Australia & New Zealand
Liver and Intestinal Transplant Registry

Report on liver and intestinal transplantation activity to 31/12/2020

32nd
ANNUAL REPORT
ANZLITR

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1 Preface

We are pleased to present the 32nd Annual Report of the Australia and New Zealand Liver and Intestinal Transplant Registry (ANZLITR). This report contains liver and intestinal transplantation data to 31st December 2020 and analyses the cumulative data since the establishment of the first liver transplant units in Australia and New Zealand in 1985. 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 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 4.3% in 2020. In 2020, one of 18 patients listed as category 1 and two of 16 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. Donors were predominantly comprising brain dead donors, including donors aged over 60 years, with a modest increase in donation after circulatory death donors to 13% of donors in 2020. Living donor liver transplantation accounts for 1.7% of transplants performed.

In 2020, 332 liver transplants were performed in 320 patients, a 10% reduction in comparison to 2019, due to reduced deceased donor numbers which is likely related to the COVID-19 pandemic. Between 1985 and 2020, 6,959 transplants were performed in 6,428 patients, including 1,212 transplants in 1,067 children and 5,787 transplants in 5,361 adults. Paediatric age at transplant has decreased progressively and adult recipient age has increased progressively over time. Split liver transplantation is the dominant form of liver transplantation in children (73% in 2020) and whole liver transplantation is the dominant form of liver transplantation in adults (90% in 2020).

The commonest indication for transplantation in children is biliary atresia and in adults is hepatitis C virus cirrhosis until 2014, after which hepatocellular carcinoma and alcoholic cirrhosis have become the commonest indication. There has also been a recent increase in patients transplanted for non-alcoholic fatty liver disease. The proportion of patients transplanted primarily for hepatitis C has decreased from 33.8% in 2012 to 8.1% in 2020.

The 1-, 3-, 5- and 10-year patient survival in recent years for paediatric patients was 97%, 97%, 96% and 91%, 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 95%, 91%, 88% and 76%, respectively. Patient survival in adults reduced progressively with increasing recipient age ($P < 0.001$), varied significantly by primary disease ($P = 0.018$), with poorer outcomes for hepatitis C virus and alcoholic cirrhosis. Patient survival has improved over time for hepatitis B ($P < 0.001$) and hepatitis C virus cirrhosis ($P = 0.002$).

The 1-, 3-, 5- and 10-year graft survival in recent years for paediatric patients was 91%, 89%, 87% and 81%, respectively. The 1-, 3-, 5- and 10-year graft survival in recent years for adult patients was 92%, 87%, 84% 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 < 450 mins, $P < 0.001$) and recipient urgency category at transplant (poorer outcome for category 1 recipients, $P = 0.006$).

The commonest indications for retransplantation were vascular problems (29%), rejection (18%), biliary (17%), primary non-function or initial poor function (15%) and recurrent disease (13%). The commonest causes of death were malignancy (25%), graft-related causes (18%), sepsis (13%), cardiovascular disease (8%) and multi-organ failure (8%).

2.2 Intestinal Transplantation

Seventeen patients have been listed for intestinal transplantation. Eight patients were transplanted, three died waiting, three were delisted, and three were still waiting at the end of 2020.

Four patients underwent liver, pancreas and small intestine transplantation, one underwent multivisceral (liver, stomach, pancreas and small intestine) transplantation, one underwent liver, pancreas, small intestine and kidney transplantation, one underwent intestine and kidney transplantation, and one patient underwent small intestine and colon transplantation.

The 1- and 3-year patient and graft survival are 87.5% and the 5- and 10-year patient and graft survival are 70.0%.

3 Australia and New Zealand Liver and Intestinal Transplant Registry Information

3.1 Australia and New Zealand Liver and Intestinal Transplant Registry Overview

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

The Registry contains de-identified data on all liver and intestinal transplantation activity across Australia and New Zealand since the first liver transplant in 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 (OTA), 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 (HREC) 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 2020, 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 2020.

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

3.4 Australia and New Zealand Liver and Intestinal Transplant Registry Website

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

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

3.5 Funding of the Registry

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

3.6 Registry Secretariat

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3.7 Registry Management Committee

Director	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 wait list data are available from 1 January 2004. The wait list dataset contains all patients who have been added to the wait 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, wait list mortality (patient died whilst wait listed 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 wait list mortality by number of patients on the wait list during the year (patients active at start of the year plus new patients listed during the year).

4.3 Liver Transplant Wait List Dataset (6,108 listings)

Comprehensive wait list data including listing and delisting date and delisting outcome are available from 1 January 2004. There are data on 6,108 wait listings from this date.

4.4 Liver Transplant Recipient Datasets

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

4.4.1 Demographics Dataset (6,428 patients)

The demographic analysis dataset is based on the first liver transplant in Australia or New Zealand for each patient. Five patients had their first liver transplant overseas and were retransplanted in Australia or New Zealand, so their first liver transplant in Australia or New Zealand (their second graft) has been used for demographic data analysis.

4.4.2 Patient Survival and Initial Diagnosis Dataset (6,423 patients)

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

4.4.3 Graft Survival Dataset (6,959 transplants)

All Australian and New Zealand transplants are included in this dataset. Patients who have had a prior transplant overseas have their first graft in Australia or New Zealand recorded as graft 2.

Both deceased and living donor grafts are included in this analysis, unless otherwise specified.

4.5 Liver Donor Datasets

4.5.1 Deceased Liver Donors (6,309 deceased donors; 6,717 transplants)

The Australia and New Zealand Organ Donation (ANZOD) Registry provides the ANZLITR with deceased donor data for analysis. A total of 6,843 grafts were sourced from 6,435 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 6,309 donors. A total of 5,899 donated livers were allocated to a single recipient and 410 donated livers were split (one graft was not utilised from each of two livers that were split), resulting in a total of 6,717 grafts with deceased donor data.

4.5.2 Living Liver Donors (116 living donors)

Data on 116 living liver donors (including four domino living donors) are collected in ANZLITR.

4.6 Intestinal Dataset (8 transplants)

The intestinal dataset includes data on all 18 wait-listed patients (the first listing was in 2007) and all eight 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.

4.7 Patient Age Groups

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

4.8 Survival Curves

4.8.1 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 2020) 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.

4.8.2 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 2020) or failed (due to death or re-transplantation).

4.9 Statistical Analysis

Statistical analyses were undertaken using IBM SPSS Statistics 27.

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.

Multivariate 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 multivariate 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.

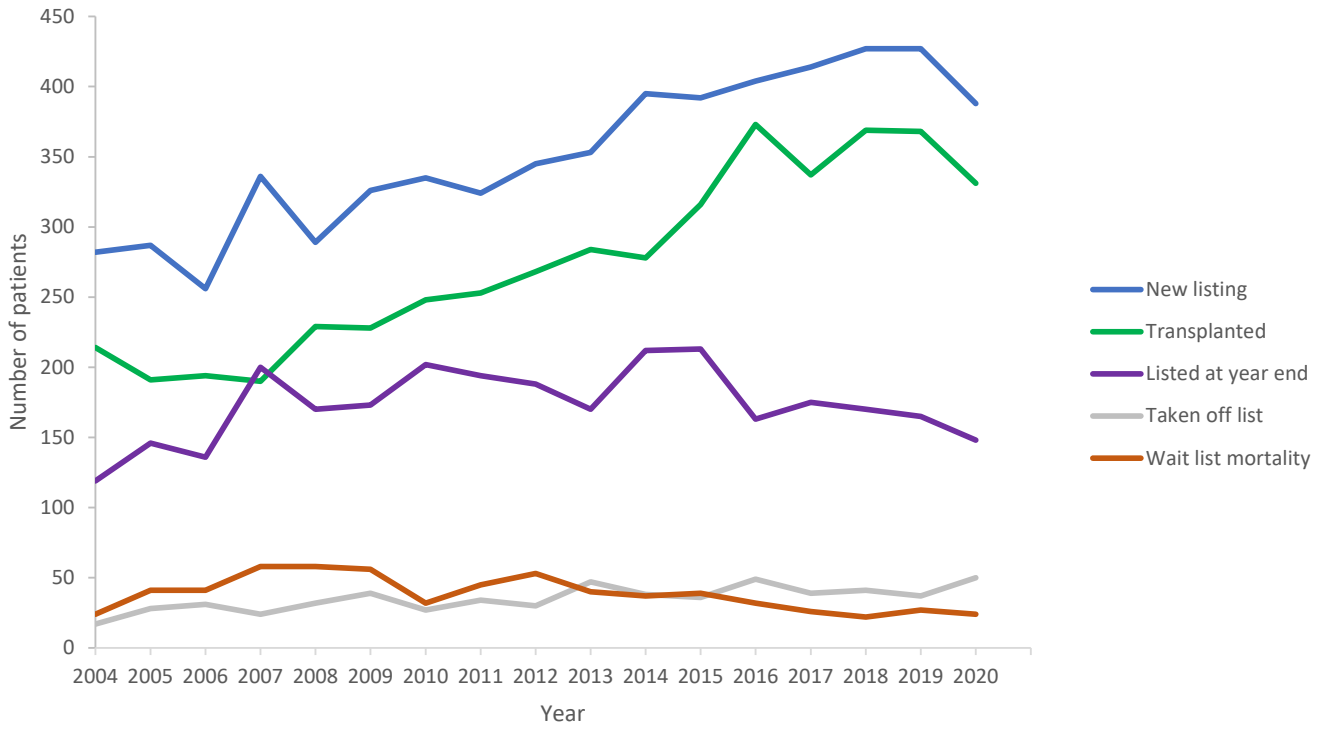
5 Liver Transplant Waiting List

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 52% from 2004 to 2019 (281 to 427, Figure 1). However, in 2020 there was a 9% decrease (to 388) in number of patients listed for liver transplantation. Between 2004 and 2019, there was a 72% increase in the number of liver transplants performed per year (214 to 368). However, in 2020, there was a 10% decrease (to 331) in the number of liver transplants performed. It is likely that the reduction in transplant activity in 2020 compared with 2019 is related to the COVID-19 pandemic. There were 148 people on the waiting list for a liver transplant at the end of 2020.

The annual waiting list mortality rate has progressively decreased from a peak of 12.3% in 2007 to 4.3% in 2020.

Figure 1. Liver transplant waiting list activity – all patients

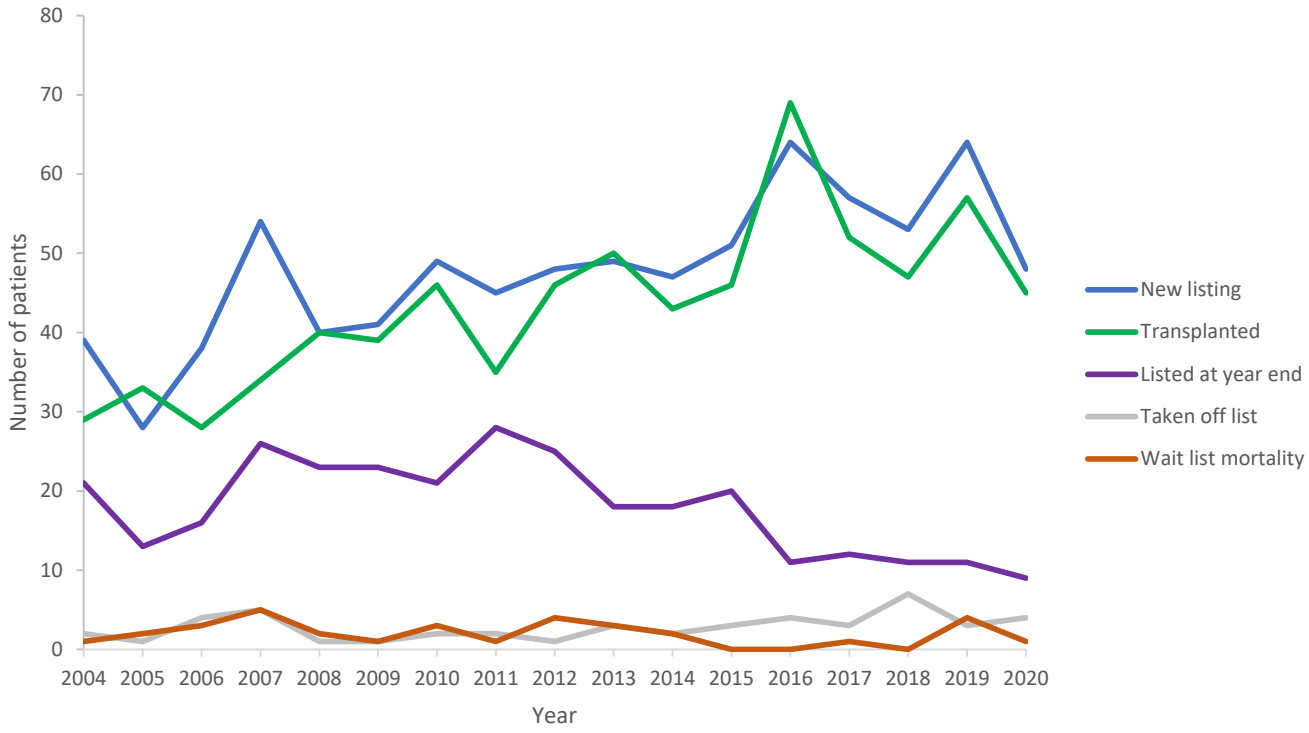


5.2 Paediatric Waiting List Activity

The number of new paediatric listings on the liver transplant waiting list showed a gradual increase over time, increasing 64% from 2004 to 2019 (39 to 64, Figure 2). However, in 2020 there was a 25% decrease (to 48) in number of children listed for liver transplantation. Between 2004 and 2019, there was a 97% increase in the number of paediatric liver transplants performed per year (29 to 57). However, in 2020, there was a 21% decrease (to 45) in the number of liver transplants performed. It is likely that the reduction in transplant activity in 2020 compared with 2019 is at least partly related to the COVID-19 pandemic. The number of children on the waiting list for a liver transplant peaked at 28 in 2011 and has fallen to 9 at the end of 2020.

The paediatric annual waiting list mortality rate has progressively decreased from a peak of 7.1% in 2007 to 1.7% in 2020.

Figure 2. Paediatric liver transplant waiting list activity

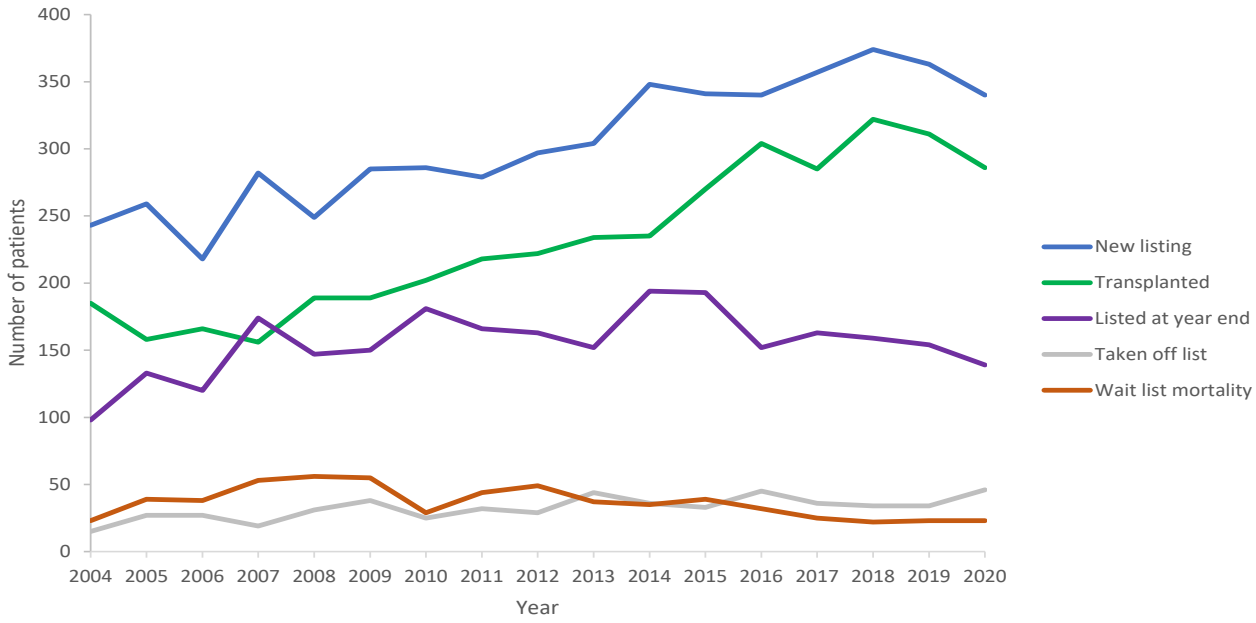


5.3 Adult Waiting List Activity

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 68% from 2004 to 2019 (243, 363, Figure 3). However, in 2020 there was a 6% decrease (to 340) in number of adults listed for liver transplantation. Between 2004 and 2019, there was a 68% increase in the number of liver transplants performed per year (185 to 311). However, in 2020, there was an 8% decrease (to 286) in the number of adult liver transplants performed. It is likely that the reduction in transplant activity in 2020 compared with 2019 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 at the end of 2020.

The adult annual waiting list mortality rate peaked at 13.2% in 2008 and has fallen to 4.7% in 2020.

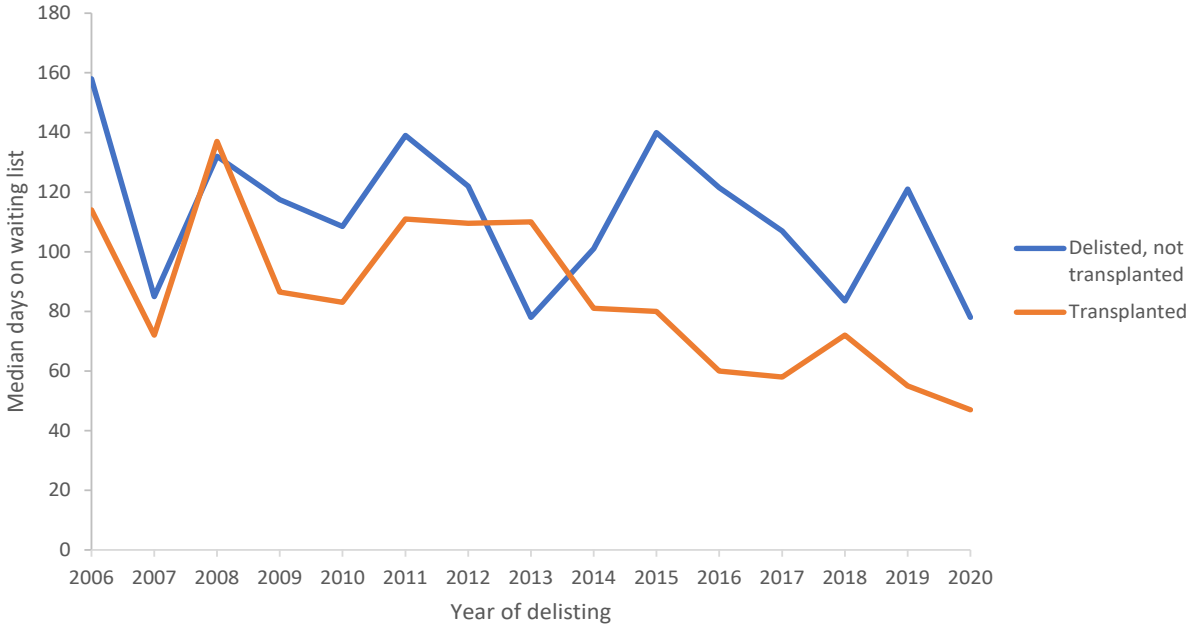
Figure 3. Adult liver transplant waiting list activity



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 47 days in 2020, despite the reduction in liver transplants performed in 2020 (Figure 4). The median time from listing to delisting without transplant was 140 days in 2015 and has decreased to 78 days in 2020.

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 wait list mortality rate for the last five years (2016 – 2020) was 9.8%. In 2020, one of the 18 patients wait listed as Category 1 died, resulting in a waiting list mortality rate of 5.6%.

The urgent category 2 wait list mortality rate for the last five years (2016 – 2020) was 3.3%. There were two urgent category 2 wait list mortality deaths out of 16 listed patients in 2020, resulting in a waiting list mortality rate of 12.5% for 2020.

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.

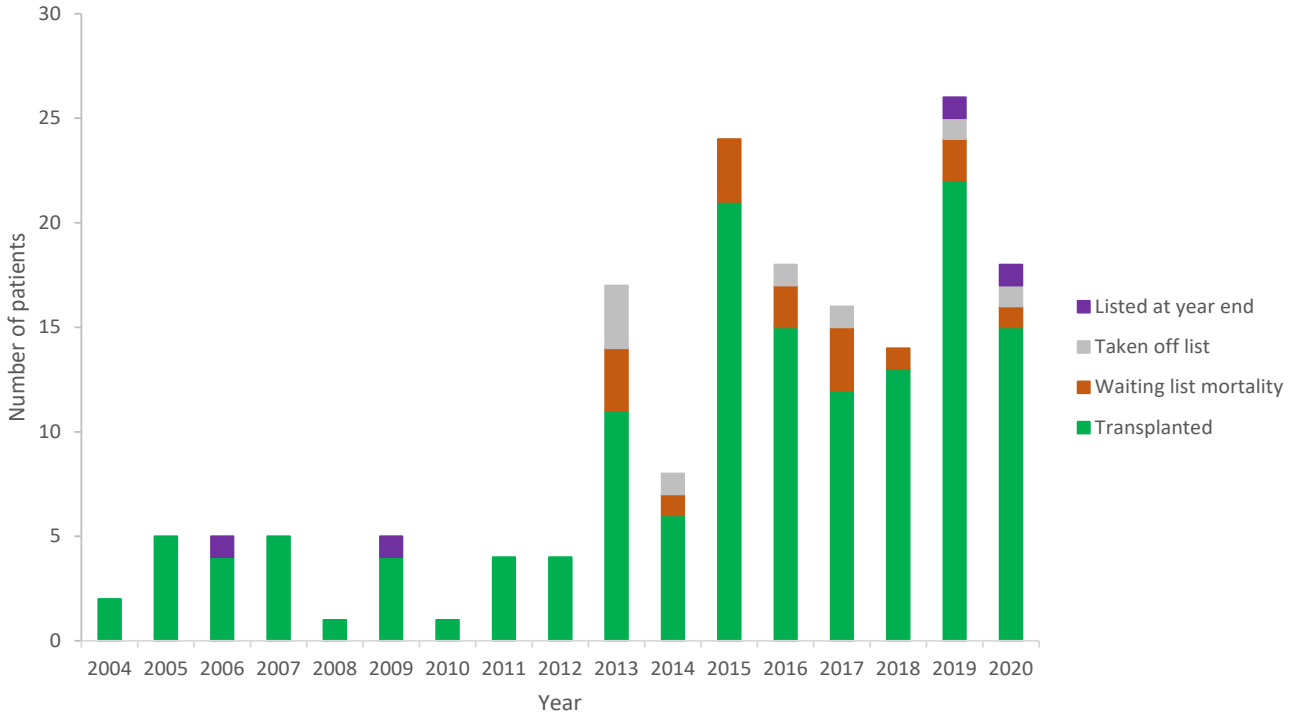
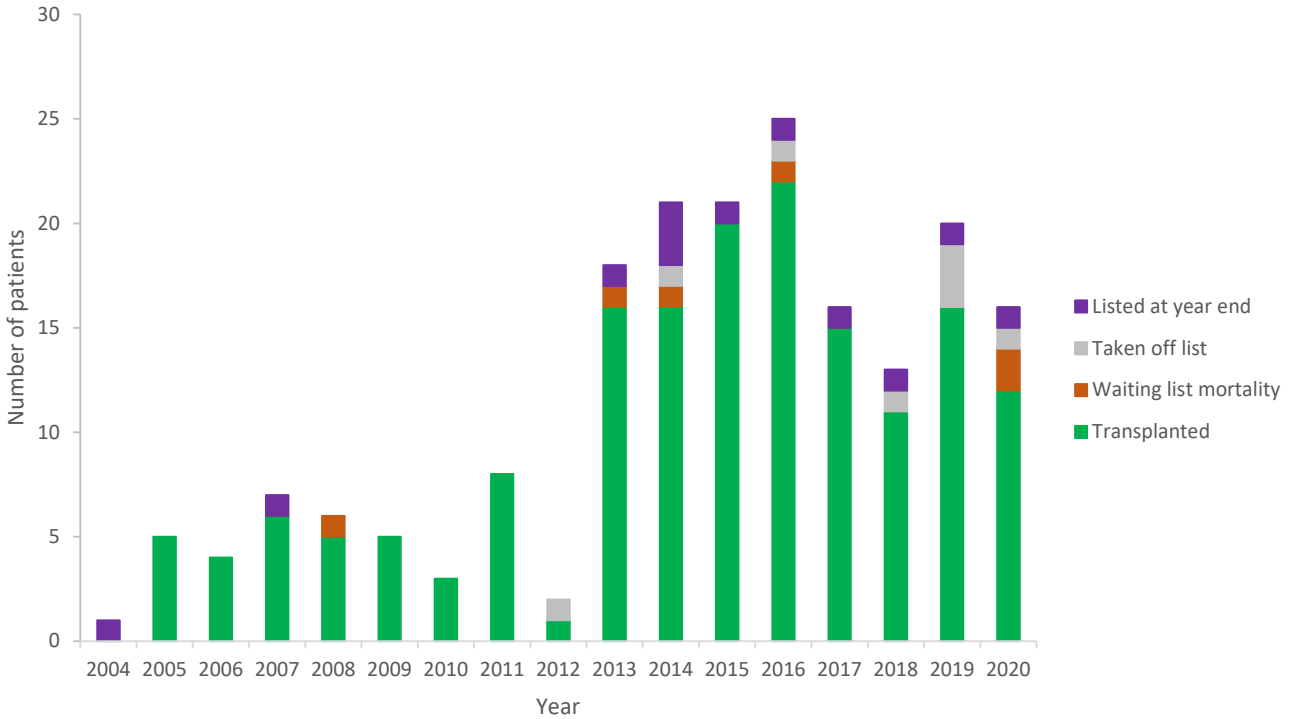


Figure 6. Urgent category 2 waiting list outcomes
Data show the outcome of urgent listings for each year. The outcomes of patients still listed at the end of the year are reported in the subsequent year.



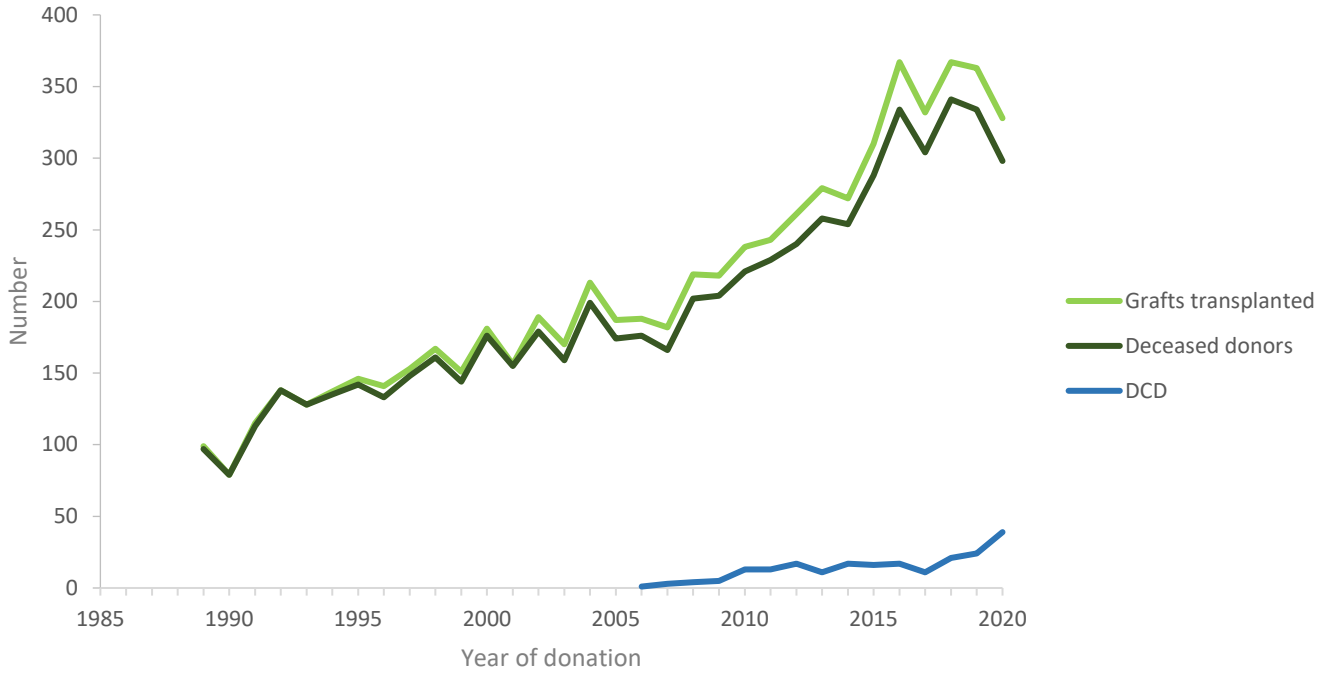
6 Deceased Liver Donors

Of 6,959 liver transplants, 6,843 (98.3%) were sourced from deceased donors, with only a small proportion from living donors (116, 1.7%). 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 6,309 deceased donors from 1989 onwards.

6.1 Deceased Donors and Grafts Transplanted Per Year

Of 6,309 deceased donors, 410 donated livers were split (one graft was not utilised from each of two livers that were split, so there were 818 split grafts), resulting in a total of 6,717 grafts. The number of deceased donors has grown steadily over the years until recently (Figure 7). There was an 11% reduction (from 334 to 298) in deceased liver donors between 2019 and 2020, likely related to the COVID-19 pandemic. Of 298 deceased donors in 2020, 39 (13.1%) were donation after circulatory death donors, up from 7.2% in 2019.

Figure 7. Deceased donors and grafts transplanted by year



Abbreviation: DCD, donation after circulatory death

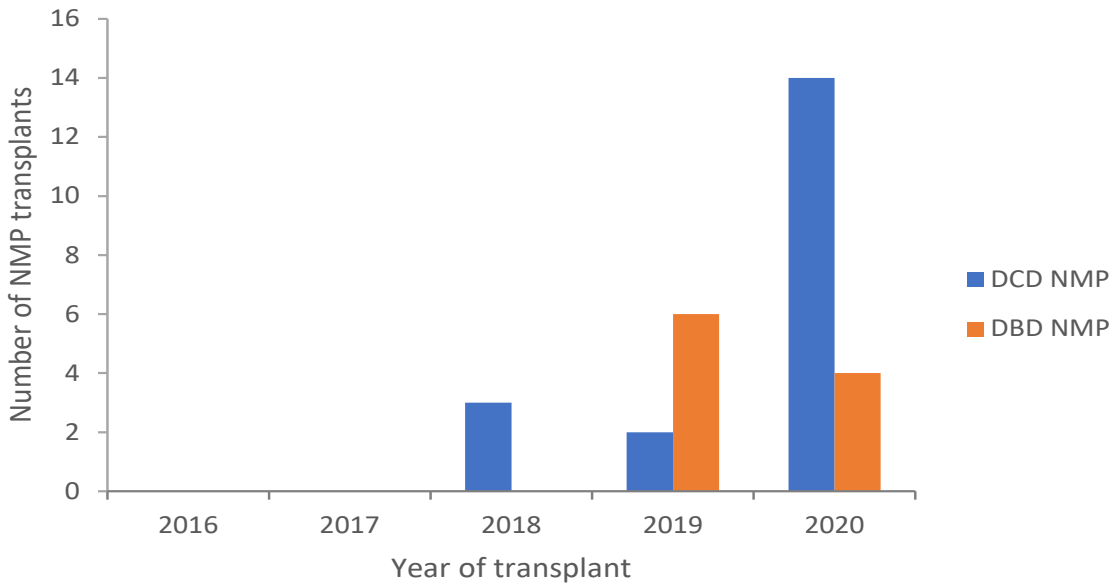
6.2 Normothermic Machine Perfusion of Deceased Donor Livers

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 and 12 in 2020 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.

In 2020, fourteen (36%) of the 39 transplanted livers sourced from donation after circulatory death donors (DCD) were supported using normothermic machine perfusion (Figure 8, Table 1). The number of DCD livers increased from 24 in 2019 to 39 in 2020.

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%*

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 over the subsequent eras (Figure 9).

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

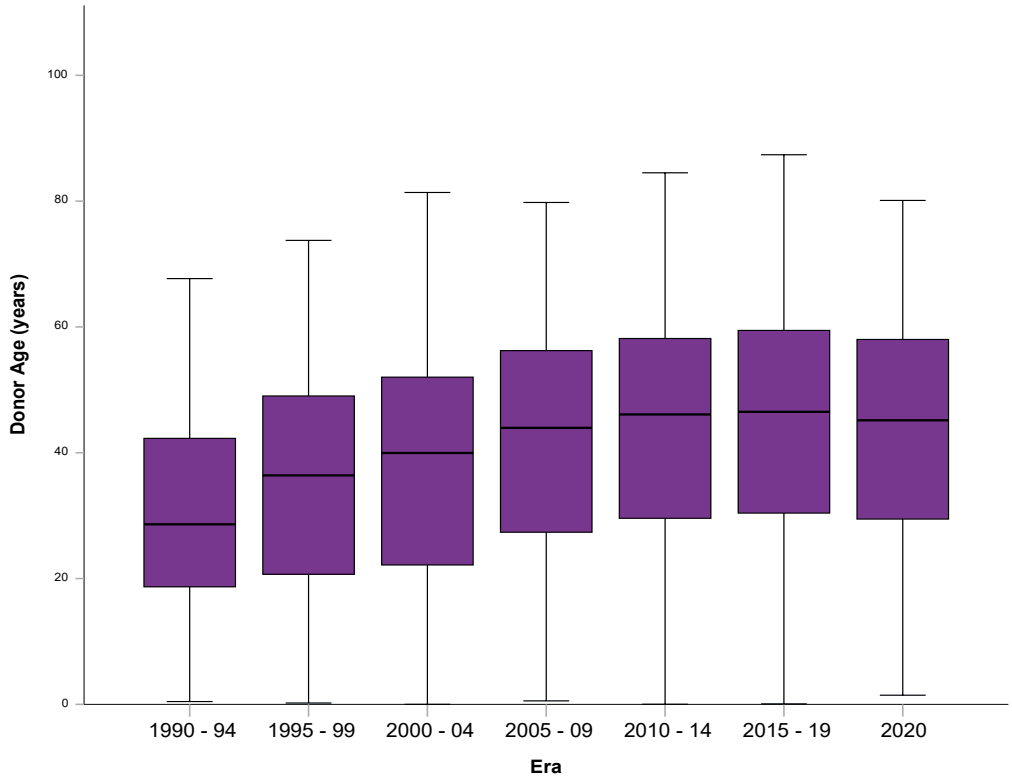
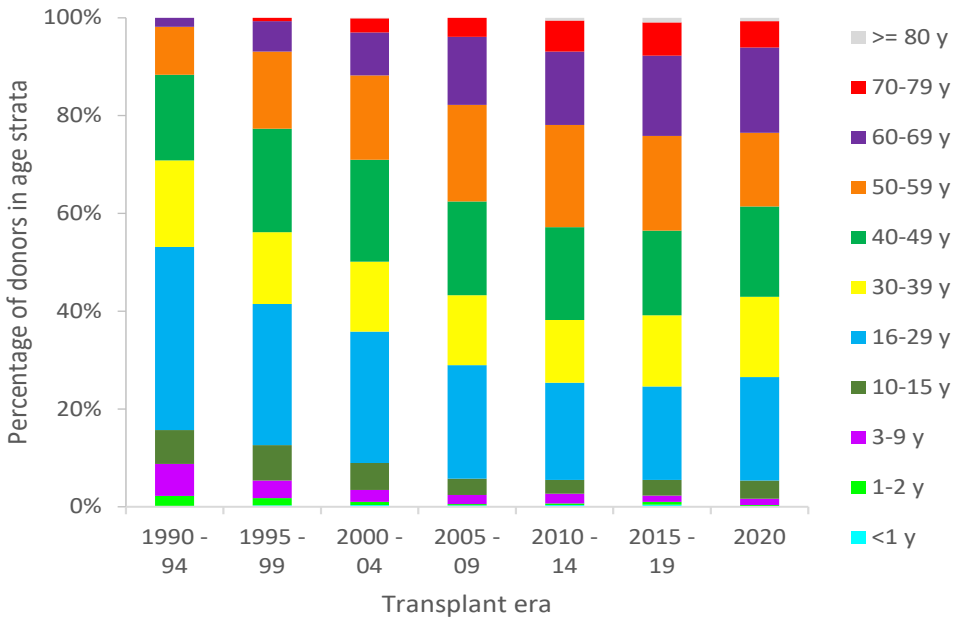


Figure 10 demonstrates the changing deceased donor age profile over the various transplant eras. There has been a progressive increase in the proportion of donors aged 50-59, 60-69, 70-79 and ≥ 80 years from 10%, 2% 0% and 0%, respectively in the 1990-94 era to 21%, 15%, 6% and 1%, respectively to – 15%, 17%, 5%, 1% in the 2010-14 era and then plateaued over the subsequent eras.

Figure 10. Deceased donor age by transplant era



7 Living Liver Donors

Of 6,959 liver transplants, 116 (1.7%) were sourced from living donors (including four domino livers). Paediatric recipients received the majority (81.9%) 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	**95**	**21**	**116**
% living donors	81.9%	18.1%	
Gender of living donor			
Female *(% age category)*	43 *(45.3%)*	8 *(38.1%)*	**51** *(44.0%)*
Male *(% age category)*	52 *(54.7%)*	13 *(61.9%)*	**65** *(56.0%)*
Age of living donor (years)			
Median	34	33	**33**
Range	19 – 54	18 – 54	**18 – 54**
Living donor relationship			
Father	41	1	**42**
Mother	24	0	**24**
Aunt	10	0	**10**
Family Friend	8	1	**9**
Brother	2	3	**5**
Son	0	5	**5**
Domino whole liver	0	4	**4**
Cousin	3	0	**3**
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 2020

There were 332 liver transplants performed on 320 recipients in 2020. This represents a 10% reduction in liver transplants compared with 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 2020 for Australia and New Zealand were 10.8 and 10.6 liver transplant recipients per million population respectively (Australia population in 2020: 25.7 million; New Zealand population in 2020: 5.1 million).

8.1 Demographic Data for Patients Transplanted in 2020

Of patients receiving a transplant in 2020, 14.1% were children. Females represented 42.2% of paediatric patients but only 33.8% of the adult population (Table 3. Patient demographics by age group (2020).

Table 3. Patient demographics by age group (2020)

Patients Transplanted in ANZ in 2020	**Children** (<16 years)	**Adults** (≥16 years)	**Total Patients**
Number of patients *(% total patients)*	45 *(14.1%)*	275 *(85.9%)*	320
Gender			
Female *(% age category)*	19 *(42.2%)*	93 *(33.8%)*	112 *(35.0%)*
Male *(% age category)*	26 *(57.8%)*	182 *(66.2%)*	208 *(65.0%)*
Age at first ANZ transplant in 2020			
Mean ± SD (years)	4 ± 4	53 ± 13	46 ± 21
Median (years)	1	56	53
Range	4 m - 14 y	17 y - 75 y	4 m - 75 y
Interquartile range	8 m - 7 y	46 y - 63 y	36 y - 62 y
Status of patients at 31/12/2020			
Alive *(% age category)*	45 *(100.0%)*	259 *(94.2%)*	304 *(95.0%)*
Deceased *(% age category)*	0 *(0.0%)*	16 *(5.8%)*	16 *(5.0%)*

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

8.2 Transplants in 2020

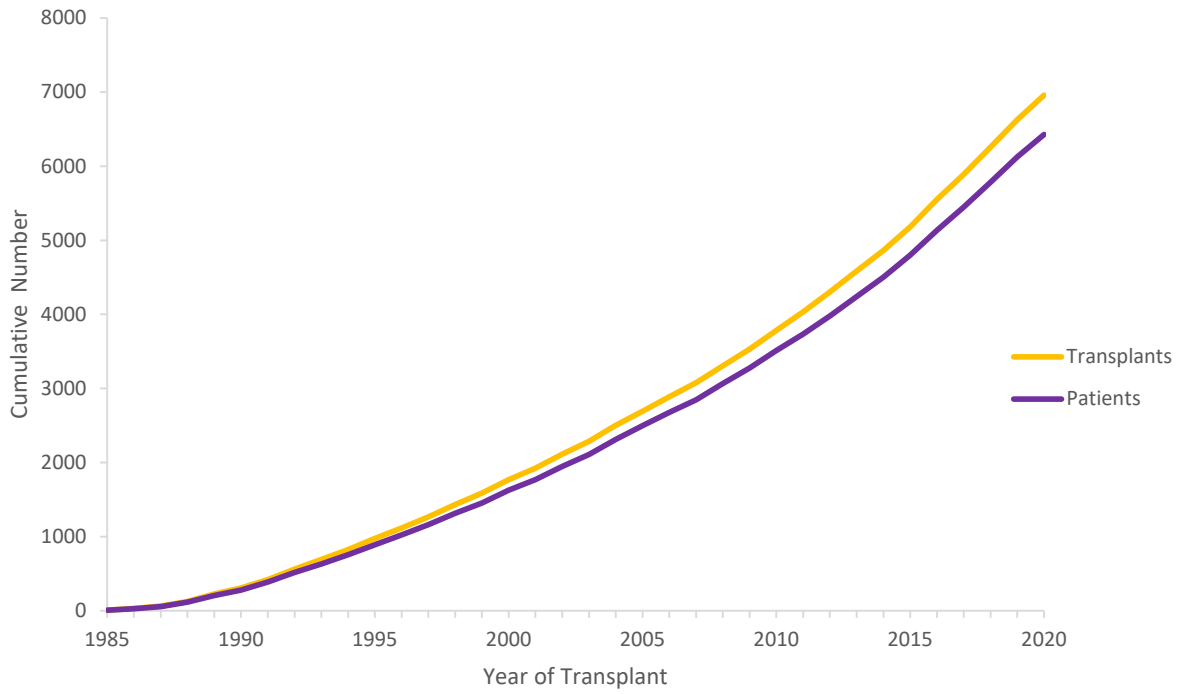
The majority of the 332 transplants were for adult patients (287, 86.4%), whilst 45 (13.6%) transplants were performed on children.

Of the 320 patients transplanted in 2020, 302 (94.4%) patients had their first transplant in 2020. Of these, eleven required retransplantation (i.e. two transplant operations in 2020). Sixteen patients who had a single transplant prior to 2020 were retransplanted in 2020. One of these went on to have their third transplant in 2020. Two patients who had two transplants prior to 2020 were retransplanted with their third graft in 2020.

9 Liver Transplantation from 1985 – 2020

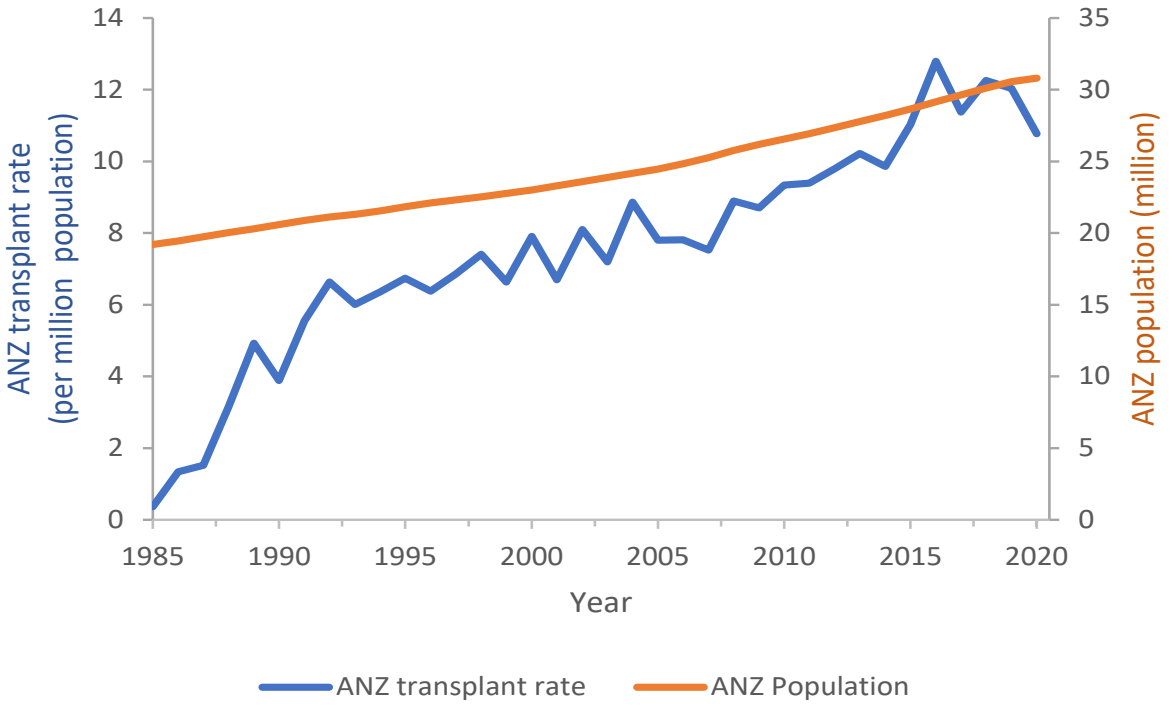
There have been 6,959 liver transplants undertaken on 6,428 patients between 1985 and 2020. Figure 11 shows the cumulative number of patients and transplants.

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, 12.0 in 2019 and then falling to 10.8 in 2020. (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 - 2020

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. (6,428 patients, 6,423 graft 1; 5 graft 2).

Of patients receiving a transplant from 1985 to 2020, 16.6% were children. Females comprised 50.9% of paediatric patients but only 36.3% of adult patients (Table 4).

Table 4. Patient demographics by age group (1985 – 2020)

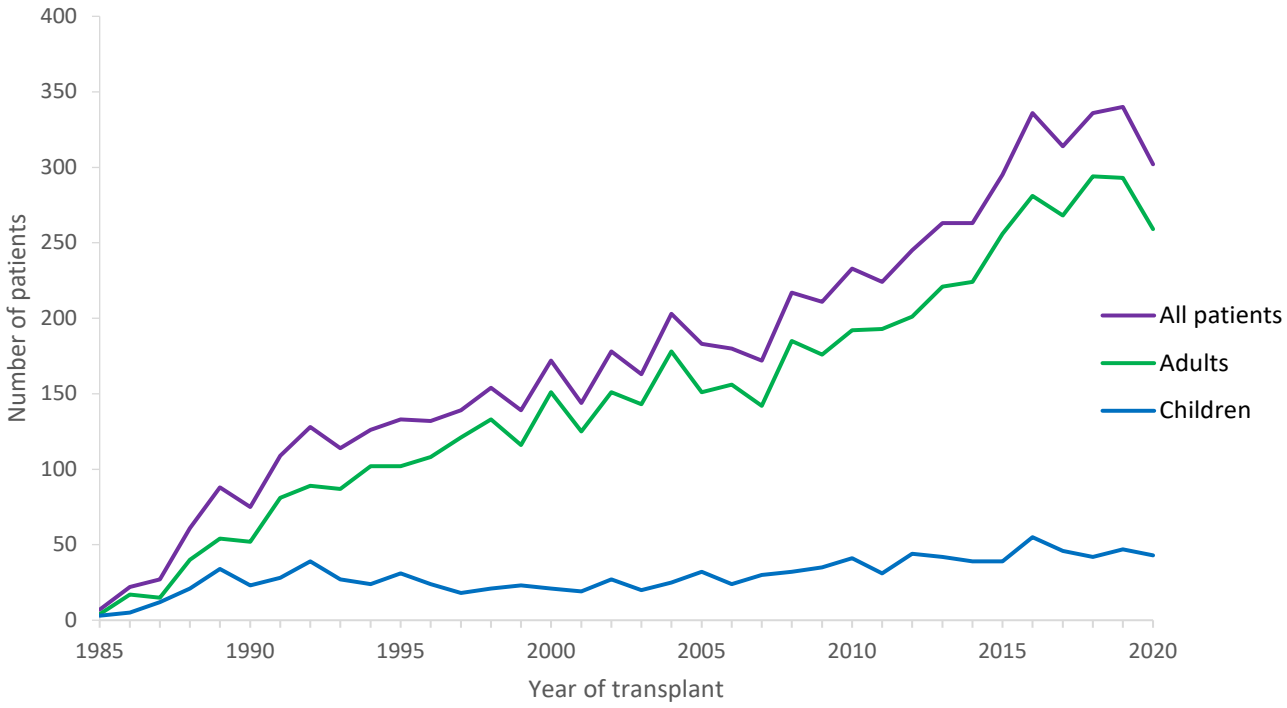
Patients Transplanted in ANZ from 1985 to 2020	**Children** (<16 years)	**Adults** (≥16 years)	**Total Patients**
Number of patients *(% total patients)*	1,067 *(16.6%)*	5,361 *(83.4%)*	6,428
Gender			
Female *(% age category)*	543 *(50.9%)*	1,788 *(33.4%)*	2,331 *(36.3%)*
Male *(% age category)*	524 *(49.1%)*	3,573 *(66.6%)*	4,097 *(63.7%)*
Age at first ANZ transplant			
Mean ± SD (years)	4 ± 4	50 ± 11	42 ± 20
Median (years)	2	52	49
Range	18 d - 15 y	16 y - 75 y	18 d - 75 y
Interquartile range	11 m - 7 y	44 y - 59 y	33 y - 57 y
Status of patient at 31/12/2020			
Alive *(% age category)*	886 *(83.0%)*	3,675 *(68.6%)*	4,561 *(71.0%)*
Deceased *(% age category)*	181 *(17.0%)*	1,686 *(31.4%)*	1,867 *(29.0%)*

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

9.1.1 Patients Transplanted by Year of First Transplant

From 2007 to 2020, there was a 75.6% increase in the number of patients transplanted per year, based on the year of their first transplant, from 172 to 302, including a 43.3% increase in the number of children transplanted (30 to 43) and a 82.4% increase in the number of adults transplanted (142 to 259, Figure 13).

