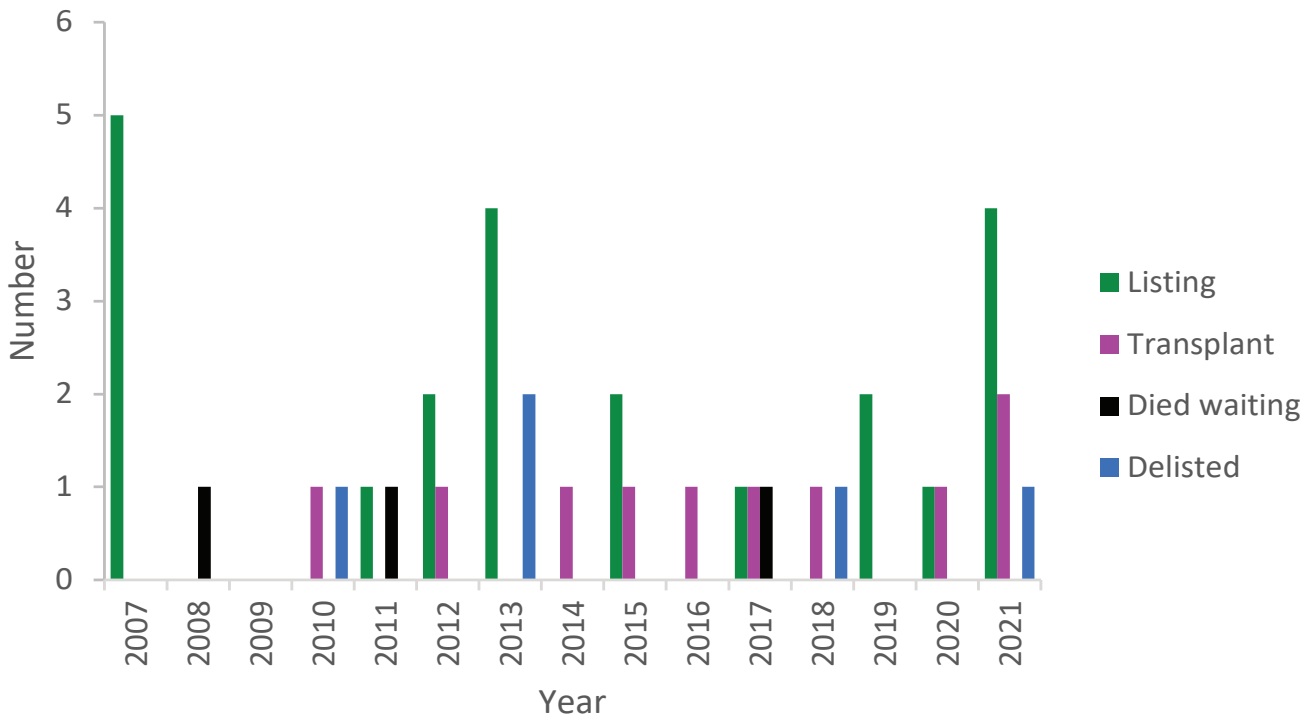
16 Intestinal Transplantation

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.

16.1 Waiting List

Twenty-one patients have been listed for intestinal transplantation, with one patient relisted in 2019, six years after initial delisting (22 listings, see Figure 101). Ten patients were transplanted, three died waiting, four were delisted without relisting and four (including the patient delisted then relisted) were still waiting at the end of 2021.

Figure 101. Waiting list trends over time for intestinal transplantation



16.2 Demographic Characteristics and Diagnoses

The demographic characteristics and diagnoses of patients listed for intestinal transplantation and for those transplanted are shown in Table 69. The majority of the eight children listed had short bowel syndrome due to gastroschisis, whilst the 13 adults were listed for short bowel syndrome after intestinal resection for a variety of causes, motor disorders and liver failure with porto-mesenteric thrombosis. Four children have been transplanted, two for short bowel syndrome, one with chronic idiopathic intestinal pseudo-obstruction and one for Hirschsprung's disease. Six adults have been transplanted, three for short bowel syndrome, two for Hirschsprung's disease and one for liver failure with porto-mesenteric thrombosis.