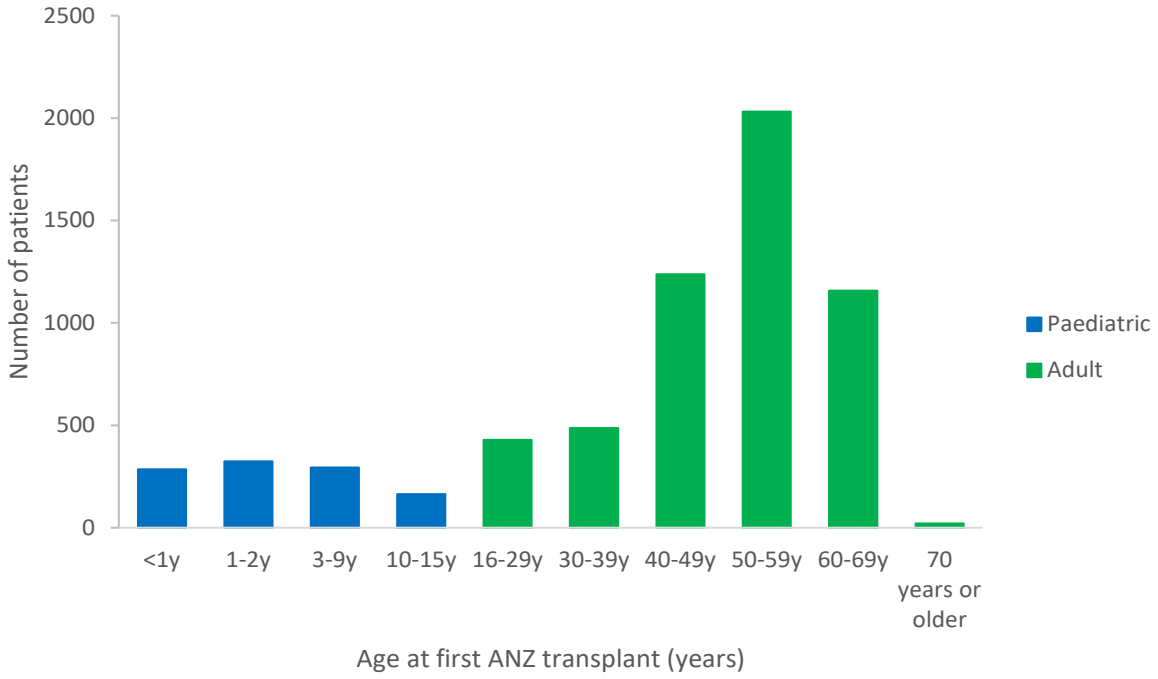
Figure 13. Number of patients transplanted by age group by year of first transplant



9.1.2 Recipient Age at First Transplant (1985 – 2020)

Of the 1,067 paediatric transplant recipients, 26.7% were infants less than one year old and 15.4% were adolescents 10 to 15 years old (Figure 14). Of the 5,361 adult recipients, 37.9% were in their 50s and only 0.4% were in their 70s.

Figure 14. Recipient age strata at first Australian or New Zealand transplant (1985 – 2020)



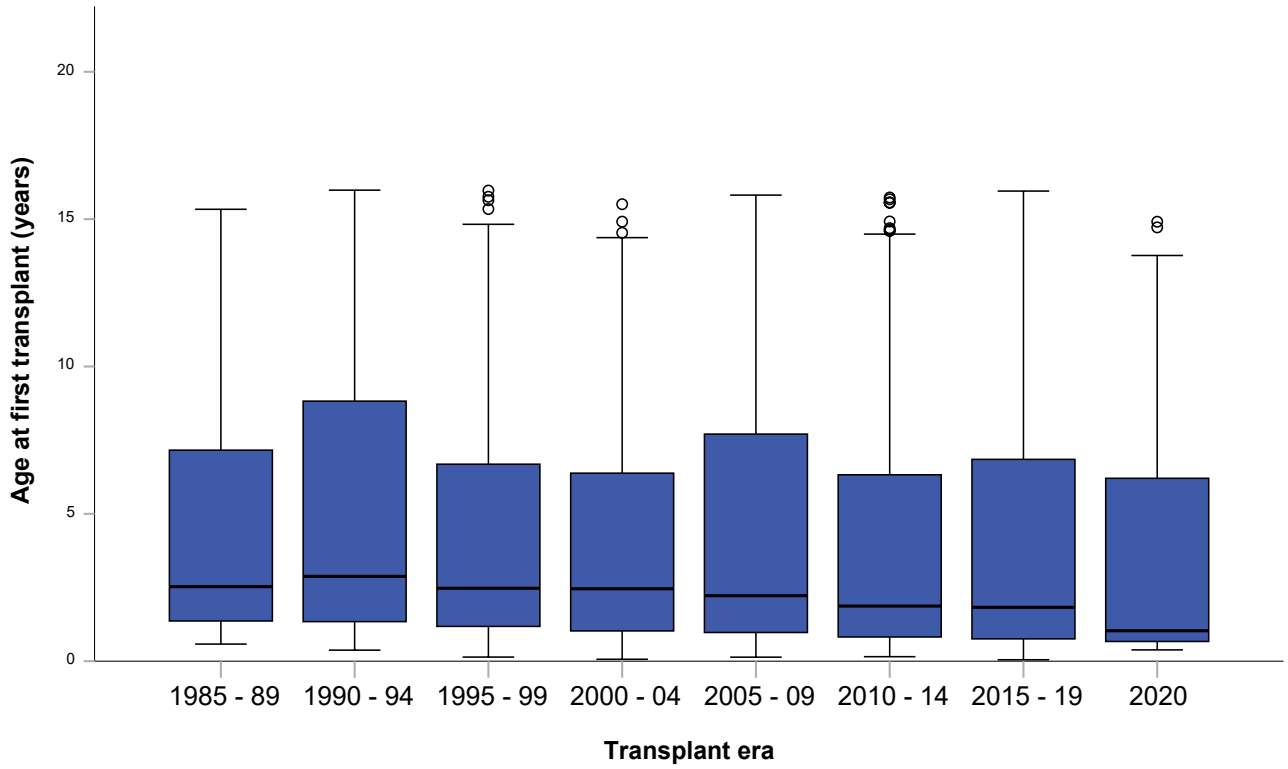
9.1.3 Recipient Age at First Transplant by Era of Transplant

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% and 0%, respectively in the 1985 - 89 era to 34% and 1%, respectively in the 2020 era. Whilst the proportion of recipients aged 50-59 years has increased over eras to peak in 2010 - 14 era at 39%, it has decreased to 32% in the 2015 - 19 era, and to 23% in 2020. The proportion of recipients aged less than one year ranged between 3% and 5% in all eras until 2020, when it increased to 7%.

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

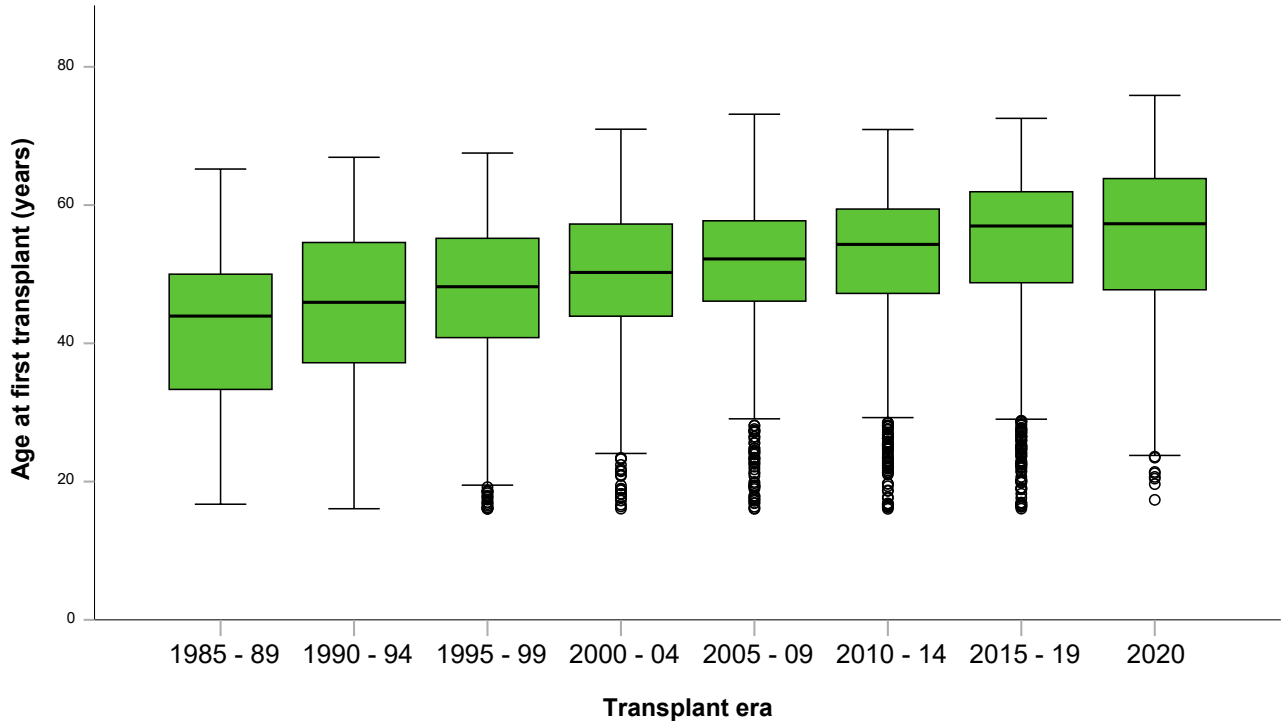
The median paediatric recipient age has been gradually decreasing over the transplant eras, from 2 years and 6 months in 1985-89 to 1 year in 2020 (P=0.020, Figure 16).

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 (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



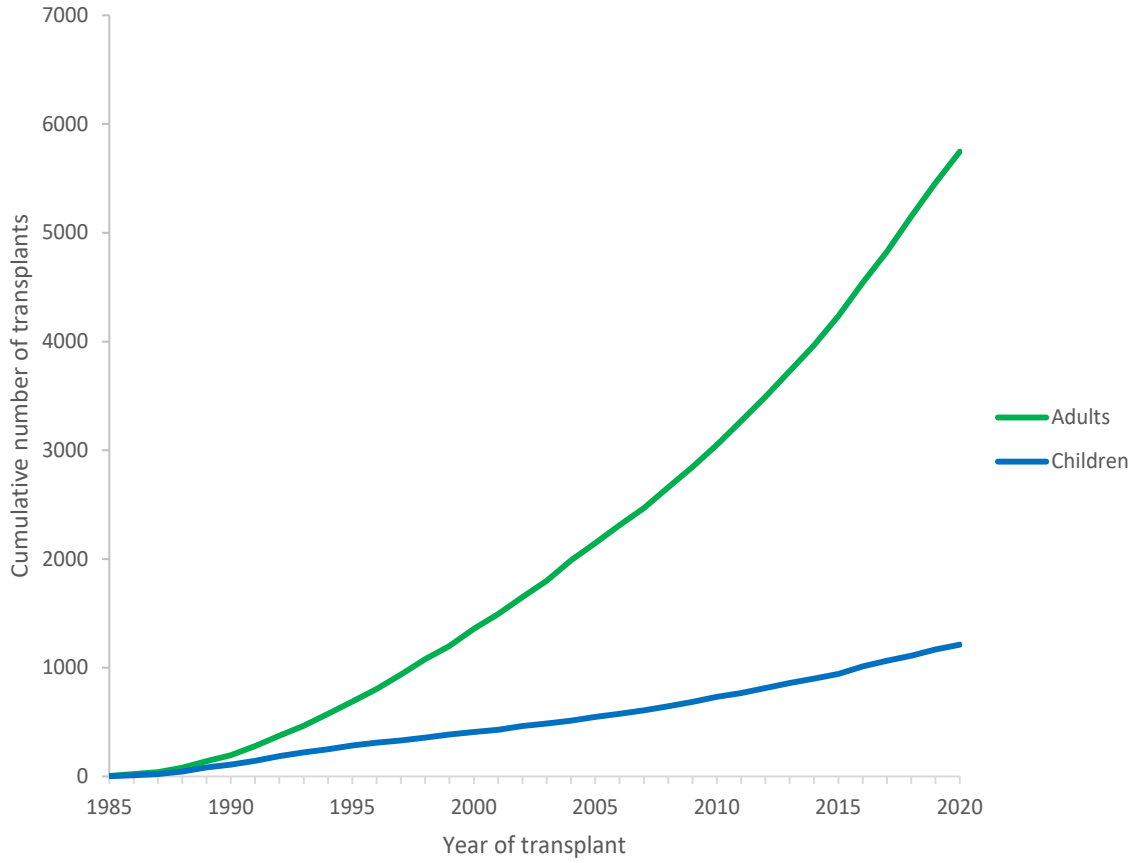
9.2 Transplants (1985 – 2020)

Of the 6,959 transplants, 5,747 (82.6%) were performed in adults and 1,212 (17.4%) in children (<16 years, Table 5, Figure 18). Since the first transplant in 1985, 474 (7.4%) recipients have undergone retransplantation. Of these, 419 patients had one retransplant, 53 patients have required two retransplants and two patients had three retransplants.

Table 5. Transplants by age group (1985 – 2020)

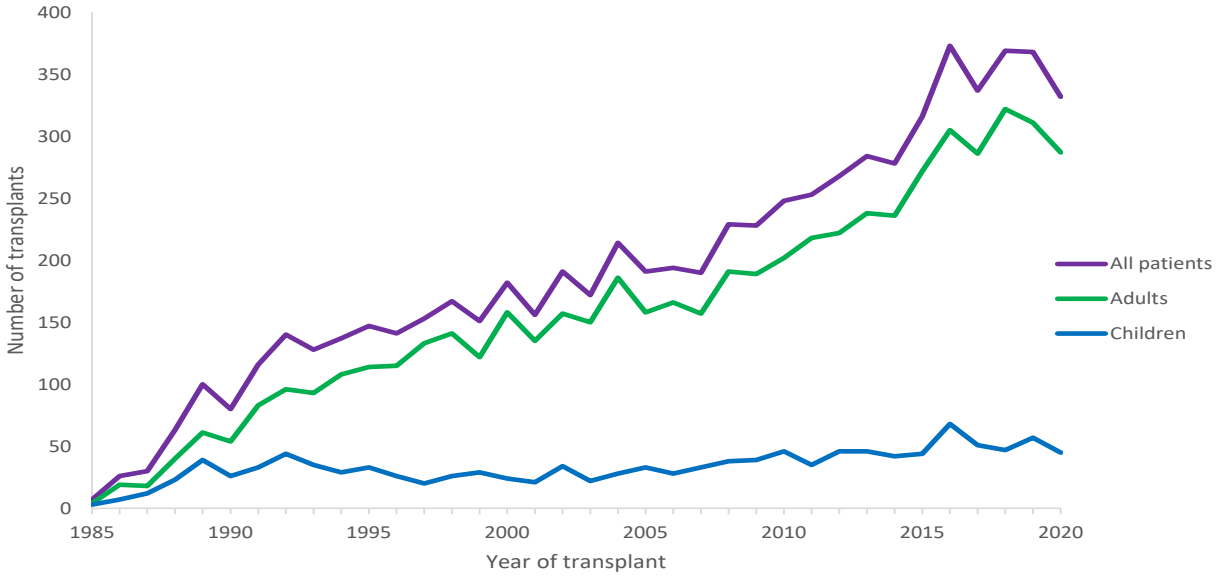
Transplants Transplanted in ANZ from 1985 to 2020	**Children** (<16 years)	**Adults** (≥16 years)	**Total**
Number of transplants *(% total transplants)*	1,212 *(17.4%)*	5,747 *(82.6%)*	**6,959**
Number of patients *(% total patients)*	1,067 *(16.6%)*	5,361 *(83.4%)*	**6,428**

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



There was a 10% reduction in liver transplants in 2020 compared with 2019. The number of transplants performed fell from 368 in 2019 to 332 in 2020. The number of transplants in children fell from 57 to 47 and adults from 311 to 287 (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.

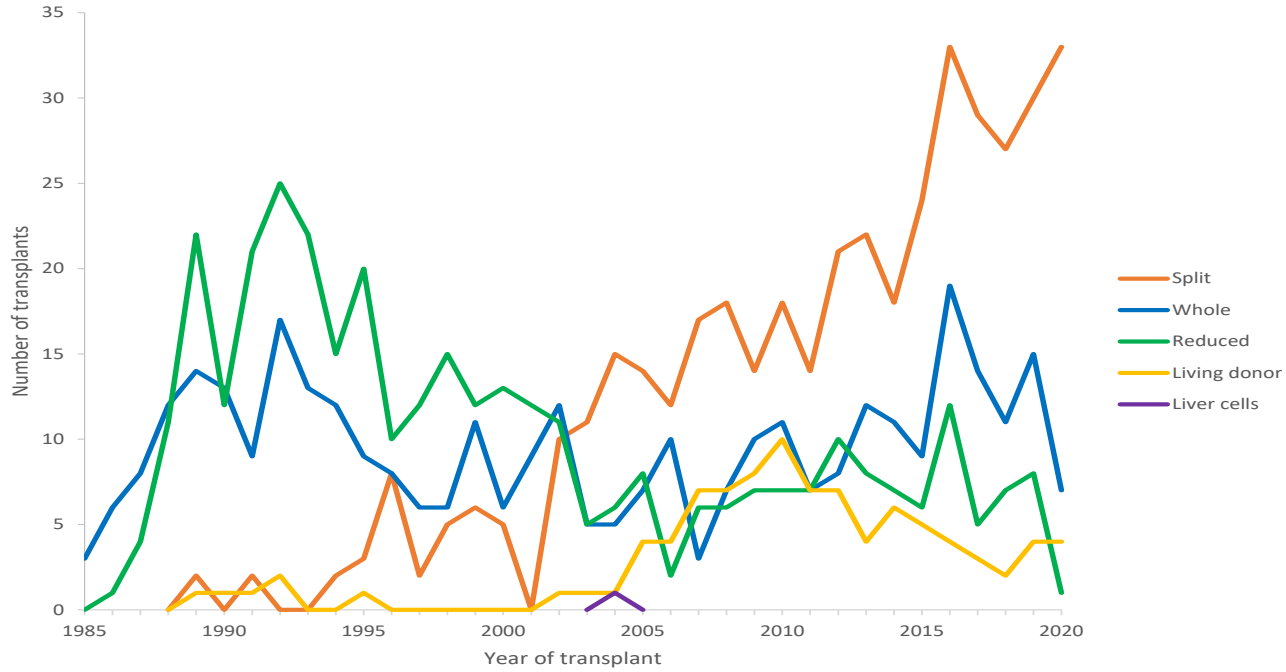
Figure 19. Number of liver transplants per year by recipient age category



9.2.1 Type of Graft – Paediatric Recipients, All Years

The first paediatric liver transplant 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 at 53% in 2019 and a significant increase to 73% in 2020 (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 2020).

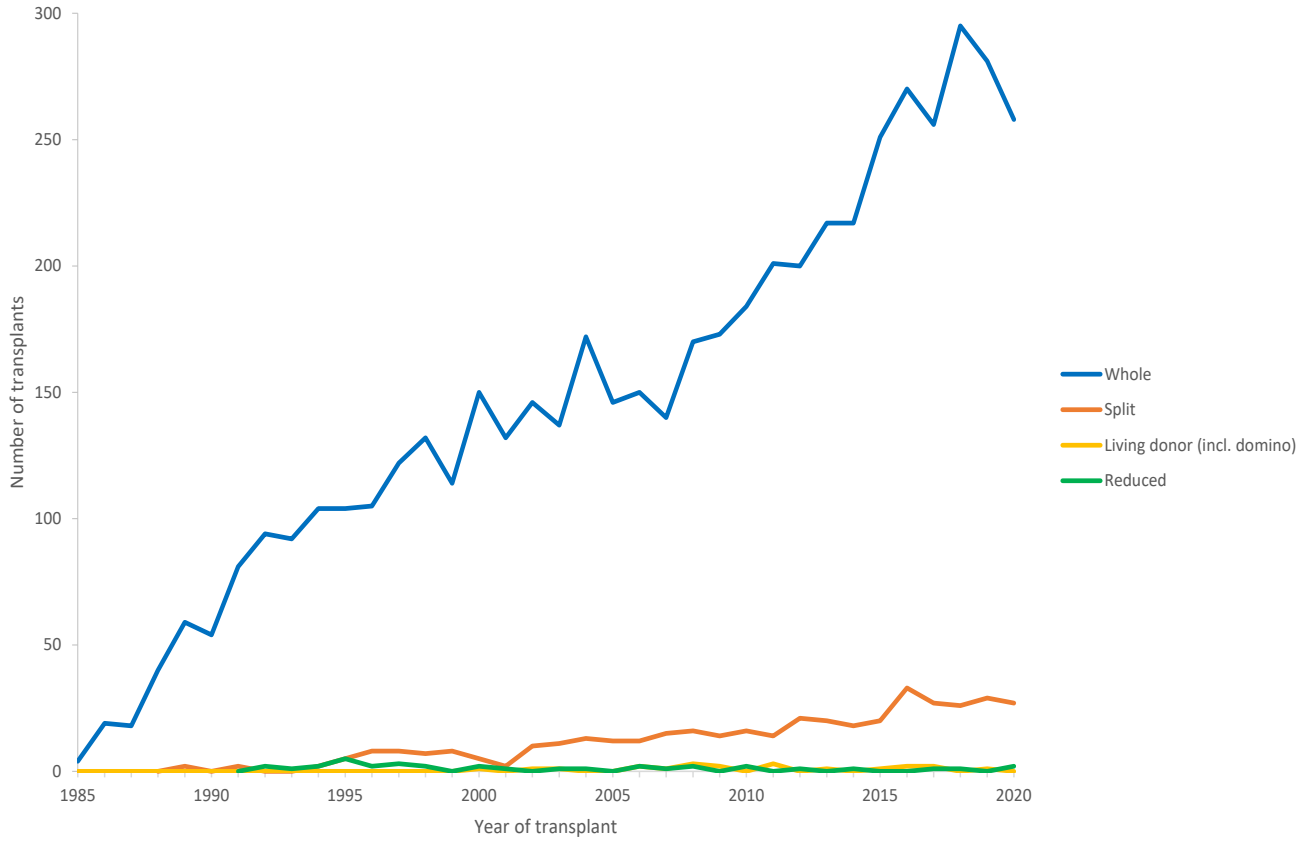
Figure 20. Type of graft for paediatric recipients – all years



9.2.2 Type of Graft – Adult Recipients, All Years

The dominant form of liver transplantation in adults is whole liver transplantation (258 of 287 transplants, 90% in 2020, Figure 21). The number of deceased donor split liver transplants in adults has increased from 5 of 158 transplants (3%) in 2000 to 27 of 287 (9%) in 2020. 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



10 Diagnoses at First Transplant

10.1 Diagnoses in Children

Of 1,065 children who underwent their first liver transplant in Australia or New Zealand, the most common primary diagnoses were biliary atresia (53.3%), metabolic disorders (14.8%) and fulminant hepatic failure (10.8%, Table 6). The primary diagnosis and up to 3 additional diagnoses are collected in the ANZLITR. There were 26 secondary diagnoses and no tertiary or quaternary diagnoses recorded for children.

Table 6. Diagnosis in children

Diagnosis	Primary Diagnosis	% Children with Primary Diagnosis	All Diagnoses	% Children with Diagnosis
Biliary atresia	568	53%	**569**	53%
Metabolic disorders*	158	15%	**161**	15%
Fulminant hepatic failure#	115	11%	**117**	11%
Alagille syndrome	41	4%	**42**	4%
Hepatoblastoma	33	3%	**34**	3%
Progressive familial intrahepatic cholestasis	33	3%	**33**	3%
Cryptogenic cirrhosis	24	2%	**24**	2%
Cystic fibrosis	17	2%	**17**	2%
Autoimmune cirrhosis	12	1%	**13**	1%
Hepatocellular carcinoma	7	0.7%	**12**	1%
Primary sclerosing cholangitis	8	0.8%	**11**	1%
Histiocytosis X	5	0.5%	**6**	0.6%
Neonatal hepatitis	6	0.6%	**6**	0.6%
Caroli's disease	4	0.4%	**4**	0.4%
Choledochal cyst	3	0.3%	**4**	0.4%
Congenital intrahepatic portosystemic shunt	3	0.3%	**3**	0.3%
Ductopenia	3	0.3%	**3**	0.3%
Cholangiocarcinoma	0	0%	**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	**1065**	**100%**	**1091**	**102%**

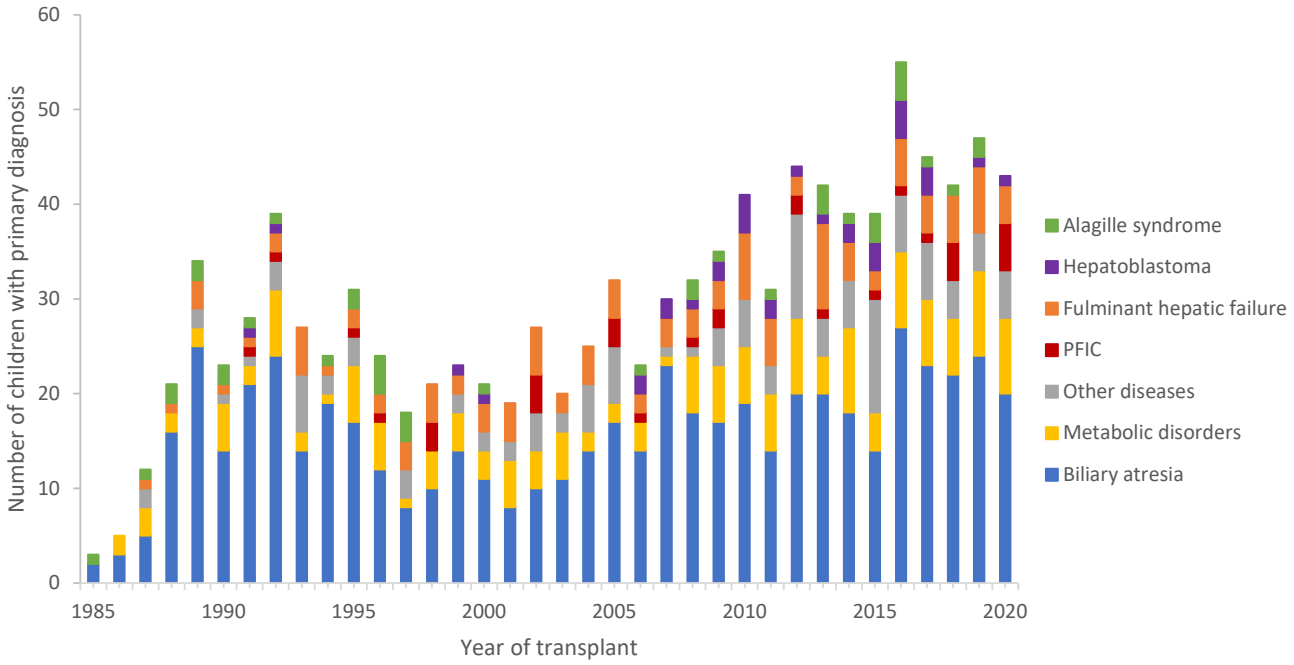
* See Table 9 for breakdown of metabolic disorders

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

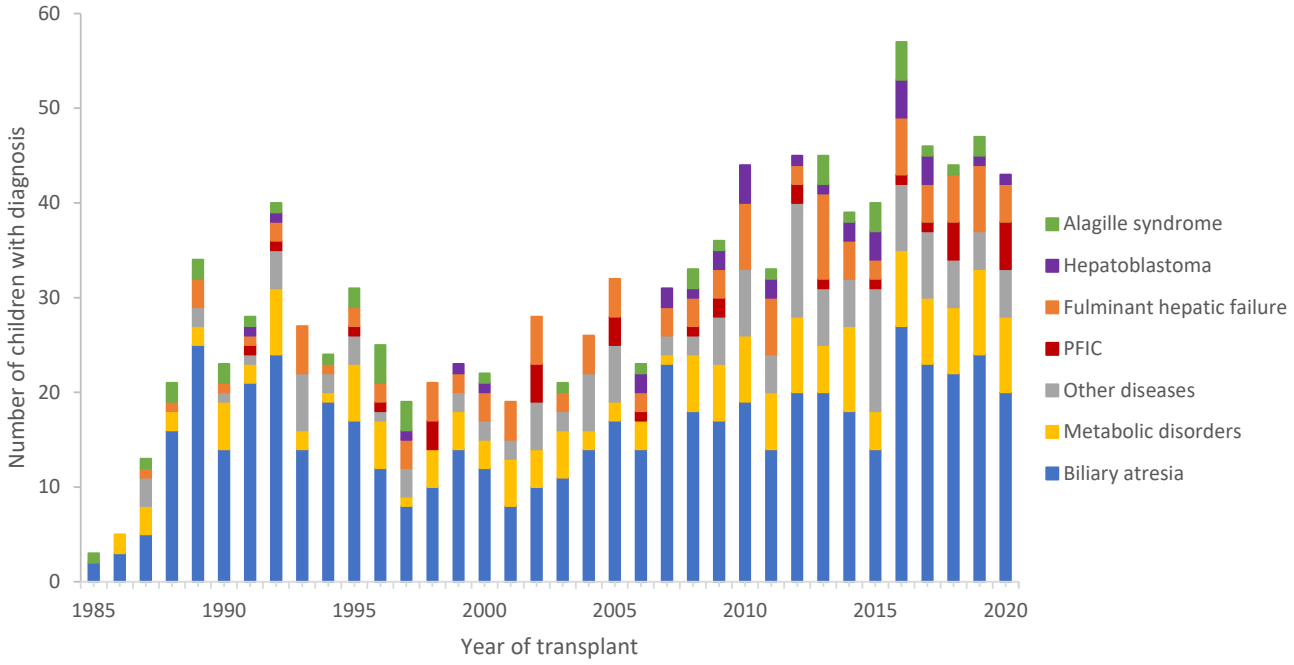


Abbreviation: PFIC, Progressive familial intrahepatic cholestasis

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 5,358 adults who underwent their first liver transplant in Australia or New Zealand, the most common primary diagnoses were hepatitis C virus cirrhosis (20.8%), alcoholic cirrhosis (13.6%) and hepatocellular carcinoma (12.2%, Table 7).

The primary diagnosis and up to 3 additional diagnoses are collected in the ANZLITR. In addition to the 5,358 primary diagnoses, there were 1,969 secondary diagnoses, 290 tertiary diagnoses and ten quaternary diagnoses recorded for adults. The proportion of patients with hepatitis C virus cirrhosis increased from 20.8% as a primary diagnosis to 28.6% across all diagnoses. The proportion of patients with hepatocellular carcinoma as a primary diagnosis was 12.2% and increased to 26.2% across all diagnoses. The proportion of patients with alcoholic cirrhosis as a primary diagnosis was 13.6% and increased to 24.1% across all diagnoses.

Table 7. Primary and additional diagnoses in adults

Diagnosis	Primary Diagnosis	% Adults with Primary Diagnosis	All Diagnoses	% Adults with Diagnosis
Hepatitis C virus cirrhosis	1114	21%	1532	29%
Hepatocellular carcinoma	656	12%	1405	26%
Alcoholic cirrhosis	731	14%	1290	24%
NAFLD / Cryptogenic cirrhosis	481	9%	617	12%
Primary sclerosing cholangitis	542	10%	560	10%
Hepatitis B virus cirrhosis	315	6%	518	10%
Fulminant hepatic failure#	468	9%	487	9%
Metabolic disorders*	218	4%	290	5%
Primary biliary cirrhosis	280	5%	284	5%
Autoimmune cirrhosis	186	3%	224	4%
Polycystic liver +/- kidney disease	62	1%	64	1%
Biliary atresia	53	1%	54	1%
Cholangiocarcinoma	14	0.3%	50	0.9%
Chronic Budd Chiari	39	0.7%	41	0.8%
Cystic fibrosis	30	0.6%	30	0.6%
Secondary biliary cirrhosis	21	0.4%	24	0.4%
Caroli's disease	20	0.4%	20	0.4%
Granulomatous hepatitis / sarcoidosis	13	0.2%	15	0.3%
Hepatopulmonary syndrome	0	0.0%	12	0.2%
Epithelioid haemangioendothelioma	10	0.2%	11	0.2%
Alagille syndrome	10	0.2%	10	0.2%
Hereditary haemorrhagic telangiectasia	9	0.2%	10	0.2%
Adenomatosis	5	0.1%	9	0.2%
Nodular regenerative hyperplasia	7	0.1%	8	0.1%
Secondary liver tumours - Neuroendocrine	6	0.1%	8	0.1%
Haemangioma	5	0.09%	6	0.1%
Portopulmonary hypertension	0	0.00%	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%
Post hepatitic cirrhosis - Drug related	3	0.06%	5	0.09%
Secondary biliary cirrhosis - hepatolithiasis	4	0.07%	5	0.09%
Cholestatic cirrhosis / Secondary cholangitis	3	0.06%	4	0.07%
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%
Haemolytic uraemic syndrome	3	0.06%	3	0.06%
Oriental cholangiohepatitis	3	0.06%	3	0.06%
Angiosarcoma	1	0.02%	2	0.04%
Choledochal cyst	2	0.04%	2	0.04%
Cirrhosis - Virus related cirrhosis - Other viruses	0	0.00%	2	0.04%
Congenital biliary fibrosis	2	0.04%	2	0.04%

(table continued on next page)

Diagnosis	Primary Diagnosis	% Adults with Primary Diagnosis	All Diagnoses	% Adults with Diagnosis
Intestinal failure associated liver disease	2	0.04%	2	0.04%
Abernethy Malformation	1	0.02%	1	0.02%
Acute alcoholic hepatitis	0	0.00%	1	0.02%
Arterio-venous malformation	1	0.02%	1	0.02%
Biliary papillomatosis	1	0.02%	1	0.02%
Chronic cholestatic liver disease	1	0.02%	1	0.02%
COACH syndrome	1	0.02%	1	0.02%
Common variable immune deficiency	1	0.02%	1	0.02%
Congenital heart disease	1	0.02%	1	0.02%
Drug induced cholestasis	1	0.02%	1	0.02%
Fasciola	1	0.0%	1	0.02%
Focal nodular hyperplasia	0	0.00%	1	0.02%
Graft vs host disease - bone marrow transplant	1	0.02%	1	0.02%
Hepatoblastoma	0	0.00%	1	0.02%
Histiocytosis X	1	0.02%	1	0.02%
Liver trauma	1	0.02%	1	0.02%
Parasitic disease - Infected hydatid cysts	1	0.02%	1	0.02%
Parasitic disease - Schistosomiasis (Bilharzia)	0	0.00%	1	0.02%
Portal biliopathy	1	0.02%	1	0.02%
Total	**5,358**		7,661	

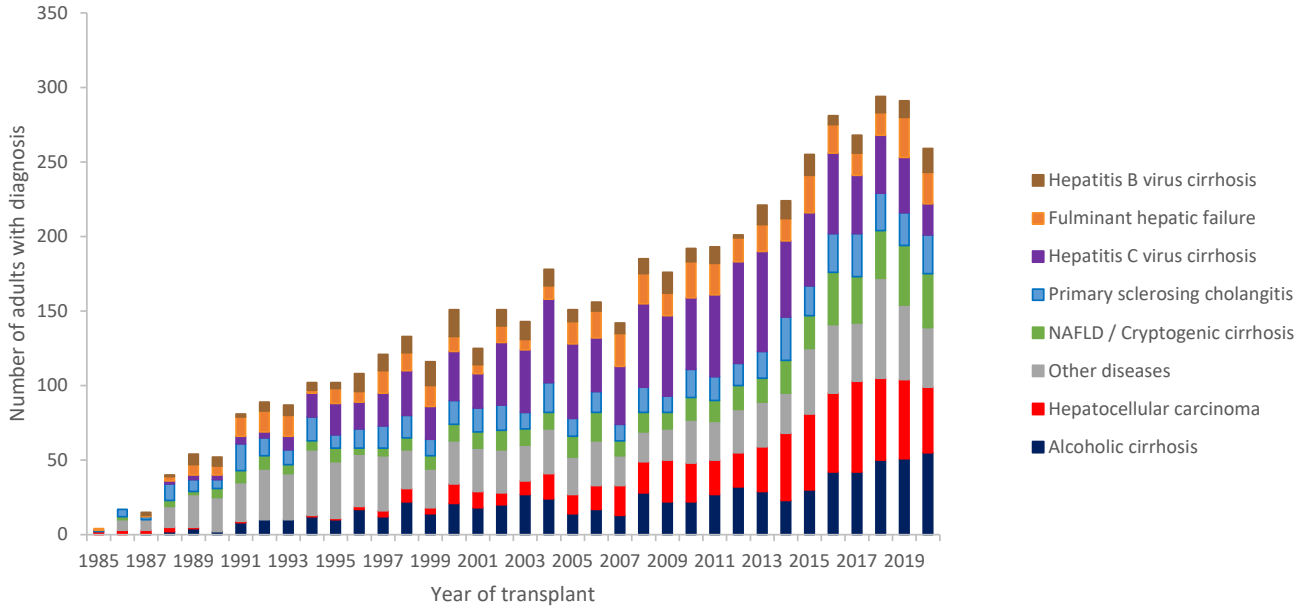
See Table 8 for breakdown of causes of fulminant hepatic failure
* See Table 9 for breakdown of metabolic disorders

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 8.1% in 2020 (Figure 24). The proportion of patients transplanted for hepatocellular carcinoma has increased from 11.4% in 2012 to 17.4% in 2020. Over the same time period, the proportion of patients transplanted for non-alcoholic fatty liver disease increased from 8.0% to 13.9%.

Figure 24. Primary diagnosis trend in adults

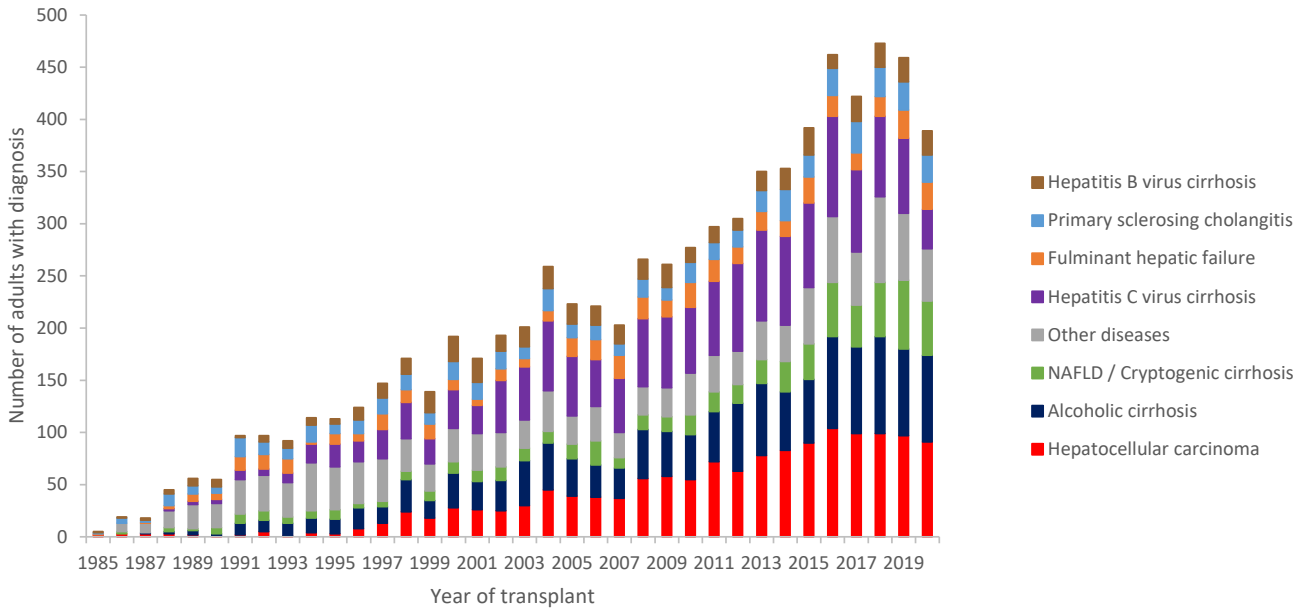


Abbreviation: NAFLD, non-alcoholic fatty liver disease

10.6 All Diagnoses Trend in Adults

The primary diagnosis and up to three additional diagnoses are collected in the ANZLITR. In addition to the 5,358 primary diagnoses, there were 2,304 additional diagnoses recorded for adults, giving a total of 7,662 diagnoses. Including any diagnosis recorded for each patient, hepatocellular carcinoma has become the commonest indication for liver transplantation in adults, rising from 1.1% in 1993 to 35.1% in 2020. Alcoholic cirrhosis has increased from 5.0% in 1988 to 32.0% in 2020 and non-alcoholic fatty liver disease has increased from 3.7% in 1993 to 20.1% in 2020, 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 14.7% in 2020. 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.

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	Adults	Children + Adults	% All Patients
Acute hepatic failure - Unknown / unspecified	62	110	172	3%
Acute hepatic failure - Hepatitis B	0	87	87	1%
Acute hepatic failure - Hepatitis non A-G	18	23	41	0.6%
Acute hepatic failure - Other drugs	3	37	40	0.6%
Subacute hepatitis - Type unknown	5	30	35	0.5%
Acute hepatic failure - Paracetamol	4	27	31	0.5%
Acute hepatic failure - Wilson's	9	22	31	0.5%
Subacute hepatitis - Autoimmune hepatitis	2	28	30	0.5%
Subacute hepatitis - Hepatitis B	0	27	27	0.4%
Subacute hepatitis - Drugs	1	19	20	0.3%
Acute hepatic failure - Autoimmune hepatitis	1	16	17	0.3%
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	1	6	7	0.1%
Subacute hepatitis - Hepatitis C	0	6	6	0.09%
Subacute hepatitis - Non A-G	0	6	6	0.09%
Acute hepatic failure - Hepatitis A	1	4	5	0.08%
Acute hepatic failure - Budd Chiari	0	4	4	0.06%
Acute hepatic failure - Toxic (non-drug)	1	3	4	0.06%
Acute hepatic failure - Alpha-1-antitrypsin	2	1	3	0.05%
Subacute hepatic failure - Budd Chiari	1	2	3	0.05%
Acute hepatic failure - Other specified	1	1	2	0.03%
Subacute hepatitis - Hepatitis A	0	2	2	0.03%
Subacute hepatitis - Herbs	0	2	2	0.03%
Acute hepatic failure - Epstein-Barr virus hepatitis	1	0	1	0.02%
Acute hepatic failure - Hepatitis D	0	1	1	0.02%
Acute hepatic failure - Hepatitis E	0	1	1	0.02%
Acute hepatic failure - Herpes simplex hepatitis	0	1	1	0.02%
Acute hepatic failure - Post traumatic	0	1	1	0.02%
Subacute hepatic failure - Post surgical resection	1	0	1	0.02%
Subacute hepatitis - Giant cell	1	0	1	0.02%
Subacute hepatitis - Ischaemic	0	1	1	0.02%
Total	**117**	**487**	**604**	9%
All Patients	*1065*	*5358*	*6428*	

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	% All Patients
Alpha-1-antitrypsin deficiency	44	99	143	2%
Haemochromatosis	3	65	68	1%
Wilson's disease	8	41	49	0.8%
Familial amyloid polyneuropathy	0	44	44	0.7%
Urea cycle disorders	30	5	35	0.5%
- Ornithine transcarbamylase (OTC) deficiency	*19*	*1*	*20*	0.3%
- Argininosuccinate lyase (ASL) deficiency	*4*	*1*	*5*	0.08%
- Carbamyl phosphate synthetase (CPS) 1 deficiency	*3*	*2*	*5*	0.08%
- Citrullinaemia, Argininosuccinate synthetase (ASS) deficiency	*4*	*1*	*5*	0.08%
Primary hyperoxaluria	12	9	21	0.3%
Glycogen storage disease	5	14	19	0.30%
Crigler-Najjar	12	1	13	0.20%
Propionic acidaemia	10	0	10	0.2%
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	0.05%
Methylmalonic acidaemia	3	0	3	0.05%
Protein C deficiency	1	2	3	0.05%
Acute intermittent porphyria	0	1	1	0.02%
Carnitine acylcarnitine translocase deficiency (CACT)	1	0	1	0.02%
Cirrhosis secondary to Niemann-Pick Type C	1	0	1	0.02%
Familial immunodeficiency syndrome	1	0	1	0.02%
Indian childhood cirrhosis	1	0	1	0.02%
Mitochondrial disease	1	0	1	0.02%
POLG mitochondrial disorder	1	0	1	0.02%
Pyridoxamine 5-phosphate oxidase deficiency	1	0	1	0.02%
Total	**161**	**290**	**451**	**7%**
All Patients	*1065*	*5358*	*6428*	

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

6,423 patients had their first liver transplant in Australia or New Zealand (i.e. Graft 1, Figure 26 and Table 10). Five 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 75.2%. The median patient survival post-transplant was 24.3 years.

Figure 26. Patient survival curve

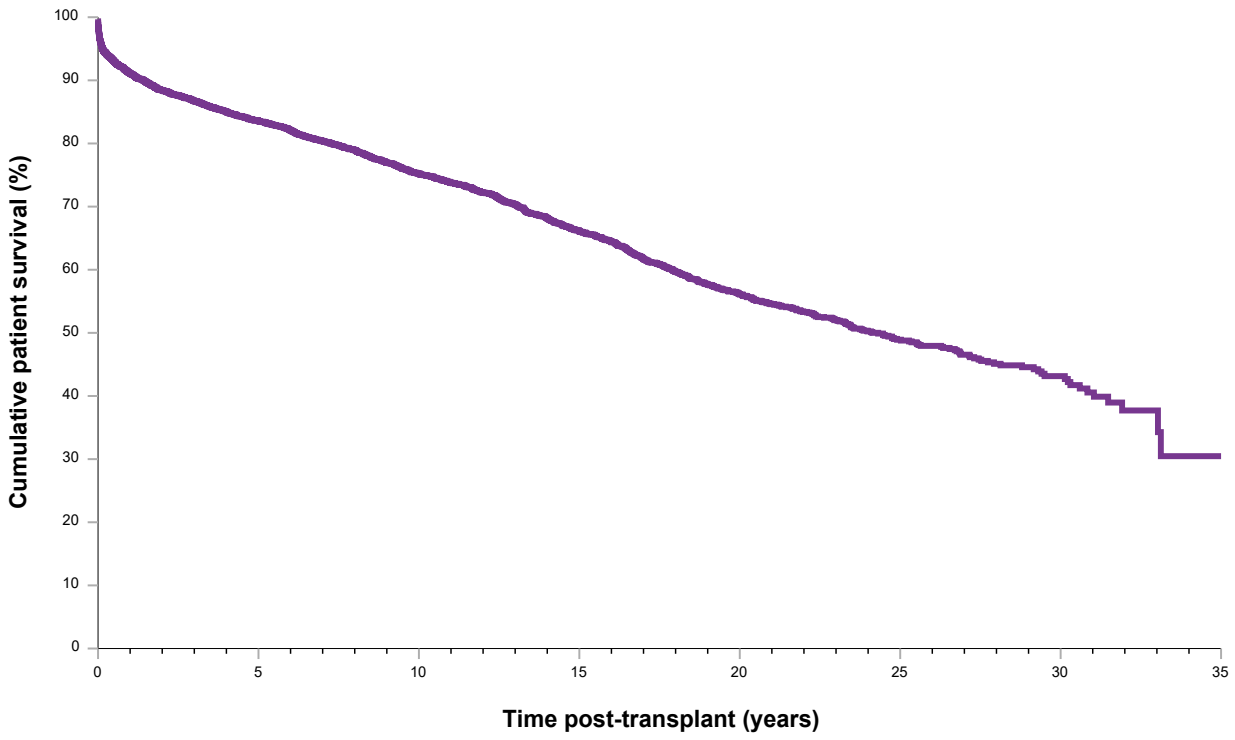


Table 10. Patient survival

Patient Survival	Time post-transplant (years)								
	0	1	3	5	10	15	20	30	35
No. at risk	6,423	5,571	4,680	3,941	2,531	1,534	816	99	1
Survival (%)		91%	87%	84%	75%	66%	56%	43%	31%

11.2 Patient Survival by Age Group

Paediatric cases are defined as less than 16 years at time of first transplant (n = 1,065). Adult cases are defined as greater than or equal to 16 years at time of first transplant (n = 5,358). 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 85.4% for children and 73.1% 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

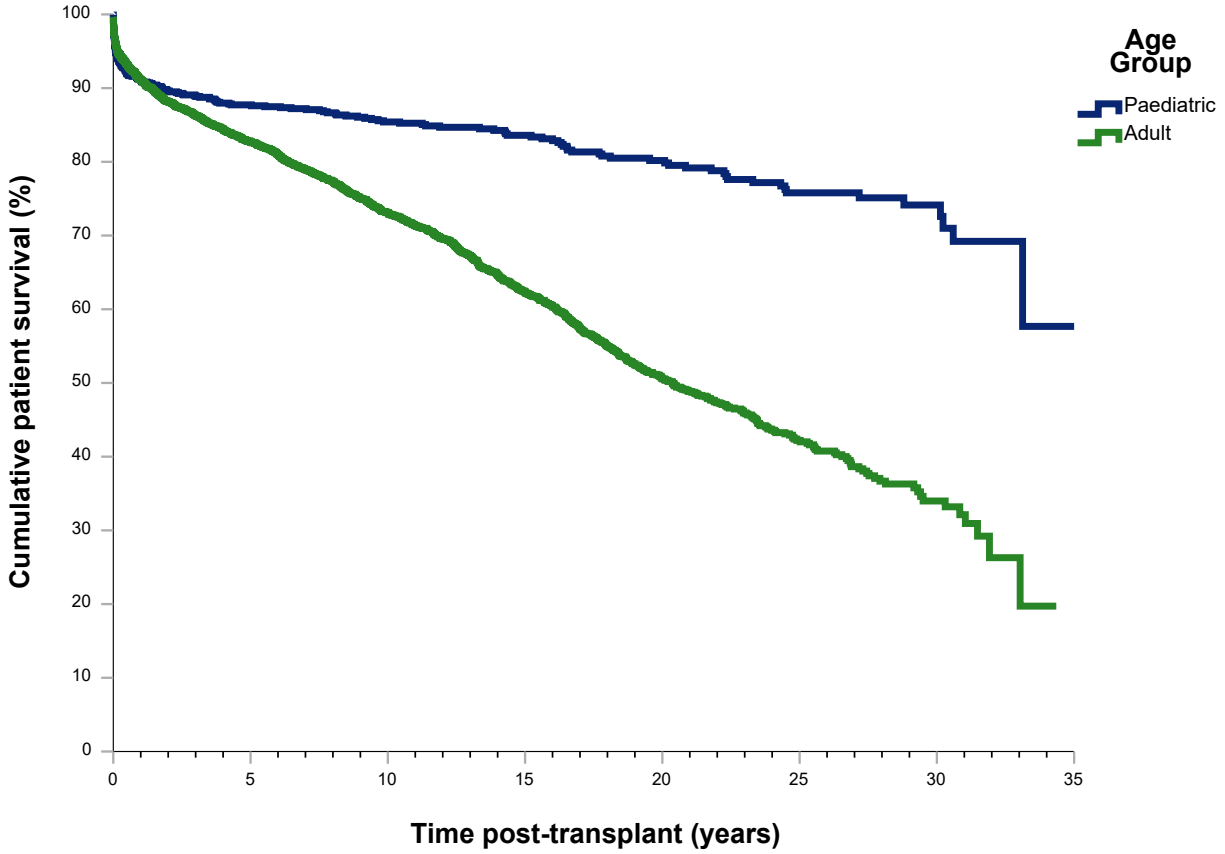


Table 11. Patient survival by age category

Age group	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
Paediatric (<16y)	No. at risk	1,065	928	820	714	518	363	244	52	1
	Survival (%)		91%	89%	88%	85%	84%	80%	74%	58%
Adults (≥16y)	No. at risk	5,358	4,643	3,860	3,227	2,013	1,171	572	47	0
	Survival (%)		91%	86%	83%	73%	62%	51%	34%	

11.3 Paediatric Patient Survival by Age Strata

There was no significant difference in patient survival by paediatric age strata (P = 0.291, Figure 28, Table 12). Ten-year patient survival was 86.8% for children less than 1 year, 81.5% for 1 – 2-year-olds, 87.0% for 3 – 9-year-olds and 88.9% for 10 – 15-year-olds. Median patient survival was not reached for paediatric age group except for the 1 – 2-year-old age group (median 33.1 years).