Table 69. 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	13	4	6
Age	8 (4-15)	43 (22-60)	11 (5-13)	38 (24-54)
Gender				
Male	4	10	3	5
Female	4	3	1	1
Diagnosis				
Short bowel syndrome				
- Gastroschisis	5	0	2	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
Motor disorder				
- Chronic idiopathic intestinal pseudo-obstruction	2	0	1	0
- Hirschsprung's disease and variants	1	3	1	2
- Hollow visceral myopathy	0	1	0	0
Other				
- Liver failure with porto-mesenteric thrombosis	0	4	0	1

16.3 Organs Transplanted

Five patients underwent liver, pancreas and small intestine transplantation, one underwent liver, stomach, pancreas and small intestine transplantation, one underwent liver, pancreas, small intestine and kidney transplantation, one underwent intestine, pancreas and stomach transplantation, one underwent intestine and kidney transplantation and one patient underwent small intestine to mid-transverse colon transplantation.

16.4 Survival

Eight of the ten intestinal transplant recipients are alive with a functioning graft and full enteral autonomy. 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 and graft survival are 88.9% and the 5- and 10-year patient and graft survival are 71.1% (Figure 102, Table 70, Figure 103, Table 71).

Figure 102. Patient survival after intestinal transplantation

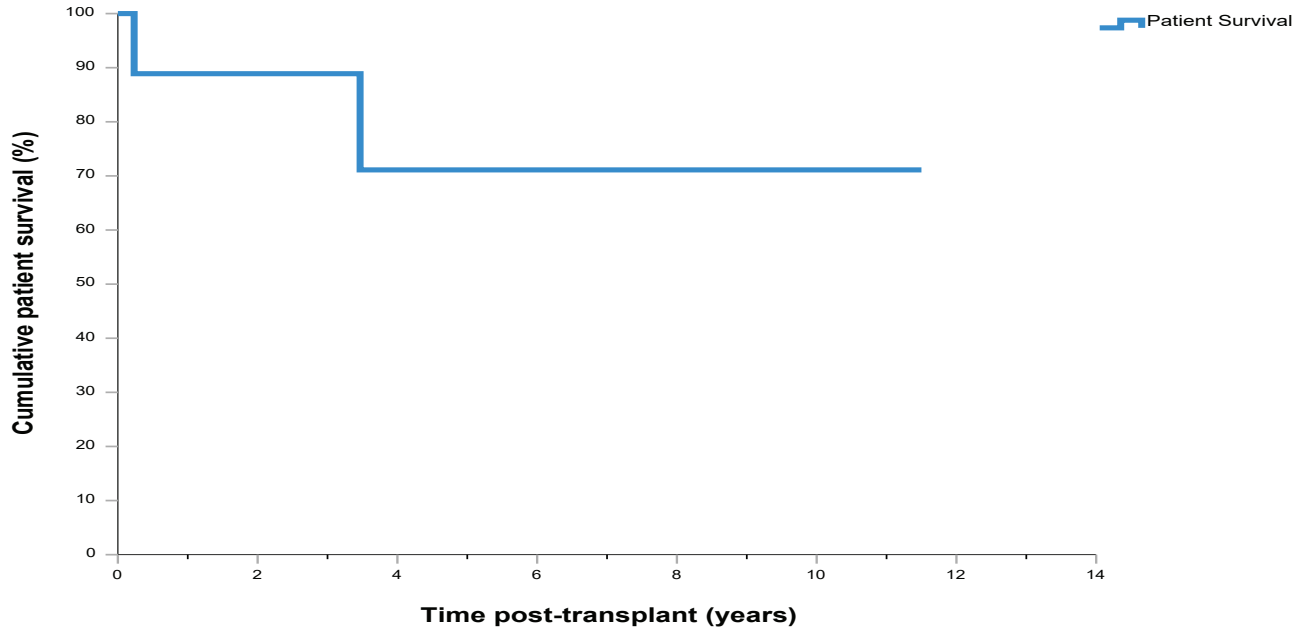


Table 70. Intestinal patient survival

Patient Survival	Time post-transplant (years)					
	0	1	3	5	10	15
No. at risk	10	7	6	4	1	0
Survival (%)		89%	89%	71%	71%	