Figure 28. Paediatric patient survival curve by age strata

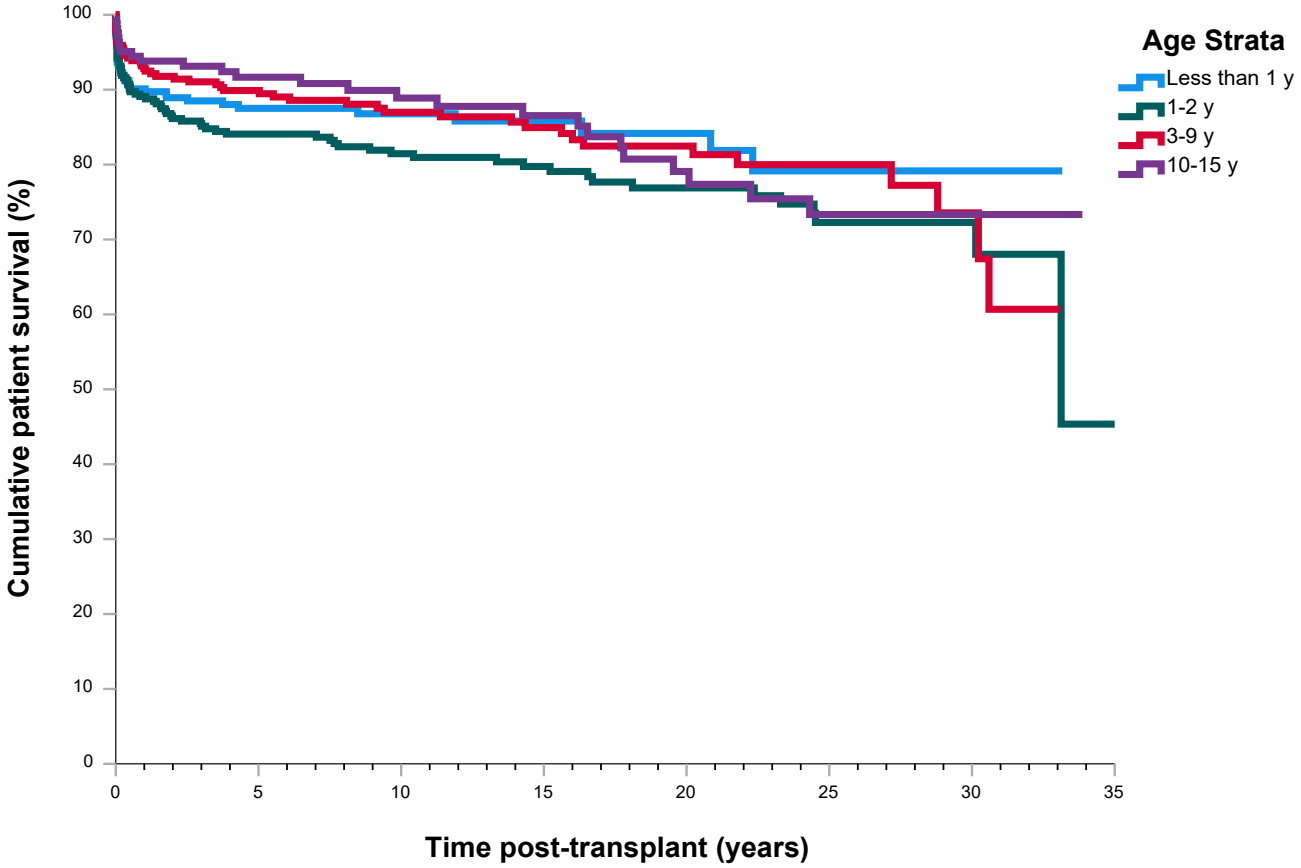


Table 12. Paediatric patient survival by age strata

Age strata	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
< 1 year	No. at risk	285	236	196	164	103	60	37	8	0
	Survival (%)		90%	89%	88%	87%	86%	84%	79%	
1 - 2 years	No. at risk	323	280	249	221	172	115	89	19	1
	Survival (%)		89%	86%	84%	82%	80%	77%	72%	45%
3 - 9 years	No. at risk	294	268	241	212	156	114	72	13	0
	Survival (%)		93%	91%	90%	87%	85%	83%	74%	
10 – 15 years	No. at risk	163	144	134	117	87	67	46	12	0
	Survival (%)		94%	93%	92%	89%	87%	79%	73%	

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 80.4%, 78.5%, 73.9%, 72.6%, 65.2% and 75.0%, 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, 15.1 and 10.9 years, respectively.

Figure 29. Adult patient survival curve by age strata

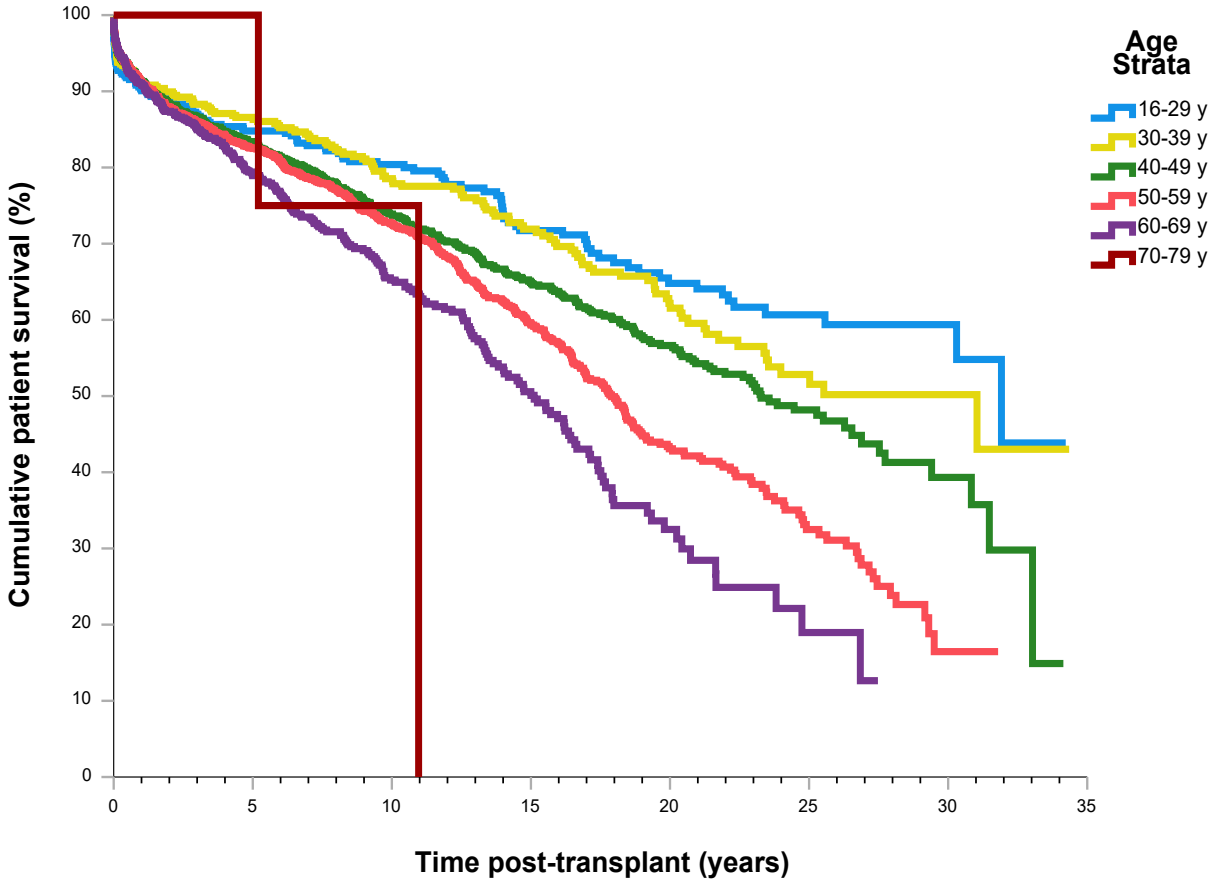


Table 13. Adult patient survival by age strata

Age strata	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
16-29 y	No. at risk	428	367	327	287	204	132	92	14	0
	Survival (%)		90%	87%	85%	80%	72%	65%	59%	
30-39 y	No. at risk	485	425	373	327	237	166	99	10	0
	Survival (%)		91%	88%	87%	79%	72%	62%	50%	
40-49 y	No. at risk	1,238	1,091	947	849	612	394	206	18	0
	Survival (%)		91%	87%	83%	74%	65%	57%	39%	
50-59 y	No. at risk	2,031	1,787	1,506	1,256	735	375	146	5	0
	Survival (%)		91%	86%	83%	73%	60%	43%	17%	
60-69 y	No. at risk	1,156	956	700	503	224	104	29	0	
	Survival (%)		91%	85%	79%	65%	50%	33%		
70-79 y	No. at risk	20	17	7	5	1	0			
	Survival (%)		100%	100%	100%	75%				

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 95.5% at 1 year, 91.8% at 3 years, 89.2% at 5 years and 78.0% at 10 years. Median patient survival was not reached for recent eras since 2000 and was 20.8 years for 1995 – 99, 20.7 years for 1990 – 94 and 11.8 years for 1985 – 89.

Figure 30. Patient survival curve by era of transplant

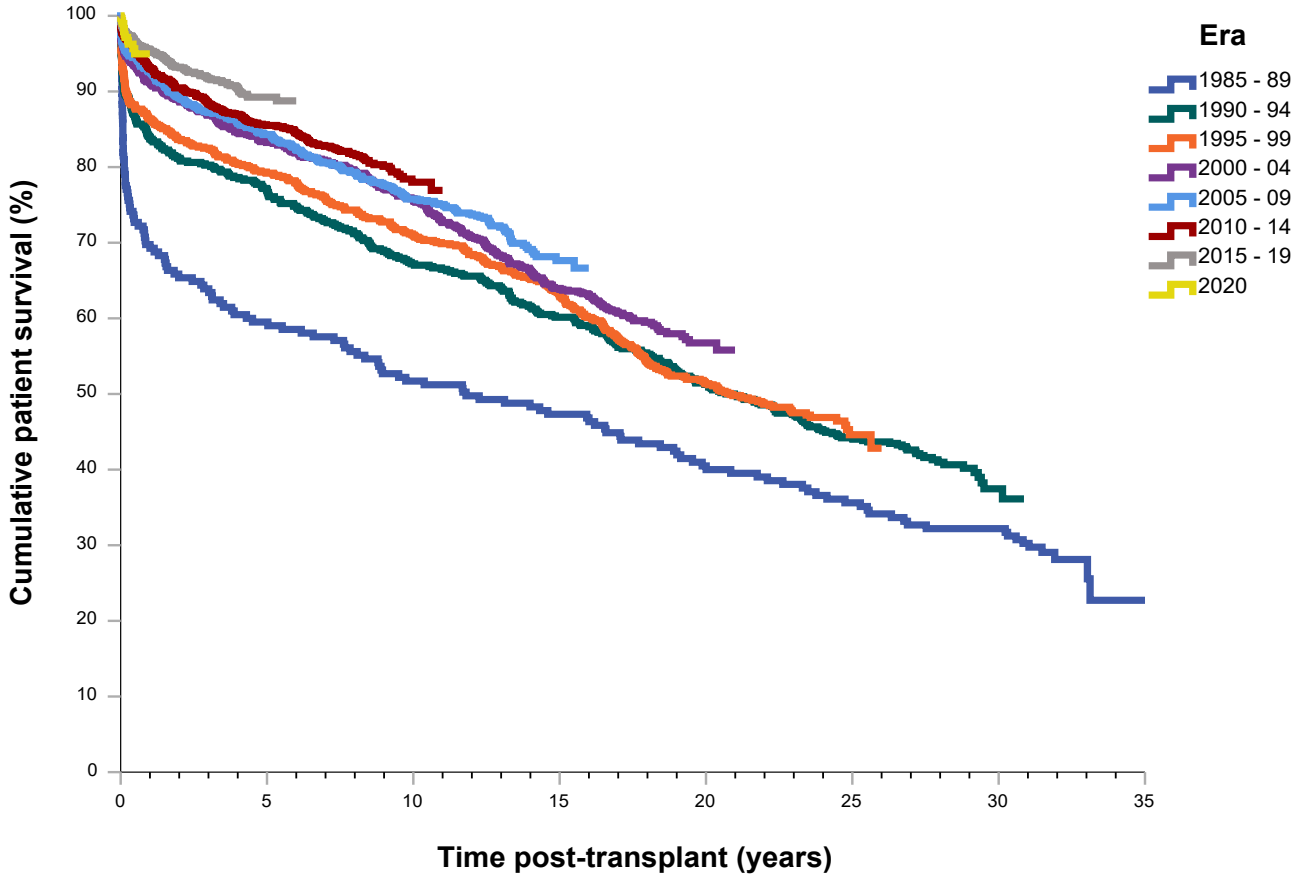


Table 14. Patient survival by transplant era

Transplant Era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
1985 - 89	No. at risk	205	143	131	122	106	97	83	66	1
	Survival (%)		70%	64%	60%	52%	47%	41%	32%	23%
1990 - 94	No. at risk	552	463	443	425	371	332	283	33	0
	Survival (%)		84%	80%	77%	67%	60%	51%	38%	
1995 - 99	No. at risk	697	602	575	552	495	439	358	0	
	Survival (%)		86%	83%	79%	71%	63%	51%		
2000 - 04	No. at risk	860	785	747	716	652	550	92	0	
	Survival (%)		91%	87%	83%	76%	64%	57%		
2005 - 09	No. at risk	962	891	839	811	729	116	0		
	Survival (%)		93%	87%	84%	76%	68%			
2010 - 14	No. at risk	1,228	1,143	1,085	1,050	178	0			
	Survival (%)		93%	88%	86%	78%				
2015 - 19	No. at risk	1,617	1,544	860	265	0				
	Survival (%)		96%	92%	89%					
2020	No. at risk	302	0							
	Survival (%)									

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 97.4% at 1 year, 96.5% at 3 years, 96.5% at 5 years and 90.9% 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

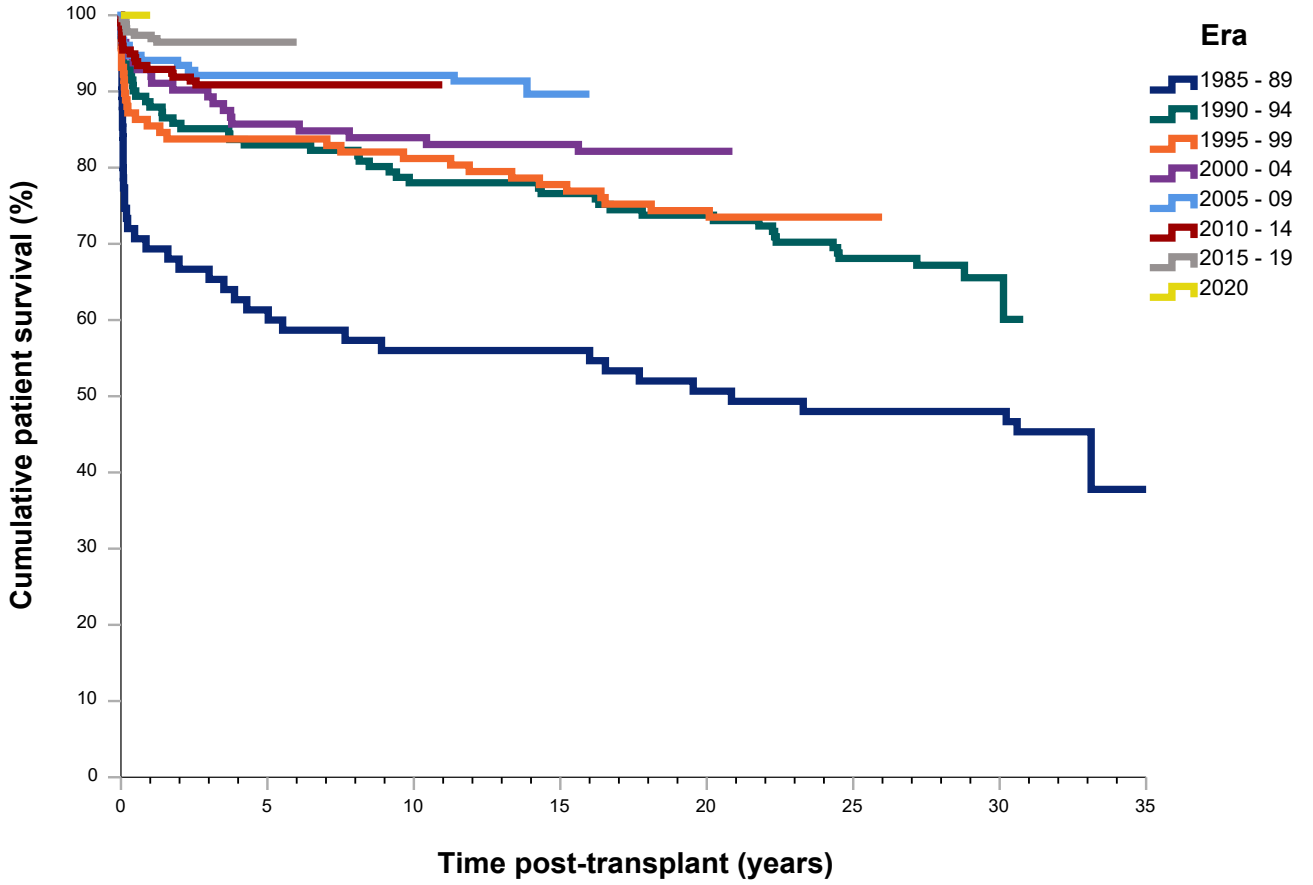


Table 15. Paediatric patient survival by transplant era

Transplant Era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
1985 - 89	No. at risk	75	52	50	46	42	42	38	36	1
	Survival (%)		69%	67%	61%	56%	56%	51%	48%	38%
1990 - 94	No. at risk	141	124	120	117	110	108	104	16	0
	Survival (%)		88%	85%	83%	78%	77%	74%	66%	
1995 - 99	No. at risk	117	100	98	98	95	91	87	0	
	Survival (%)		86%	84%	84%	81%	78%	74%		
2000 - 04	No. at risk	112	104	100	96	94	93	15	0	
	Survival (%)		93%	89%	86%	84%	83%	82%		
2005 - 09	No. at risk	152	143	140	140	140	29	0		
	Survival (%)		94%	92%	92%	92%	90%			
2010 - 14	No. at risk	197	183	179	179	37	0			
	Survival (%)		93%	91%	91%	91%				
2015 - 19	No. at risk	228	222	133	38	0				
	Survival (%)		97%	97%	97%					
2020	No. at risk	43	0							
	Survival (%)									

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 95.2% at 1 year, 91.0% at 3 years, 88.0% at 5 years and 75.5% at 10 years. Median adult patient survival was not reached for recent eras since 2000 and was 18.0 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

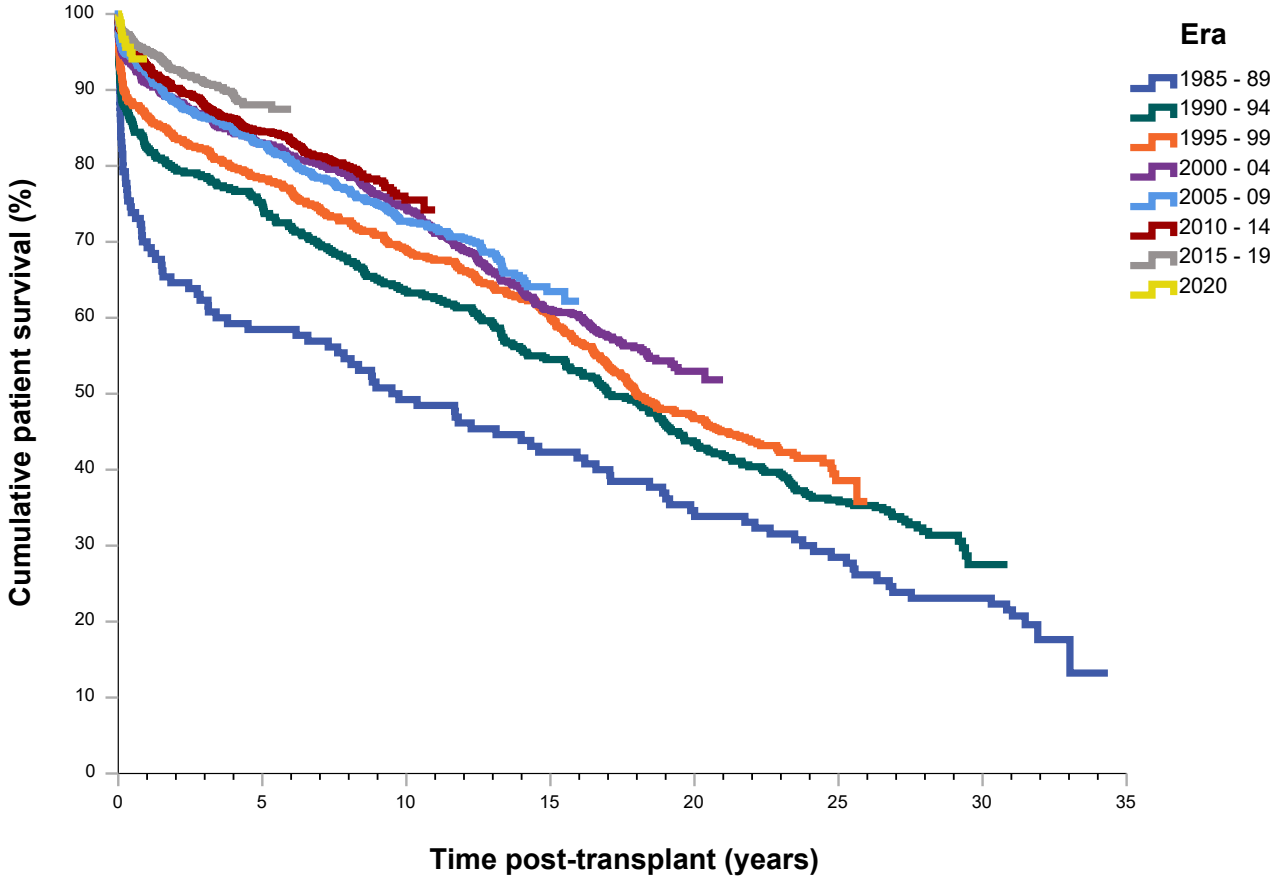


Table 16. Adult patient survival by transplant era

Transplant Era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
1985 - 89	No. at risk	130	91	81	76	64	55	45	30	0
	Survival (%)		70%	62%	59%	49%	42%	35%	23%	
1990 - 94	No. at risk	411	339	323	308	261	224	179	17	0
	Survival (%)		83%	79%	75%	64%	55%	44%	28%	
1995 - 99	No. at risk	580	502	477	454	400	348	271	0	
	Survival (%)		87%	82%	78%	69%	60%	47%		
2000 - 04	No. at risk	748	681	647	620	558	457	77	0	
	Survival (%)		91%	87%	83%	75%	61%	53%		
2005 - 09	No. at risk	810	748	699	671	589	87	0		
	Survival (%)		92%	86%	83%	73%	64%			
2010 - 14	No. at risk	1,031	960	906	871	141	0			
	Survival (%)		93%	88%	85%	76%				
2015 - 19	No. at risk	1,389	1,322	727	227	0				
	Survival (%)		95%	91%	88%					
2020	No. at risk	259	0							
	Survival (%)									

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 91.7% for split liver grafts, 89.7% for living donor grafts, 85.9% for whole liver grafts and 77.0% for reduced grafts. Median paediatric patient survival was not reached for graft types other than reduced grafts whose recipients had a median survival of 33.1 years.

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

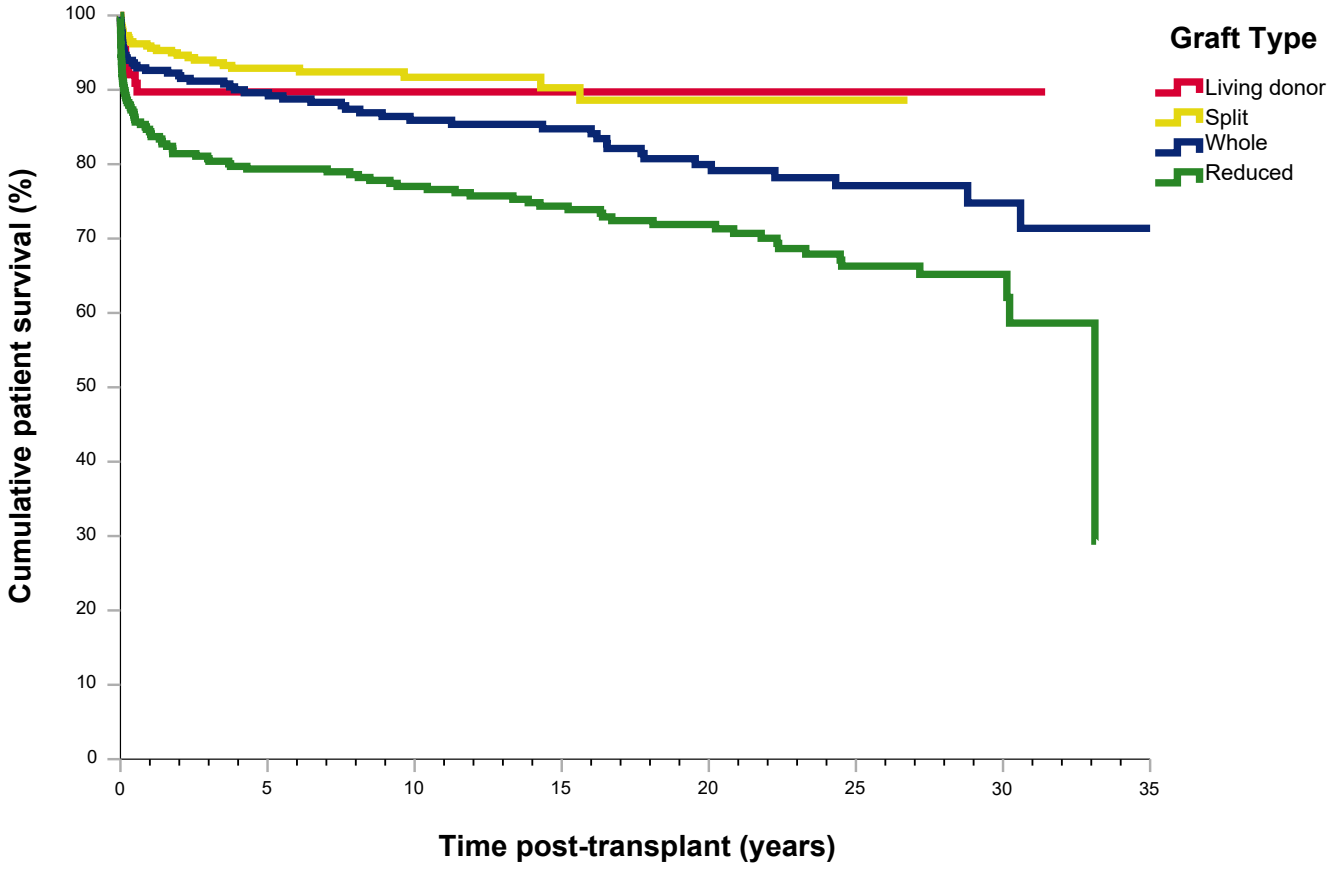


Table 17. Paediatric patient survival by type of primary graft

Graft Type Category	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
Living donor	No. at risk	88	76	70	65	41	10	3	1	0
	Survival (%)		90%	90%	90%	90%	90%	90%	90%	
Split	No. at risk	371	324	267	211	122	57	18	0	
	Survival (%)		96%	94%	93%	92%	90%	89%		
Whole	No. at risk	298	269	245	215	167	136	98	26	1
	Survival (%)		93%	91%	90%	86%	85%	80%	75%	71%
Reduced	No. at risk	307	258	237	222	187	159	125	25	0
	Survival (%)		84%	81%	79%	77%	75%	72%	65%	

11.9 Adult Patient Survival by Type of Primary Graft

There was no significant difference in patient survival in adults by type of primary graft, although there was a trend to worse survival after reduced liver transplantation (P = 0.240, Figure 34, Table 18). Ten-year patient survival was 79.0% for living donor grafts, 77.5% for split grafts, 72.8% for whole grafts, 52.1% for reduced grafts and 0 for domino grafts. Median adult patient survival was not reached for split and living donor grafts, and was 20.0 years for whole grafts, 10.9 years for reduced grafts and 9.4 years for domino grafts.

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

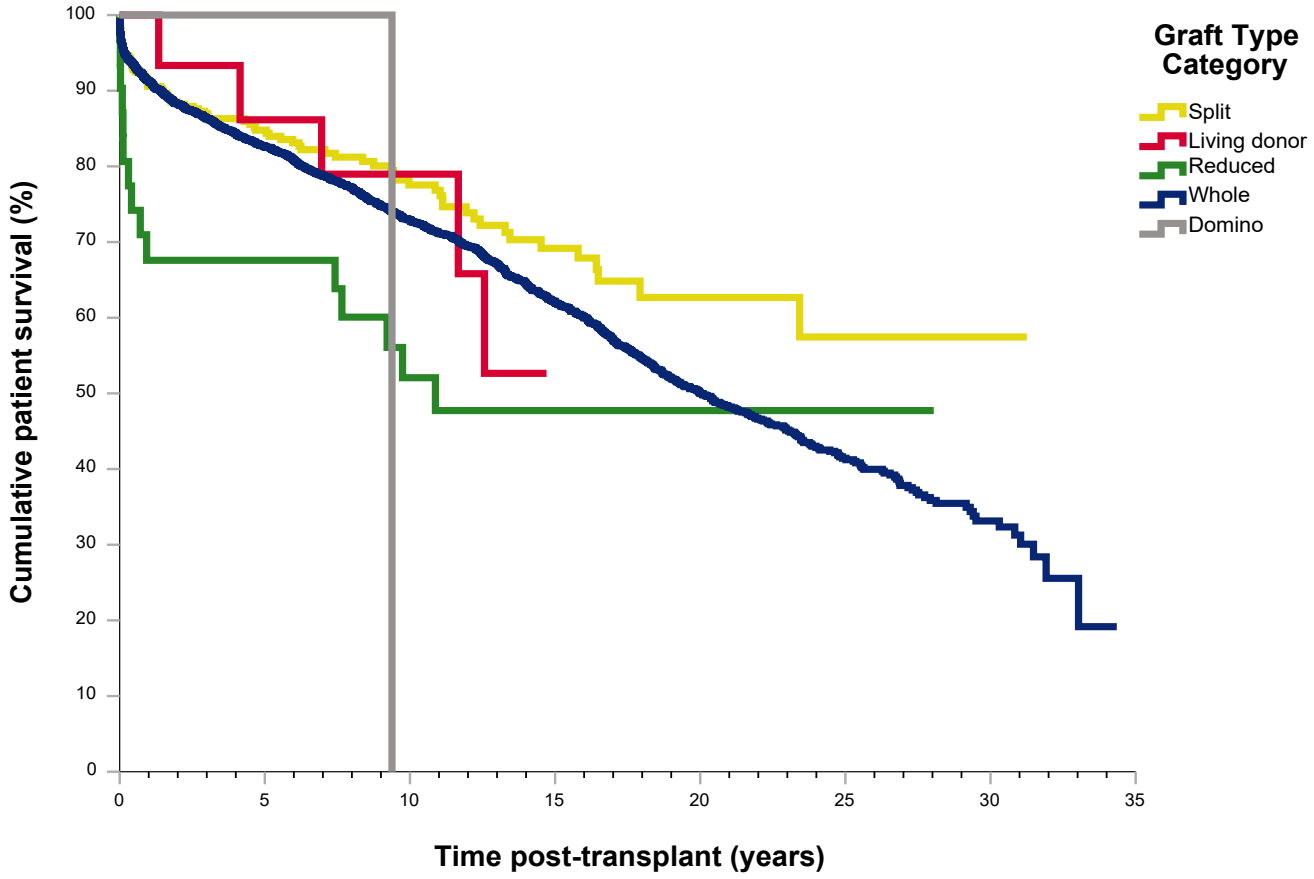


Table 18. Adult patient survival by type of primary graft

Graft Type Category	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
Living donor	No. at risk	16	16	14	12	8	0			
	Survival (%)		100%	93%	86%	79%				
Split	No. at risk	390	329	267	209	119	59	22	1	0
	Survival (%)		91%	87%	85%	78%	69%	63%	58%	
Reduced	No. at risk	31	20	20	19	13	10	8	0	
	Survival (%)		68%	68%	68%	52%	48%	48%		
Whole	No. at risk	4,917	4,274	3,555	2,984	1,873	1,102	542	46	0
	Survival (%)		91%	86%	83%	73%	62%	50%	33%	
Domino	No. at risk	4	4	4	3	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 = 0.453, Figure 35 and Table 19). Ten-year paediatric patient survival was 89.3% for children over 20 kg, 84.9% for children weighing between 8.01 and 20 kg, 82.2% for children between 5 and 8 kg and 80.0% for children under 5 kg. Median paediatric patient survival was not reached for weight categories other than children weighing between 5 and 8 kg who had a median survival of 33.1 years.

Figure 35. Paediatric patient survival curve by transplant weight

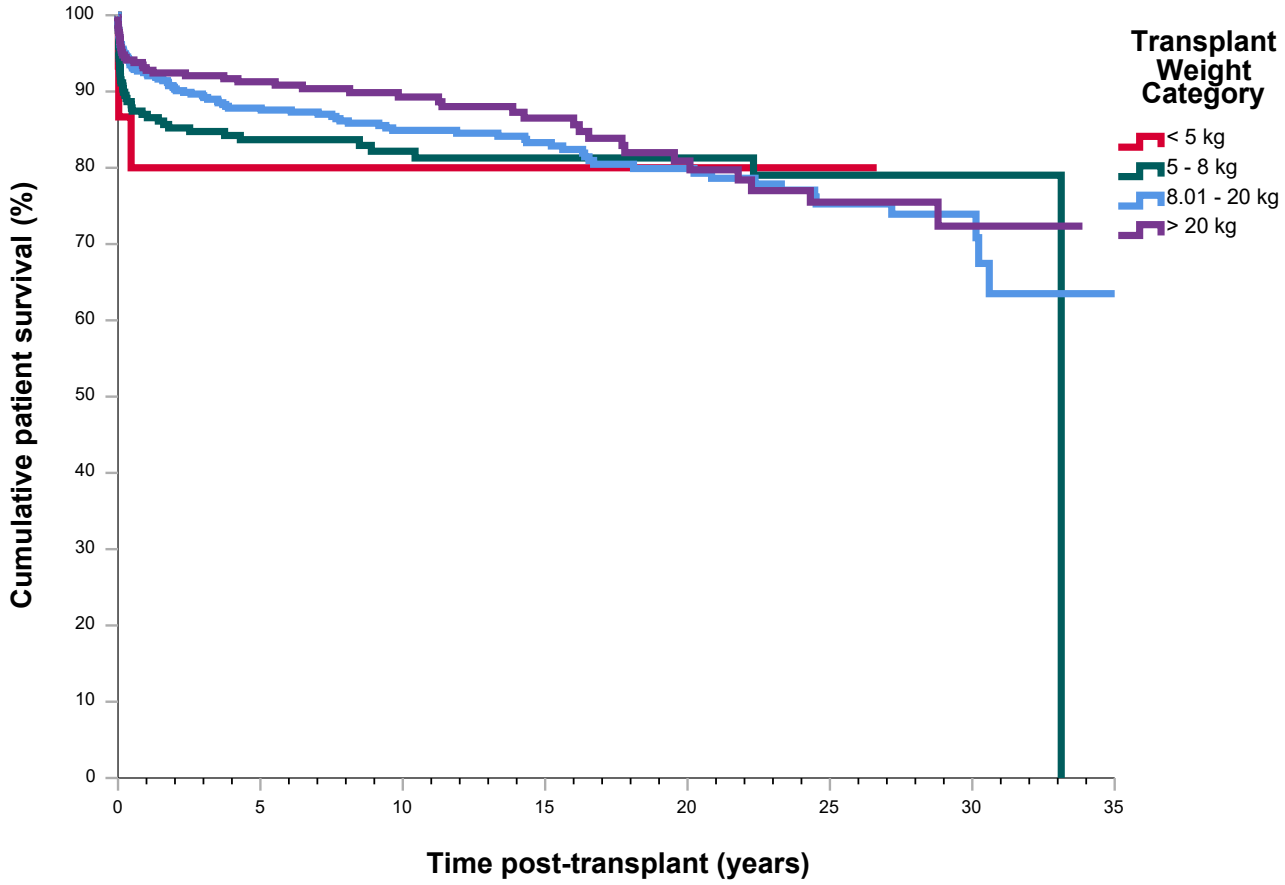


Table 19. Paediatric patient survival by transplant weight

Transplant weight	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
< 5 kg	No. at risk	15	12	7	7	5	3	2	0	
	Survival (%)		80%	80%	80%	80%	80%	80%		
5 - 8 kg	No. at risk	248	200	171	144	95	58	43	13	0
	Survival (%)		87%	85%	84%	82%	81%	81%	79%	
8.01 - 20 kg	No. at risk	495	444	396	349	262	192	129	24	1
	Survival (%)		93%	89%	88%	85%	83%	80%	74%	64%
> 20 kg	No. at risk	307	272	246	214	156	109	70	15	0
	Survival (%)		93%	92%	91%	89%	87%	81%	72%	

11.11 Paediatric Patient Survival by Primary Disease

There was a trend to difference in patient survival between different disease categories in children (P = 0.092, Figure 36, Table 20). Children with fulminant hepatic failure had the poorest ten-year survival of 76.5%. Children with hepatoblastoma had a ten-year survival of 79.3%. All other paediatric disease categories had an 85% or higher 10-year survival. Median patient survival was 33.1 years for children with biliary atresia, 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

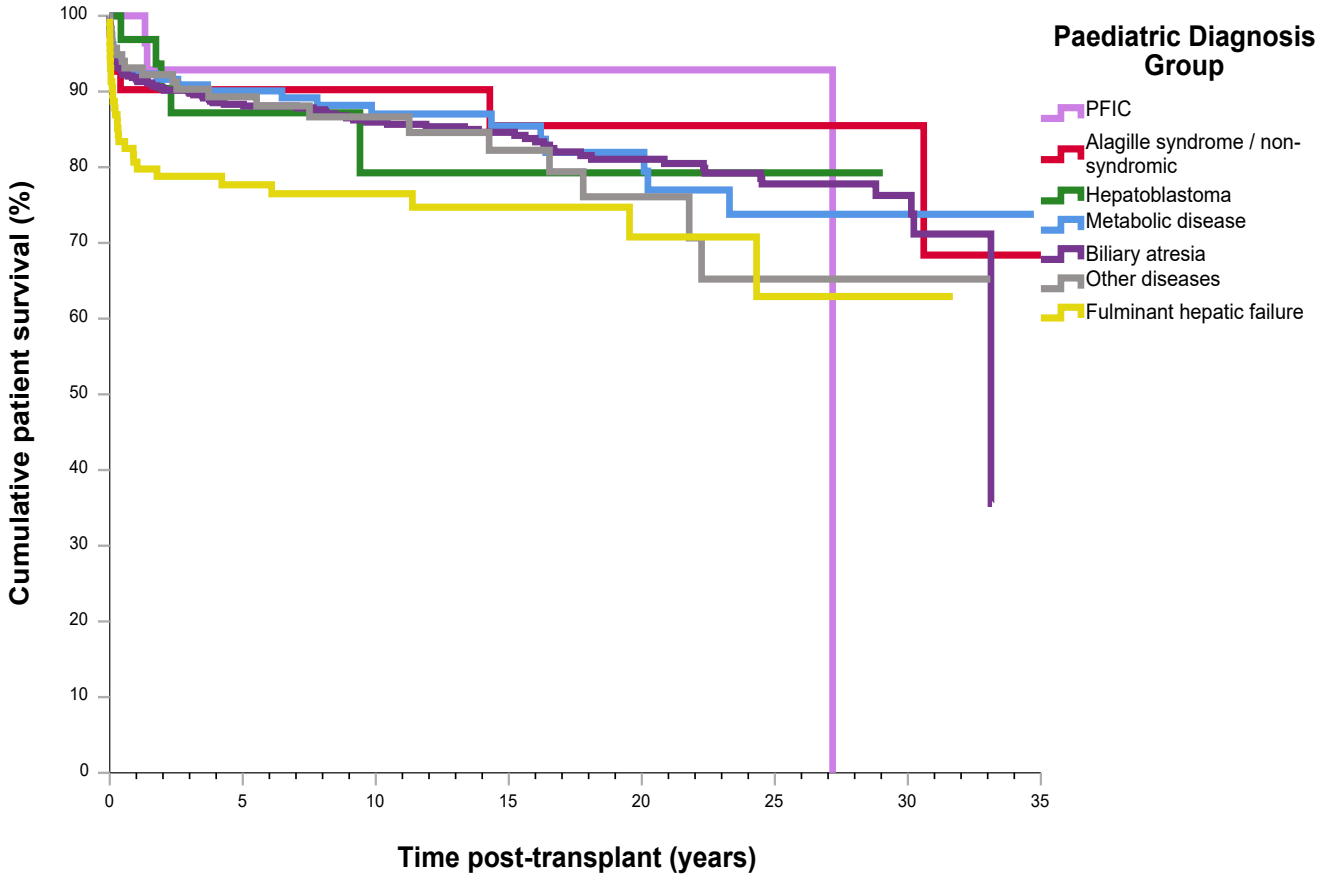


Table 20. Paediatric patient survival by primary disease

Primary Diagnosis	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
PFIC	No. at risk	33	28	22	20	16	12	5	0	
	Survival (%)		100%	93%	93%	93%	93%	93%		
Alagille syndrome / non-syndromic	No. at risk	41	37	34	29	21	17	17	6	1
	Survival (%)		90%	90%	90%	90%	86%	86%	86%	68%
Hepatoblastoma	No. at risk	33	31	27	20	10	2	2	0	
	Survival (%)		97%	87%	87%	79%	79%	79%		
Metabolic Diseases	No. at risk	158	138	121	106	75	52	33	7	0
	Survival (%)		92%	91%	90%	87%	85%	82%	74%	
Biliary atresia	No. at risk	568	501	447	390	301	210	152	34	0
	Survival (%)		92%	90%	88%	86%	85%	81%	76%	
Other Diseases	No. at risk	117	104	94	82	46	35	17	3	
	Survival (%)		93%	90%	89%	87%	82%	76%	65%	
Fulminant hepatic failure	No. at risk	115	89	75	67	49	35	18	2	0
	Survival (%)		81%	79%	78%	77%	75%	71%	63%	

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 = 0.018, Figure 37, Table 21). Patients with hepatocellular carcinoma, hepatitis C virus cirrhosis and non-alcoholic fatty liver disease (NAFLD) / cryptogenic cirrhosis had the poorest 10-year patient survival (67.9%, 70.0% and 71.9%, respectively), while those with alcoholic cirrhosis, hepatitis C virus cirrhosis and NAFLD / cryptogenic cirrhosis had the poorest median survival (17.7 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%), but long-term survival was similar to patients transplanted for other diagnoses.

Figure 37. Adult patient survival curve by primary disease

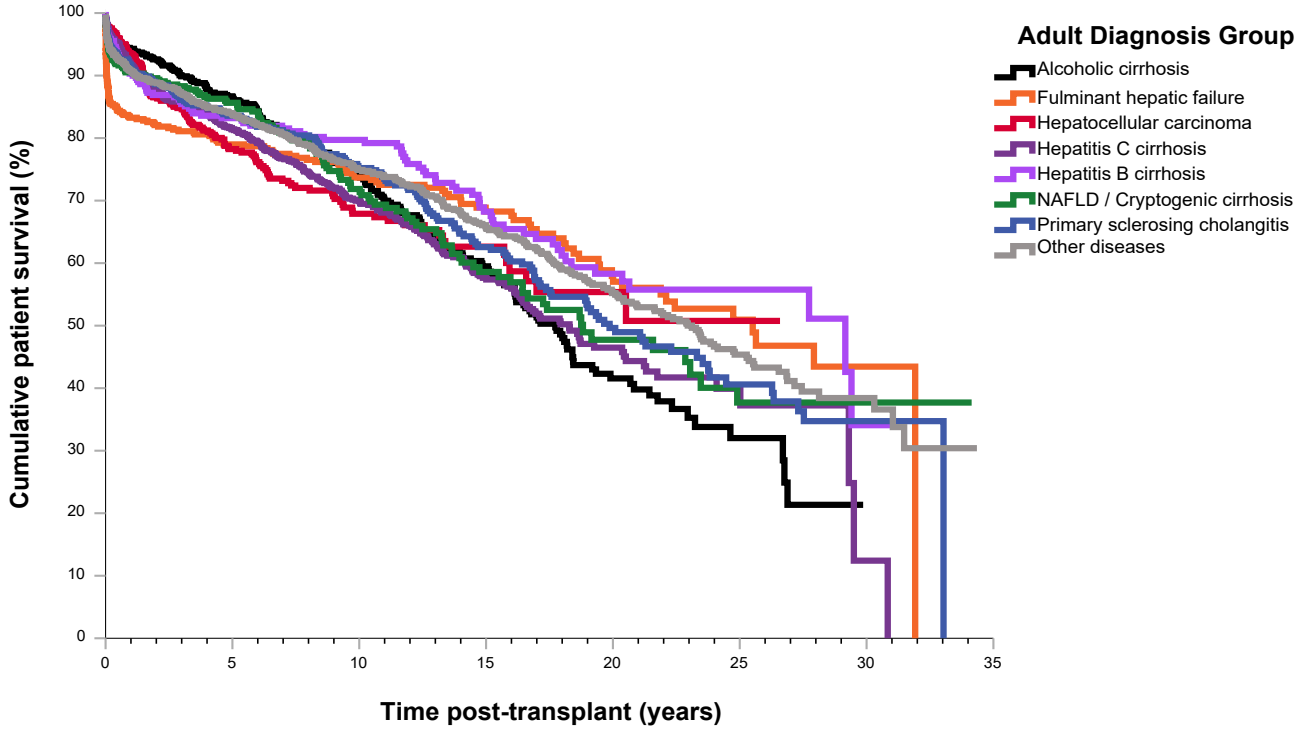


Table 21. Adult patient survival by primary disease

Primary Diagnosis	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
Alcoholic cirrhosis	No. at risk	731	636	512	420	249	139	56	0	
	Survival (%)		94%	90%	87%	74%	60%	42%		
Fulminant hepatic failure	No. at risk	468	372	324	285	198	110	63	7	0
	Survival (%)		83%	81%	79%	74%	68%	58%	43%	
Hepatocellular carcinoma	No. at risk	653	573	421	295	135	53	12	0	
	Survival (%)		94%	85%	78%	68%	63%	55%		
Hepatitis B virus cirrhosis	No. at risk	315	269	233	212	157	100	53	3	0
	Survival (%)		90%	85%	83%	80%	68%	58%	34%	
Hepatitis C virus cirrhosis	No. at risk	1,114	1,002	866	745	420	215	71	1	0
	Survival (%)		92%	86%	81%	70%	58%	47%	12%	
NAFLD / Cryptogenic cirrhosis	No. at risk	481	402	326	254	145	76	37	3	0
	Survival (%)		91%	88%	86%	72%	59%	48%	38%	
Primary sclerosing cholangitis	No. at risk	542	471	401	342	232	142	74	10	0
	Survival (%)		91%	86%	84%	75%	63%	50%	35%	
Other diseases	No. at risk	1,054	918	777	674	477	336	206	23	0
	Survival (%)		91%	87%	84%	75%	66%	55%	38%	

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 (FHF) as a primary diagnosis or other diagnosis (P = 0.246, Figure 38 and Table 22). Ten-year patient survival was 76.9% for children and 73.8% for adults. Median patient survival was not reached for children and was 25.5 years for adults.

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

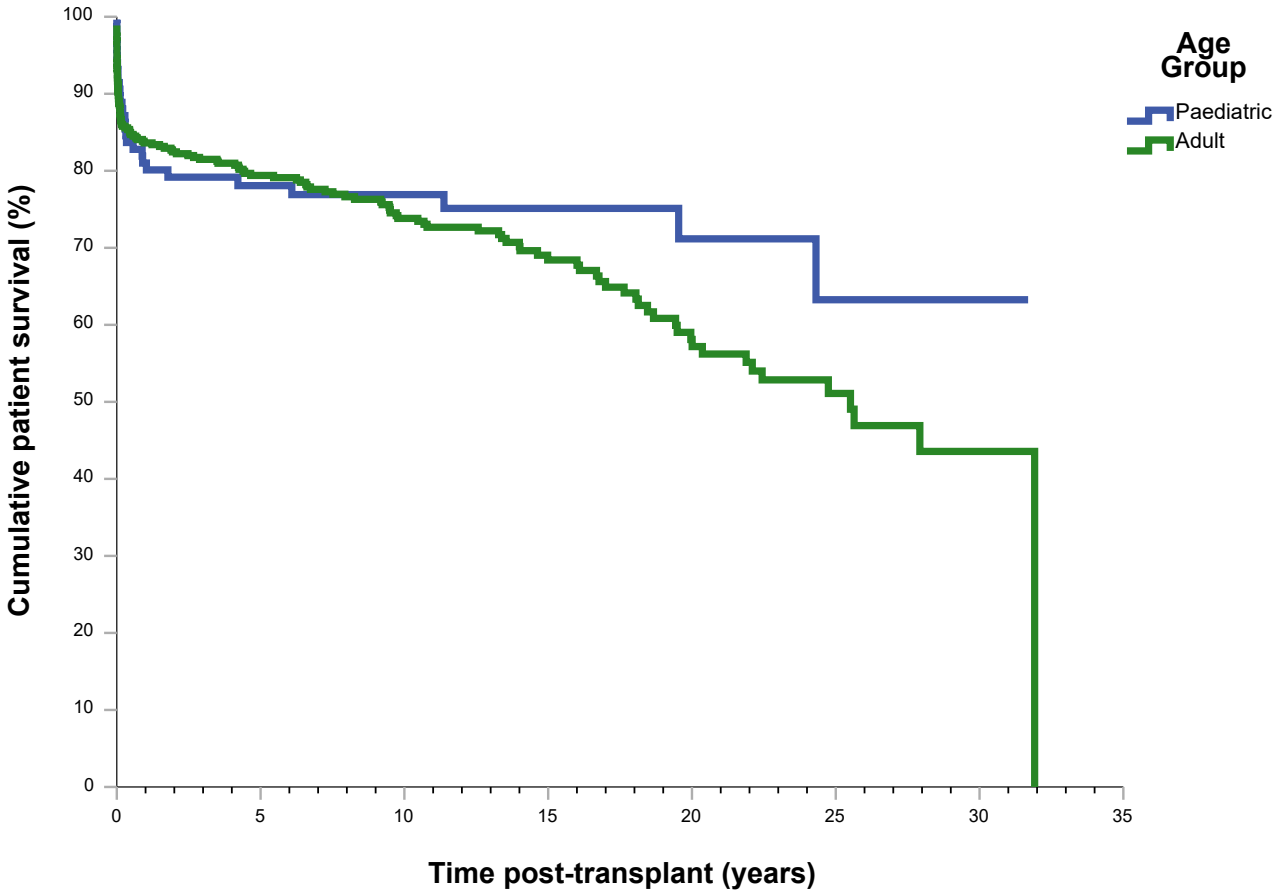


Table 22. Patient survival by age group with fulminant hepatic failure – all diagnoses

Primary Diagnosis	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
Paediatric FHF	No. at risk	117	91	77	68	49	35	18	2	0
	Survival (%)		81%	79%	78%	77%	75%	71%	63%	
Adult FHF	No. at risk	479	378	329	288	200	111	63	7	0
	Survival (%)		84%	82%	79%	74%	68%	58%	44%	

11.14 Adult 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 100% at 1 year, 91.6% at 3 years, 88.0% at 5 years and 83.1% at 10 years. Median adult 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. Adult patient survival curve by transplant era with hepatitis B virus cirrhosis – all diagnoses

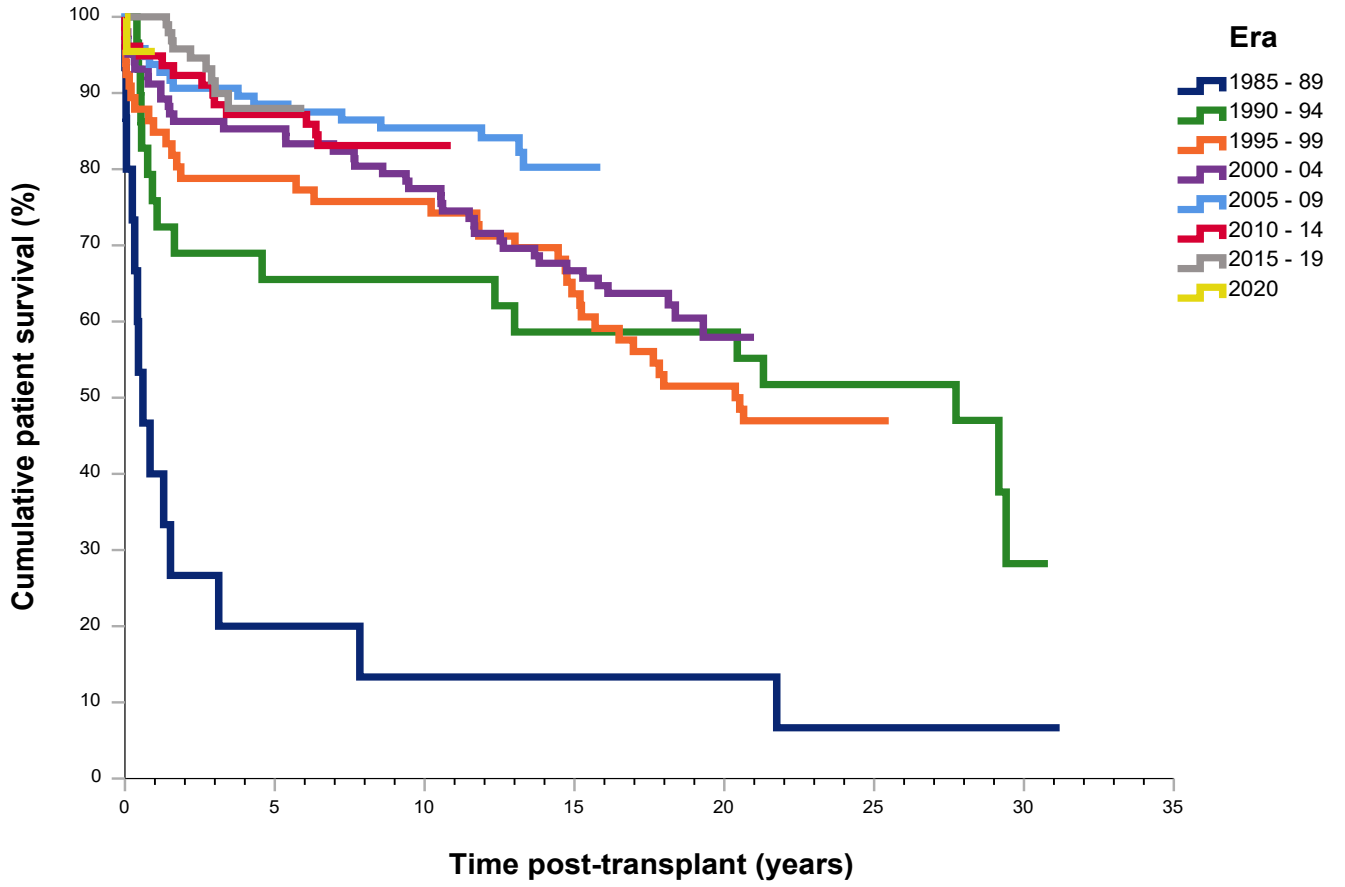


Table 23. Patient survival by transplant era with hepatitis B virus cirrhosis – all diagnoses

Transplant era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
1985 - 89	No. at risk	15	6	4	3	2	2	2	1	0
	Survival (%)		40%	27%	20%	13%	13%	13%	1%	
1990 - 94	No. at risk	29	22	20	19	19	17	17	2	0
	Survival (%)		76%	69%	66%	66%	59%	59%	28%	
1995 - 99	No. at risk	66	56	52	52	50	42	34	0	
	Survival (%)		85%	79%	79%	76%	64%	52%		
2000 - 04	No. at risk	102	93	88	87	79	68	14	0	
	Survival (%)		91%	86%	85%	78%	67%	58%		
2005 - 09	No. at risk	96	90	87	85	82	16	0		
	Survival (%)		94%	91%	89%	85%	80%			
2010 - 14	No. at risk	78	74	69	68	12	0			
	Survival (%)		95%	89%	87%	83%				
2015 - 19	No. at risk	109	109	56	23	0				
	Survival (%)		100%	92%	88%					
2020	No. at risk	23	0							
	Survival (%)									

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 (85.9%) in 2015 - 19 (P = 0.004, Figure 40 and Table 24). Median patient survival was not reached for the recent eras since 2005 and was 20.4 years for 2000 - 04, 17.1 years for 1985 – 89, 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

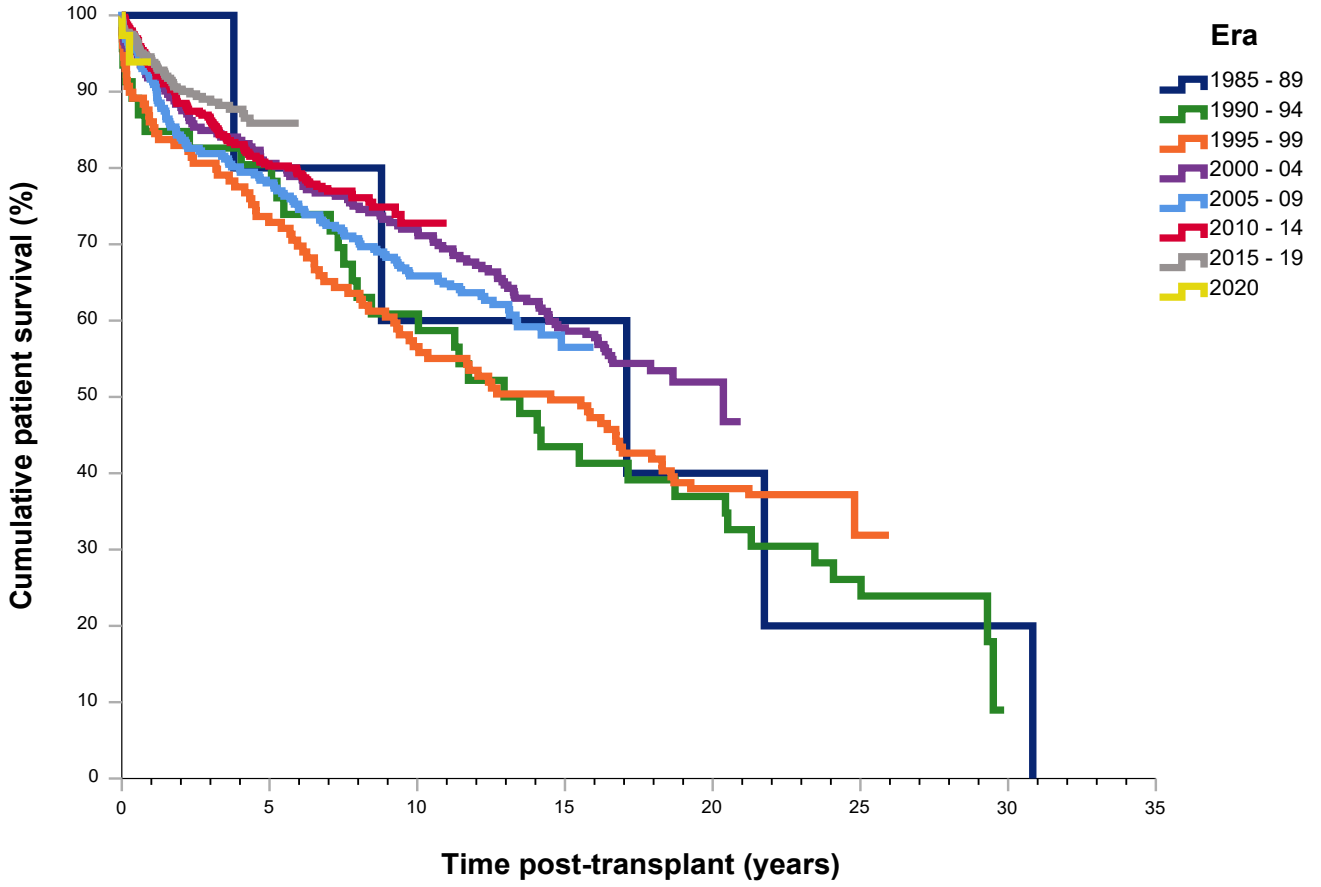


Table 24. Patient survival curve by transplant era with hepatitis C virus cirrhosis – all diagnoses

Transplant era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
1985 - 89	No. at risk	5	5	5	4	3	3	2	1	0
	Survival (%)		100%	100%	80%	60%	60%	40%	20%	
1990 - 94	No. at risk	46	39	38	37	28	20	17	0	
	Survival (%)		85%	83%	80%	61%	44%	37%		
1995 - 99	No. at risk	129	111	104	94	73	64	49	0	
	Survival (%)		86%	81%	73%	57%	50%	38%		
2000 - 04	No. at risk	232	213	197	187	167	137	15	0	
	Survival (%)		92%	85%	81%	72%	59%	52%		
2005 - 09	No. at risk	287	263	235	224	189	30	0		
	Survival (%)		92%	82%	78%	66%	57%			
2010 - 14	No. at risk	390	364	336	313	41	0			
	Survival (%)		93%	86%	80%	73%				
2015 - 19	No. at risk	405	382	227	74	0				
	Survival (%)		94%	89%	86%					
2020	No. at risk	38	0							
	Survival (%)									

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). Median patient survival was not reached for the recent eras since 2000 and was 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

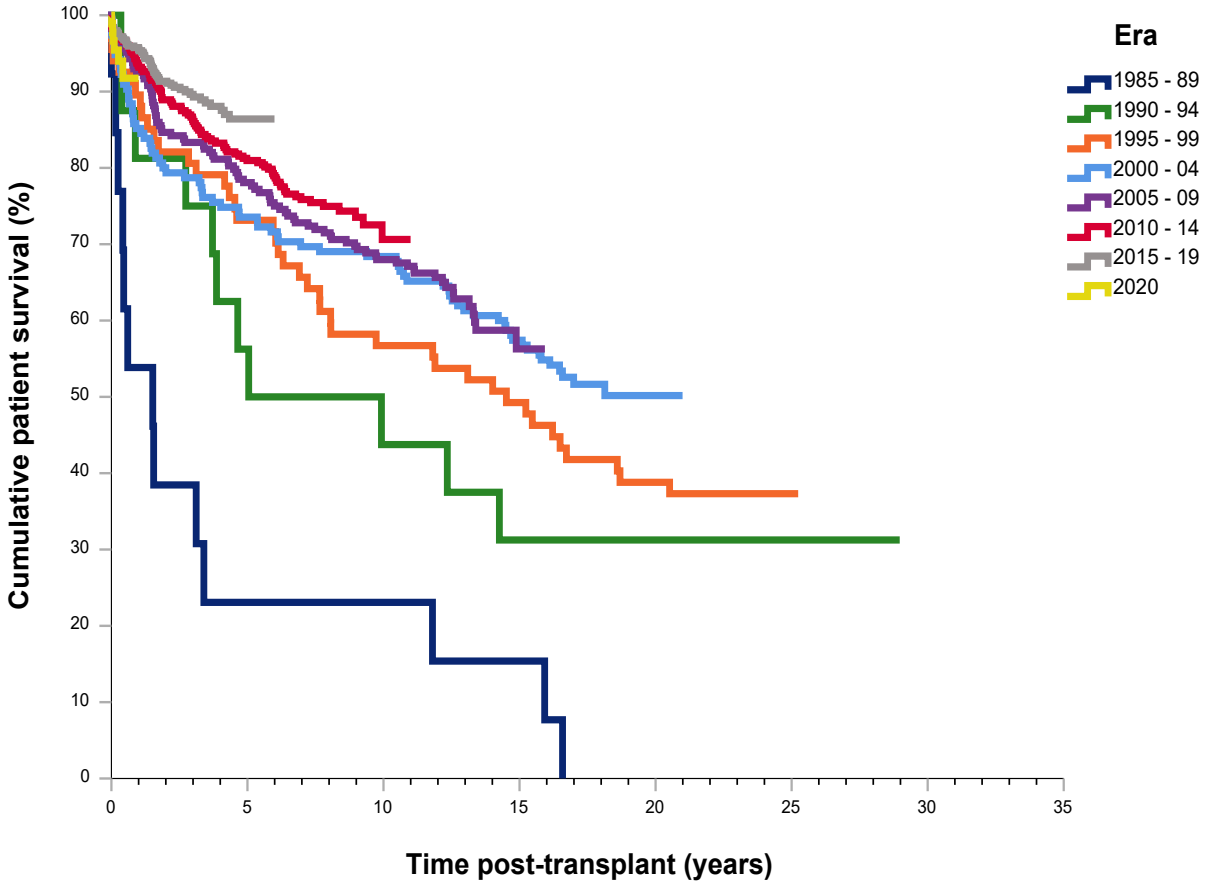


Table 25. Patient survival curve with a diagnosis of hepatocellular carcinoma by transplant era – all diagnoses

Transplant era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
1985 - 89	No. at risk	13	7	5	3	3	2	0		
	Survival (%)		54%	39%	23%	23%	15%			
1990 - 94	No. at risk	16	13	12	9	7	5	5	0	
	Survival (%)		81%	75%	56%	44%	31%	31%		
1995 - 99	No. at risk	67	60	54	49	38	33	26	0	
	Survival (%)		90%	81%	73%	57%	49%	39%		
2000 - 04	No. at risk	155	132	122	114	106	89	8	0	
	Survival (%)		85%	79%	74%	68%	57%	50%		
2005 - 09	No. at risk	228	211	190	178	155	20	0		
	Survival (%)		93%	83%	78%	68%	56%			
2010 - 14	No. at risk	352	329	303	285	36	0			
	Survival (%)		94%	86%	81%	71%				
2015 - 19	No. at risk	495	474	263	82	0				
	Survival (%)		96%	90%	86%					
2020	No. at risk	91	0							
	Survival (%)									

11.17 Paediatric Patient Survival with Diagnosis of Malignancy – All Diagnoses

There was a trend to improved survival of children with cholangiocarcinoma or histiocytosis X in comparison to those with hepatoblastoma or hepatocellular carcinoma. Hepatoblastoma had a better survival than those transplanted with hepatocellular carcinoma (P = 0.053, Figure 42 and Table 26). Ten-year paediatric patient survival was 100% for cholangiocarcinoma and histiocytosis X, 80.3% for hepatoblastoma and 64.3% 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

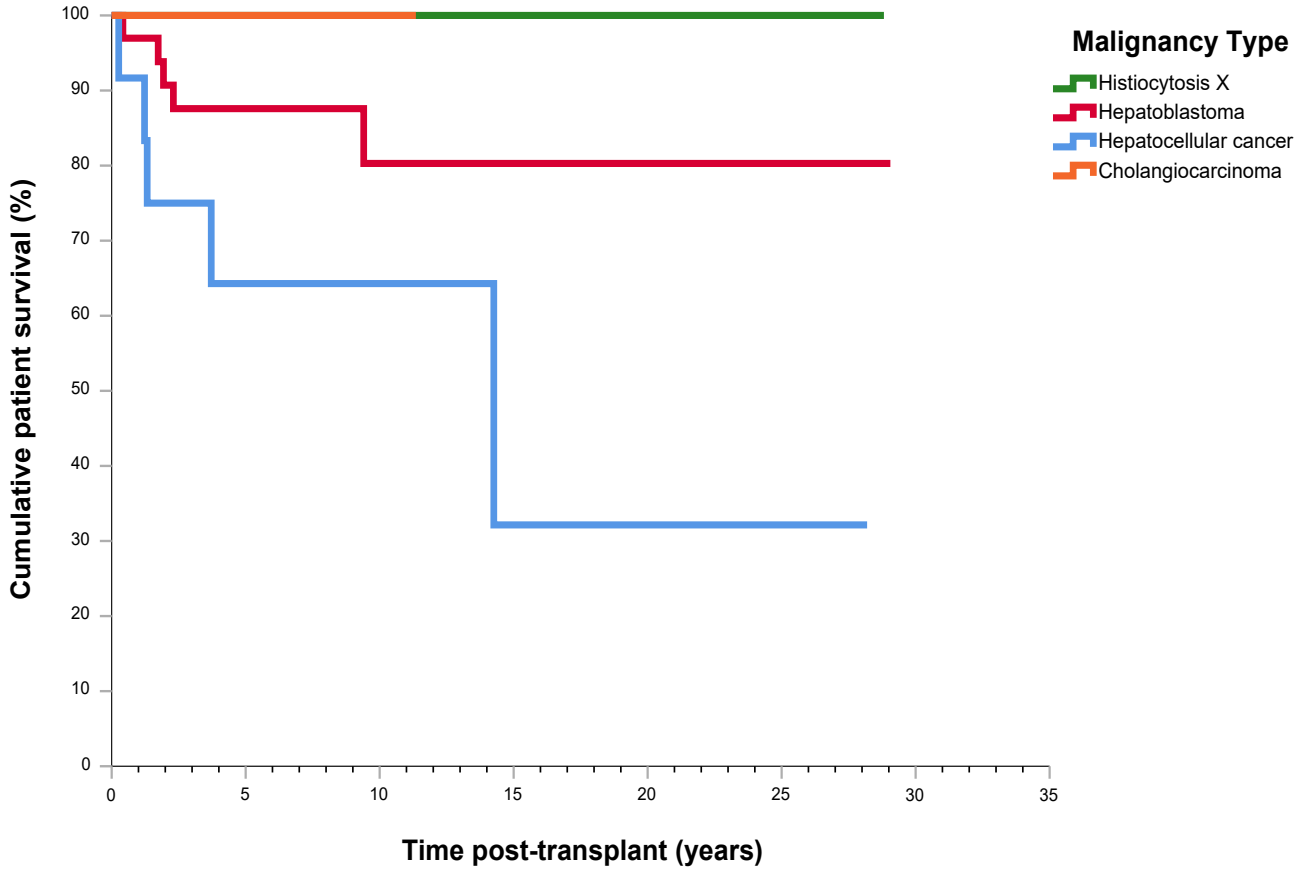


Table 26. Paediatric patient survival with malignancy diagnosis – all diagnoses

Primary Diagnosis	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
Cholangiocarcinoma	No. at risk	3	3	3	2	1	0			
	Survival (%)		100%	100%	100%	100%				
Histiocytosis X	No. at risk	6	6	6	6	4	4	2	0	
	Survival (%)		100%	100%	100%	100%	100%	100%		
Hepatoblastoma	No. at risk	34	32	28	21	11	3	3	0	
	Survival (%)		97%	88%	88%	80%	80%	80%		
Hepatocellular carcinoma	No. at risk	12	11	7	5	2	1	1	0	
	Survival (%)		92%	75%	64%	64%	32%	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), 72.9% for epithelioid haemangio-endothelioma, 70.1% for hepatocellular carcinoma, 29.2% for cholangiocarcinoma and 0 for metastatic neuroendocrine tumours and angiosarcoma. Median adult patient survival was 18.7 years for hepatocellular carcinoma, 16.7 years for hepatoblastoma, 14.2 years for epithelioid haemangio-endothelioma, 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

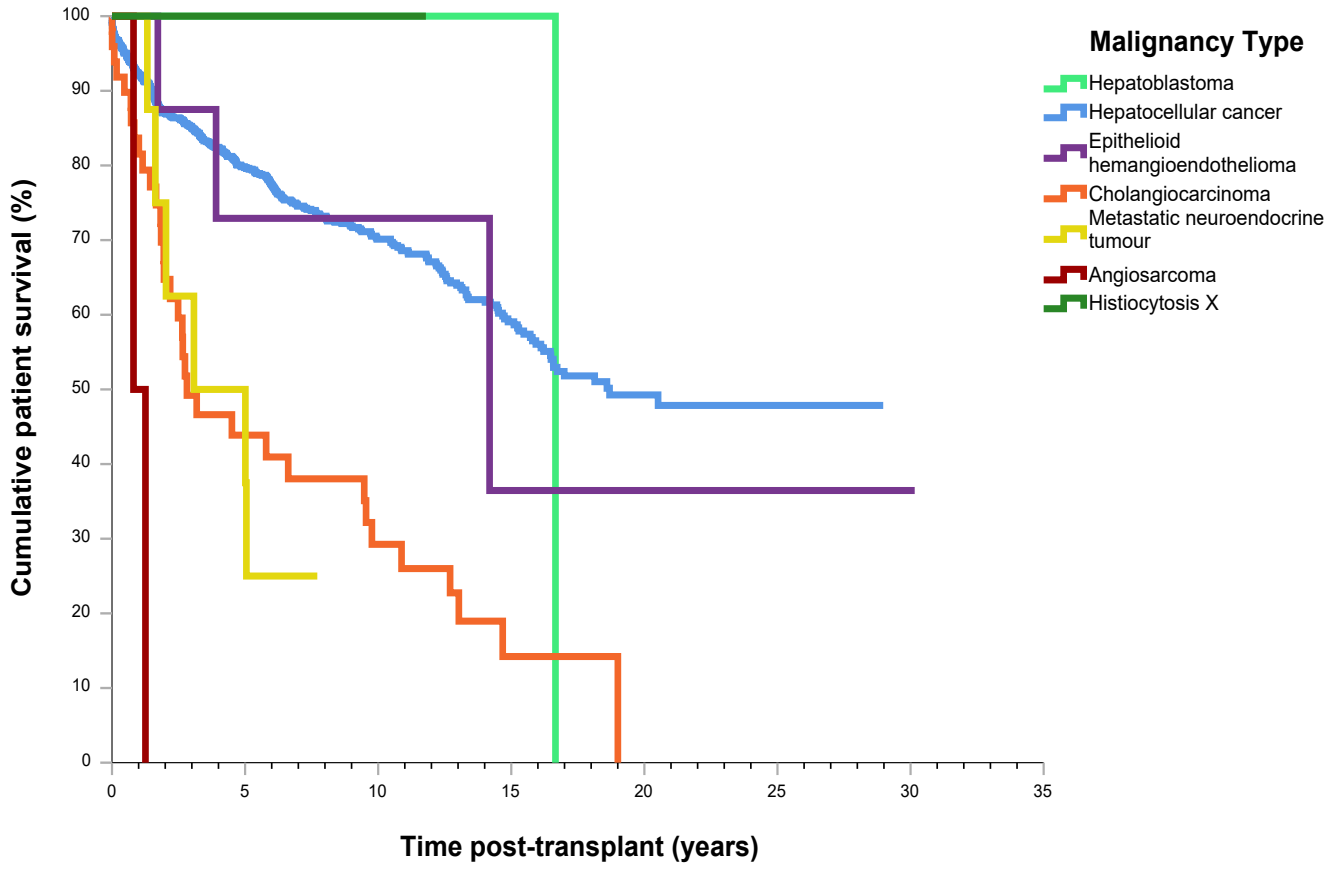


Table 27. Adult patient survival curve with a malignancy diagnosis - all diagnosis

Primary Diagnosis	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
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	1	0		
	Survival (%)		100%	100%	100%	100%	100%			
Hepatocellular carcinoma	No. at risk	1,405	1,215	942	715	343	148	38	0	
	Survival (%)		92%	85%	80%	70%	59%	49%		
Epithelioid haemangio-endothelioma	No. at risk	11	9	6	4	3	1	1	1	0
	Survival (%)		100%	88%	73%	73%	37%	37%	37%	
Cholangiocarcinoma	No. at risk	49	39	19	16	10	3	0		
	Survival (%)		84%	49%	44%	29%	14%			
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 6,959 grafts in 6,428 patients (Figure 44 and Table 28). Ten-year graft survival was 69.3% across all grafts. The median graft survival was 20.0 years.

Figure 44. Graft survival curve for all grafts

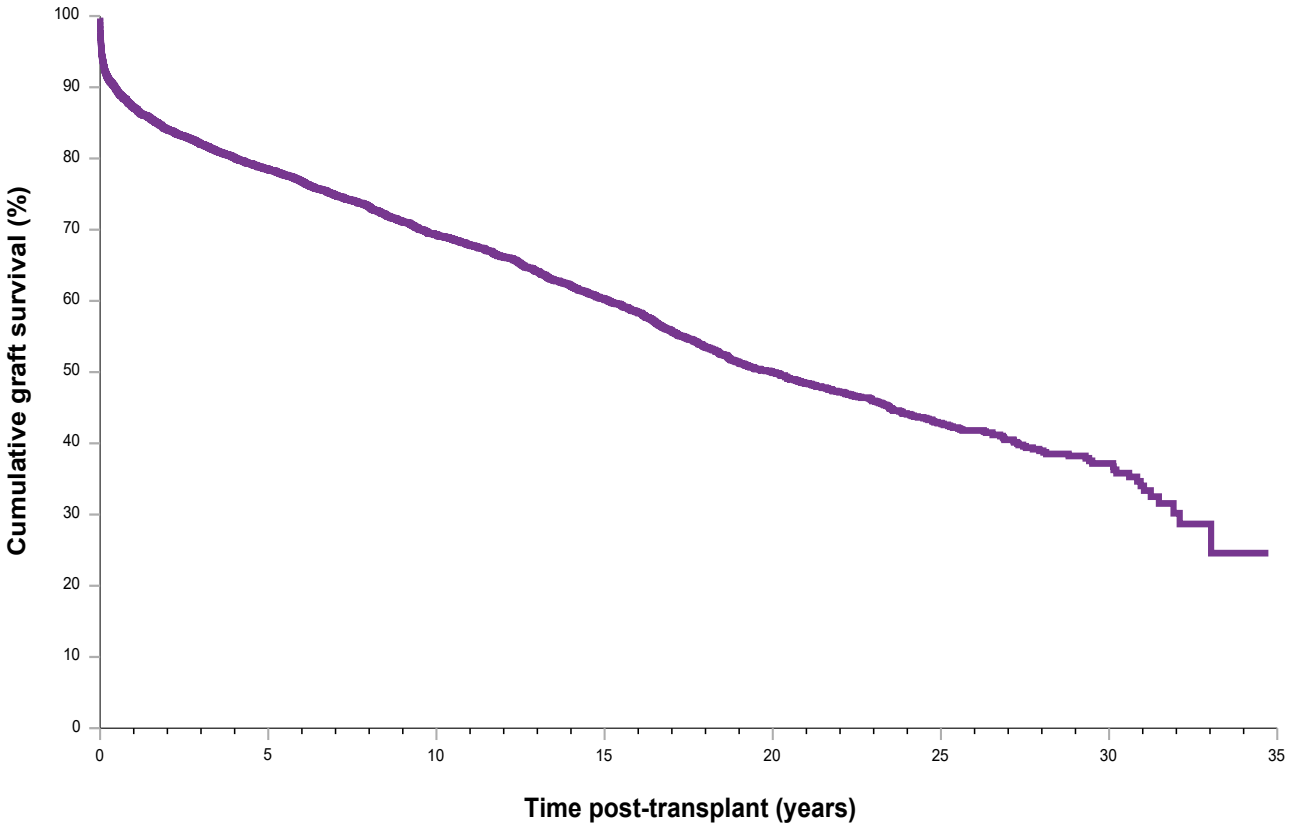


Table 28. Graft survival - all grafts

Graft Survival	Time post-transplant (years)								
	0	1	3	5	10	15	20	30	35
No. at risk	6,959	5,772	4,777	3,992	2,497	1,491	774	88	0
Survival (%)		87%	82%	79%	69%	60%	50%	37%	

12.2 Outcome of All Grafts by Age Group

A total of 1,212 transplants were performed in children and 5,747 in adults. Post-transplant graft survival was superior in the paediatric population (P < 0.001, Figure 45, Table 29). Ten-year graft survival was 73.2% for children and 68.4% for adults. Median graft survival was 30.9 years in children and 18.2 years in adults. Although 1-year survival was slightly worse in children (84.9% vs 87.7%), 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

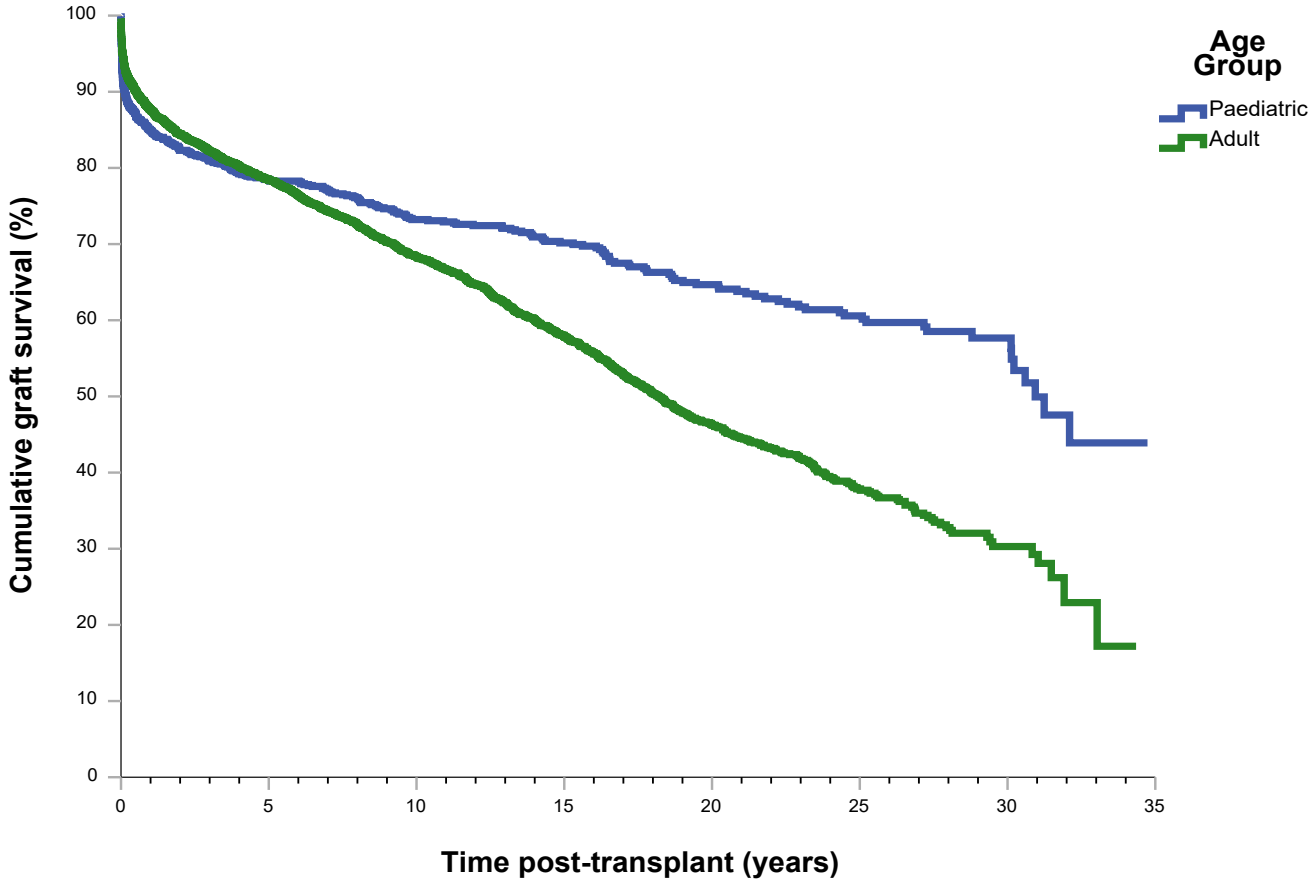


Table 29. Graft survival by age group - all grafts

Age Group	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
Paediatric <16 years	No. at risk	1,212	985	845	720	504	343	223	45	0
	Survival (%)		85%	81%	79%	73%	70%	65%	58%	
Adult ≥16 years	No. at risk	5,747	4,787	3,932	3,272	1,993	1,148	551	43	0
	Survival (%)		88%	82%	78%	68%	58%	46%	30%	

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 70.3% for the first graft, 56.2% for the second graft, 61.1% for the third graft and not reached for the fourth graft. Median graft survival was 20.4 years for the first graft, 12.9 years for the second graft, 12.4 years for the third graft and not reached for the fourth graft.

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

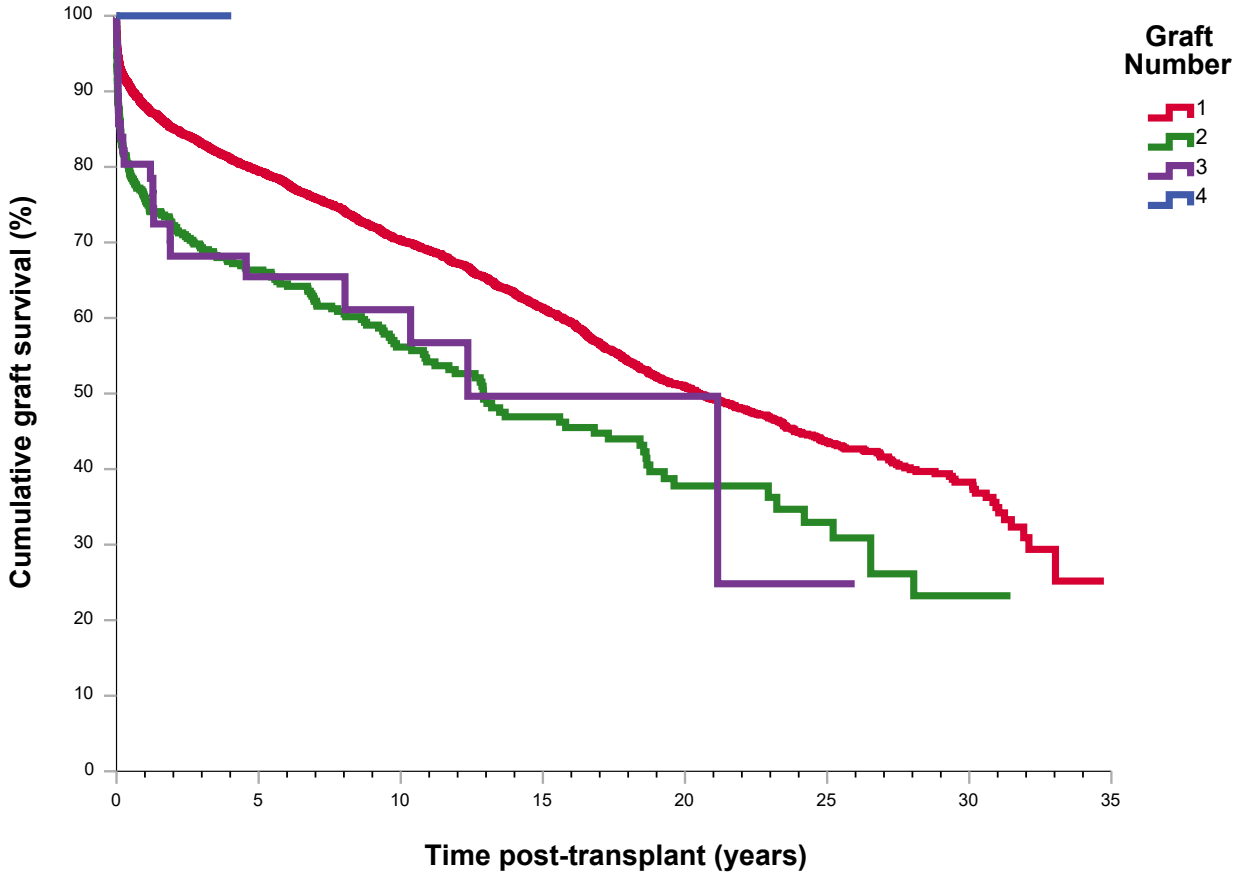


Table 30. Graft survival - all grafts

Graft Number	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
1	No. at risk	6,423	5,385	4,475	3,747	2,358	1,418	734	85	0
	Survival (%)		88%	83%	80%	70%	61%	51%	38%	
2	No. at risk	478	342	274	223	125	68	38	3	0
	Survival (%)		76%	69%	66%	56%	47%	38%	23%	
3	No. at risk	56	43	26	22	14	5	2	0	
	Survival (%)		80%	68%	66%	61%	50%	50%		
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 76.1% for the first graft, 50.8% for the second graft and 60.6% for the third graft. Median graft survival was 31.2 years for the first graft, 10.4 years for the second graft and 21.1 years for the third graft.

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

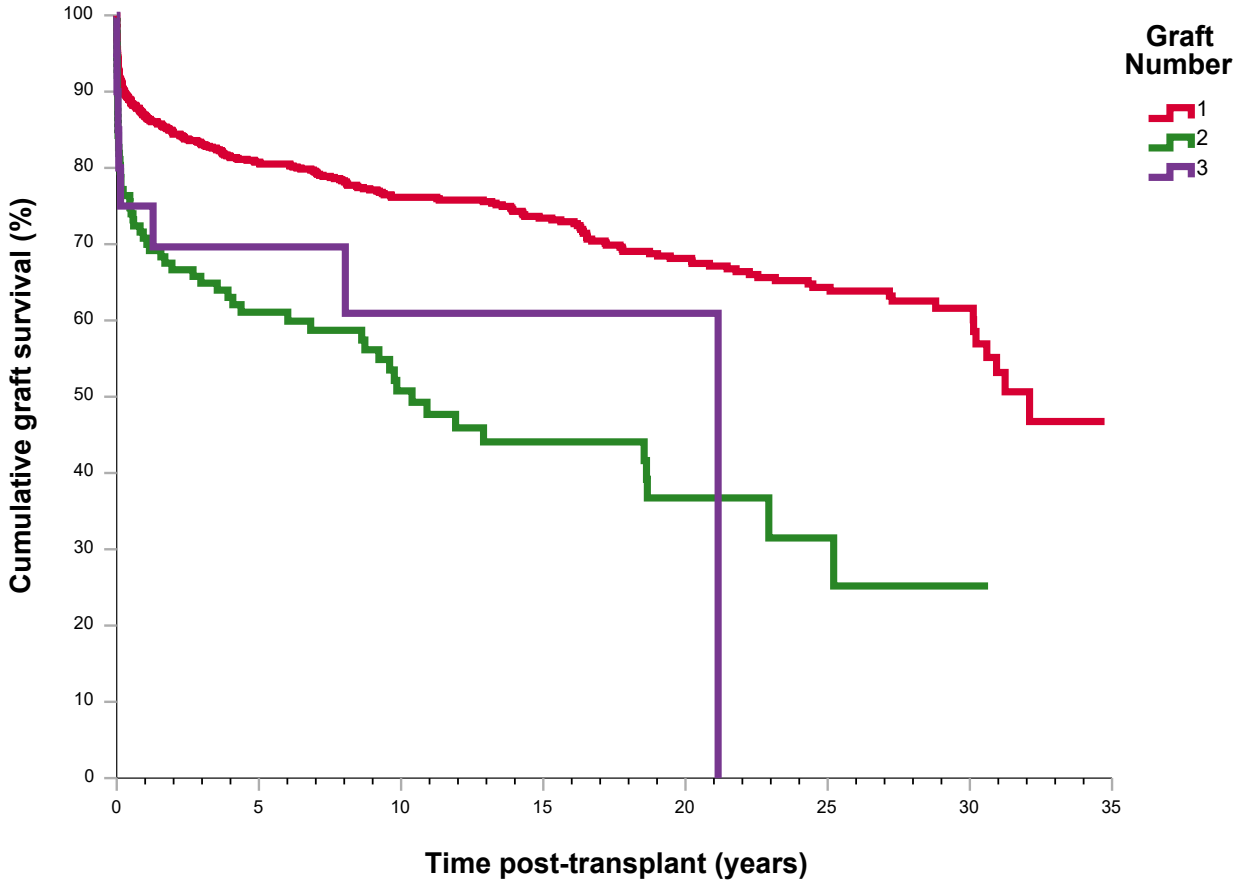


Table 31. Graft survival - paediatric by graft number

Graft Number	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
1	No. at risk	1,065	882	762	656	460	320	209	44	0
	Survival (%)		87%	83%	81%	76%	73%	68%	62%	
2	No. at risk	127	88	73	55	37	20	13	1	0
	Survival (%)		71%	65%	61%	51%	44%	37%	25%	
3	No. at risk	20	15	10	9	7	3	1	0	
	Survival (%)		75%	70%	70%	61%	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 69.1% for the first graft, 58.4% for the second graft, 62.7% for the third graft and not reached for the fourth graft. Median graft survival was 18.4 years for the first graft, 13.1 years for the second graft, 12.4 years for the third graft and not reached for the fourth graft.

Figure 48. Graft survival curve for adults by graft number

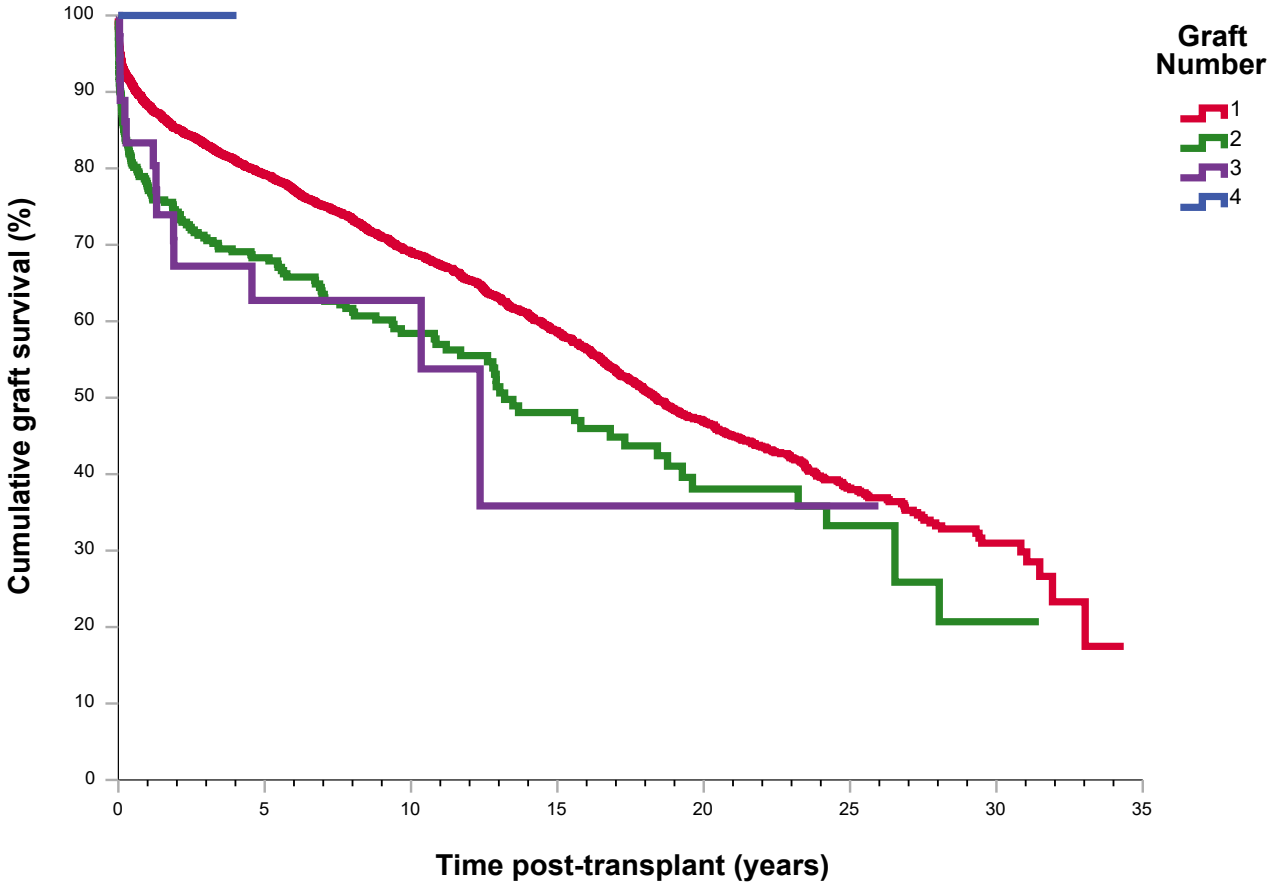


Table 32. Graft survival – adults by graft number

Graft Number	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
1	No. at risk	5,358	4,503	3,713	3,091	1,898	1,098	525	41	0
	Survival (%)		88%	83%	79%	69%	59%	47%	31%	
2	No. at risk	351	254	201	168	88	48	25	2	0
	Survival (%)		78%	71%	68%	58%	48%	38%	21%	
3	No. at risk	36	28	16	13	7	2	1	0	
	Survival (%)		83%	67%	63%	63%	36%	36%		
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 = 0.046, Figure 49 and Table 33). Ten-year graft survival was 78.2% for living donor grafts, 72.7% for split grafts, 69.3% for whole grafts, 60.2% 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

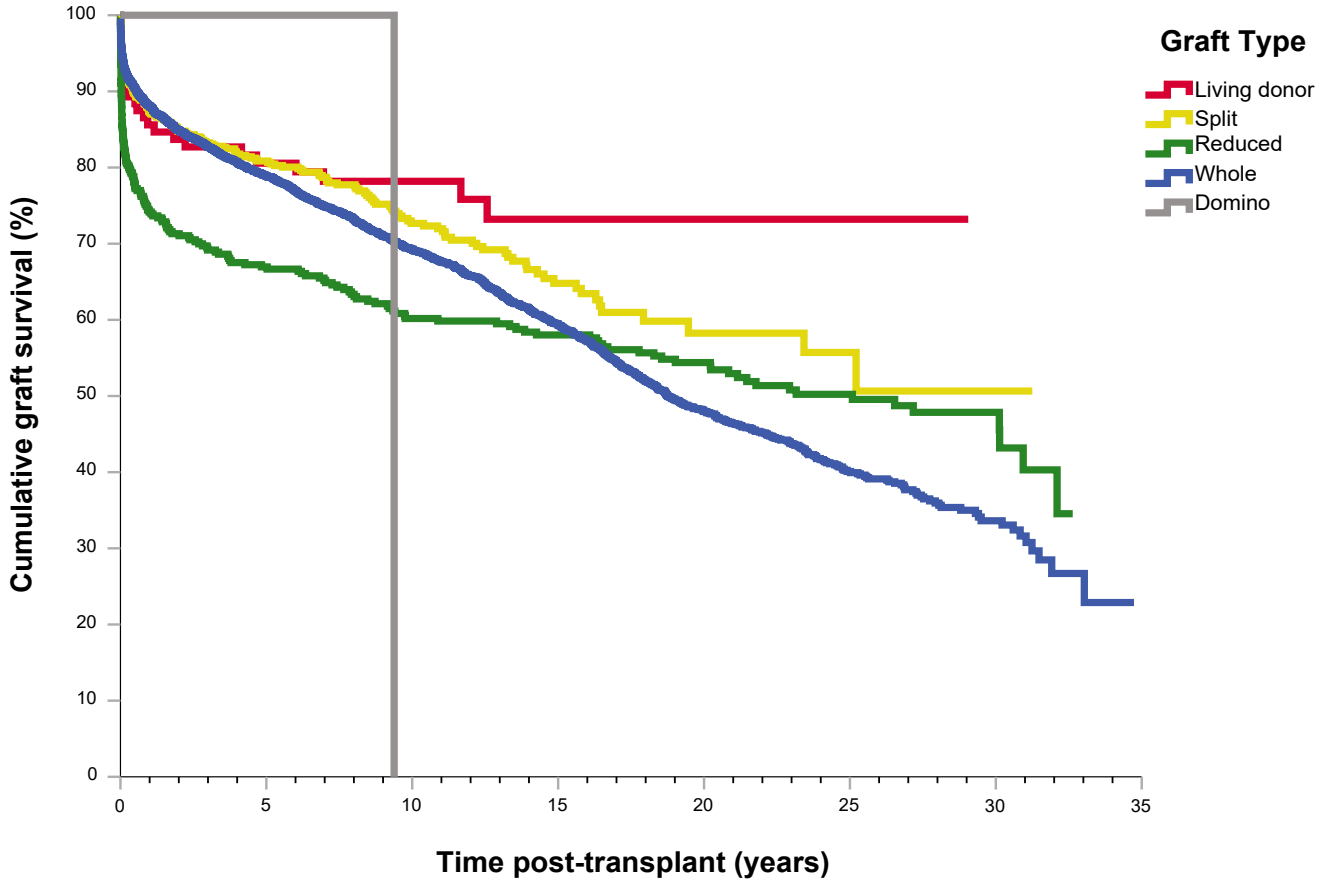


Table 33. Graft survival by type of graft - all grafts

Graft Type	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
Domino	No. at risk	4	4	4	3	0				
	Survival (%)		100%	100%	100%					
Living donor	No. at risk	112	92	82	74	50	9	2	0	
	Survival (%)		86%	83%	81%	78%	73%	73%		
Split	No. at risk	818	660	532	414	221	102	37	1	0
	Survival (%)		87%	83%	81%	73%	65%	58%	51%	
Reduced	No. at risk	391	288	255	233	183	157	116	24	0
	Survival (%)		74%	69%	67%	60%	58%	54%	48%	
Whole	No. at risk	5,633	4,727	3,904	3,268	2,043	1,223	619	63	0
	Survival (%)		88%	83%	79%	69%	59%	48%	34%	

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 80.4% for living donor liver transplantation, 78.8% for whole liver transplantation, 77.0% for split liver transplantation and 61.6% for reduced liver transplantation. Median graft survival was not reached for living donor and whole grafts and was 27.2 years for reduced grafts and 25.2 for split grafts.