Figure 103. Graft survival after intestinal transplantation

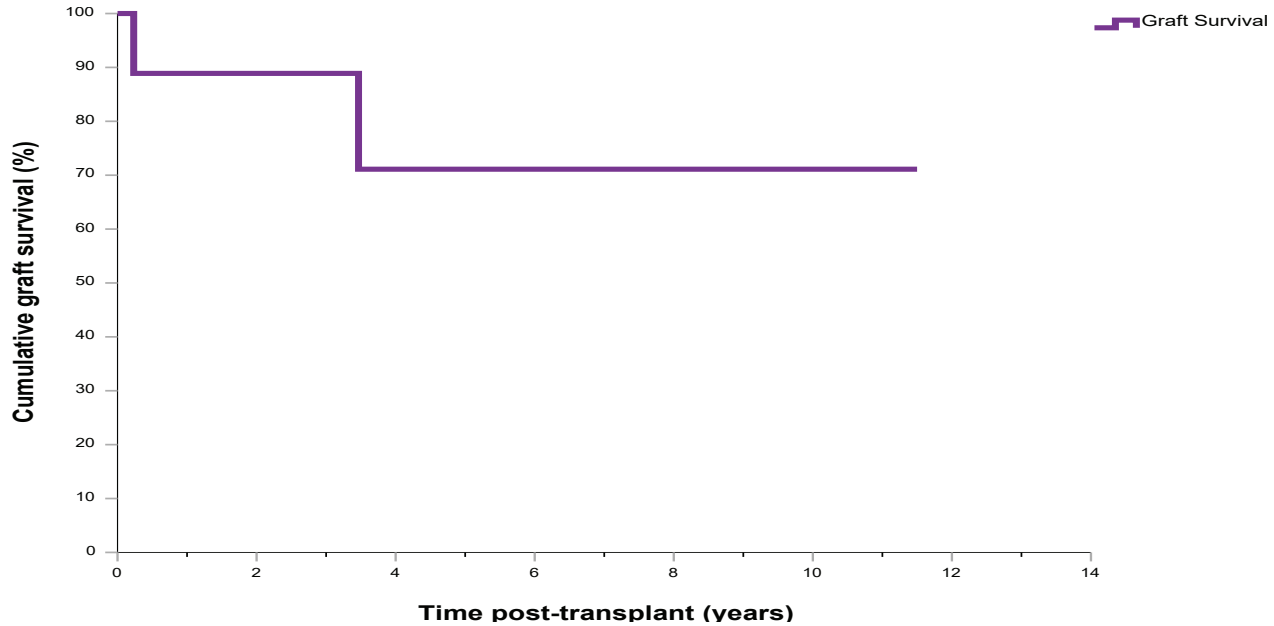


Table 71. Intestinal graft survival

Graft Survival	Time post-transplant (years)					
	0	1	3	5	10	15
No. at risk	10	7	6	4	1	0
Survival (%)		89%	89%	71%	71%	

17 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 liver or part of their liver 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 liver transplantation 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 until the end of the reporting year (31 December, 2021 for this report) 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.
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 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 until the end of the reporting year (31 December 2021 for this report) 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 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 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 liver transplantation to delisting (in the case of waiting time to transplantation, this the time from listing for liver transplantation to the 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.

18 Appendix II. Publications utilising ANZLITR data

18.1 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.

18.2 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.

18.3 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.

18.4 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.

18.5 Publications in 2016

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.

18.6 Publications in 2015 and Earlier

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.
Chinnaratha MA; Chelvaratnam U; Stuart KA; Strasser SI; McCaughan GW; Gow P; Adams LA; Wigg AJ; Australia and New Zealand Liver Transplant Clinical Study Group. Liver Transplantation. 20(7):798-806, 2014 Jul.

Nature and outcomes of the increased incidence of colorectal malignancy after liver transplantation in Australasia.
Verran DJ, Mulhearn MH, Dilworth PJ, Balderson GA, Munn S, Chen JW, Fink MA, Crawford MD, McCaughan GW. Medical Journal of Australia. 199(9):610-2, 2013 Nov 04.

Comparison of De Novo Cancer Incidence in Australian Liver, Heart and Lung Transplant Recipients.
Na R, Grulich AE, Meagher NS, McCaughan GW, Keogh AM, Vajdic CM, Am J Transplant. 2013 Jan;13(1):174-83.

De Novo cancer- related death in Australian Liver and cardiothoracic transplant recipients.
Na R, Grulich AE, Meagher NS, McCaughan GW, Keogh AM, Vajdic CM. American Journal of Transplantation. 2013; 13:1293-1304.

Combination of lamivudine and adefovir without hepatitis B immune globulin is safe and effective prophylaxis against hepatitis B virus recurrence in hepatitis B surface antigen-positive liver transplant candidates.
Gane EJ, Patterson S, Strasser SI, McCaughan GW, Angus PW. Liver Transplantation. 2013;3: 268-274.

Minimal but significant improvement in survival for non-hepatitis C-related adult liver transplant patients beyond the one-year posttransplant mark.
McCaughan GW, Shackel NA, Strasser SI, Dilworth P, Tang P for Australian and New Zealand Liver Transplant Study Group. Liver Transplantation 16: 130-137, 2010.

Poorer survival in patients whose explanted hepatocellular carcinoma (HCC) exceeds Milan or UCSF Criteria. An analysis of liver transplantation in HCC in Australia and New Zealand.
Chen JWC, Know L, Verran DJ, McCall JL, Munn S, Balderson GA, Fawcett JW, Gow PJ, Jones RM, Jeffrey GP, House AK, Strasser SI. HPB 2009, 11, 81–89.

The epidemiology of hepatitis C in Australia: Notifications, treatment uptake and liver transplantations, 1997–2006.
Gidding HF, Topp L, Middleton M, Robinson K, Hellard M, McCaughan G, Maher L, Kaldor JM, Dore GJ and Law MG. Journal of Gastroenterology and Hepatology 24 (2009) 1648–165**4.**

A randomised study of Adefovir dipivoxil in place of HBIG in combination with lamivudine as post-liver transplantation hepatitis B prophylaxis.
Angus PW, Patterson SJ, Strasser SI, McCaughan GW, Gane E. Hepatology. 2009;48:1460-6.

Lamivudine plus Low-Dose Hepatitis B Immunoglobulin to Prevent Recurrent Hepatitis B Following Liver Transplantation.
Gane EJ, Angus PW, Strasser SI, Crawford DHG, Ring J, Jeffrey GP, McCaughan GW. Gastroenterology 2007;132:931-937.

Patient and graft survival after liver transplantation for hereditary hemochromatosis: Implications for pathogenesis.
Crawford DH, Fletcher LM, Hubscher SG, Stuart KA, Gane E, Angus PW, Jeffrey GP, McCaughan GW, Kerlin P, Powell LW, Elias EE. Hepatology 2004;39:1655-662.

Liver transplantation for HCV-associated liver cirrhosis: predictors of outcomes in a population with significant genotype 3 and 4 distribution.
Zekry A, Whiting P, Crawford DH, Angus PW, Jeffrey GP, Padbury RT, Gane EJ and McCaughan GW. Liver Transplantation 2003;9:339-347.

Combination low-dose hepatitis B immune globulin and lamivudine therapy provides effective prophylaxis against posttransplantation hepatitis B.
Angus PW, McCaughan GW, Gane EJ, Crawford DHG, Harley H. Liver Transplantation 2000;6(4)429-433.

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Designed by Debbie Cormack
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