Figure 50. Paediatric graft survival curve for type of graft

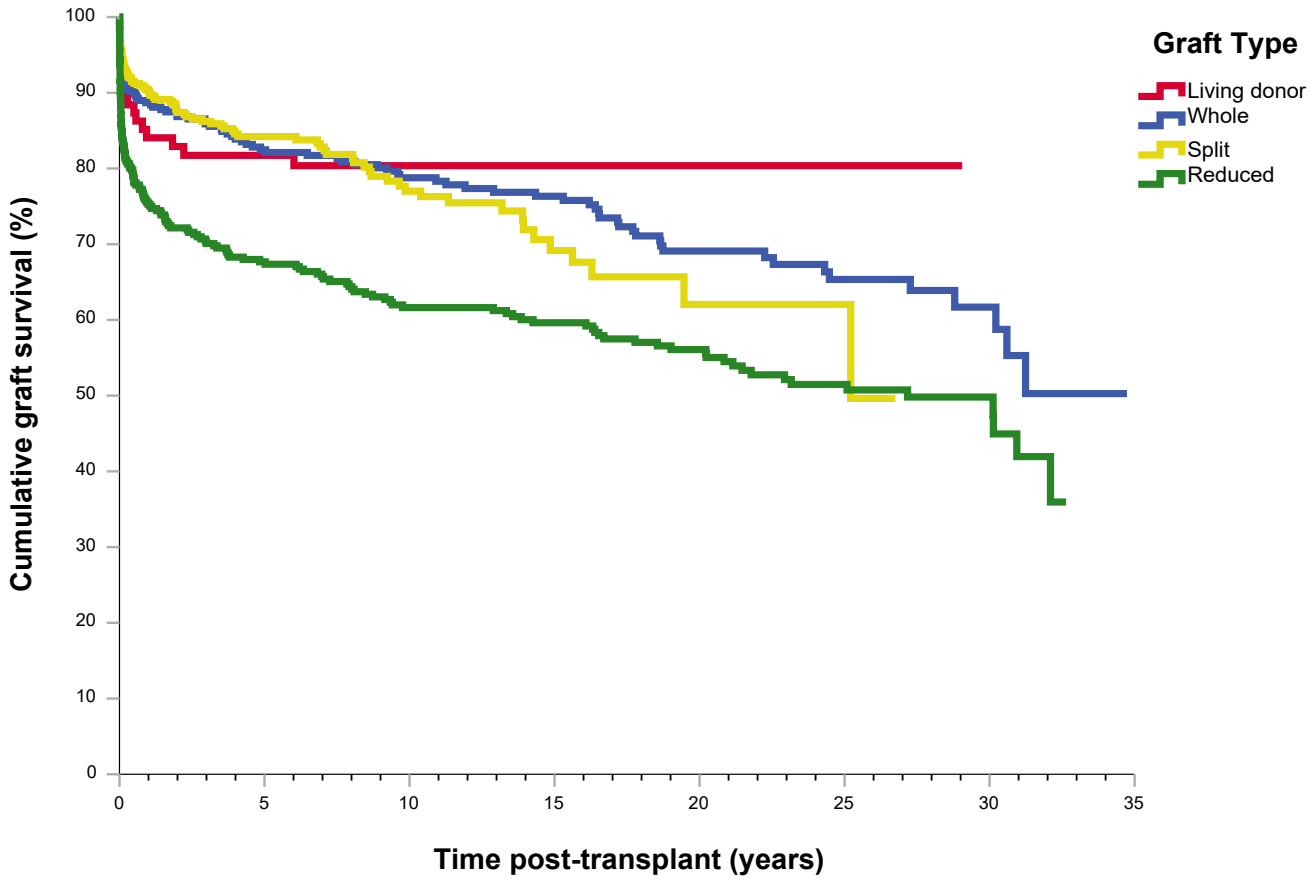


Table 34. Paediatric recipient graft survival by type of graft - all grafts

Graft Type	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
Living donor	No. at risk	95	76	68	63	41	9	2	0	
	Survival (%)		84%	82%	82%	80%	80%	80%		
Whole	No. at risk	345	299	265	227	179	140	95	21	0
	Survival (%)		89%	86%	83%	79%	76%	69%	62%	
Split	No. at risk	415	342	276	215	113	47	17	0	
	Survival (%)		90%	86%	84%	77%	69%	62%		
Reduced	No. at risk	356	267	236	215	171	147	109	24	0
	Survival (%)		75%	70%	68%	62%	60%	56%	50%	

12.8 Graft Survival by Graft Type in Adults

There was no significant difference in graft survival in adults by graft type, although there was a trend to worse graft survival after reduced liver transplantation (P = 0.328, Figure 51 and Table 35). Ten-year graft survival was 68.6% for whole liver transplantation, 68.3% for split liver transplantation, 67.6% for living donor liver transplantation, 45.3% for reduced liver transplantation and 0 for domino liver transplantation. Median graft survival was 23.4 years for split transplantation, 18.1 years for whole liver transplantation, 12.6 years for living donor transplantation, 9.4 years for domino liver transplantation and 9.2 years for reduced liver transplantation.

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

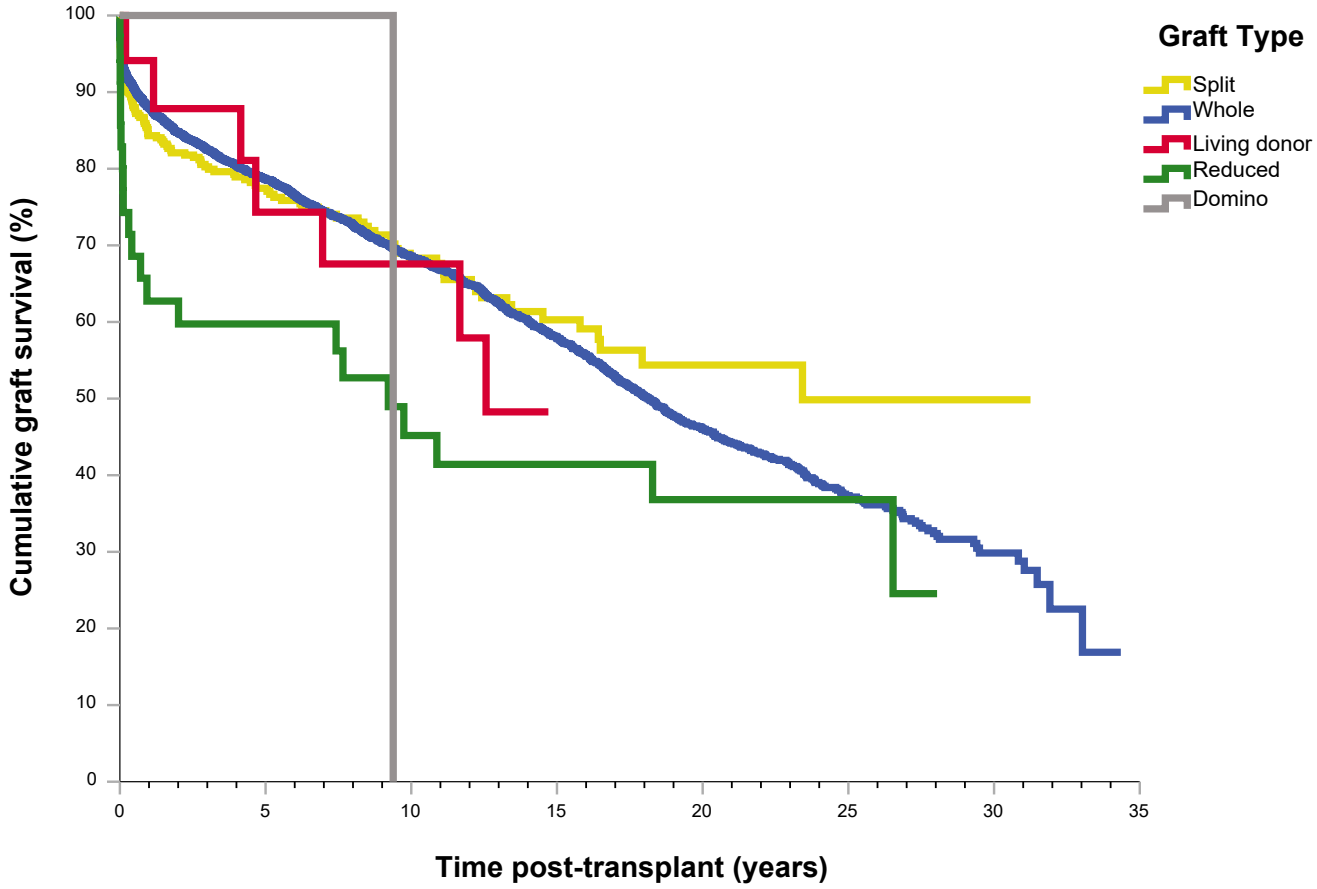


Table 35. Adult graft survival for type of graft, all grafts

Graft Type	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
Domino	No. at risk	4	4	4	3	0				
	Survival (%)		100%	100%	100%					
Split	No. at risk	403	318	256	199	108	55	20	1	0
	Survival (%)		84%	80%	77%	68%	60%	54%	50%	
Whole	No. at risk	5,288	4,428	3,639	3,041	1,864	1,083	524	42	0
	Survival (%)		88%	83%	79%	69%	58%	46%	30%	
Living donor	No. at risk	17	16	14	11	9	0			
	Survival (%)		94%	88%	74%	68%				
Reduced	No. at risk	35	21	19	18	12	10	7	0	
	Survival (%)		63%	60%	60%	45%	41%	37%		

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 91.7% at 1 year, 87.3% at 3 years, 84.1% at 5 years and 73.2% at 10 years. Median graft survival was not reached for recent eras since 2000 and was 17.1 years for 1995 – 99, 17.0 years for 1990 – 94 and 7.7 years for 1985 – 89.

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

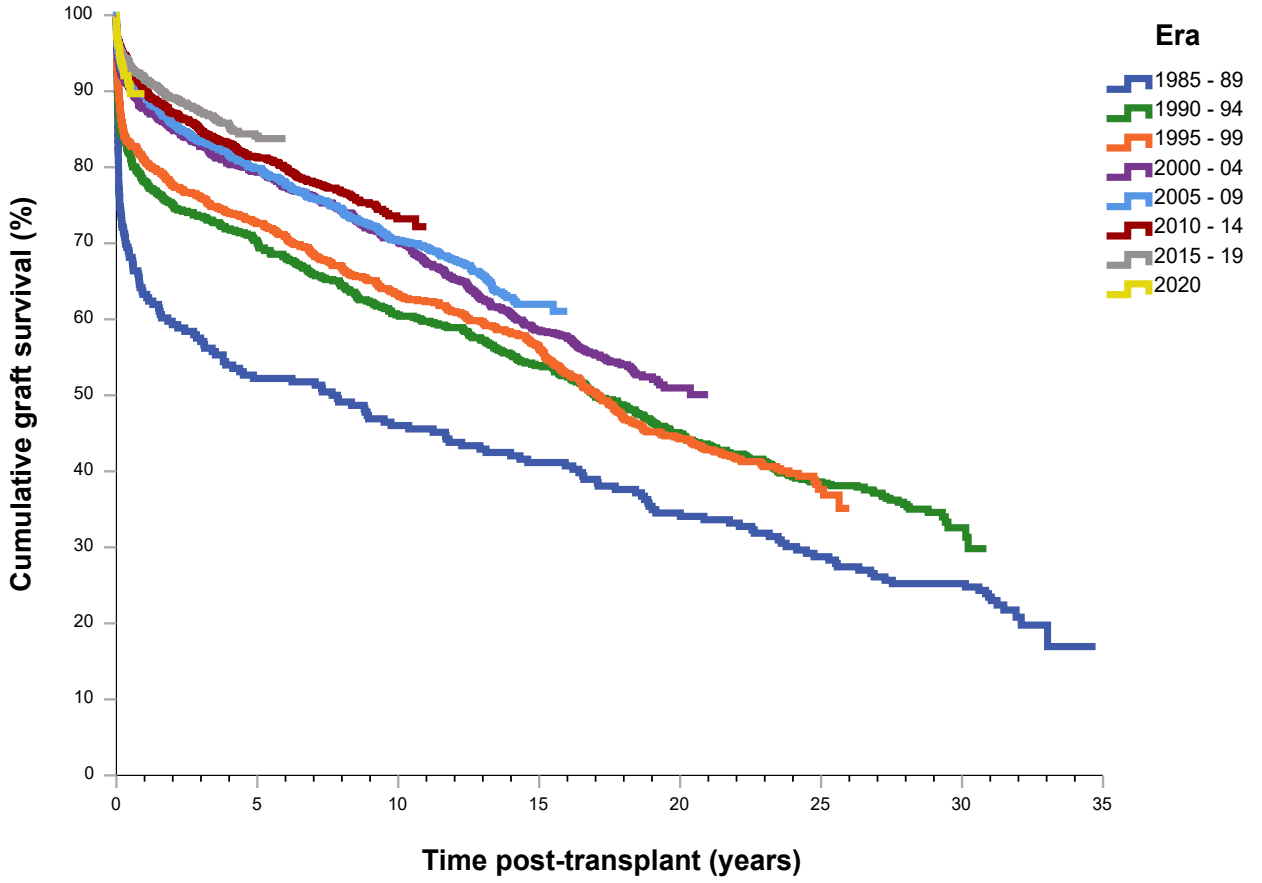


Table 36. Graft (deceased and living donors) survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
1985 - 89	No. at risk	226	143	129	118	104	93	78	53	0
	Survival (%)		63%	57%	52%	46%	41%	35%	24%	
1990 - 94	No. at risk	601	470	442	422	364	324	270	31	0
	Survival (%)		78%	74%	70%	61%	54%	45%	33%	
1995 - 99	No. at risk	759	614	577	551	480	426	336	0	
	Survival (%)		81%	76%	73%	63%	56%	44%		
2000 - 04	No. at risk	915	803	757	726	644	536	90	0	
	Survival (%)		88%	83%	79%	70%	59%	51%		
2005 - 09	No. at risk	1,032	925	860	824	726	112	0		
	Survival (%)		90%	83%	80%	70%	62%			
2010 - 14	No. at risk	1,331	1,201	1,128	1,082	179	0			
	Survival (%)		90%	85%	81%	73%				
2015 - 19	No. at risk	1,763	1,616	884	269	0				
	Survival (%)		92%	87%	84%					
2020	No. at risk	332	0							
	Survival (%)									

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 91.0% at 1 year, 88.8% at 3 years, 86.5% at 5 years and 80.7% at 10 years. Median paediatric graft survival was not reached for all transplant eras other than the 1985 – 89 era for which it was 7.7 years.

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

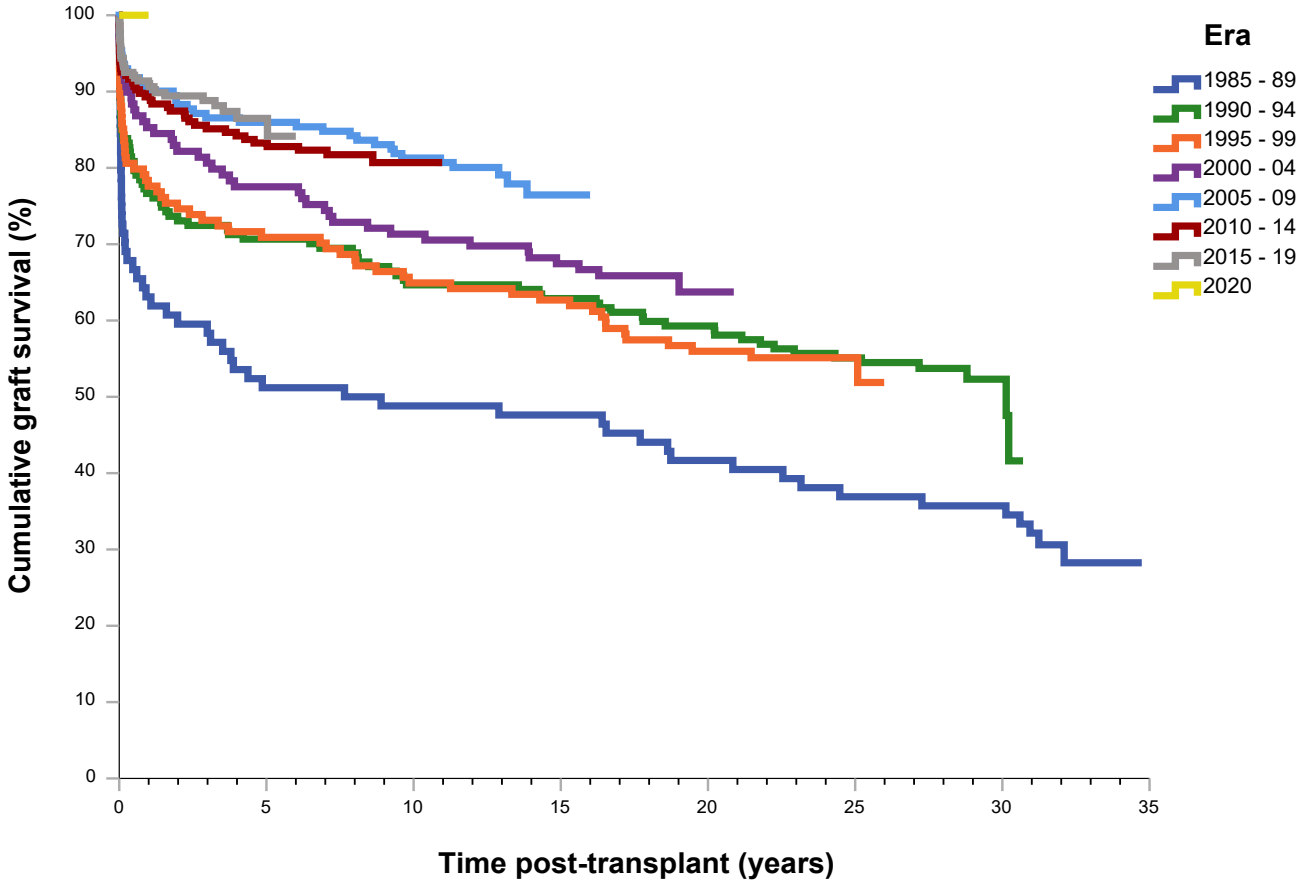


Table 37. Paediatric graft (deceased and living donors) survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
1985 - 89	No. at risk	84	53	49	43	41	40	35	30	0
	Survival (%)		63%	58%	51%	49%	48%	42%	36%	
1990 - 94	No. at risk	167	128	121	118	108	105	99	15	0
	Survival (%)		77%	73%	71%	65%	63%	59%	52%	
1995 - 99	No. at risk	134	104	98	95	87	84	75	0	
	Survival (%)		78%	73%	71%	65%	63%	56%		
2000 - 04	No. at risk	129	110	104	100	92	87	14	0	
	Survival (%)		85%	81%	78%	71%	67%	64%		
2005 - 09	No. at risk	171	155	148	147	139	27	0		
	Survival (%)		91%	87%	86%	81%	77%			
2010 - 14	No. at risk	215	192	183	179	37	0			
	Survival (%)		89%	85%	83%	81%				
2015 - 19	No. at risk	267	243	142	38	0				
	Survival (%)		91%	89%	87%					
2020	No. at risk	45	0							
	Survival (%)									

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 91.8% at 1 year, 87.0% at 3 years, 83.7% at 5 years and 71.7% at 10 years. Median adult graft survival was not reached for transplant eras since 2005 and was 19.2 years for 2000 – 04, 16.5 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

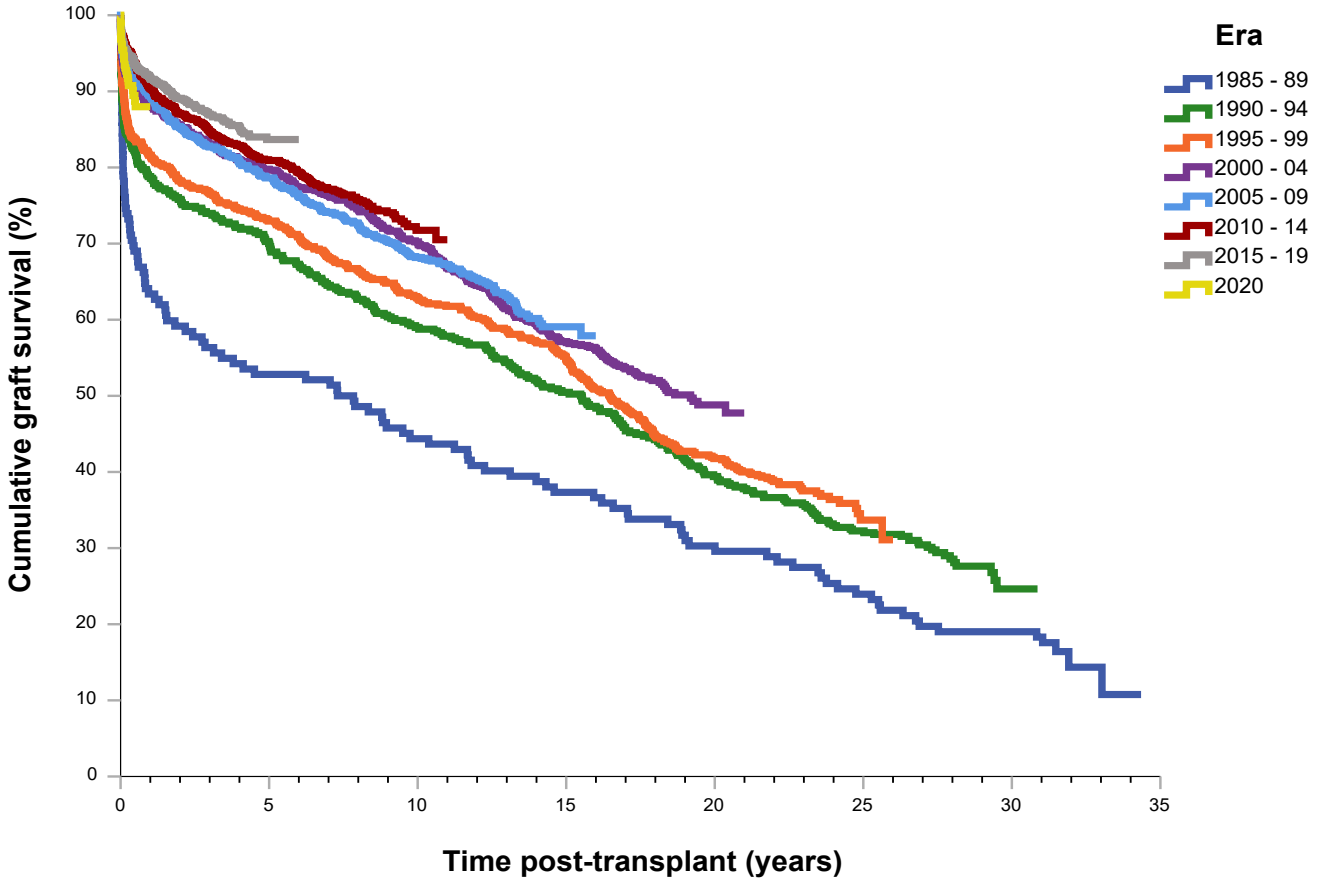


Table 38. Adult graft (deceased and living donors) survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
1985 - 89	No. at risk	142	90	80	75	63	53	43	27	0
	Survival (%)		63%	56%	53%	44%	37%	30%	19%	
1990 - 94	No. at risk	434	342	321	304	256	219	171	16	0
	Survival (%)		79%	74%	70%	59%	51%	39%	25%	
1995 - 99	No. at risk	625	510	479	456	393	342	261	0	
	Survival (%)		82%	77%	73%	63%	55%	42%		
2000 - 04	No. at risk	786	693	653	626	552	449	76	0	
	Survival (%)		88%	83%	80%	70%	57%	49%		
2005 - 09	No. at risk	861	770	712	677	587	85	0		
	Survival (%)		89%	83%	79%	68%	59%			
2010 - 14	No. at risk	1,116	1,009	945	903	142	0			
	Survival (%)		90%	85%	81%	72%				
2015 - 19	No. at risk	1,496	1,373	742	231	0				
	Survival (%)		92%	87%	84%					
2020	No. at risk	287	0							
	Survival (%)									

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 92.2% at 1 year, 87.4% at 3 years, 83.8% at 5 years and 72.8% at 10 years. Median graft survival was not reached for eras since 2005 and was 20.4 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

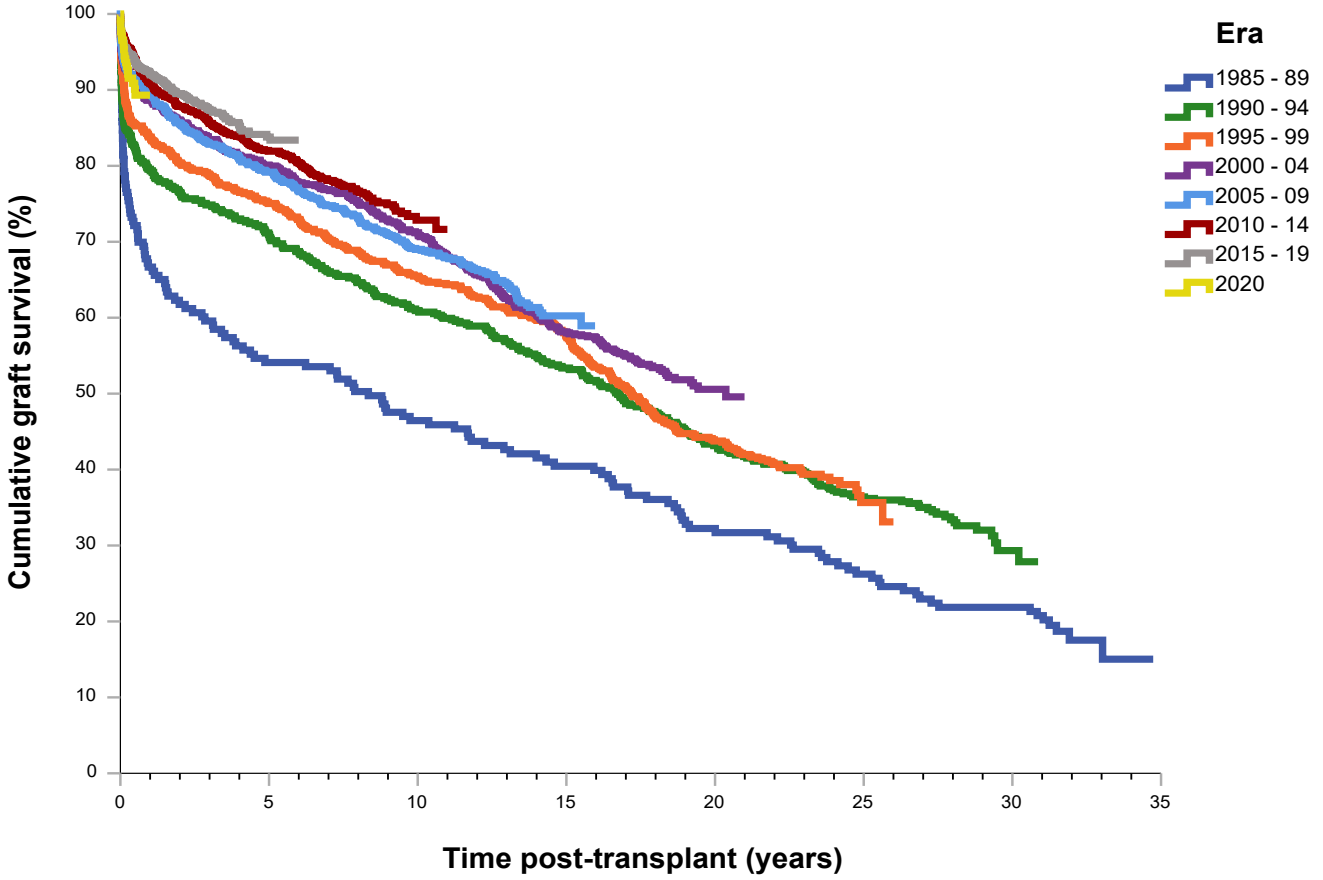


Table 39. Whole graft survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
1985 - 89	No. at risk	183	122	109	99	85	74	59	40	0
	Survival (%)		68%	60%	54%	46%	40%	32%	22%	
1990 - 94	No. at risk	489	389	366	347	298	261	211	23	0
	Survival (%)		80%	75%	71%	61%	53%	43%	29%	
1995 - 99	No. at risk	617	517	486	463	404	355	270	0	
	Survival (%)		84%	79%	75%	66%	58%	44%		
2000 - 04	No. at risk	774	686	646	619	551	450	79	0	
	Survival (%)		89%	84%	80%	71%	58%	51%		
2005 - 09	No. at risk	816	732	676	646	563	83	0		
	Survival (%)		90%	83%	79%	69%	60%			
2010 - 14	No. at risk	1,068	971	914	875	142	0			
	Survival (%)		91%	86%	82%	73%				
2015 - 19	No. at risk	1,421	1,310	707	219	0				
	Survival (%)		92%	87%	84%					
2020	No. at risk	265	0							
	Survival (%)									

12.13 Reduced Graft Survival by Era of Transplant

Graft survival after reduced liver transplantation varied over transplant eras without a clear trend (P = 0.047, Figure 56, Table 40). Graft survival in the most recent era was 87.5% at 1 year, 84.8% at 3 years, 80.4% at 5 years and 62.8% at 10 years. Median graft survival was not reached for eras since 2000 and was 21.1 years for 1990 – 94, 9.2 years for 1995 – 99 and 3.0 years for 1985 – 89.

Figure 56. Reduced graft survival curve by era of transplant

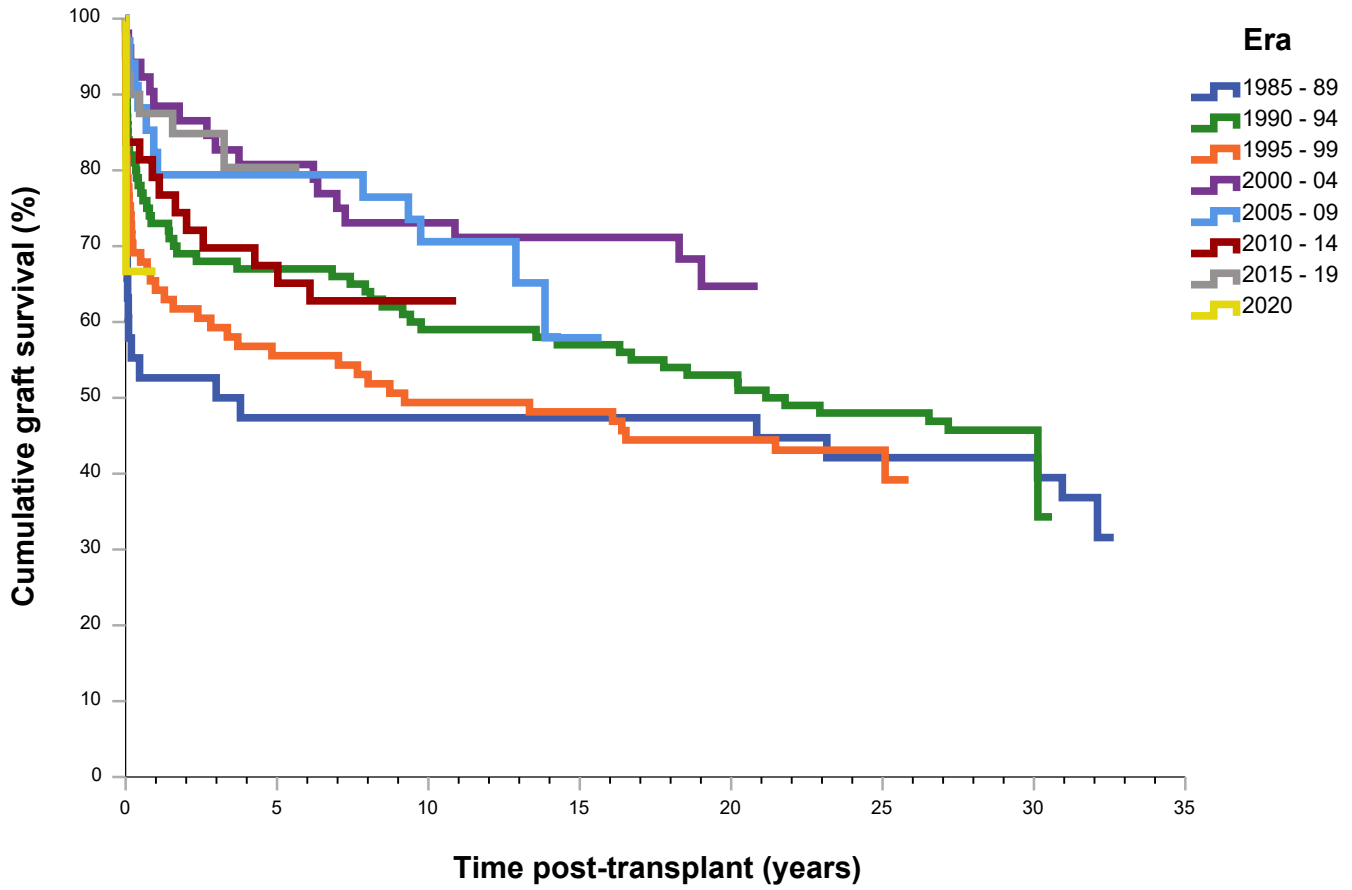


Table 40. Reduced graft (deceased donor) survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
1985 - 89	No. at risk	38	20	19	18	18	18	18	16	0
	Survival (%)		53%	50%	47%	47%	47%	47%	42%	
1990 - 94	No. at risk	100	73	68	67	59	57	53	8	0
	Survival (%)		73%	68%	67%	59%	57%	53%	46%	
1995 - 99	No. at risk	81	52	48	45	40	39	36	0	
	Survival (%)		64%	59%	56%	49%	48%	44%		
2000 - 04	No. at risk	52	46	43	42	38	37	9	0	
	Survival (%)		89%	83%	81%	73%	71%	65%		
2005 - 09	No. at risk	34	28	27	27	24	6	0		
	Survival (%)		82%	79%	79%	71%	58%			
2010 - 14	No. at risk	43	34	30	29	4	0			
	Survival (%)		79%	70%	67%	63%				
2015 - 19	No. at risk	40	35	20	5	0				
	Survival (%)		88%	85%	80					
2020	No. at risk	3	0							
	Survival (%)									

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 90.6% at 1 year, 87.6% at 3 years, 87.6% at 5 years and 76.0% at 10 years. Median graft survival was not reached for transplant eras since 2005 and was 19.5 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

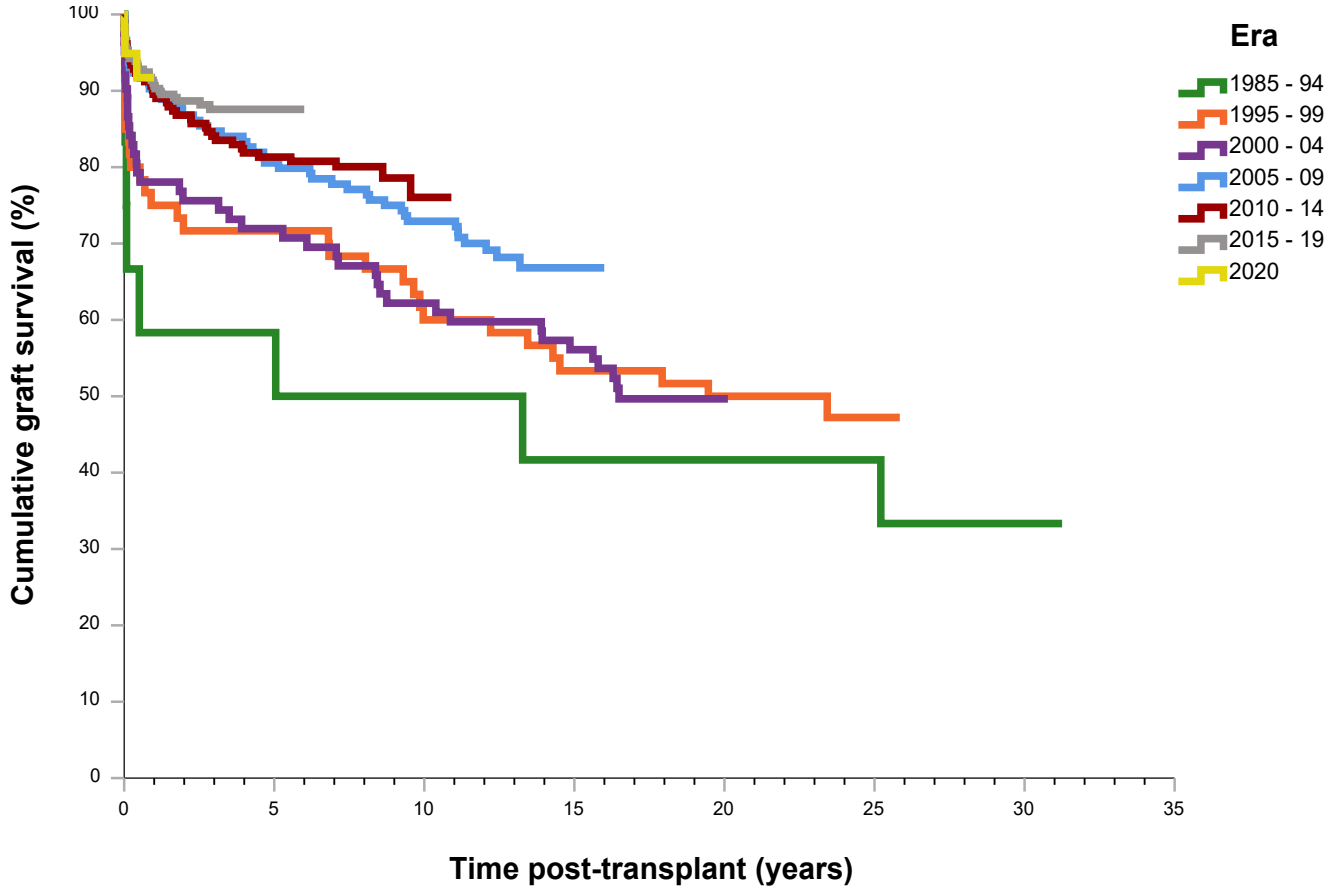


Table 41. Split graft (deceased donor) survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
1985 - 94	No. at risk	12	7	7	7	6	5	5	1	0
	Survival (%)		58%	58%	58%	50%	42%	42%	33%	
1995 - 99	No. at risk	60	45	43	43	36	32	30	0	
	Survival (%)		75%	72%	72%	60%	53%	50%		
2000 - 04	No. at risk	82	64	62	59	51	46	2	0	
	Survival (%)		78%	76%	72%	62%	56%	50%		
2005 - 09	No. at risk	144	129	122	116	105	19	0		
	Survival (%)		90%	85%	81%	73%	67%			
2010 - 14	No. at risk	182	163	153	148	23	0			
	Survival (%)		90%	84%	81%	76%				
2015 - 19	No. at risk	278	252	145	41	0				
	Survival (%)		91%	88%	88%					
2020	No. at risk	60	0							
	Survival (%)									

12.15 Living Donor Graft Survival by Era of Transplant

There were 112 living donor grafts (excluding domino grafts). There has 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 (P = 0.014, Figure 58 and Table 42). Graft survival in the most recent era was 77.3% at 1 year, 77.3% at 3 years, 64.4% 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. Multivariate analysis determined that transplant era was not independently associated with graft survival.

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

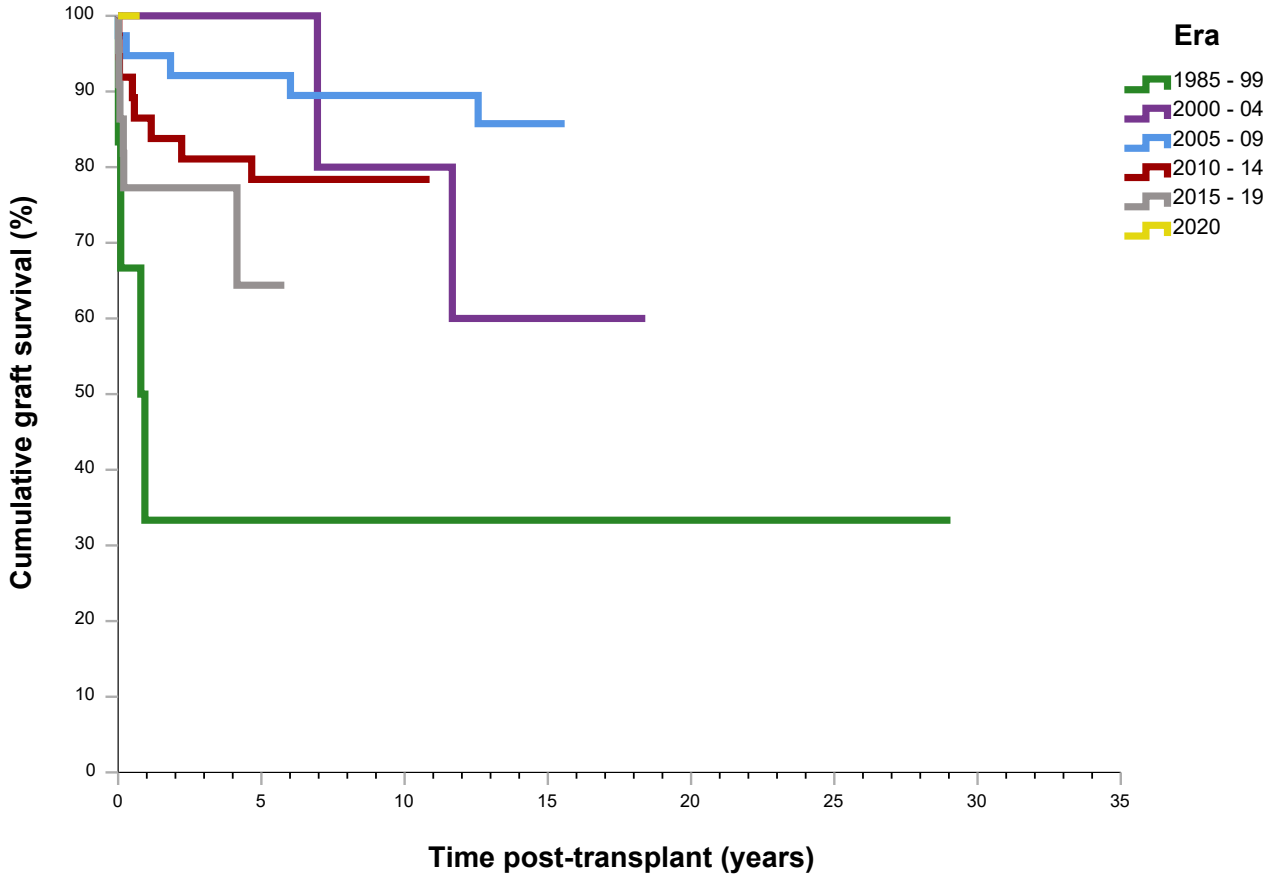


Table 42. Living donor (excluding domino) graft survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
1985 - 99	No. at risk	6	2	2	2	2	2	2	0	
	Survival (%)		33%	33%	33%	33%	33%	33%		
2000 - 04	No. at risk	5	5	5	5	4	3	0		
	Survival (%)		100%	100%	100%	80%	60%			
2005 - 09	No. at risk	38	36	35	35	34	4	0		
	Survival (%)		95%	92%	92%	90%	86%			
2010 - 14	No. at risk	37	32	30	29	10	0			
	Survival (%)		87%	81%	78%	78%				
2015 - 19	No. at risk	22	17	10	3	0				
	Survival (%)		77%	77%	64%					
2020	No. at risk	4	0							
	Survival (%)									

12.16 Graft Survival by Deceased Donor Age

A total of 6,843 grafts were sourced from 6,435 deceased donors however there is no deceased donor information on 126 grafts from 1985 to 1988. This survival analysis is limited to 6,717 grafts (from 6,309 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 80.3% for donors aged 10 – 15 years, 77.8% for donors aged 0 – 9 years, 71.8% for donors aged 16 – 29 years, 68.3% for donors aged 30 – 39 years, 68.1% for donors aged 40 – 49 years, 67.7% for donors aged 60 – 69 years, 67.4% for donors aged 70 years and older and 65.0% 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, 18.5 years for donors aged 30 – 39 years, 18.4 years for donors aged 40 – 49 years, 17.6 years for donors aged 70 years and older, 17.1 years for donors aged 60 – 69 years and 16.1 years for donors aged 50 - 59 years.

Figure 59. Graft survival curve by deceased donor age

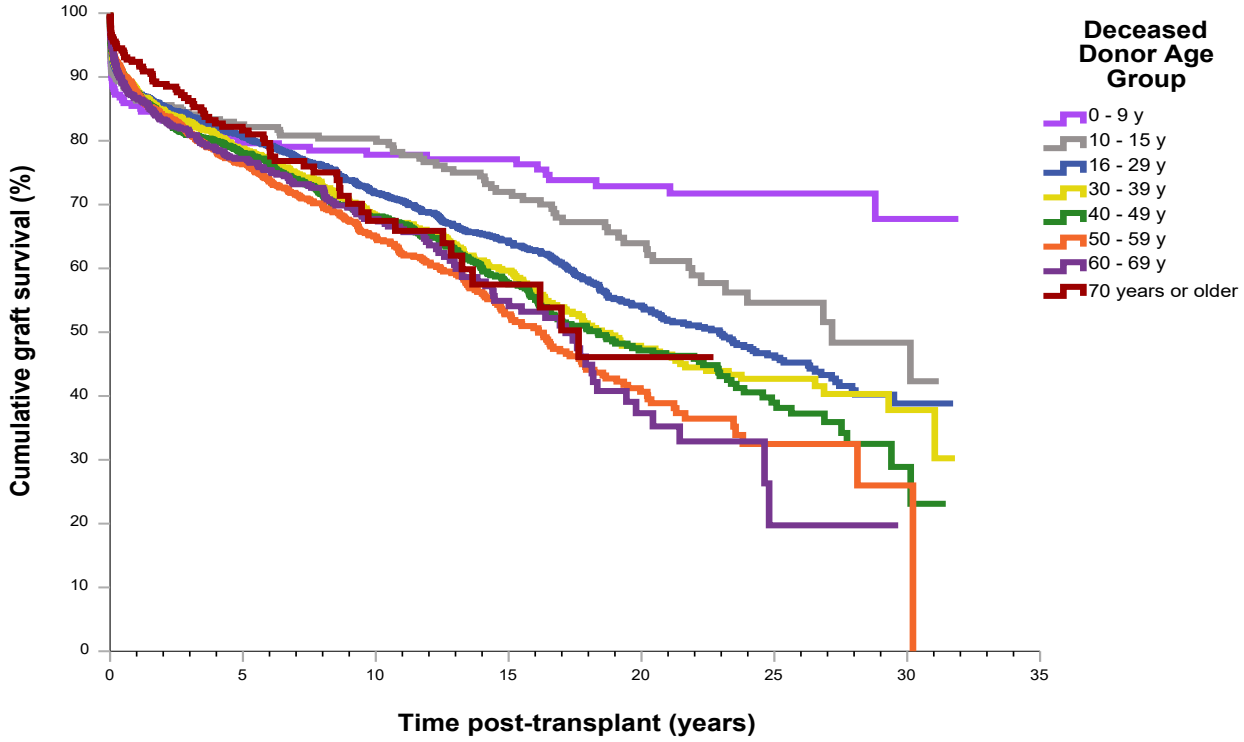


Table 43. Graft survival by deceased donor age

	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
0 – 9 y	No. at risk	227	189	171	150	119	98	70	10	0
	Survival (%)		86%	83%	80%	78%	77%	73%	68%	
10 – 15 y	No. at risk	309	255	226	195	155	114	70	8	0
	Survival (%)		86%	84%	83%	80%	72%	64%	48%	
16 – 29 y	No. at risk	1,721	1,435	1,242	1,074	718	474	257	23	0
	Survival (%)		88%	84%	81%	72%	64%	54%	39%	
30 – 39 y	No. at risk	1,000	831	688	562	366	212	110	12	0
	Survival (%)		88%	83%	79%	68%	60%	47%	38%	
40 – 49 y	No. at risk	1,271	1,062	872	735	465	277	130	7	0
	Survival (%)		87%	81%	78%	68%	58%	47%	29%	
50 – 59 y	No. at risk	1,139	957	770	619	346	177	72	1	0
	Survival (%)		88%	81%	76%	65%	53%	41%	26%	
60 – 69 y	No. at risk	758	611	471	375	173	65	19	0	
	Survival (%)		87%	81%	77%	68%	55%	37%		
70 years and older	No. at risk	292	253	179	139	49	19	5	0	
	Survival (%)		92%	86%	82%	67%	58%	46%		

12.17 Graft Survival by Donor Type

There was a trend to better graft survival for transplantation from living donors and slightly worse graft survival for transplantation from donation after circulatory death donors up to 10 years in comparison to transplantation from donation after brain death donors (P = 0.108, Figure 60 and Table 44). Ten-year graft survival was 77.5% for transplantation from living donors, 69.2% for transplantation from donation after brain death donors and 66.0% for transplantation from donation after circulatory death donors. Median survival was not reached for transplantation from living donors and donation after circulatory death donors and was 19.9 years for transplantation from donation after brain death donors.

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

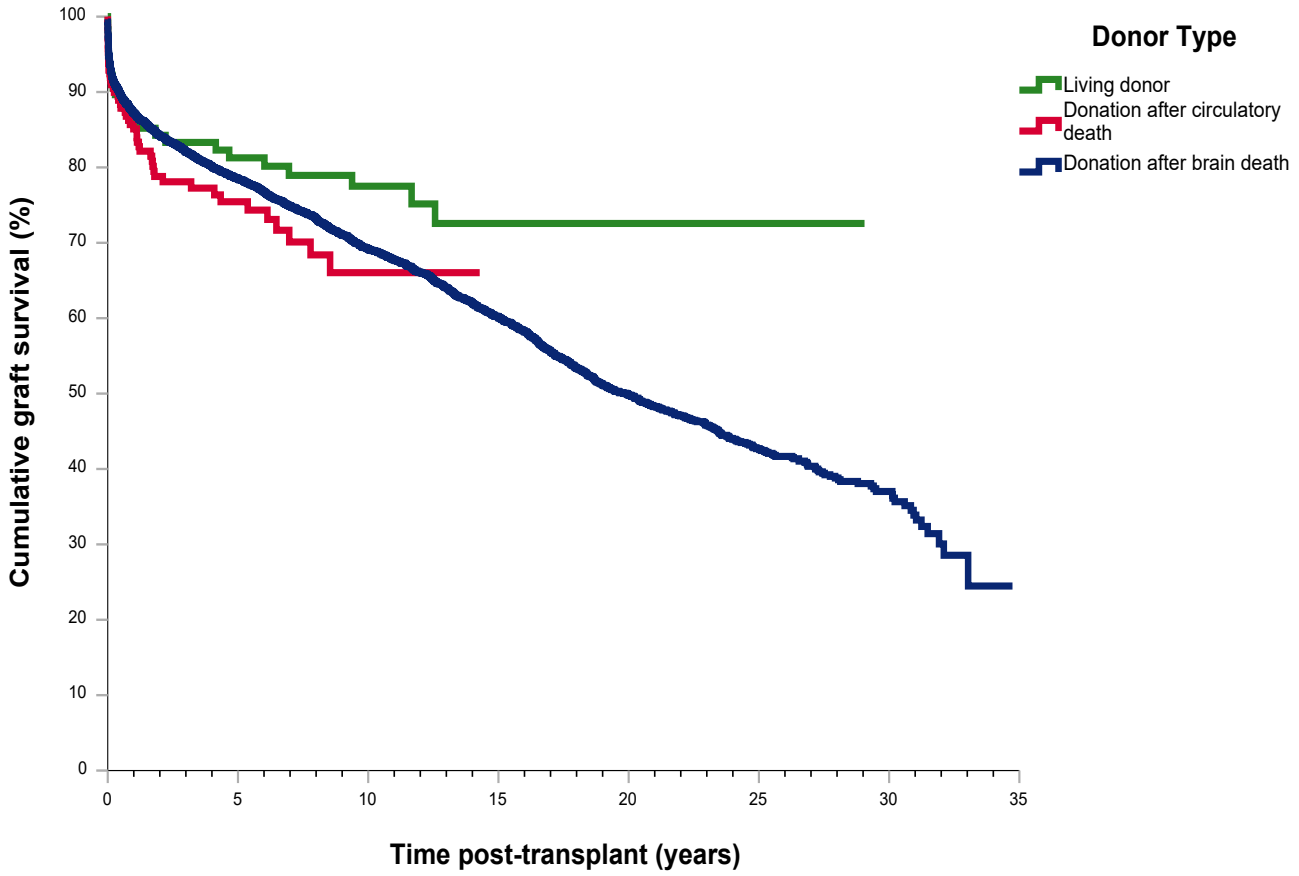


Table 44. Graft survival by donor type – all grafts

Donor Type	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
Living donor	No. at risk	116	96	86	77	50	9	2	0	
	Survival (%)		86%	83%	81%	78%	73%	73%		
DBD	No. at risk	6,631	5,528	4,595	3,844	2,427	1,482	772	88	0
	Survival (%)		87%	82%	79%	69%	60%	50%	37%	
DCD	No. at risk	212	148	96	71	20	0			
	Survival (%)		85%	78%	75%	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 74.8% for other cause, 71.6% for anoxia, 70.7% for trauma and 67.3% for stroke. Median survival was 26.5 years for other cause, 22.2 years for trauma, 20.4 years for anoxia and 17.9 years for stroke.

Figure 61. Graft survival curve by donor cause of death

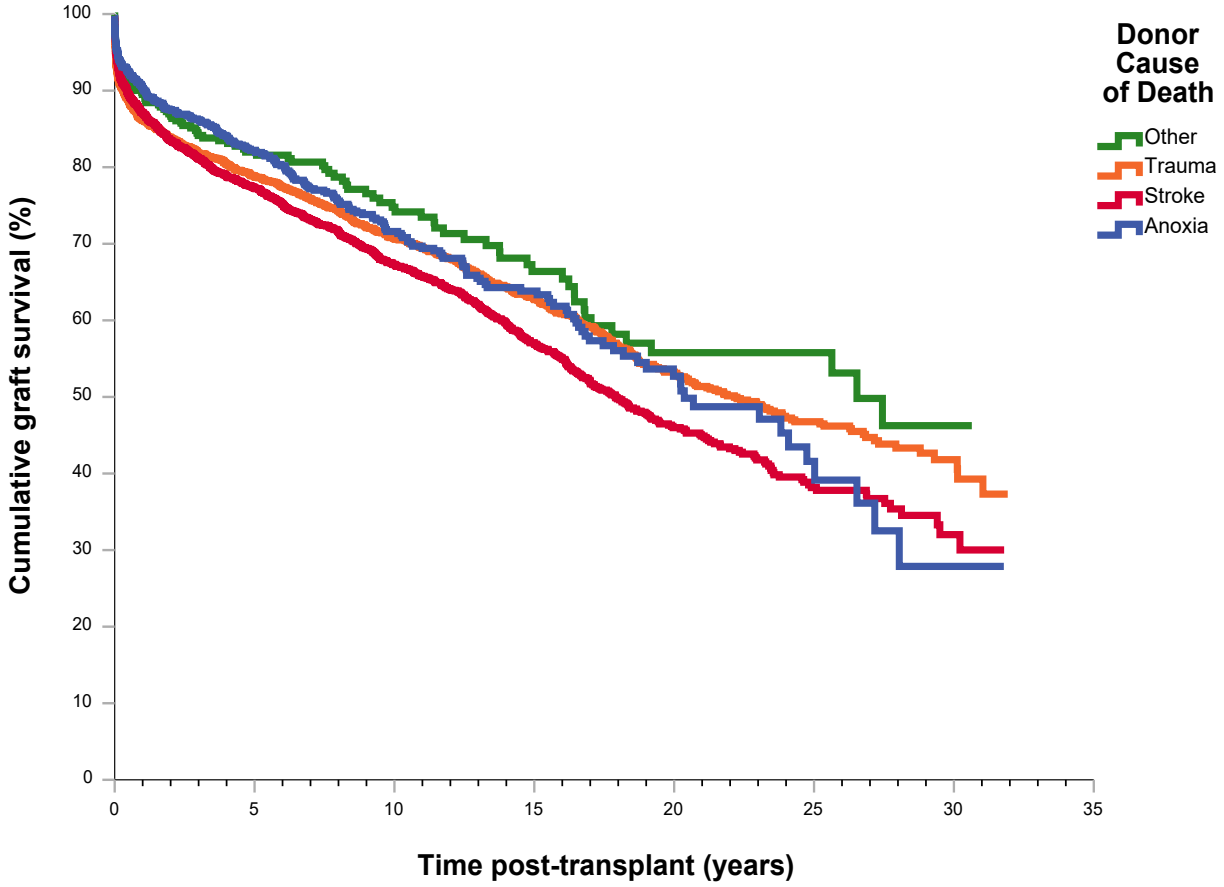


Table 45. Graft survival by donor cause of death

Donor cause of death	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
Other	No. at risk	395	338	256	202	123	75	43	4	0
	Survival (%)		90%	84%	82%	75%	66%	56%	46%	
Trauma	No. at risk	1,959	1,624	1,433	1,278	914	626	355	34	0
	Survival (%)		86%	82%	79%	71%	63%	53%	42%	
Stroke	No. at risk	3,083	2,571	2,123	1,788	1,080	601	279	20	0
	Survival (%)		87%	81%	77%	67%	57%	46%	32%	
Anoxia	No. at risk	1,280	1,060	807	581	274	134	56	3	0
	Survival (%)		90%	86%	82%	72%	64%	53%	28%	

All deceased donors since 1989

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 71.1% for transplants performed with a non-shipped liver and 65.4% for a liver shipped from another unit. Median graft survival was 20.6 years for transplants performed with a donor liver from the unit's donor region and 19.1 years for a liver shipped from another unit.

Figure 62. Graft survival curve by organ shipping

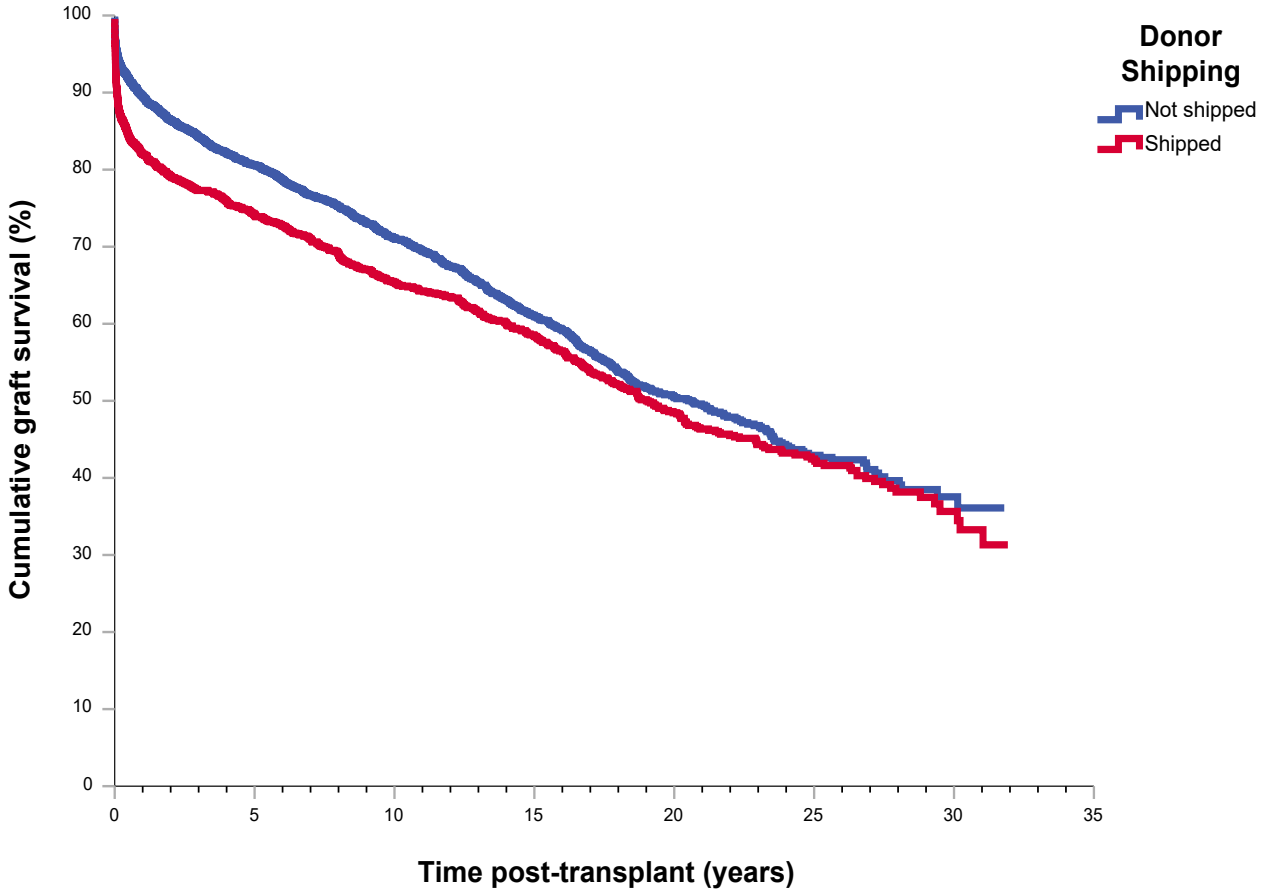


Table 46. Graft survival by organ shipping

Organ Shipping	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
Not shipped	No. at risk	4,982	4,222	3,424	2,805	1,639	892	400	30	0
	Survival (%)		90%	84%	81%	71%	61%	51%	38%	
Shipped	No. at risk	1,735	1,371	1,195	1,044	752	544	333	31	0
	Survival (%)		82%	77%	74%	65%	59%	49%	36%	

All deceased donors since 1989

12.20 Graft Survival by Cold Ischaemia Time

Graft survival was significantly better for transplants performed with a cold ischaemia time less than 450 minutes compared to transplants performed with a cold ischaemia time 450 minutes or greater (P < 0.001, see Figure 63 and Table 47). Ten-year graft survival was 72.5% for transplants with a cold ischaemia time less than 450 minutes and 67.3% for transplants with a cold ischaemia time greater than or equal to 450 minutes. Median survival was 19.7 years for transplants with a cold ischaemia time less than 450 minutes and 15.8 years for transplants with a cold ischaemia time greater than or equal to 450 minutes.

Figure 63. Graft survival curve by cold ischaemia time

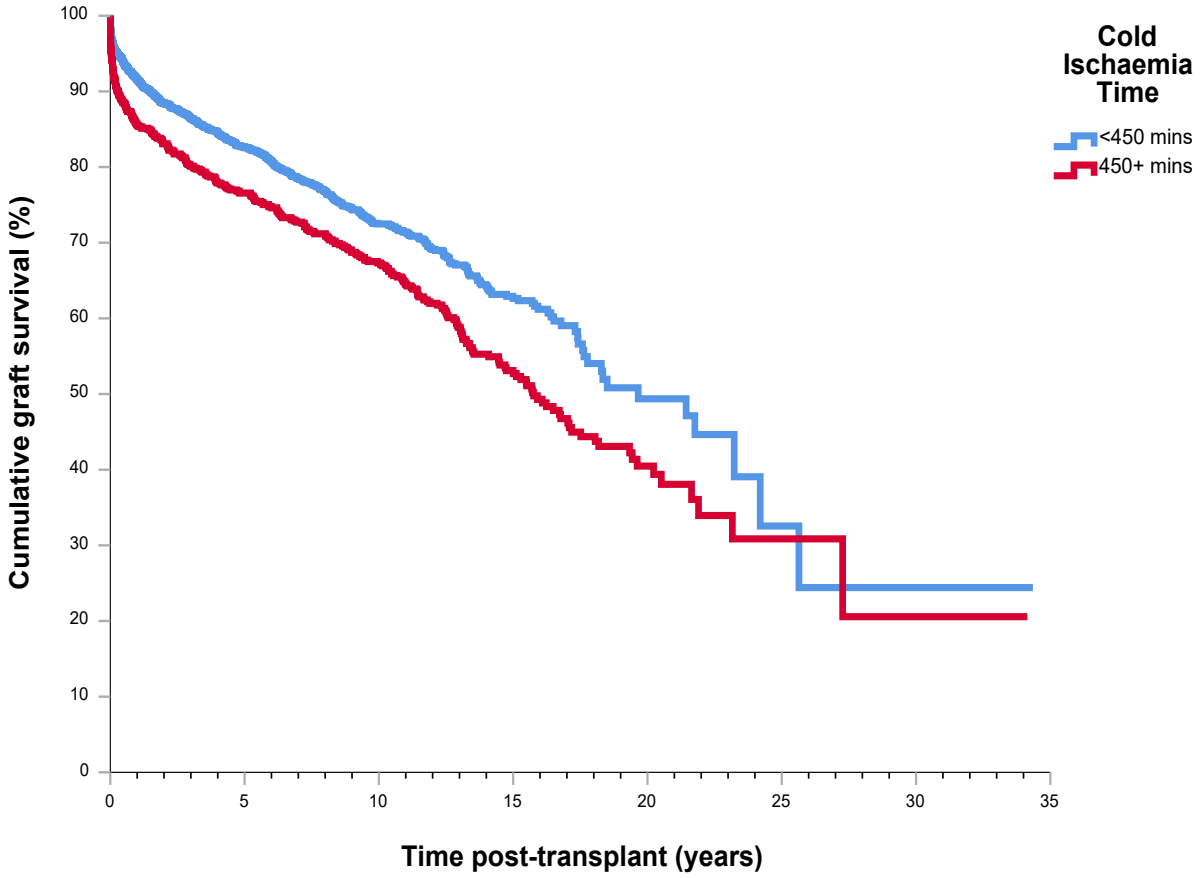


Table 47. Graft survival by cold ischaemia time

Cold Ischaemia Time	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
0 – 449 min	No. at risk	3,974	3,368	2,578	1,936	826	226	33	1	0
	Survival (%)		92%	86%	83%	73%	63%	49%	24%	
450+ min	No. at risk	879	732	636	563	370	135	40	1	0
	Survival (%)		86%	80%	77%	67%	53%	41%	21%	

2,106 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 donor/recipient blood group compatibility (P=0.990, Figure 64 and Table 48). Ten-year graft survival was 74.1% for blood group-incompatible "A2" transplants (i.e. blood group A, non-A1 donor to O or B recipient or blood group AB, non-A1B to B recipient), 70.5% for blood group-compatible transplants, 71.1% for blood group incompatible transplants (excluding A2 donors) and 69.4% for blood group-identical transplants. Median graft survival was not reached for blood group incompatible transplants and incompatible "A2" transplants, 22.0 years for transplants in which the donor and recipient blood groups were compatible and 19.9 years for transplants between identical blood groups.

Figure 64. Graft survival curve by blood group compatibility

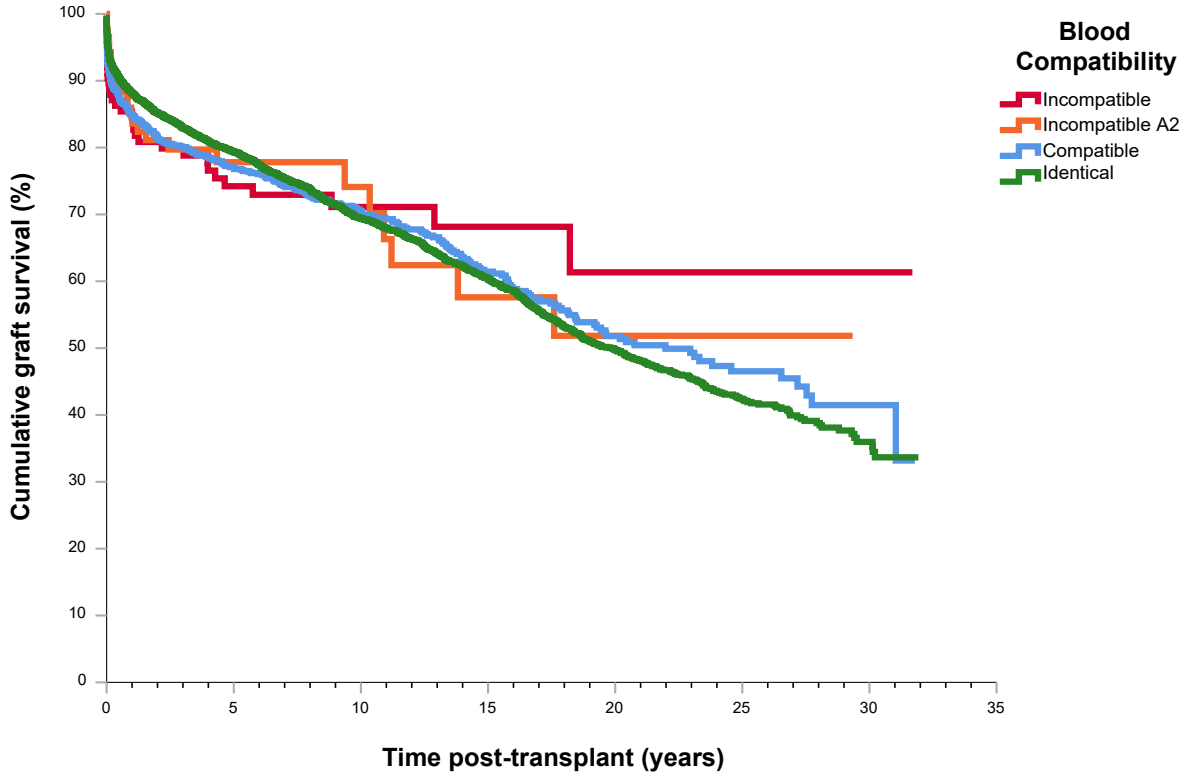


Table 48. Graft survival by blood group compatibility

Compatibility	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
Incompatible	No. at risk	124	93	76	62	32	16	7	2	0
	Survival (%)		85%	80%	74%	71%	68%	61%	61%	
Incompatible A2	No. at risk	87	71	50	33	20	12	7	0	
	Survival (%)		85%	80%	78%	74%	58%	52%		
Compatible	No. at risk	935	756	631	527	360	220	119	8	0
	Survival (%)		85%	80%	77%	71%	61%	52%	42%	
Identical	No. at risk	5,563	4,673	3,862	3,227	1,979	1,188	600	51	0
	Survival (%)		88%	83%	79%	69%	60%	50%	36%	

250 cases missing

12.22 Graft Survival by Recipient Urgency at Listing

Graft survival varied significantly by recipient urgency at listing (P = 0.006, Figure 65 and Table 49). Ten-year graft survival was 78.7% for category 2, 69.3% for non-urgent and 62.6% for category 1 patients. Median graft survival was 25.6 years for category 2, 23.2 years for category 1 and 20.0 years for non-urgent patients.

Figure 65. Graft survival curve by recipient urgency at listing

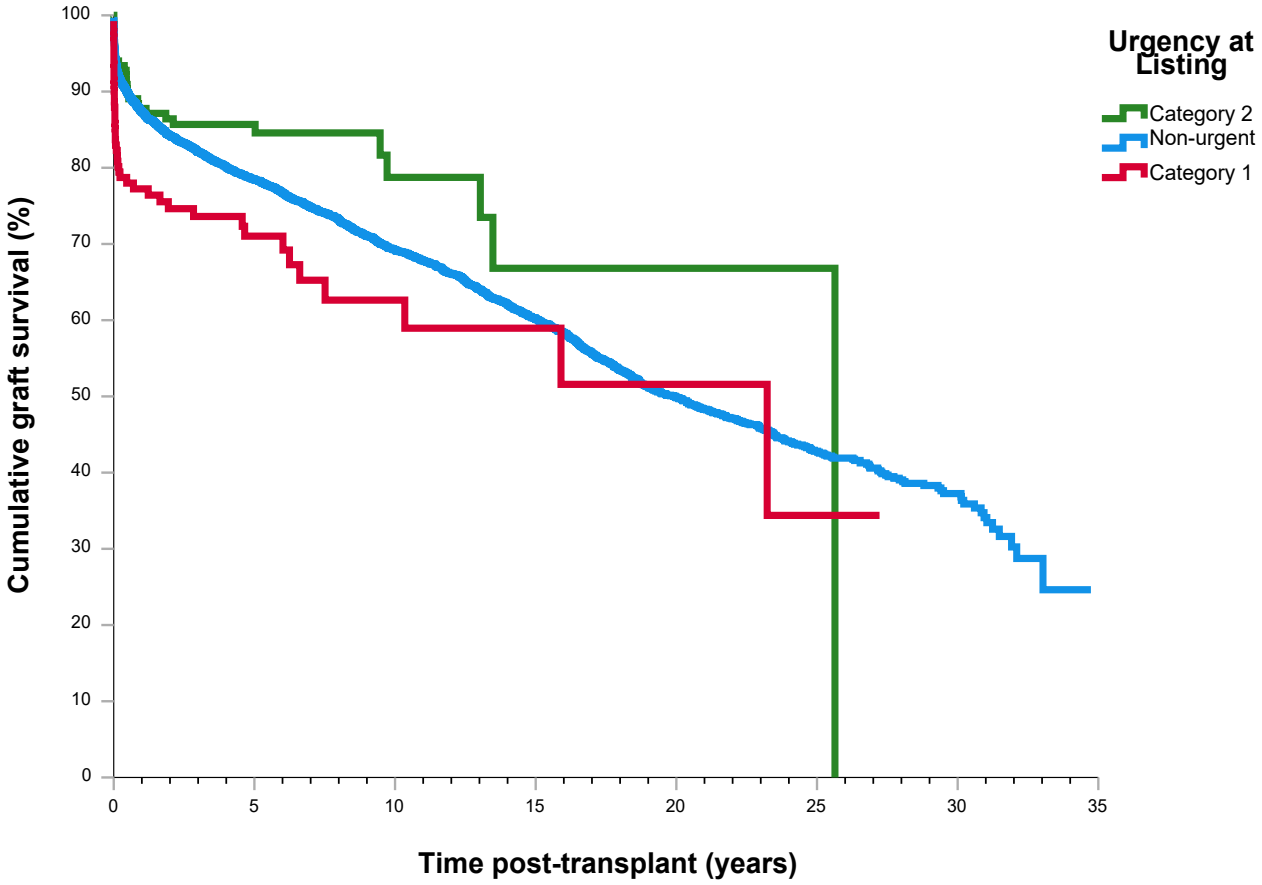


Table 49. Graft survival by recipient urgency at listing

Urgency at Listing	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
Category 2	No. at risk	167	136	108	77	24	6	3	0	
	Survival (%)		88%	86%	86%	79%	67%	67%		
Non-urgent	No. at risk	6,651	5,538	4,599	3,864	2,456	1,475	767	88	0
	Survival (%)		87%	82%	79%	69%	60%	50%	37%	
Category 1	No. at risk	141	98	70	51	17	10	4	0	
	Survival (%)		77%	74%	71%	63%	59%	52%		

12.23 Graft Survival by Recipient Transplant Urgency

Graft survival varied significantly by recipient urgency at listing (P = 0.006, Figure 66 and Table 50). Ten-year graft survival was 80.8% for category 2, 69.3% for non-urgent and 57.1% for category 1 patients. Median graft survival was 25.6 years for category 2, 20.0 years for non-urgent patients and 15.9 years for category 1.

Figure 66. Graft survival curve by recipient urgency at transplant

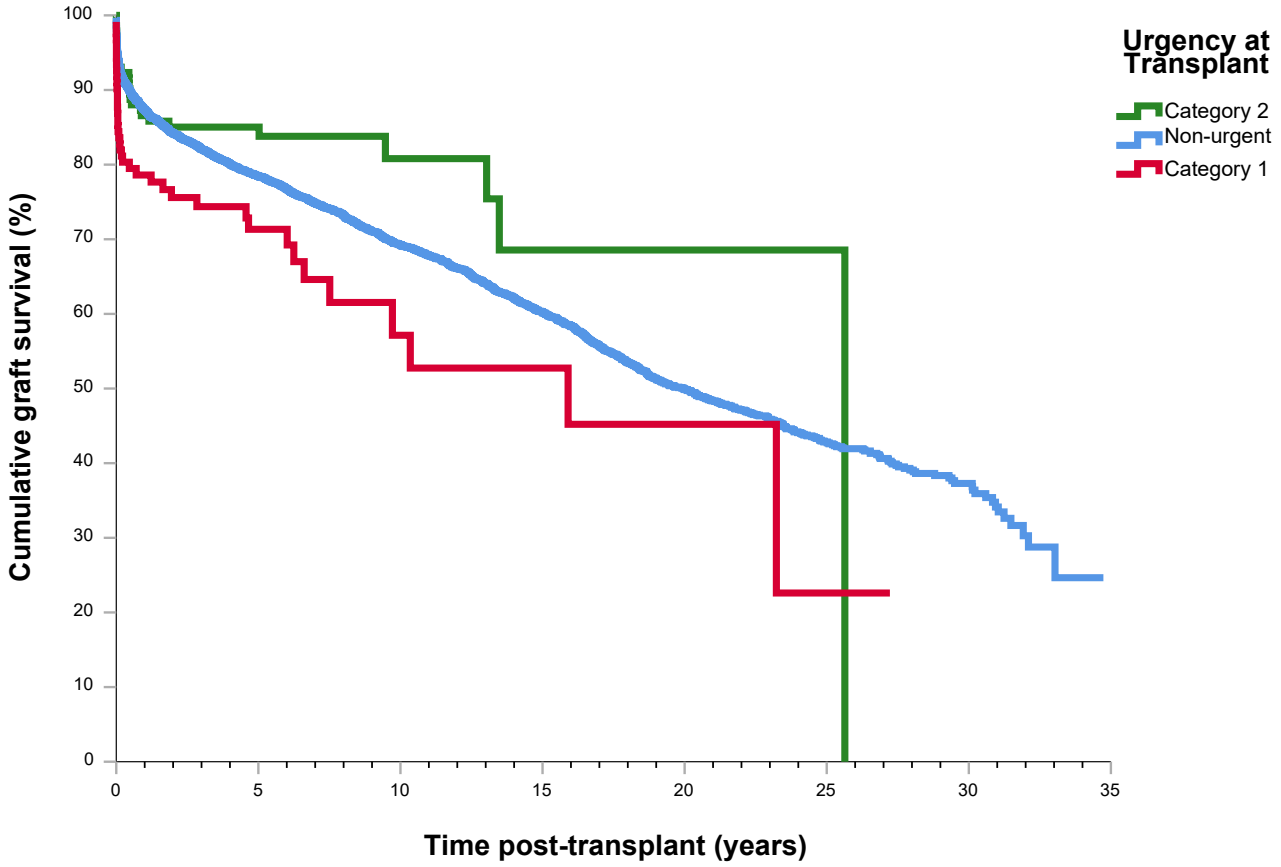


Table 50. Graft survival by recipient urgency at transplant

Urgency at Transplant	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	30	35
Category 2	No. at risk	144	118	97	69	24	6	3	0	
	Survival (%)		87%	85%	85%	81%	69%	69%		
Non-urgent	No. at risk	6,693	5,567	4,621	3,881	2,460	1,478	768	88	0
	Survival (%)		87%	82%	79%	69%	60%	50%	37%	
Category 1	No. at risk	122	87	59	42	13	7	3	0	
	Survival (%)		79%	74%	71%	57%	53%	45%		

13 Indication for Retransplantation

13.1 All Retransplants

There were 529 retransplants after the previous graft failed. There have been 471 second grafts, 56 third grafts and two fourth grafts. The commonest indications for retransplantation were vascular complications (29.1%), rejection (18.1%), biliary complications (16.6%), primary non-function or initial poor function (14.9%) and recurrent disease (13.4%, Table 51).

Table 51. Reason for retransplantation

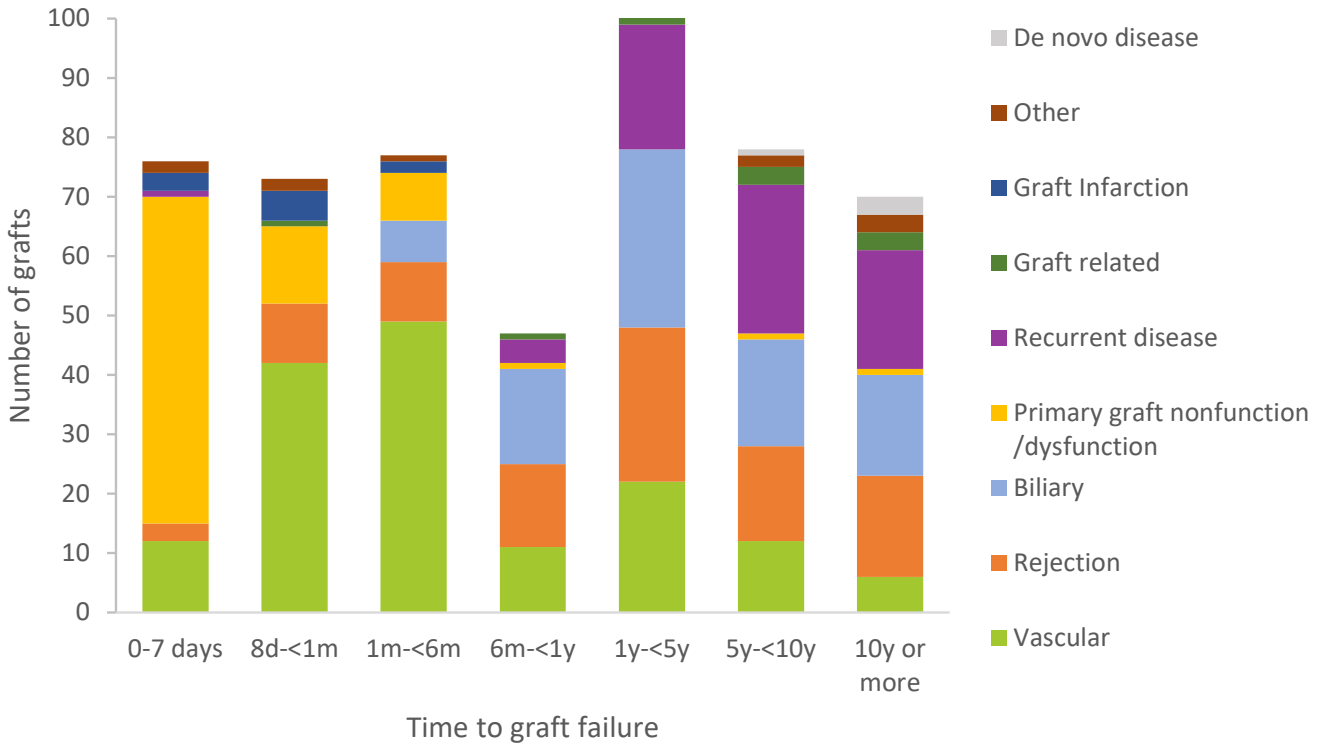
Reason for retransplantation	Graft 2	Graft 3	Graft 4	Total grafts	% total
Vascular	**137**	**17**	**0**	**154**	**29%**
Hepatic artery thrombosis	*103*	*12*	*0*	*115*	*22%*
Portal vein thrombosis	*10*	*0*	*0*	*10*	*2%*
Hepatic vein thrombosis	*6*	*1*	*0*	*7*	*1%*
Unspecified	*5*	*0*	*0*	*5*	*0.9%*
Haemorrhage (hepatic artery)	*4*	*0*	*0*	*4*	*0.8%*
Hepatic artery stenosis	*3*	*0*	*0*	*3*	*0.6%*
Hepatic vein stenosis	*1*	*2*	*0*	*3*	*0.6%*
Hepatic artery pseudoaneurysm	*2*	*0*	*0*	*2*	*0.4%*
Arterio-portal vein fistula	*1*	*0*	*0*	*1*	*0.2%*
Budd Chiari	*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%*
Rejection	**83**	**12**	**1**	**96**	**18%**
Chronic rejection	*60*	*11*	*0*	*71*	*13%*
Acute rejection	*16*	*1*	*1*	*18*	*3%*
ABO incompatible	*4*	*0*	*0*	*4*	*0.8%*
Hyperacute rejection	*2*	*0*	*0*	*2*	*0.4%*
Donor antibody mediated	*1*	*0*	*0*	*1*	*0.2%*
Biliary	**84**	**4**	**0**	**88**	**17%**
Cholangiopathy	*58*	*2*	*0*	*60*	*11.3%*
Anastomotic	*6*	*0*	*0*	*6*	*1.1%*
Biliary cirrhosis / fibrosis	*6*	*0*	*0*	*6*	*1.1%*
Cholangitis	*5*	*0*	*0*	*5*	*0.9%*
Cholestatic disease	*4*	*0*	*0*	*4*	*0.8%*
Ischaemic biliopathy	*2*	*1*	*0*	*3*	*0.6%*
Ductopenia	*2*	*0*	*0*	*2*	*0.4%*
Biliary necrosis	*0*	*1*	*0*	*1*	*0.2%*
Biliopathy caused by ABO incompatible transplant	*1*	*0*	*0*	*1*	*0.2%*
Primary graft nonfunction /dysfunction	**69**	**10**	**0**	**79**	**15%**
Primary nonfunction (ReTx or death <= 7 days)	*52*	*8*	*0*	*60*	*11%*
Primary dysfunction (ReTx or death > 7 days)	*17*	*2*	*0*	*19*	*4%*
Recurrent disease	**64**	**7**	**0**	**71**	**13%**
Primary sclerosing cholangitis	*23*	*5*	*0*	*28*	*5%*
Hepatitis C	*22*	*0*	*0*	*22*	*4%*
Autoimmune hepatitis	*7*	*1*	*0*	*8*	*2%*
Primary biliary cirrhosis	*6*	*1*	*0*	*7*	*1%*
Hepatitis B	*4*	*0*	*0*	*4*	*0.8%*
Crigler-Najjar	*1*	*0*	*0*	*1*	*0.2%*
Erythropoietic protoporphyria	*1*	*0*	*0*	*1*	*0.2%*
Graft related	**10**	**3**	**0**	**13**	**2%**
Post necrotic cirrhosis	*5*	*3*	*0*	*8*	*2%*
Nodular regenerative hyperplasia	*3*	*0*	*0*	*3*	*0.6%*
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	**8**	**3**	**0**	**11**	**2%**
Unspecified	*3*	*1*	*0*	*4*	*0.8%*
Cryptogenic cirrhosis	*2*	*1*	*0*	*3*	*0.6%*
Donor derived malignancy	*2*	*1*	*0*	*3*	*0.6%*
Acute hepatic failure - Drug related: interferon	*1*	*0*	*0*	*1*	*0.2%*
De novo disease	**5**	**0**	**0**	**5**	**0.9%**
Hepatitis C	*2*	*0*	*0*	*2*	*0.4%*
Hepatitis B	*1*	*0*	*0*	*1*	*0.2%*
Hepatitis D	*1*	*0*	*0*	*1*	*0.2%*
Hepatocellular cancer	*1*	*0*	*0*	*1*	*0.2%*
Total	**471**	**56**	**2**	529	100%

Forty-three percent of graft failures occurred within the first six months' post-transplant (14.4% 0 – 7 days, 13.8% day 8 to less than 1 month, 14.6% 1 month to less than 6 months). Primary graft non-function (72.4%) 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 (57.5%) and 1 month to less than 6 months (63.6% Figure 67). Recurrent disease was the leading cause of graft failure after five years post-transplant.

Figure 67. Time to graft failure by reason for retransplantation



13.2 Paediatric Retransplantation

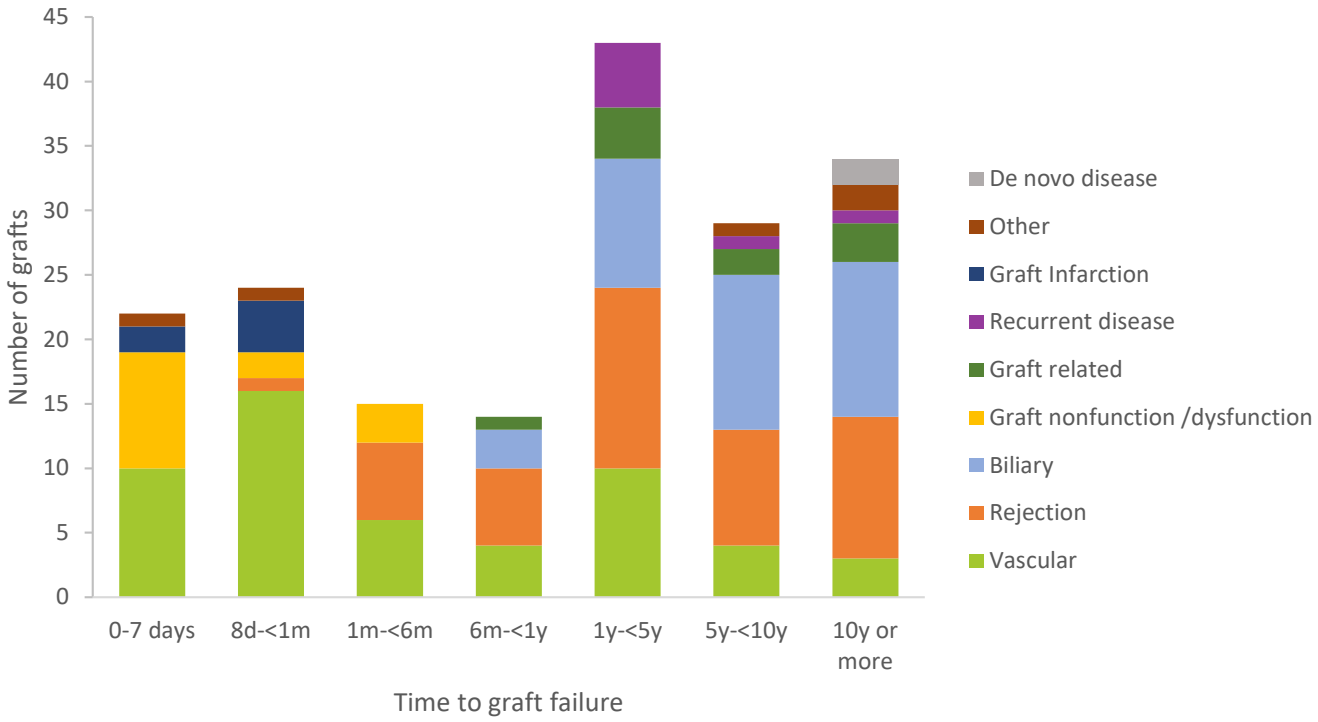
There were 181 retransplants following paediatric graft failure. There have been 153 second grafts and 28 third grafts. The commonest indications for retransplantation were vascular complications (29.3%), rejection (26.0%) and biliary complications (20.4%, Table 52).

Table 52. Reason for retransplantation following paediatric graft failure

Reason for retransplantation	Graft 2	Graft 3	Total grafts	% Total
Vascular	**44**	**9**	**53**	**29%**
Hepatic artery thrombosis	*28*	*6*	*34*	*19%*
Portal vein thrombosis	*7*	*0*	*7*	*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*	*0.6%*
Budd Chiari	*1*	*0*	*1*	*0.6%*
Hepatic artery stenosis	*1*	*0*	*1*	*0.6%*
Recurrent bleeds	*0*	*1*	*1*	*0.6%*
Rejection	**37**	**10**	**47**	**26%**
Chronic rejection	*36*	*9*	*45*	*25%*
Acute rejection	*1*	*1*	*2*	*1%*
Biliary	**35**	**2**	**37**	**20%**
Cholangiopathy	*19*	*1*	*20*	*11%*
Anastomotic	*4*	*0*	*4*	*2%*
Biliary cirrhosis / fibrosis	*4*	*0*	*4*	*2%*
Cholangitis	*4*	*0*	*4*	*2%*
Ductopenia	*2*	*0*	*2*	*1%*
Biliary necrosis	*0*	*1*	*1*	*1%*
Biliopathy caused by ABO incompatible transplant	*1*	*0*	*1*	*1%*
Cholestatic disease	*1*	*0*	*1*	*1%*
Primary graft nonfunction /dysfunction	**11**	**3**	**14**	**8%**
Primary nonfunction (ReTx or death <= 7 days)	*6*	*3*	*9*	*5%*
Primary dysfunction (ReTx or death > 7 days)	*5*	*0*	*5*	*3%*
Graft related	**9**	**1**	**10**	**6%**
Post necrotic cirrhosis	*5*	*1*	*6*	*3%*
Immune/nonviral hepatitis	*2*	*0*	*2*	*1%*
Nodular regenerative hyperplasia	*2*	*0*	*2*	*1%*
Recurrent disease	**6**	**1**	**7**	**4%**
Autoimmune hepatitis	*2*	*1*	*3*	*2%*
Primary biliary cirrhosis	*2*	*0*	*2*	*1%*
Crigler-Najjar	*1*	*0*	*1*	*0.6%*
Primary sclerosing cholangitis	*1*	*0*	*1*	*0.6%*
Graft Infarction	**6**	**0**	**6**	**3%**
Thrombotic	*4*	*0*	*4*	*2%*
Non thrombotic	*2*	*0*	*2*	*1%*
Other	**3**	**2**	**5**	**3%**
Cryptogenic cirrhosis	*2*	*1*	*3*	*2%*
Donor derived malignancy	*0*	*1*	*1*	*0.6%*
Unspecified	*1*	*0*	*1*	*0.6%*
De novo disease	**2**	**0**	**2**	**1%**
Hepatitis C	*1*	*0*	*1*	*0.6%*
Hepatocellular cancer	*1*	*0*	*1*	*0.6%*
Total	**153**	**28**	**181**	*100%*

Thirty-four percent of graft failures occurred within the first six months' post-transplant (12.2% 0 – 7 days, 13.3% day 8 to less than 1 month, 8.3% 1 month to less than 6 months). Vascular causes were the main reason for retransplantation in the first month post-transplant (Figure 68). Rejection, biliary and vascular causes were the leading causes of graft failure after one-year post-transplant.

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



13.3 Adult Retransplantation

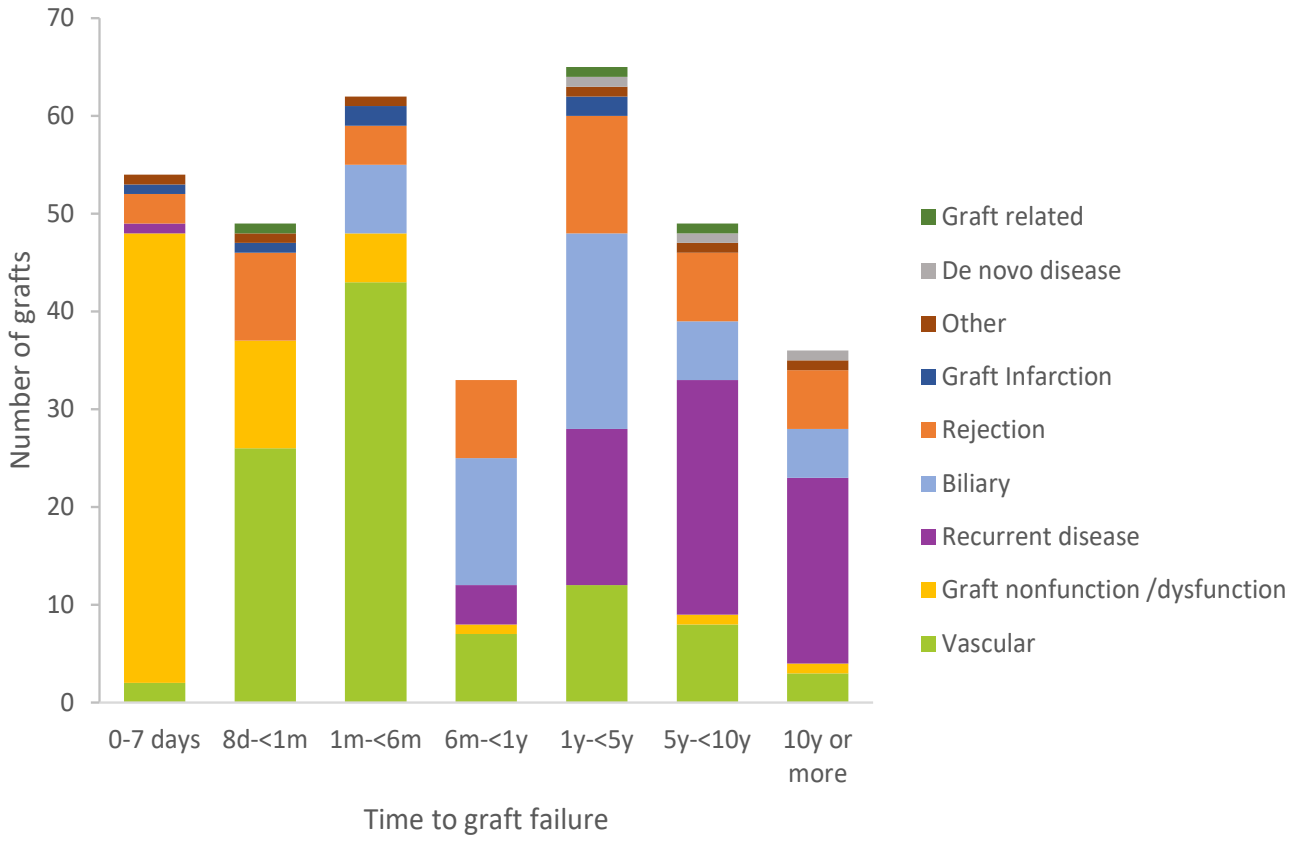
There were 348 retransplants following adult graft failure. There have been 318 second grafts, 28 third grafts and two fourth grafts. The commonest indications for retransplantation were vascular (29.0%), primary non-function or initial poor function (18.7%) and disease recurrence (18.4%, Table 53).

Table 53. Reason for retransplantation following adult graft failure

Reason for retransplantation	Graft 2	Graft 3	Graft 4	All grafts	% total
Vascular	**93**	**8**	0	**101**	**29%**
Hepatic artery thrombosis	*75*	*6*	0	*81*	*23%*
Haemorrhage (hepatic artery)	*4*	0	0	*4*	*1%*
Hepatic vein thrombosis	*4*	0	0	*4*	*1%*
Portal vein thrombosis	*3*	0	0	*3*	*0.9%*
Hepatic artery pseudoaneurysm	*2*	0	0	*2*	*0.6%*
Hepatic artery stenosis	*2*	0	0	*2*	*0.6%*
Unspecified	*2*	0	0	*2*	*0.6%*
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%*
Primary graft nonfunction /dysfunction	**58**	**7**	0	**65**	**19%**
Primary nonfunction (ReTx or death <= 7 days)	*46*	*5*	0	*51*	*15%*
Primary dysfunction (ReTx or death > 7 days)	*12*	*2*	0	*14*	*4%*
Recurrent disease	**58**	**6**	0	**64**	**18%**
Primary sclerosing cholangitis	*22*	*5*	0	*27*	*8%*
Hepatitis C	*22*	0	0	*22*	*6%*
Autoimmune hepatitis	*5*	0	0	*5*	*1%*
Primary biliary cirrhosis	*4*	*1*	0	*5*	*1%*
Hepatitis B	*4*	0	0	*4*	*1%*
Erythropoietic protoporphyria	*1*	0	0	*1*	*0.3%*
Biliary	**49**	**2**	0	**51**	**15%**
Cholangiopathy	*39*	*1*	0	*40*	*11%*
Cholestatic disease	*3*	0	0	*3*	*0.9%*
Ischaemic biliopathy	*2*	*1*	0	*3*	*0.9%*
Anastomotic	*2*	0	0	*2*	*0.6%*
Biliary cirrhosis / fibrosis	*2*	0	0	*2*	*0.6%*
Cholangitis	*1*	0	0	*1*	*0.3%*
Rejection	**46**	**2**	**1**	**49**	**14%**
Chronic rejection	*24*	*2*	0	*26*	*7%*
Acute rejection	*15*	0	*1*	*16*	*5%*
ABO incompatible	*4*	0	0	*4*	*1%*
Hyperacute rejection	*2*	0	0	*2*	*0.6%*
Donor antibody mediated	*1*	0	0	*1*	*0.3%*
Graft Infarction	**5**	0	**1**	**6**	**2%**
Non thrombotic	*3*	0	*1*	*4*	*1%*
Thrombotic	*2*	0	0	*2*	*0.6%*
Other	**5**	**1**	0	**6**	**2%**
Unspecified	*2*	*1*	0	*3*	*0.9%*
Donor derived malignancy	*2*	0	0	*2*	*0.6%*
Acute hepatic failure - Drug related: interferon	*1*	0	0	*1*	*0.3%*
De novo disease	**3**	0	0	**3**	**0.9%**
Hepatitis B	*1*	0	0	*1*	*0.3%*
Hepatitis C	*1*	0	0	*1*	*0.3%*
Hepatitis D	*1*	0	0	*1*	*0.3%*
Graft related	**1**	**2**	0	**3**	**0.9%**
Post necrotic cirrhosis	0	*2*	0	*2*	*0.6%*
Nodular regenerative hyperplasia	*1*	0	0	*1*	*0.3%*
Total	**318**	**28**	**2**	**348**	

Forty-seven percent of graft failures occurred within the first six months' post-transplant (15.5% 0 – 7 days, 14.1% day 8 to less than 1 month, 17.8% 1 month to less than 6 months). Primary graft non-function was the main reason for retransplantation in the first 7 days post-transplant whilst vascular causes were the main type between 8 days and less than 6 months (Figure 69). Recurrent disease was the leading cause of graft failure after five years post-transplant.

Figure 69. Adult time to graft failure by reason for retransplantation

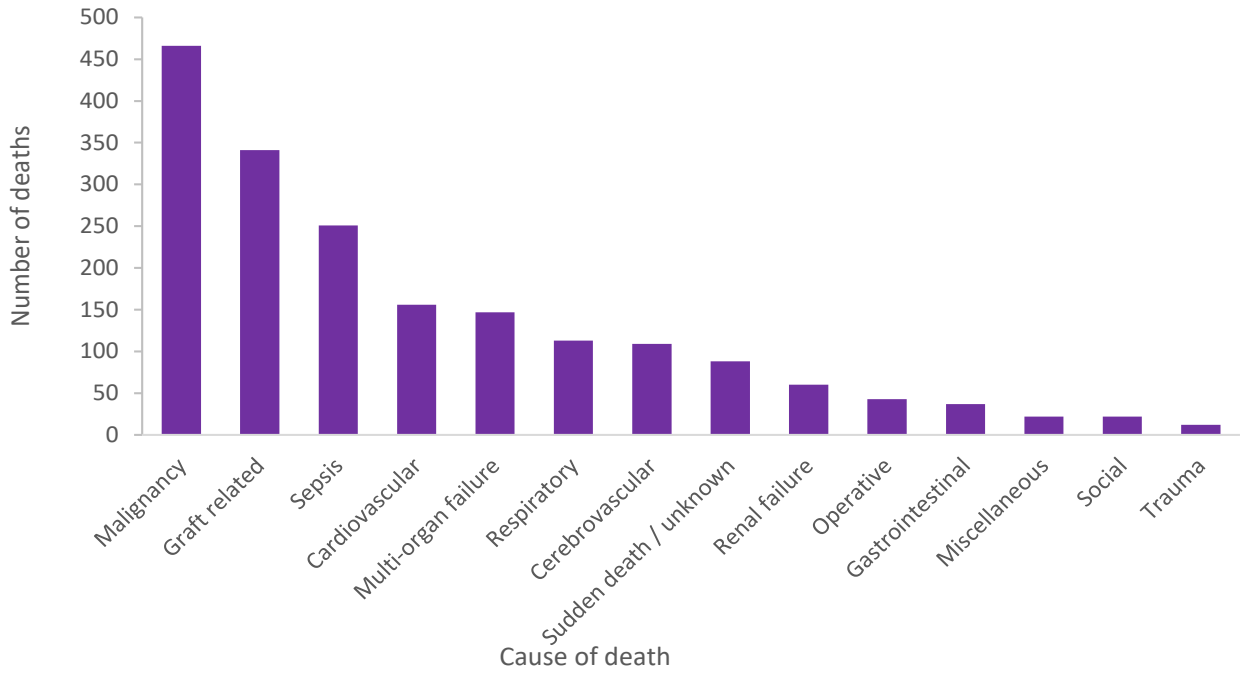


14 Cause of Patient Death

14.1 Cause of Death – All Patients

1,867 liver transplant patients (181 children and 1,686 adults based on age at first transplant) have died. The commonest causes of death were malignancy (25.0%), graft-related causes (18.3%), sepsis (13.4%), cardiovascular disease (8.4%) and multi-organ failure (7.9%, Figure 70).

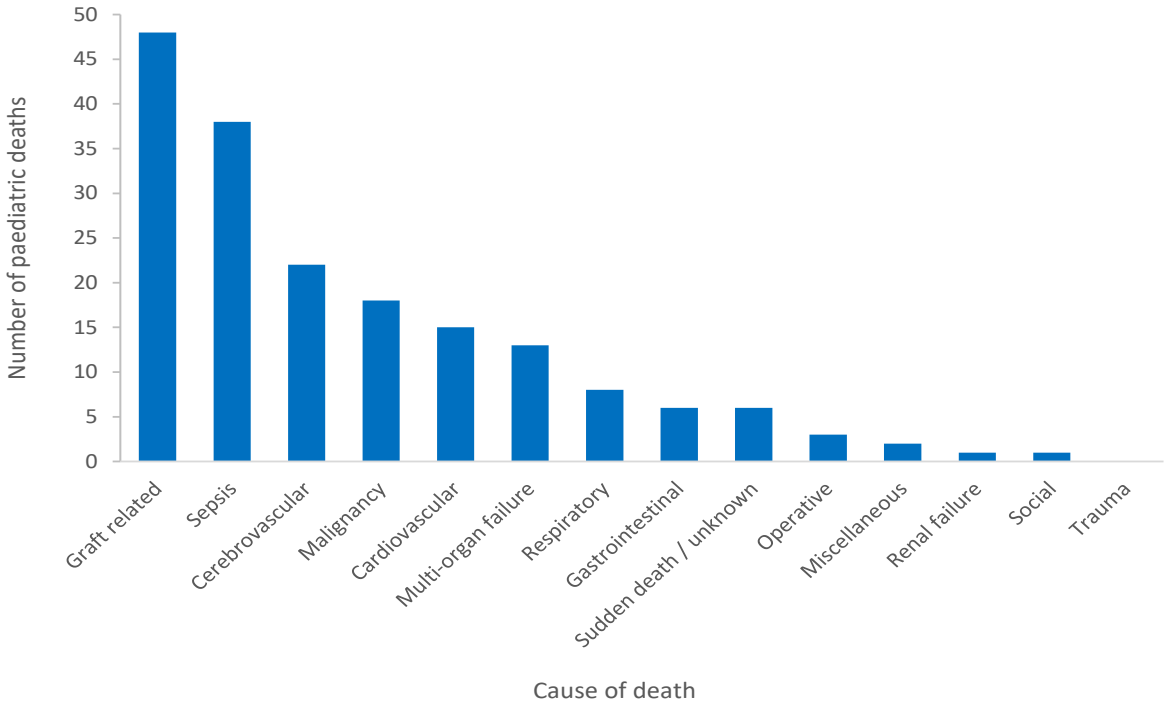
Figure 70. Cause of death by categories



14.2 Paediatric Patients - Cause of Death

Graft-related causes (26.5%) are the leading cause of death in children, with sepsis being the cause of death in a further 21.0% of paediatric patients (Figure 71).

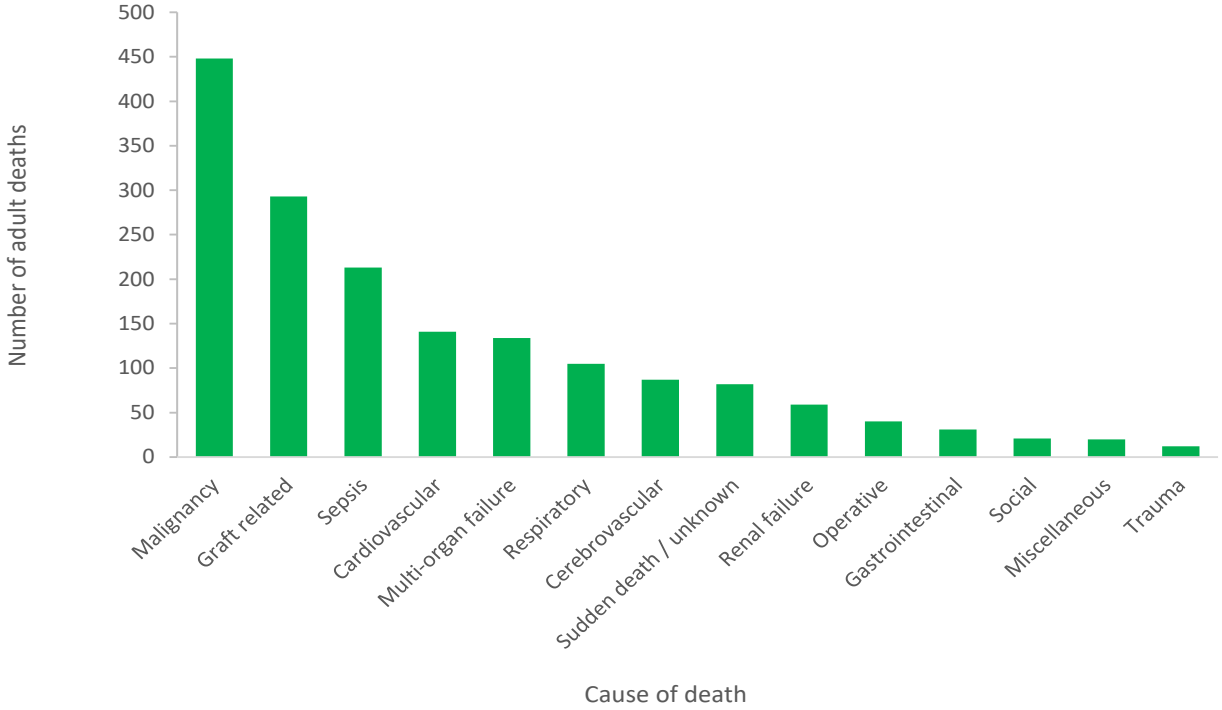
Figure 71. Paediatric cause of death



14.3 Adult Patients – Cause of Death

Malignancy (26.6% total: de novo malignancy 14.5%; recurrent malignancy 11.9%; donor transmitted malignancy 0.1%) is the most frequent cause of death in adult patients. Graft-related causes (17.4%) and sepsis (12.6%) are the next largest categories of adult deaths (Figure 72).

Figure 72. Adult cause of death



14.4 Cause of Death Types by Age Group

Table 54. Cause of death by age group

Cause of death	Children	Adults	Total deaths	% of all deaths
Malignancy	**18**	**448**	**466**	**25%**
- De novo malignancy	11	244	255	14%
- Recurrent malignancy	7	202	209	11%
- Donor transmitted malignancy	0	2	2	0.1%
Graft related	**48**	**293**	**341**	**18%**
Other graft related	37	128	165	9%
- Rejection	*17*	*72*	*89*	*5%*
- Primary non-function / dysfunction	*5*	*20*	*25*	*1%*
- Biliary complications	*3*	*16*	*19*	*1%*
- Graft vs host disease	*0*	*10*	*10*	*0.5%*
- Hepatitis	*4*	*0*	*4*	*0.2%*
- Late graft failure	*0*	*4*	*4*	*0.2%*
- Massive haemorrhagic necrosis	*4*	*0*	*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%*
- Outflow obstruction	*1*	*0*	*1*	*0.05%*
- Portopulmonary hypertension	*0*	*1*	*1*	*0.05%*
- Post necrotic cirrhosis	*1*	*0*	*1*	*0.05%*
Disease recurrence	0	145	145	8%
- Alcoholic cirrhosis	*0*	*12*	*12*	*1%*
- Autoimmune hepatitis	*0*	*4*	*4*	*0%*
- Erythropoietic protoporphyria	*0*	*1*	*1*	*0.1%*
- Hepatitis B	*0*	*18*	*18*	*1.0%*
- Hepatitis C	*0*	*95*	*95*	*5%*
- NASH	*0*	*2*	*2*	*0.1%*
- Primary biliary cirrhosis	*0*	*3*	*3*	*0.2%*
- Primary sclerosing cholangitis	*0*	*8*	*8*	*0.4%*
- Progressive familial amyloid polyneuropathy	*0*	*2*	*2*	*0.1%*
Vascular complications	11	20	31	2%
- Hepatic artery thrombosis	4	9	13	*1%*
- Portal vein thrombosis	2	10	12	*1%*
- Non-thrombotic infarction	3	1	4	*0.2%*
- Hepatic vein thrombosis	2	0	2	*0.1%*
Sepsis	**38**	**213**	**251**	**13%**
- Bacterial	14	83	97	5%
- Fungal	7	43	50	3%
- Unspecified infection	6	44	50	3%
- Mixed	5	25	30	2%
- Viral	6	18	24	1%
Cardiovascular	**15**	**141**	**156**	**8%**
Multi-organ failure	**13**	**134**	**147**	**8%**
Respiratory	**8**	**105**	**113**	**6%**
Cerebrovascular	**22**	**87**	**109**	**6%**
Sudden death / unknown	**6**	**82**	**88**	**5%**
Renal failure	**1**	**59**	**60**	**3%**
Operative	**3**	**40**	**43**	**2%**
Gastrointestinal	**6**	**31**	**37**	**2%**
Miscellaneous	**2**	**20**	**22**	**1%**
- Neurological	0	6	6	0.3%
- Haematological	1	3	4	0.2%
- Dementia	0	3	3	0.2%
- Metabolic	1	2	3	0.2%
- Old age	0	3	3	0.2%

(table continued on next page)

Cause of death	Children	Adults	Total deaths	% of all deaths
- Allergy		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	8	8	0.4%
- Suicide	0	7	7	0.4%
- Overdose / Substance abuse	0	4	4	0.2%
- Non-compliance immunosupportive therapy	1	2	3	0.2%
Trauma	**0**	**12**	**12**	**1%**
- Motor vehicle accident	0	7	7	0.4%
- Other accident excluding MVA	0	3	3	0.2%
- Homicide	0	2	2	0.1%
Total	**181**	**1686**	**1867**	

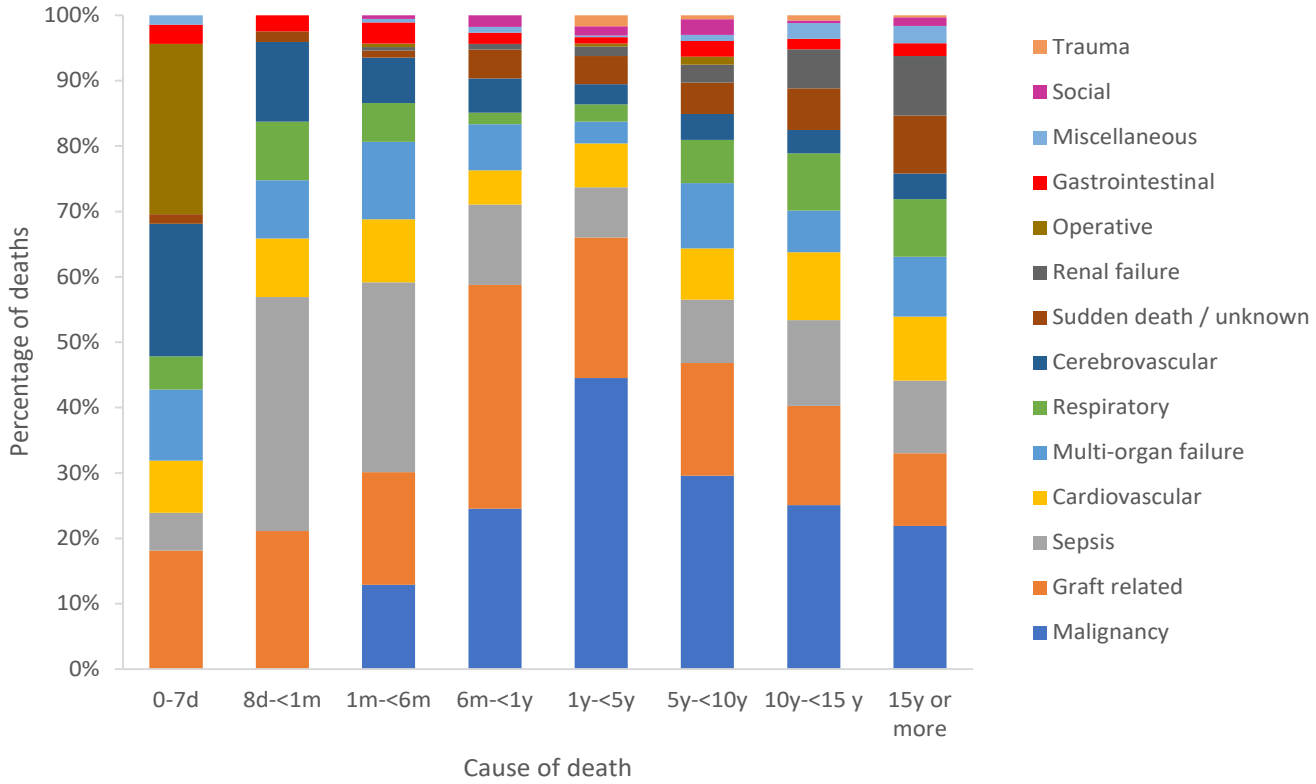
Abbreviation: NASH, non-alcoholic steatohepatitis; OTC, Ornithine transcarbamylase

14.5 Cause of Death by Time to Death

Just under one third of post-transplant deaths occurred within the first year of transplant (7.4% In the first 7 days, 6.6% from day 8 to the end of the first month and 16.1% after the first month and before the end of the first year), a little more than one third between 1 and 10 years (22.4% between years 1 and 5 and 17.7% between years 5 and 10) and just under one third (29.8%) after 10 years.

The cause of death profile changes over the different post-transplant time periods (Figure 73). 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 73. Cause of death by time to death post-transplant – all patients

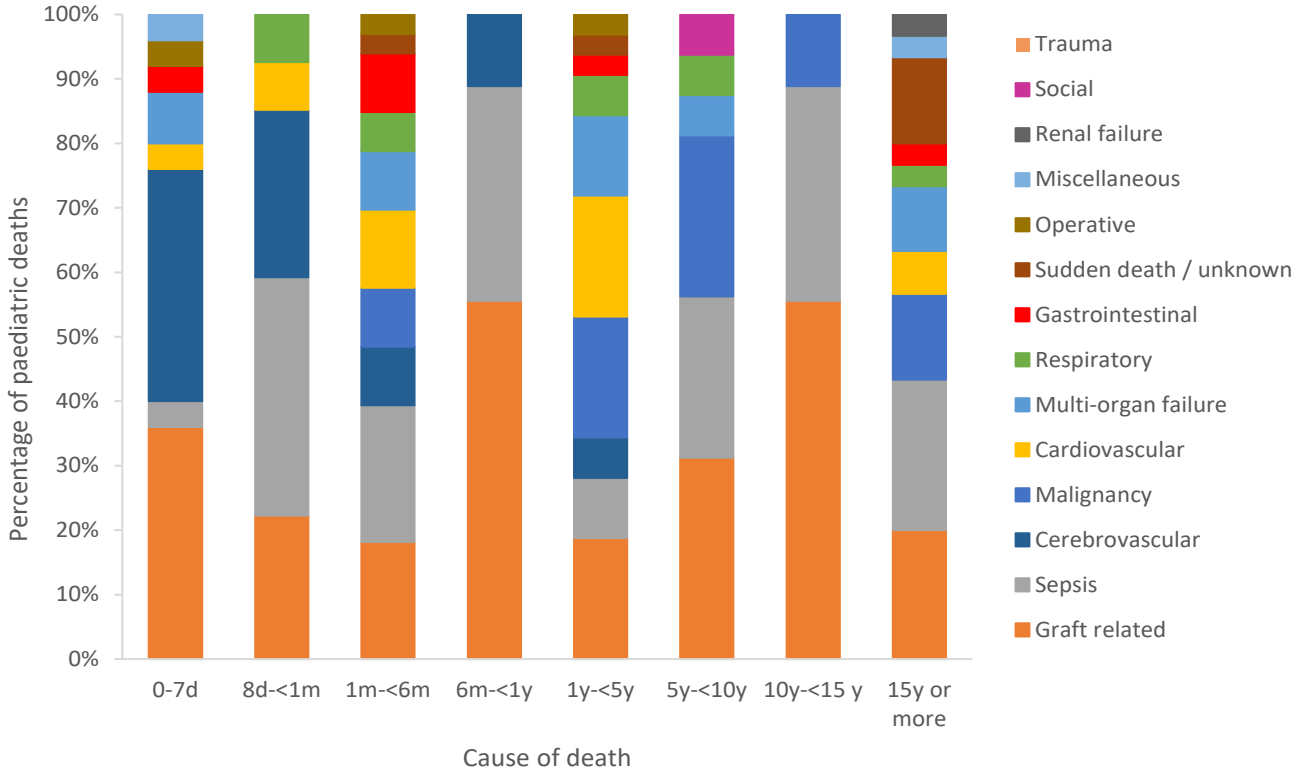


14.6 Paediatric Cause of Death by Time to Death

In children, 51.9% of deaths occurred within the first year of transplant (13.8% in the first 7 days, 14.9% from day 8 to the end of the first month and 23.2% after the first month and before the end of the first year), 17.7% between years 1 and 5, 8.8% between years 5 and 10 and 21.6% after 10 years.

Cerebrovascular and graft-related causes of death predominated in the first week post-transplant (Figure 74). 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 74. Paediatric cause of death by time to death post-transplant

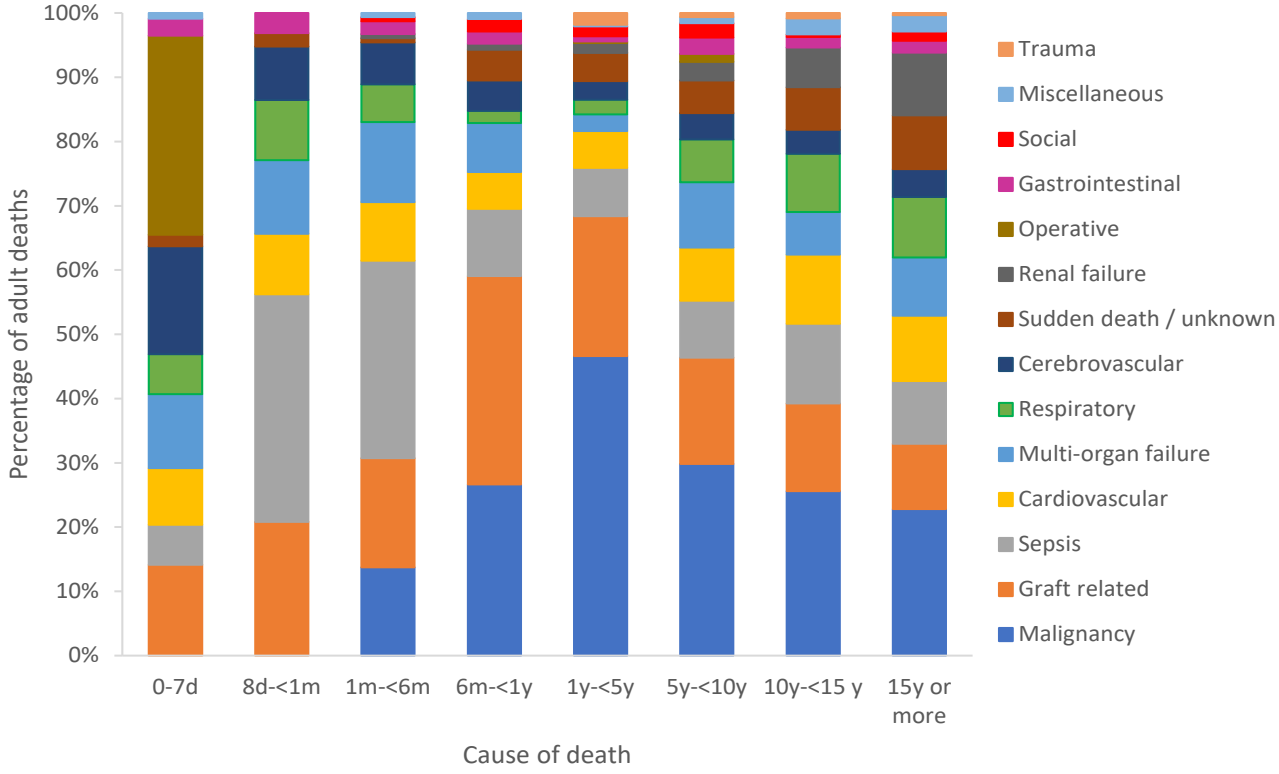


14.7 Adult Cause of Death by Time to Death

In adults, 27.7% of deaths occurred within the first year of transplant (6.7% in the first 7 days, 5.7% from day 8 to the end of the first month and 15.3% after the first month and before the end of the first year), 22.9% between years 1 and 5, 18.7% between years 5 and 10 and 30.8% after 10 years.

Operative, cerebrovascular and graft-related causes and multi-organ failure were prominent in the first week post-transplant (Figure 75). Sepsis was the predominant cause from 8 days to 6 months and malignancy and graft related causes from 6 months.

Figure 75. 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) 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, 1624 (25%) patients were transplanted with a liver malignancy, 659 (10%) as a primary diagnosis and 968 (15%) as a secondary diagnosis or incidental tumour (Table 55). Three patients had liver cancer types as their primary and secondary diagnosis. Another five patients had two secondary or incidental liver cancers.

Table 55. Cancer in liver transplant recipients

	Number patients		% all transplant patients (n = 6,428)
At Transplant			
Liver cancer as indication for transplant	659		10%
Liver cancer as a secondary/incidental diagnosis#	968	(973 cancers)	15%
Total unique liver cancer patients*	**1,624**		**25%**
Post-transplant			
Recurrent liver cancer	184		3%
De novo non-skin cancer	518	(560 cancers)	8%
Skin cancer	968	(5,308 cancers)	15%
Total	**1,670**		**26%**
Multiple non-skin cancers	**150**		**2%**
Developed non-skin cancer < 90 days	**10**		**0.2%**

5 patients had 2 cancer types

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

Post-transplant 184 (11%) patients with a primary, secondary, or incidental diagnosis of liver cancer developed a recurrent cancer and in 183 of these (11% of liver cancer patients and 99% of patients with recurrent liver cancer), death was related to their initial cancer. There were 518 patients (8% of all transplant recipients) who developed one or more de novo non-skin cancer types (560 cancer types). A total of 150 (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 659 (10%) liver transplant recipients. Eighty-five of these (13%) developed a recurrence of their primary tumour causing death.

Hepatocellular cancer was the most common type of liver cancer as a primary diagnosis (89.7%, Table 56). Whilst 22% of patients with hepatocellular carcinoma as a primary diagnosis have died, only 11% died as a result of this cancer.

Table 56. 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	591	89.7%	131	22%	67	11%
Hepatoblastoma	34	5.2%	5	15%	4	12%
Cholangiocarcinoma	12	1.8%	3	25%	2	17%
Fibrolamellar	5	0.8%	5	100%	2	40%
Epithelioid haemangioendothelioma	8	1.2%	2	25%	2	25%
Carcinoid	4	0.6%	4	100%	4	100%
Hepatocellular malignant neoplasm	2	0.3%	1	50%	1	50%
Angiosarcoma	1	0.2%	1	100%	1	100%
Gastrinoma	1	0.2%	1	100%	1	100%
Pancreatic islet cell	1	0%	1	100%	1	100%
Total primary liver cancers	659		154		85	
Percentage all liver transplant patients (n = 6,428)	10%		2%		1%	
Percentage primary liver cancer patients (n = 659)			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 68% (Figure 76, Table 57).

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

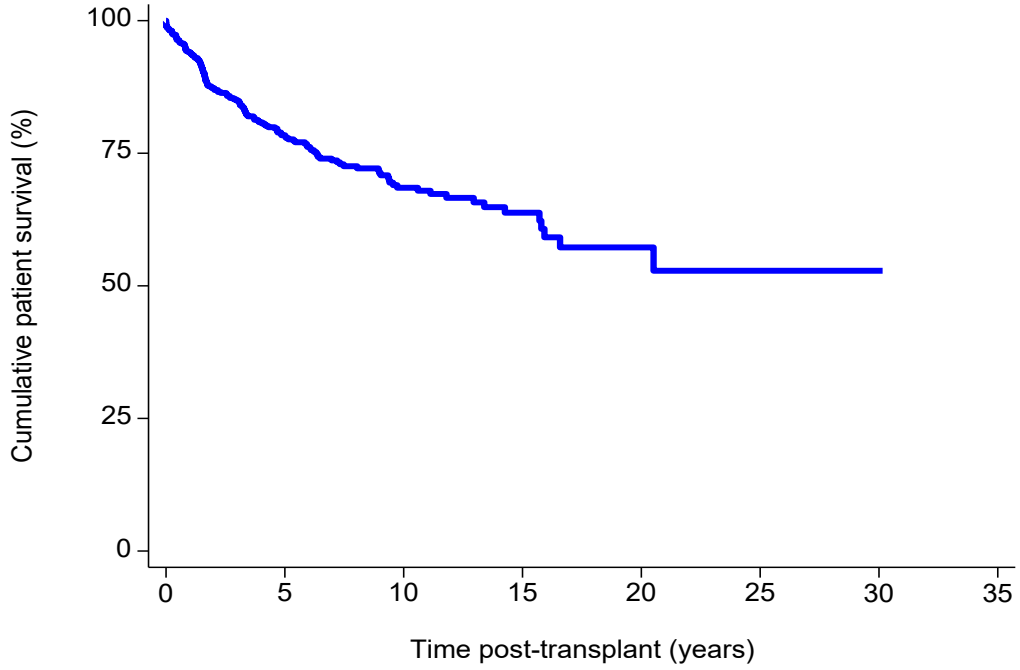
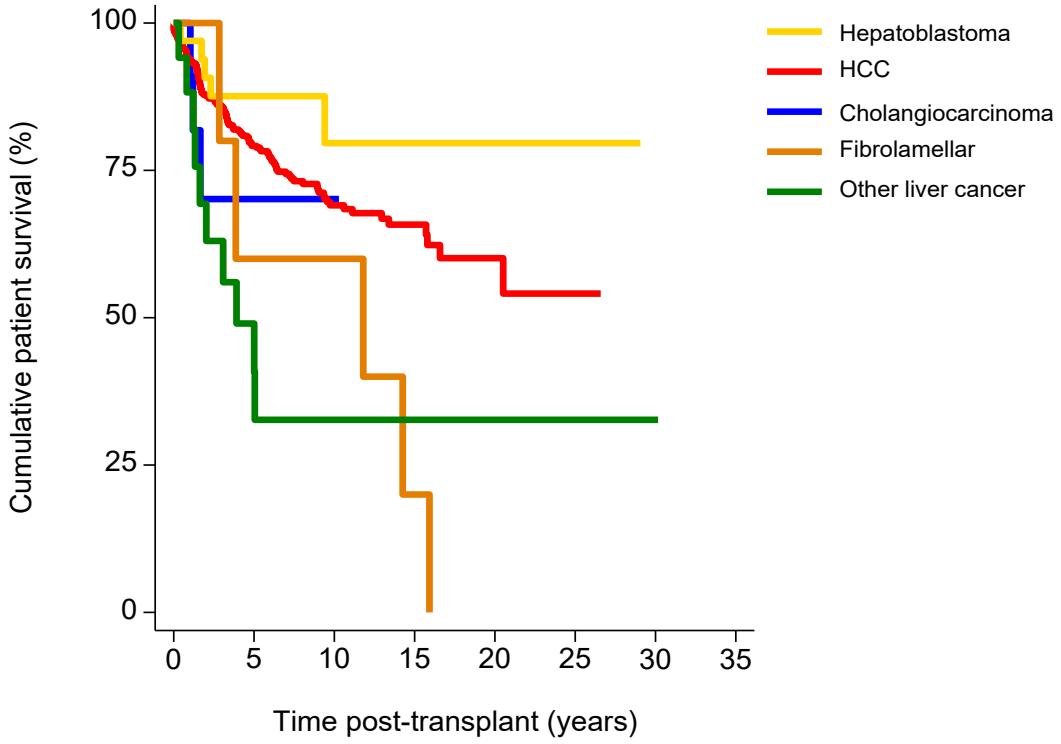


Table 57. Patient survival for patients with a primary diagnosis of liver cancer

Patient Survival	Time post-transplant (years)							
	0	1	5	10	15	20	25	30
No. at risk	659	583	306	138	50	14	5	2
Survival (%)		94%	78%	68%	64%	57%	53%	53%

There was a significant difference in patient survival between patients with different liver cancers as a primary diagnosis (P<0.0001). Ten-year patient survival for those with hepatoblastoma, cholangiocarcinoma, hepatocellular carcinoma, fibrolamellar variant and other liver cancers was 80%, 70%, 68%, 60% and 33% respectively (Figure 77, Table 58).

Figure 77. 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

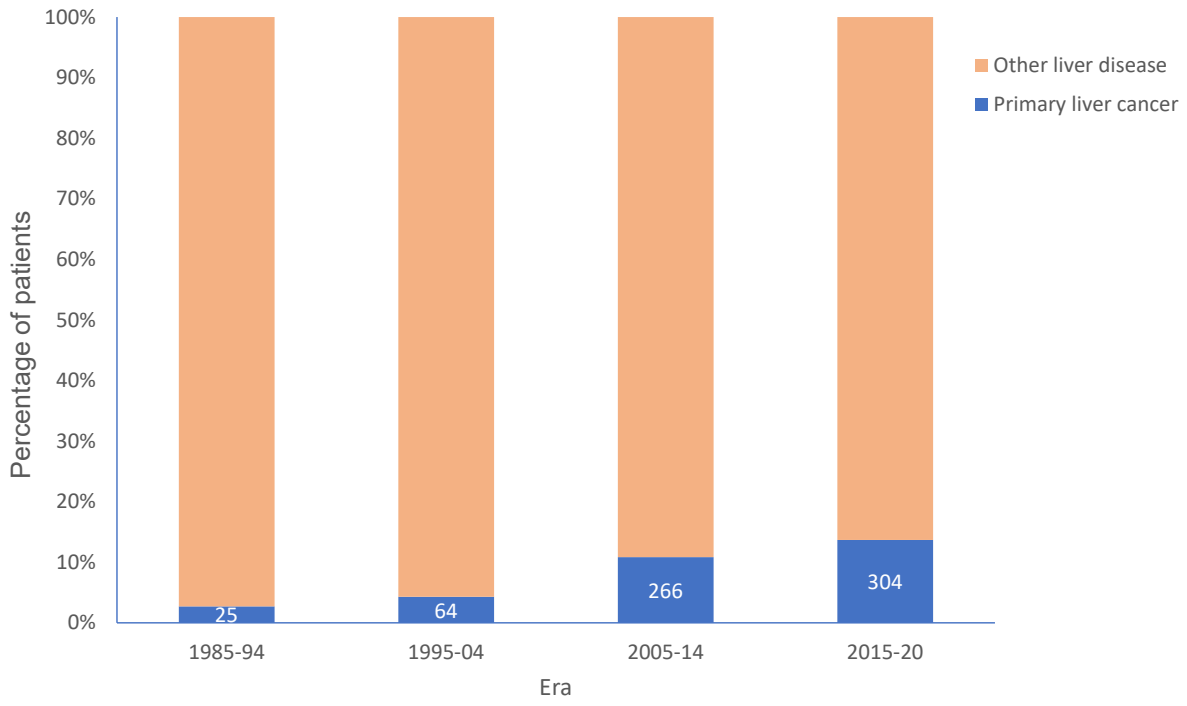
Table 58. Patient survival for patients with a primary diagnosis of liver cancer by type of cancer

Cancer type	Patient Survival	Time post-transplant (years)							
		0	1	5	10	15	20	25	30
Hepatoblastoma	No. at risk	34	33	22	11	3	3	2	1
	Survival (%)		97%	88%	80%	80%	80%	80%	
Hepatocellular carcinoma	No. at risk	591	520	275	122	46	11	3	1
	Survival (%)		94%	78%	68%	66%	61%	54%	
Cholangiocarcinoma	No. at risk	12	12	2	2	1	1	1	1
	Survival (%)		100%	100%	70%	70%			
Fibrolamellar	No. at risk	5	5	4	4	2	1	1	1
	Survival (%)		100%	60%	60%	20%			
Other liver cancer	No. at risk	17	16	7	3	2	2	2	2
	Survival (%)		88%	49%	33%	33%	33%	33%	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 25 in the 1985 - 94 era to 304 in the 2015 - 20 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 2015 - 20 era (Figure 78).

Figure 78. 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

968 patients with 973 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 59). Whilst 26% of patients with hepatocellular carcinoma as a secondary / incidental diagnosis have died, only 8% died as a result of this cancer.

Table 59. 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*	912	93.7%	234	26%	72	8%
Cholangiocarcinoma*	48	4.9%	35	73%	23	48%
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	973		275		97	
Percentage all liver transplant patients (n = 6,428)		15%		4%		2%
Percentage liver cancer patients as a secondary / incidental diagnosis (n = 968)				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 68% (Figure 79, Table 60). The median survival was 16 years.

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

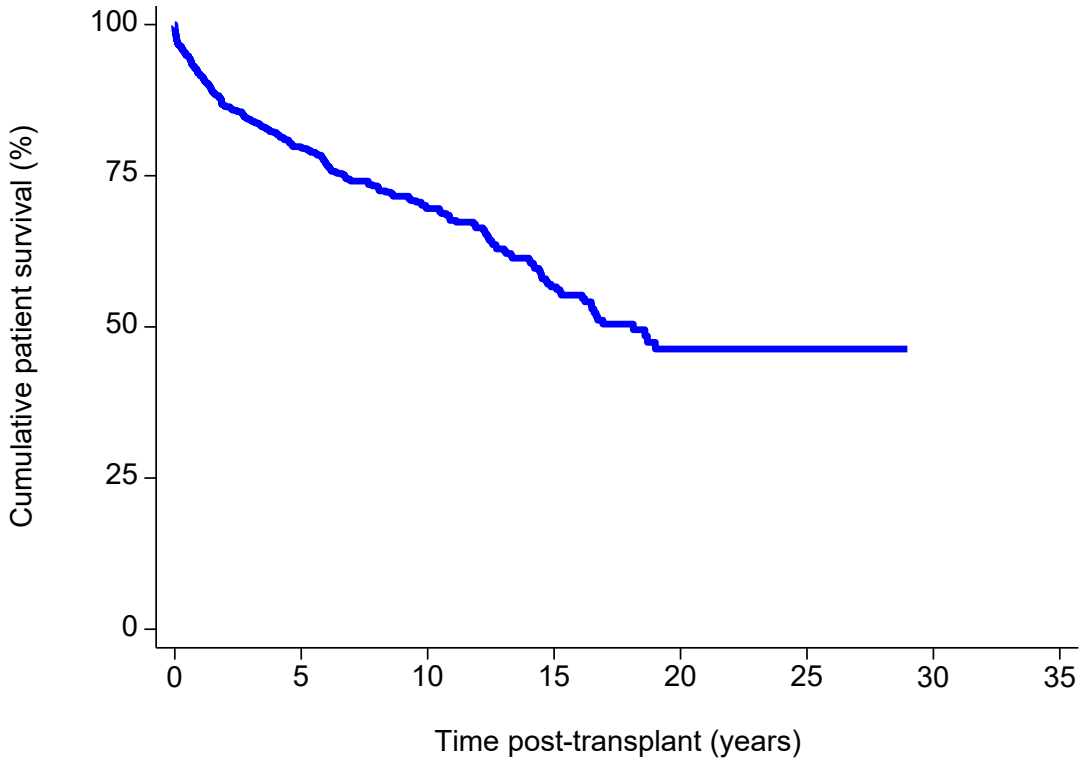
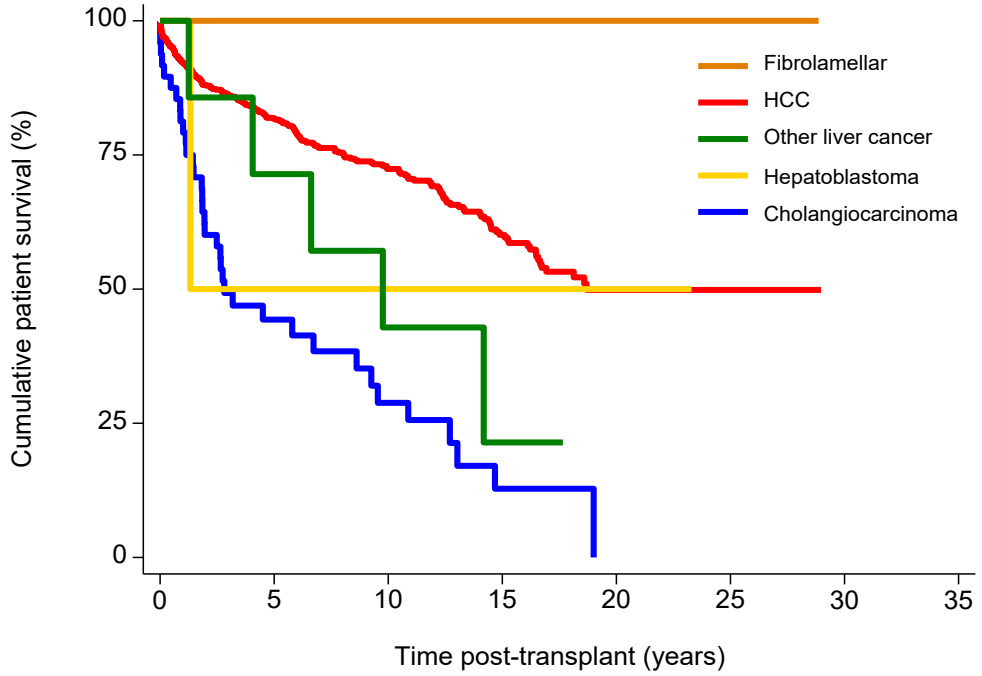


Table 60. Patient survival for patients with a secondary / incidental diagnosis of liver cancer

Patient Survival	Time post-transplant (years)							
	0	1	5	10	15	20	25	30
No. at risk	968	583	306	138	50	14	5	2
Survival (%)		94%	78%	68%	64%	57%	53%	53%

There was a significant difference in survival between patients with different liver cancers as a secondary / incidental diagnosis (P<0.0001, Figure 80, Table 61). Ten-year patient survival for those with a secondary diagnosis of fibrolamellar variant, hepatocellular carcinoma, hepatoblastoma, other liver cancers and cholangiocarcinoma was 100%, 72%, 50%, 43% and 29% respectively.

Figure 80. 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 61. 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
Fibrolamellar	No at risk	4	4	4	4	2	2	2	1
	Survival %		100%	100%	100%	100%	100%	100%	
Hepatocellular carcinoma	No at risk	912	788	500	245	121	31	5	1
	Survival %		92%	82%	72%	60%	50%	50%	
Other liver cancer	No at risk	7	7	6	4	2	1	1	1
	Survival %		100%	71%	43%	21%			
Hepatoblastoma	No at risk	2	2	2	2	2	2	1	1
	Survival %		100%	50%	50%	50%	50%		
Cholangiocarcinoma	No at risk	48	40	18	10	4	1	1	1
	Survival %		81%	44%	29%	13%			

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

Of 6,428 transplanted patients, 1,624 (25%) patients had 1,673 liver cancers as a primary or secondary/incidental diagnosis (Table 62). Three patients had two liver cancer types as their primary and secondary diagnoses. Five patients had two liver cancers as secondary/incidental diagnoses.

Table 62. 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*	1,503	92.1%	365	24%	139	9%
Cholangiocarcinoma*	60	3.7%	38	63%	25	42%
Hepatoblastoma*	36	2.2%	6	17%	4	11%
Fibrolamellar	9	0.6%	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%
Erythroid leukaemia	1	0.1%	1	100%	1	100%
Total liver cancers*	1,632		430		183	
Percentage all liver transplant patients (n=6,428)		25%		9%		4%
Percentage all liver cancer patients (n=1,624)				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, 4,804 had benign liver disease and 1,624 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 77% and 27 years, compared to 69% and 19 years for those with liver malignancy (Figure 81, Table 63).

Figure 81. Patient survival – pretransplant benign disease versus pretransplant liver malignancy

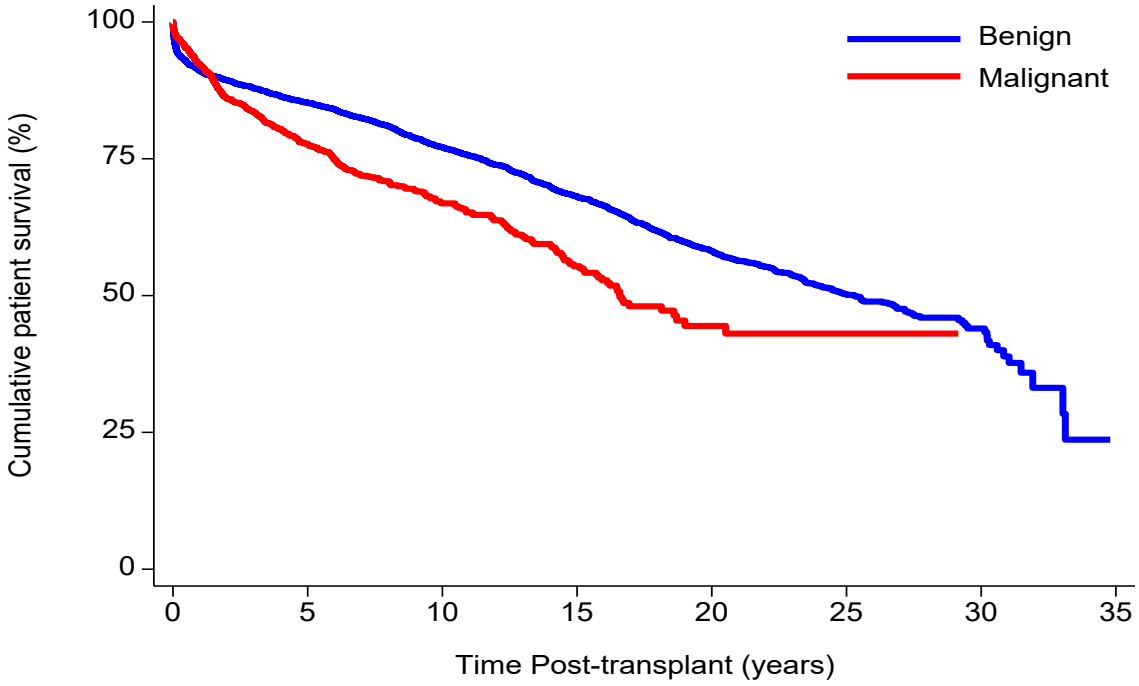


Table 63. Patient survival – pretransplant benign disease versus pretransplant liver malignancy

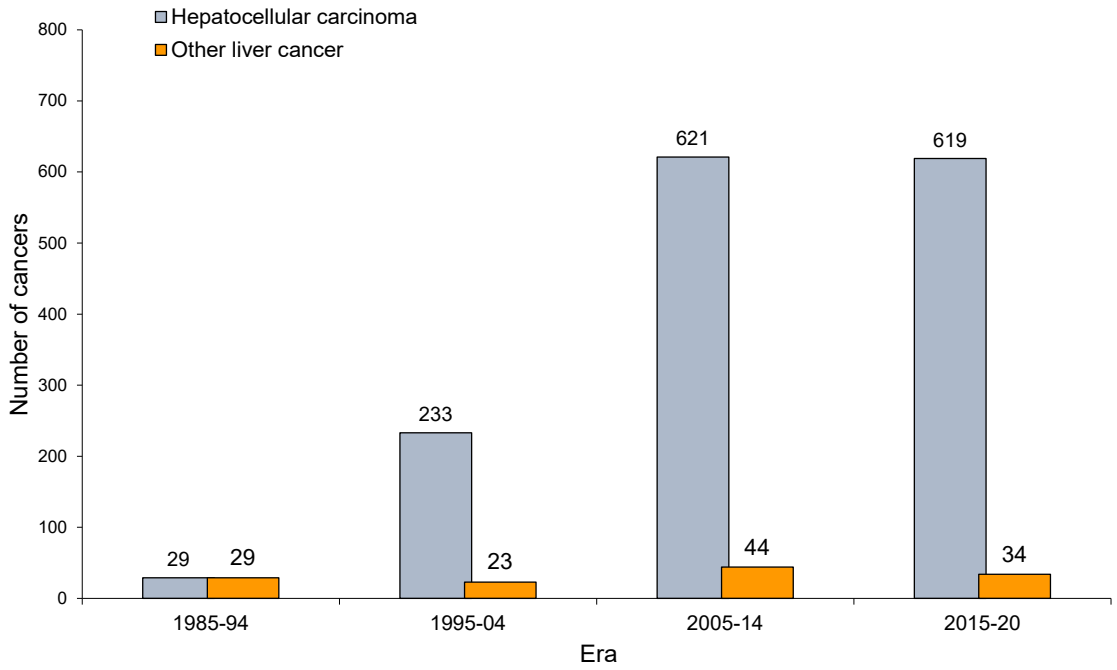
Cancer type	Patient Survival	Time post-transplant (years)								
		0	1	5	10	15	20	25	30	35
Benign	No at risk	4,804	3,937	2,948	2,009	1,279	698	319	70	1
	Survival %		91%	85%	77%	68%	58%	50%	44%	
Malignant	No at risk	1,624	1,311	735	355	146	37	8	1	0
	Survival %		93%	79%	69%	58%	47%	46%		

15.6 Hepatocellular Carcinoma Diagnosis Versus Other Liver Cancers at Transplantation

15.6.1 Hepatocellular Carcinoma Versus Other Liver Cancers at Transplantation by Era

1502 (23%) patients were transplanted with hepatocellular carcinoma as a primary, secondary, or incidental diagnosis. The incidence of hepatocellular carcinoma has increased over the years (Figure 82).

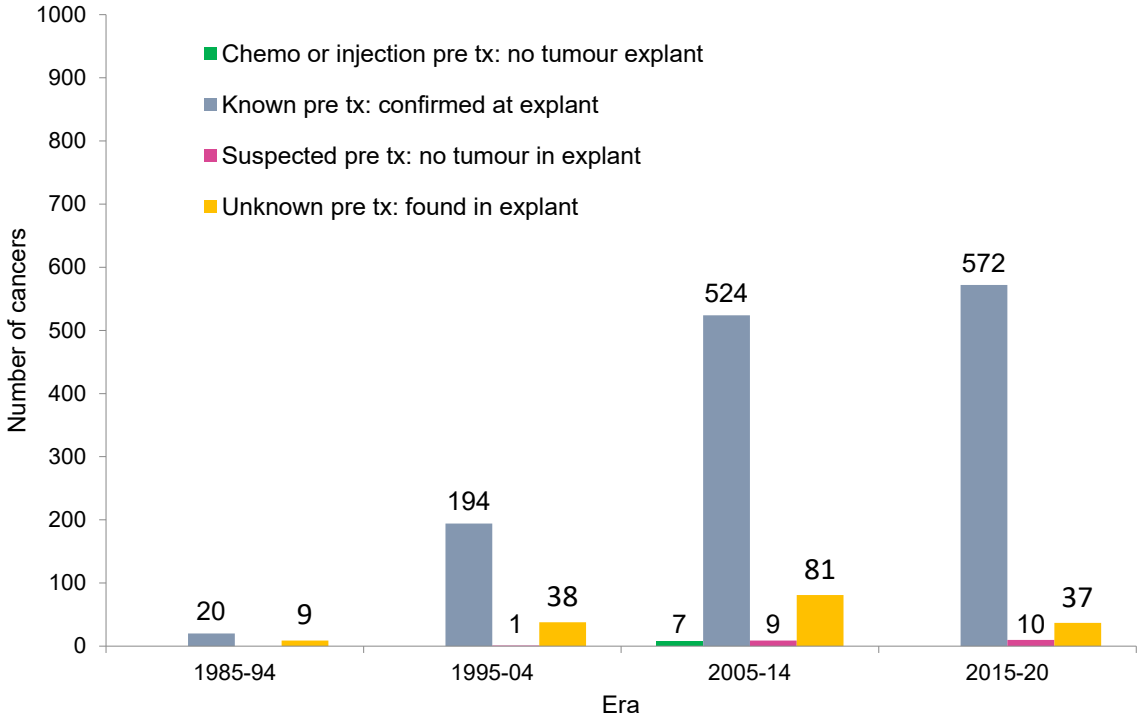
Figure 82. Hepatocellular carcinoma versus other liver cancers at transplantation by era



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) resulting in 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 214 patients. The number of patients transplanted with known HCC has increased over the eras (Figure 83).

Figure 83. Hepatocellular carcinoma status at transplant by era



15.6.3 Patient Survival of 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 84, Table 64). Median survival between 1985 - 94 and 1995 - 2004 was 3 years and 18 years respectively and not reached in the 2005 - 14 and 2015 - 20 eras.

Figure 84. Patient survival of hepatocellular carcinoma by era

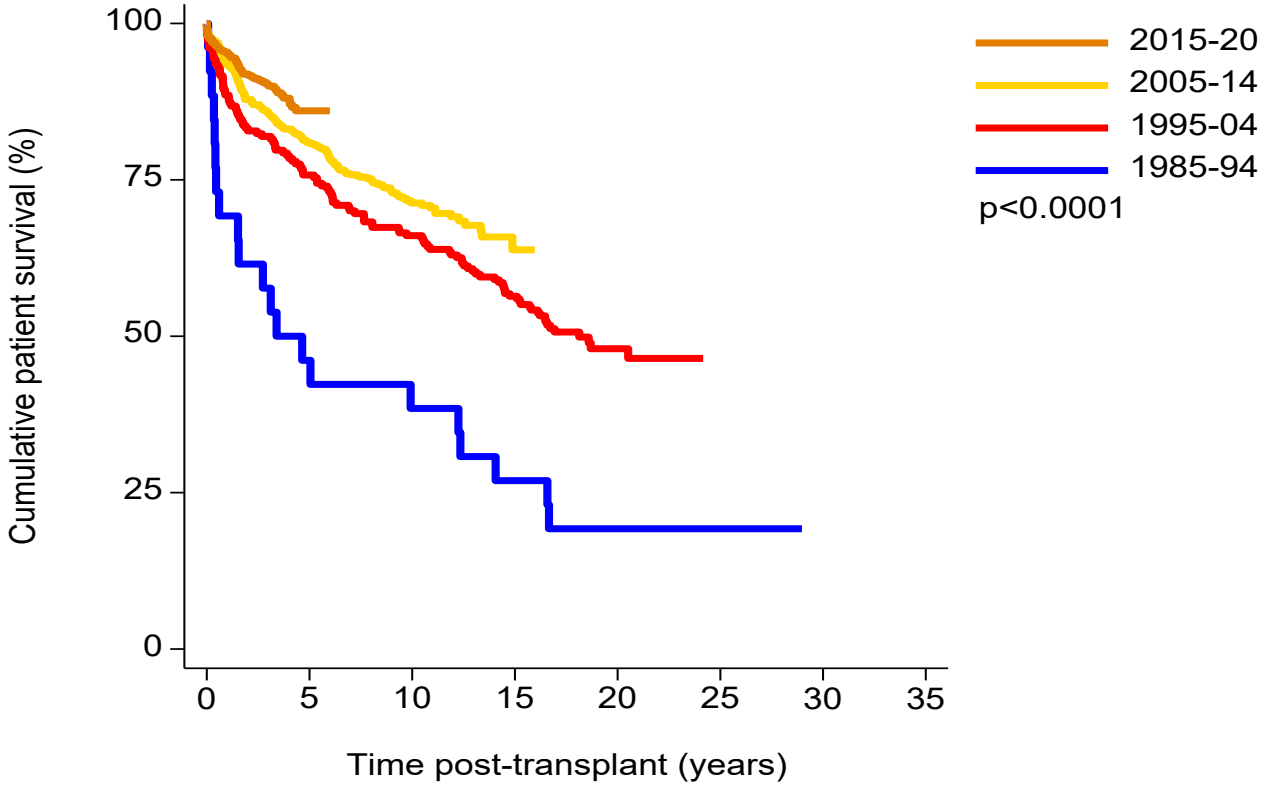


Table 64. Patient survival of hepatocellular carcinoma by era

Era of Transplant	Patient Survival	Time post-transplant (years)							
		0	1	5	10	15	20	25	30
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	1
	Survival %		89%	76%	66%	56%	48%		
2005 - 2014	No at risk	621	577	499	204	29	1	1	1
	Survival %		94%	81%	71%	64%			
2015- 2020	No at risk	619	502	89	1	1	1	1	1
	Survival %		95%	86%					

15.6.4 Patient Survival of 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=0.431, Figure 85, Table 65). Ten-year patient survival was 72% when there was known hepatocellular carcinoma and 68% when the hepatocellular carcinoma was not known pretransplant. Median survival for patients with hepatocellular carcinoma unknown pretransplant was 17 years and not reached where known pretransplant. Median time from first transplant to development of a non-skin cancer post-transplant ranged from 23 to 125 months.

Figure 85. Patient survival of hepatocellular carcinoma status at transplant

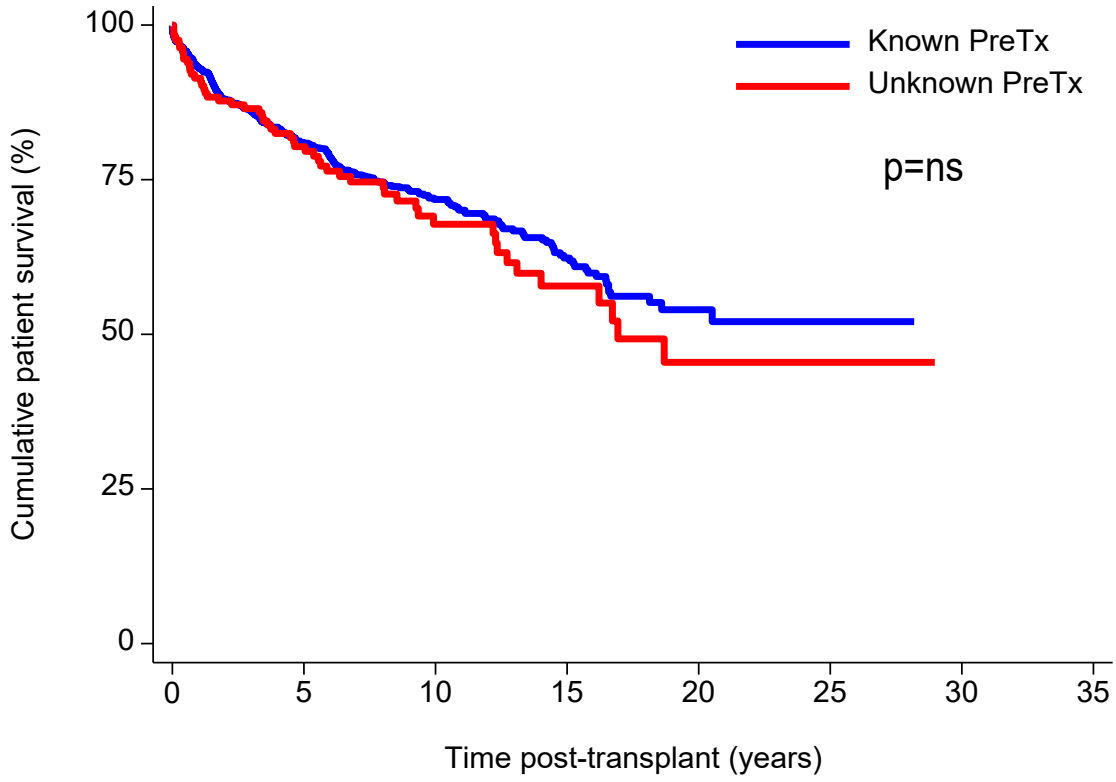


Table 65. Patient survival of hepatocellular carcinoma status at transplant

HCC Category	Patient Survival	Time post-transplant (years)							
		0	1	5	10	15	20	25	30
Known pretransplant	No at risk	1,311	1,157	669	315	140	31	6	1
	Survival %		93%	81%	72%	62%	54%	52%	
Unknown pretransplant	No at risk	165	150	108	52	27	11	2	1
	Survival %		91%	80%	68%	58%	45%	45%	

Note: 27 patients that were excluded from this analysis as suspected or treated HCC, not confirmed HCC, prior to transplant

15.7 De Novo Non-Skin Cancer

15.7.1 De Novo Non-Skin Cancer Types

Five hundred and eighteen patients (8%) developed 560 de novo non-skin cancers post-transplant with 37 patients developing more than one non-skin cancer type (Table 66). Of 560 cancers, 242 (43%) died of this cancer type. Median time from first transplant to development of a non-skin cancer post-transplant ranged from 23 to 104 months.

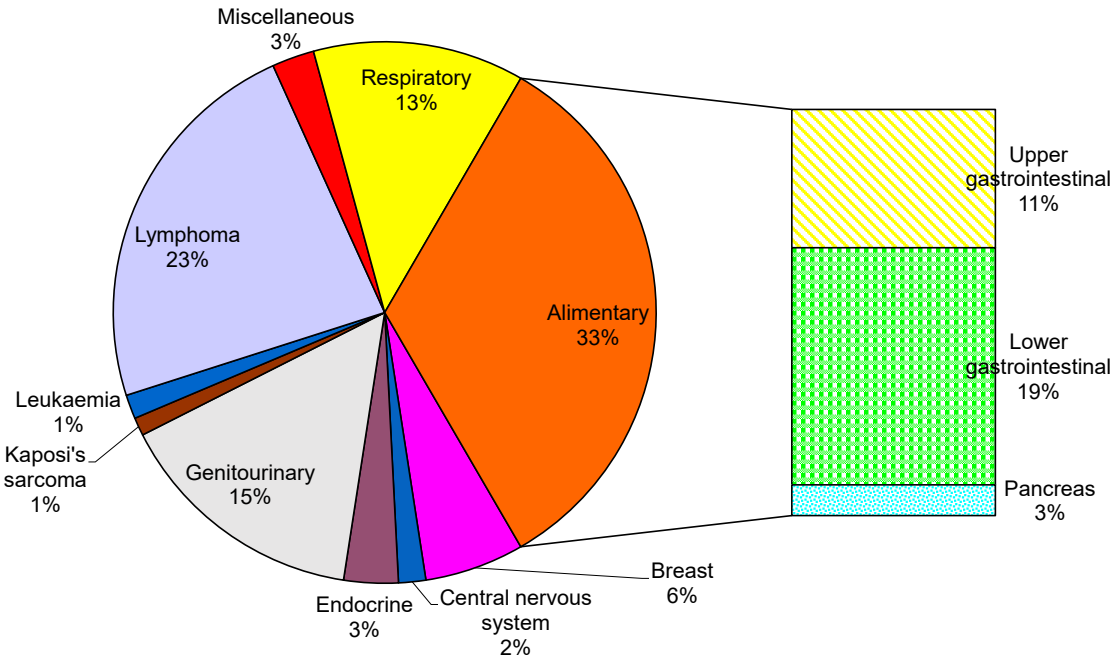
The three most common types of cancers were cancers of the alimentary tract (189, 34%), lymphoma (129, 23%) and genitourinary tract (84, 15%, Table 66, Figure 86). Lower GI cancers account for 58% of alimentary tract cancers and 15% of all de novo non-skin cancers.

Table 66. 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*	189	134	55	5 – 84	61	1 – 376	91	93	49%
Lymphoma*	129	76	53	1 – 82	50	1 – 283	65	56	43%
Genitourinary*	84	55	29	21 – 82	63	2 – 363	104	10	12%
Respiratory*	70	53	17	29 – 80	62	7 – 284	103	51	73%
Breast*	33	1	32	30 – 74	57	11 – 291	97	14	42%
Endocrine	18	9	9	32 – 77	56	6 – 346	60	3	17%
Miscellaneous*	14	8	14	49 – 82	64	6 – 301	99	7	50%
Central nervous system*	9	6	9	16 – 75	65	14– 212	85	6	67%
Leukaemia*	8	6	8	3 – 66	58	15 – 157	37	2	25%
Kaposi's	6	4	6	31 – 76	56	2 – 254	23	0	0%
Total cancers	**560**	**352**	**199**	**1 – 84**	**59**	**1 – 376**	**80**	**242**	**43%**
Total patients	**518**	**329**	**189**					**242**	**47%**

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

Figure 86. De novo non-skin cancer types



Males (64%) were more likely to develop non-skin cancers post-transplant and, except for cancers of the central nervous system, more likely to die from their cancer.

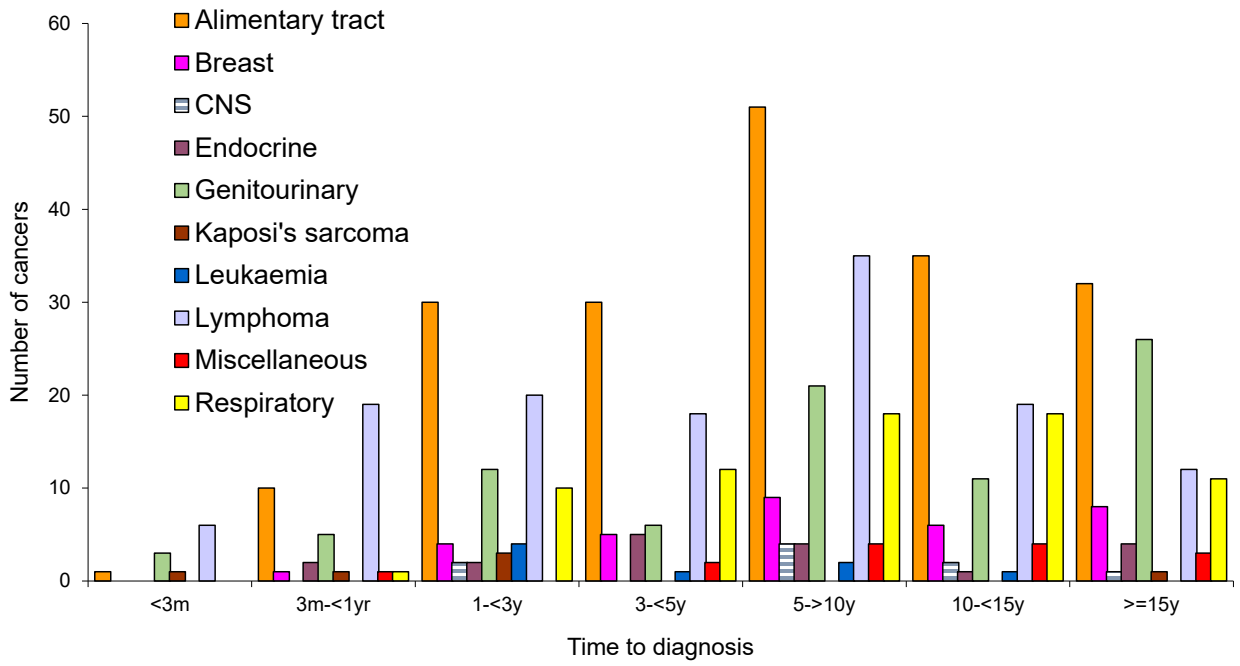
Table 67. De novo non-skin cancer types – gender versus death outcome

	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	133	75	56%	55	18	33%
Lymphoma	77	34	44%	53	22	42%
Genitourinary	55	6	11%	29	4	14%
Breast	1	0	0%	32	14	44%
Endocrine	9	3	33%	9	0	0%
Respiratory	53	40	75%	17	11	65%
Miscellaneous	8	4	50%	6	3	50%
Central nervous system	6	5	83%	3	1	33%
Leukaemia	6	2	33%	2	0	0%
Kaposi's sarcoma	4	0	0%	2	0	0%
Total cancers	**352**	**169**	**48%**	**208**	**73**	**35%**

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 87).

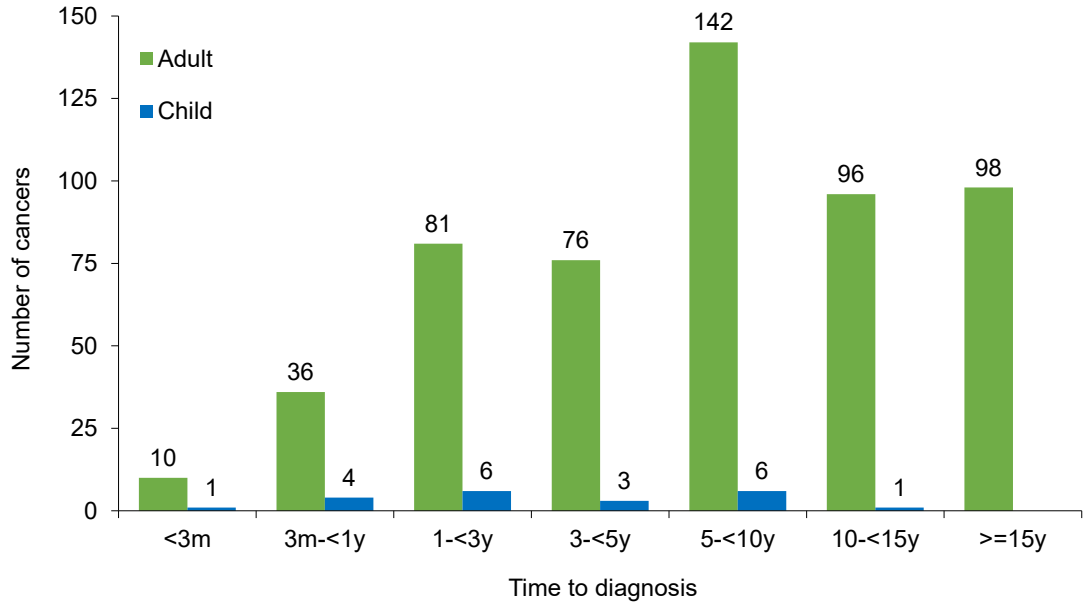
Figure 87. Time to diagnosis of de novo non-skin cancer



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 203 in the first 5 years, 142 from five to ten years post-transplant and 194 cases ten years or more post-transplant (Figure 88).

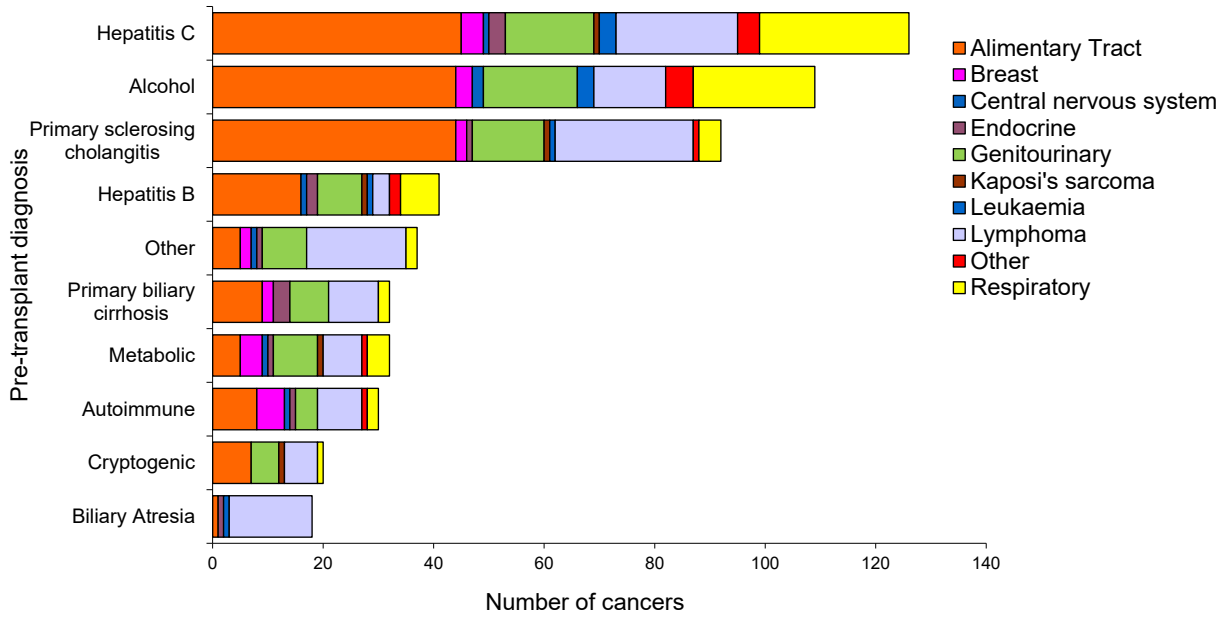
Figure 88. Time to diagnosis of any non-skin cancer by age category



15.7.4 Pretransplant Diagnosis and De Novo Non-Skin Cancer Types

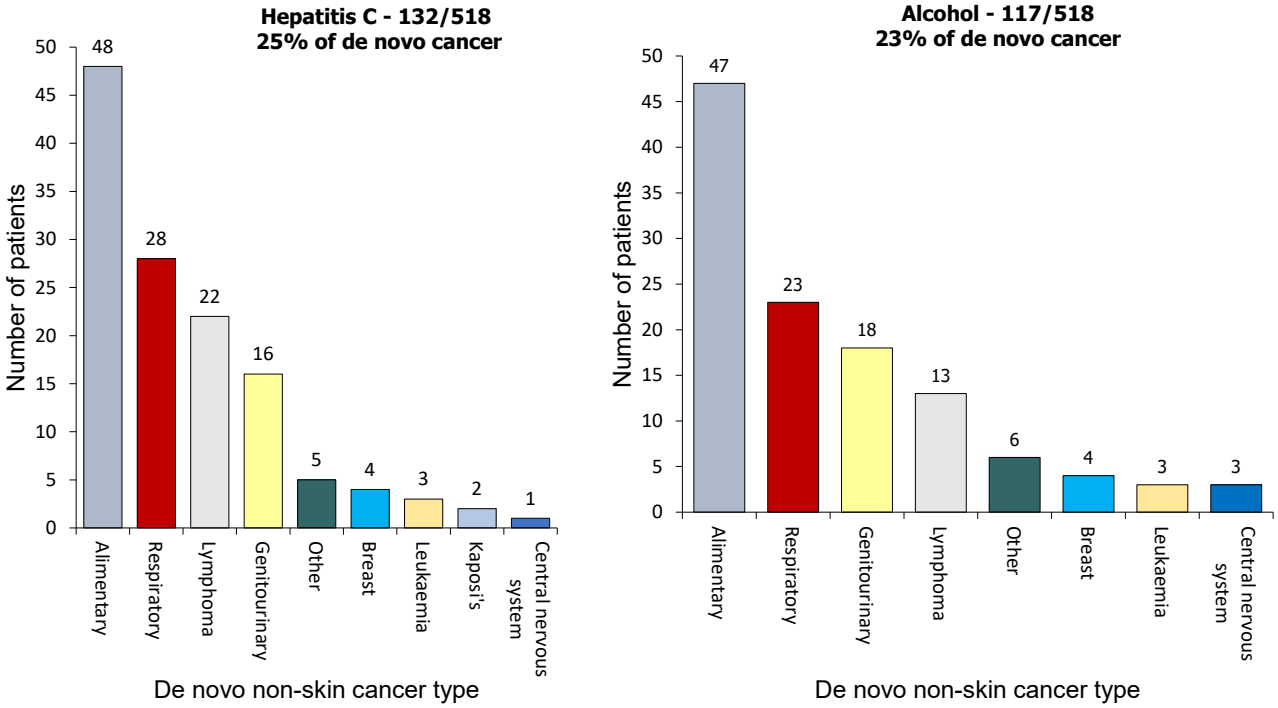
The incidence of de novo non-skin cancers appears to be related to the type of pretransplant underlying disease. Most notable is the incidence of de novo non-skin cancers in patients with underlying hepatitis C virus, alcohol and primary sclerosing cholangitis, being statistically significant ($p<0.0001$, Figure 89).

Figure 89. Pretransplant diagnosis and de novo non-skin cancer types



Pretransplant hepatitis C infection and alcoholic liver disease were the dominant underlying disease in those patients who developed alimentary tract and respiratory cancers (Figure 90).

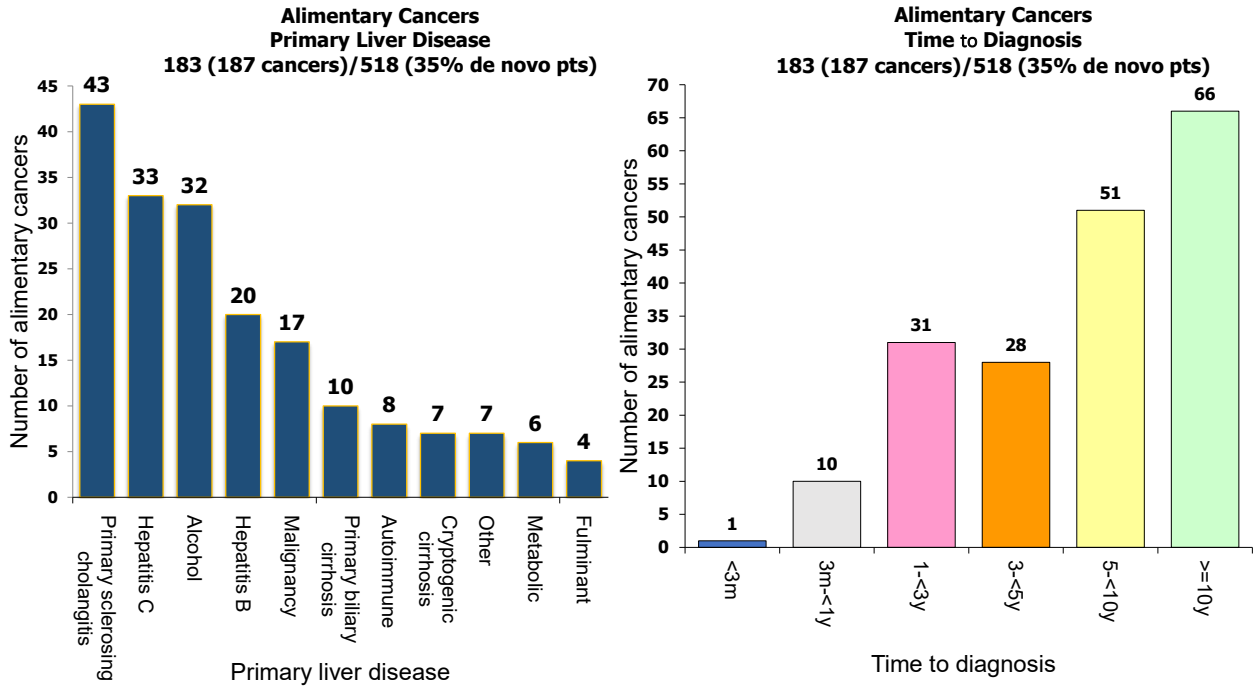
Figure 90. Hepatitis C virus and alcohol diagnosis and types of de novo skin cancer



15.7.5 De Novo Alimentary Cancers

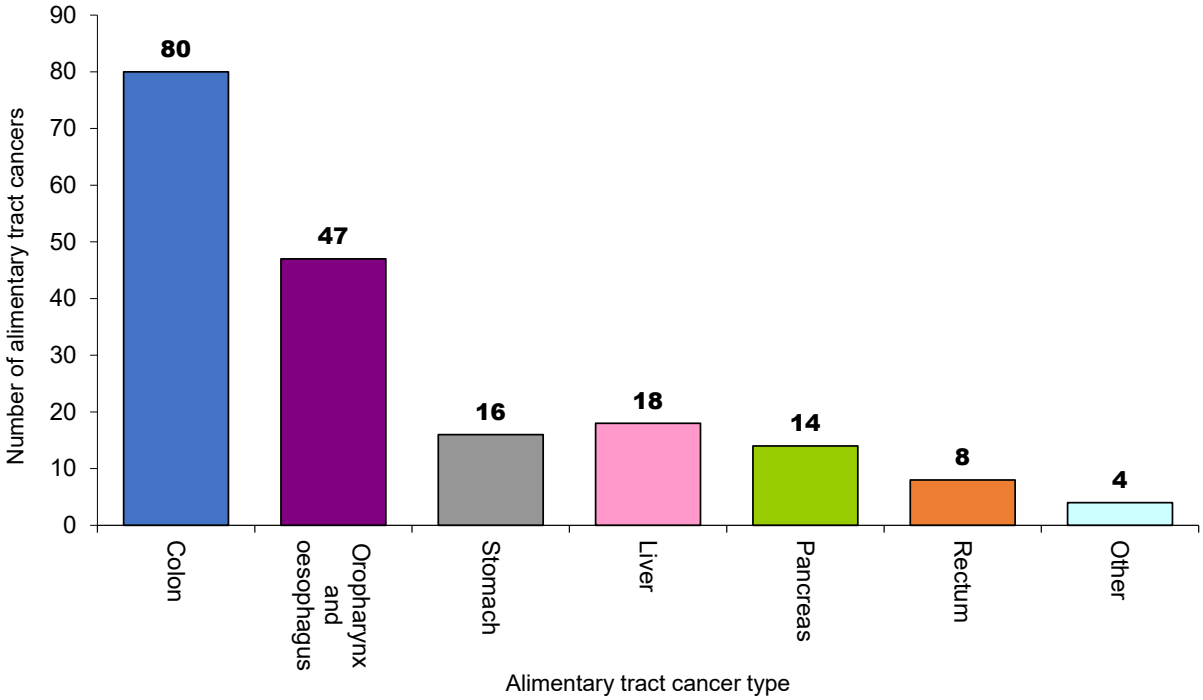
Cancer of the alimentary tract was the most prevalent non-skin cancer to develop post-transplant affecting 183 patients. Time to development ranged from 1 month to greater than 10 years with 63% being diagnosed after 5 years (Figure 91). Median time to diagnosis was 83 months. Pretransplant liver disease was predominantly primary sclerosing cholangitis, hepatitis C infection and alcoholic liver disease.

Figure 91. Pretransplant diagnosis and de novo alimentary cancers



43% of alimentary cancers were of the colon; 25% were oropharynx and oesophagus (Figure 92).

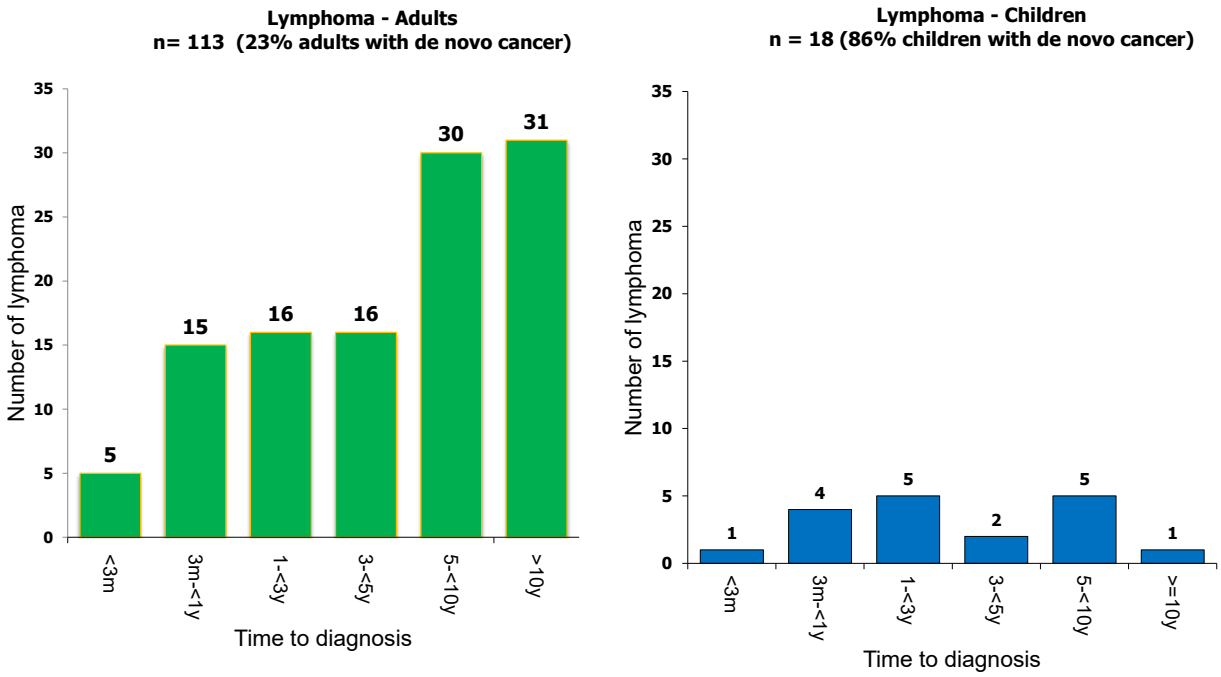
Figure 92. Incidence of de novo alimentary tract cancers by type



15.7.6 De Novo Lymphoma

Lymphoma was the second most prevalent non-skin cancer to develop post-transplant affecting 113 adults and 18 children. Time to development ranged from 1 month to greater than 10 years with 54% developing after 5 years in adults and 33% after 5 years in children (Figure 93). Median time to diagnosis in adults and children were 67 and 34 months respectively.

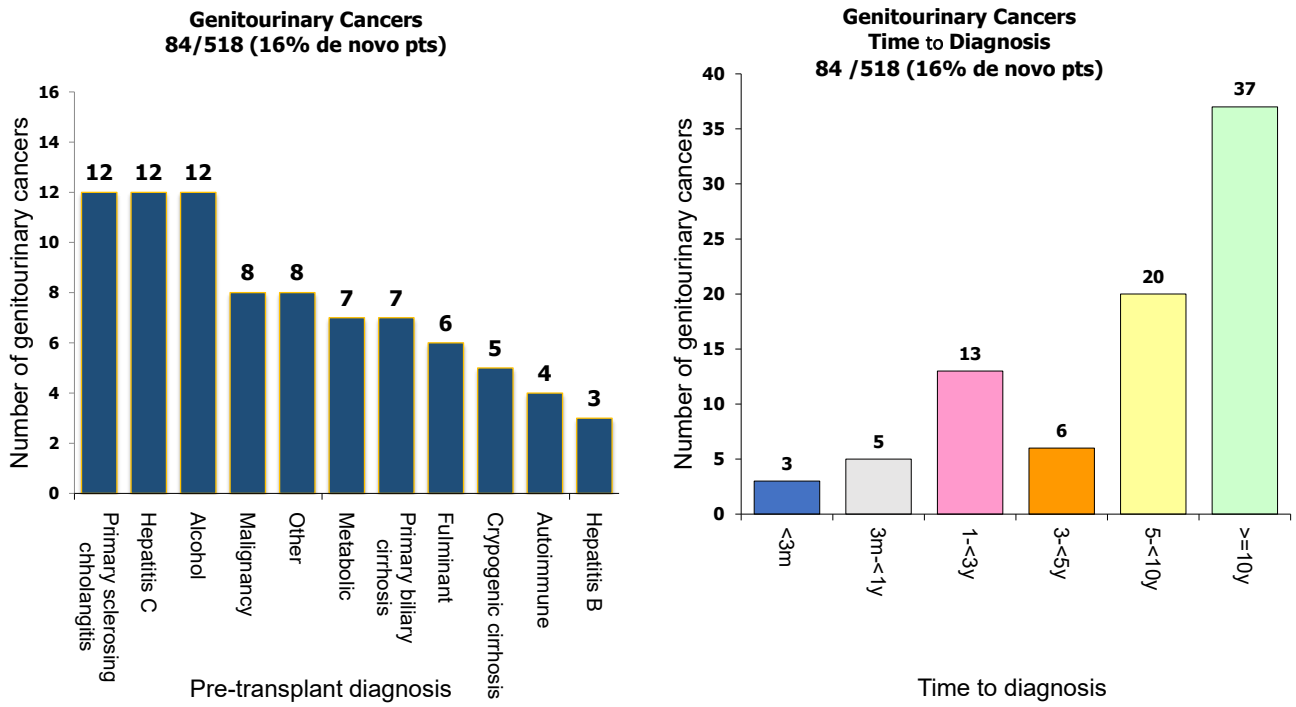
Figure 93. Time to diagnosis of de novo lymphoma by age category



15.7.7 De Novo Genitourinary Cancers

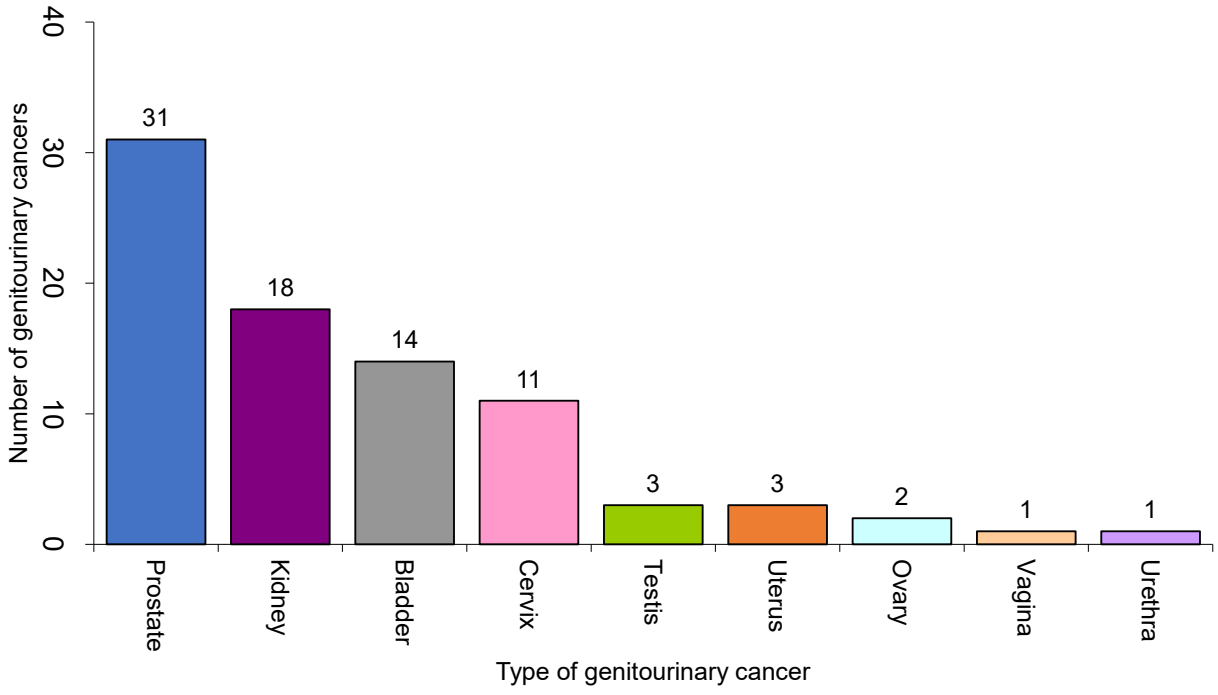
Cancers of the genitourinary tract consisted of 16% of all de novo non-skin cancers. Thirty-six (42%) of these patients were transplanted for primary sclerosing cholangitis, hepatitis C infection or alcoholic liver disease (Figure 94). Time to development ranged from less than 3 months to greater than 10 years with 68% developing after 5 years. Median time to diagnosis was 104 months.

Figure 94. Pretransplant diagnosis and de novo genitourinary cancers



Thirty-one (37%) of genitourinary tract cancers were cancers of the prostate (Figure 95).

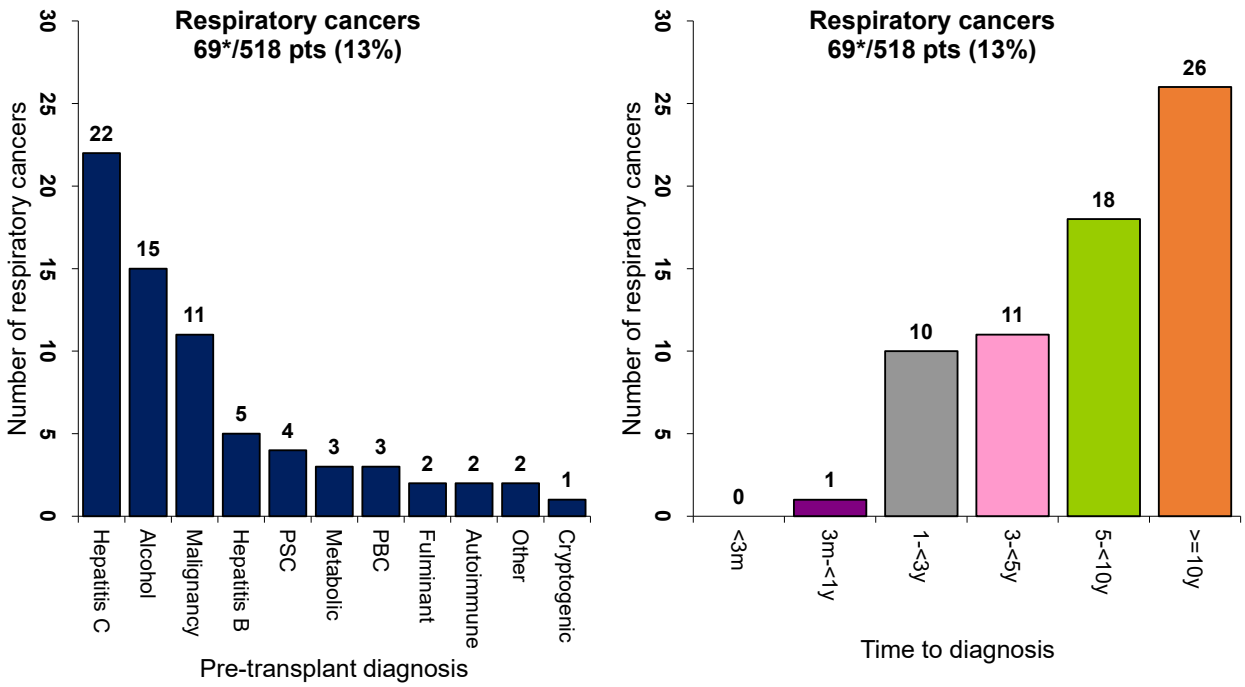
Figure 95. Incidence of de novo genitourinary tract cancers by type



15.7.8 De Novo Respiratory Cancers

Respiratory cancers consisted of 13% of all de novo non-skin cancers. Forty-eight (70%) of these patients were transplanted for either hepatitis C infection, alcoholic liver disease or pretransplant liver cancer (Figure 96). Time to development ranged from 3 months to greater than 10 years with 63% developing after 5 years. Median time to diagnosis was 103 months. 92% of respiratory cancers were of the lung (Figure 97).

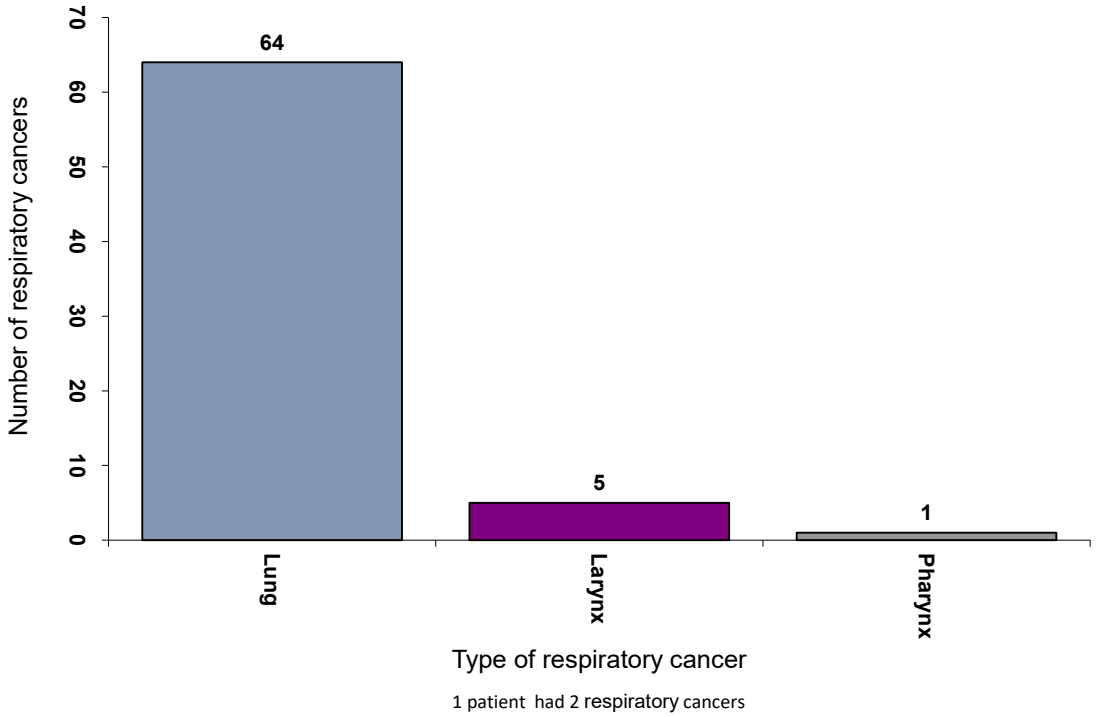
Figure 96. Pretransplant diagnosis and de novo respiratory cancers



*1 patient had 2 respiratory cancers

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

Figure 97. Incidence of de novo respiratory tract cancers by type

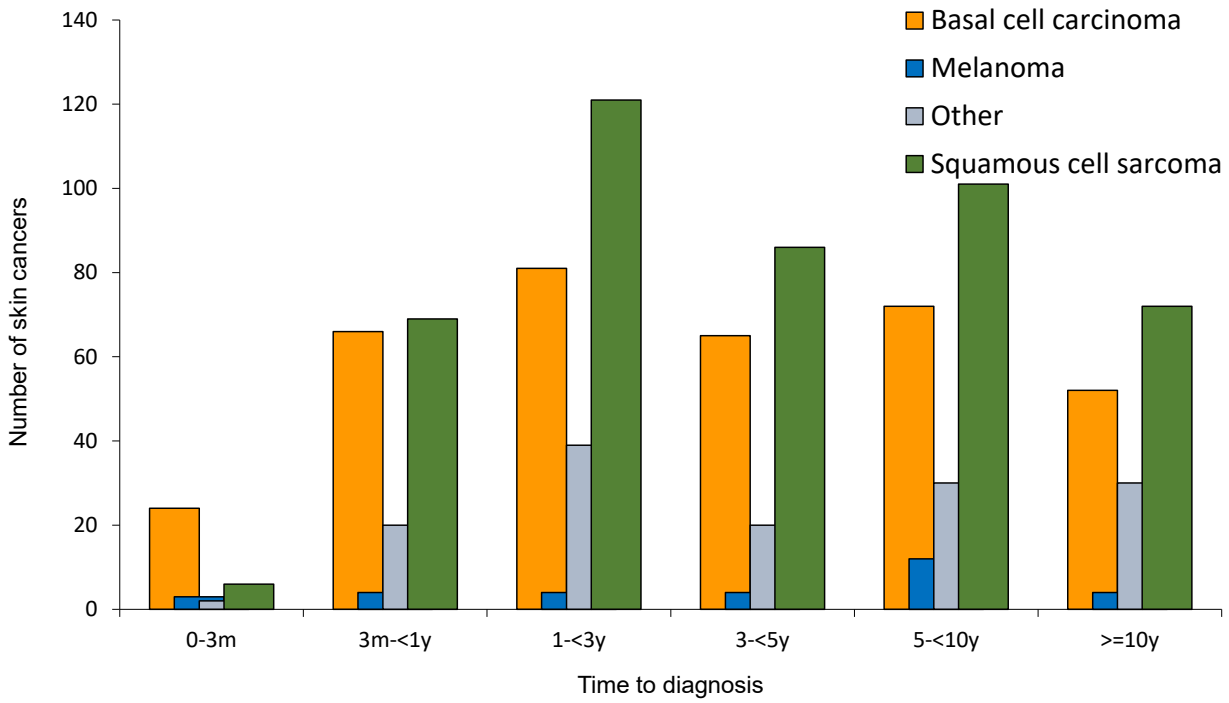


1 patient had 2 respiratory cancers

15.8 Skin Cancer Development Post-Transplant

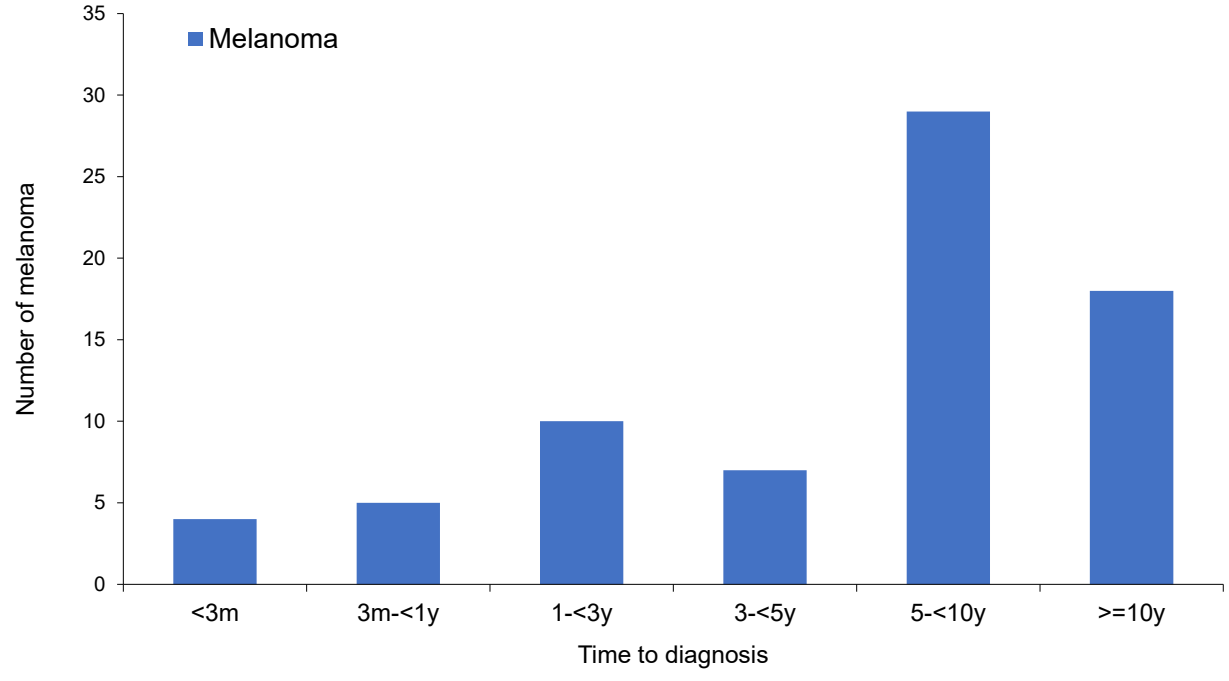
Nine hundred and sixty-eight patients (15%) developed a first skin cancer post-transplant with 451 going on to develop multiple skin cancer types (Figure 98).

Figure 98. Time to first skin cancer development post-transplant by type of skin cancer



Seventy-one (1% of all patients) developed 73 melanomas (Figure 99).

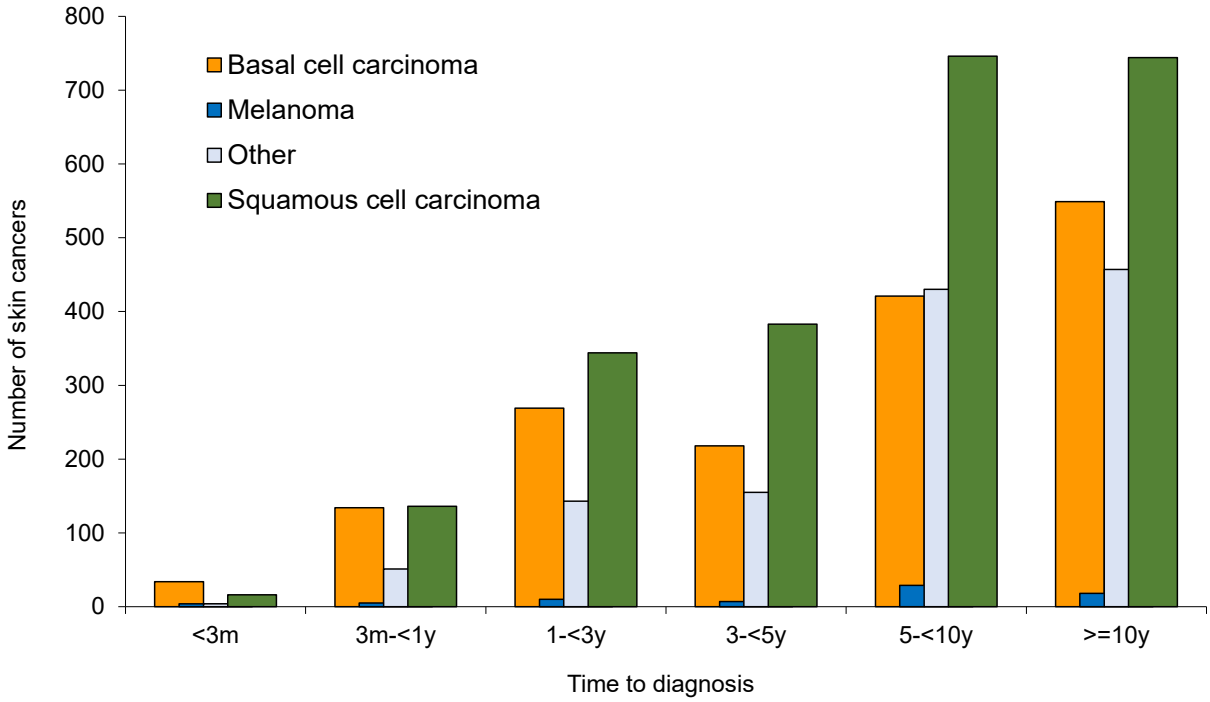
Figure 99. Time to first melanoma development post-transplant
Note: This includes patients who developed melanoma after a non-melanoma skin cancer (first skin cancer)



* 2 patients developed 2 melanoma

Skin cancers increased over time (Figure 100).

Figure 100. Time to any skin cancer development post-transplant



Males were more likely to develop skin cancer post-transplant than females (28% versus 22%) but, except for melanoma development, were not more likely to die from their skin cancer.

Table 68. Skin cancer development post-transplant

	Number of recipients with new skin cancers	Male				Female			
		Male recipients	% of all male transplant recipients	Died of this cancer	% died of this cancer	Female recipients	% of all female transplant recipients	Died of this cancer	% died of this cancer
Squamous Cell	677	480	12%	16	3%	197	8%	3	2%
Basal Cell	554	396	10%	0	0%	158	7%	0	0%
Bowen's disease	264	167	4%	0	0%	97	4%	0	0%
Miscellaneous	120	46	1%	0	0%	29	1%	0	0%
Melanoma	71	47	1%	9	19%	24	1%	14	58%
Merkel Cell	5	5	0.1%	1	20%	0	0%	-	-
Total skin cancer patients*	**968**	**1,141**	**28%**	**26**		**505**	**22%**	**17**	**2%**
Total transplant recipients	**6,428**	**4,097**				**2,331**			

* Note: Some patients developed more than one skin cancer type. 968 patients developed 5,308 skin cancers

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 101, Table 69). Cumulative risk of developing any cancer, skin cancer or non-skin cancer at 10 years post-transplant is 24%, 21% and 9% respectively.

Figure 101. Cumulative risk of diagnosis of skin or non-skin cancer following liver transplantation

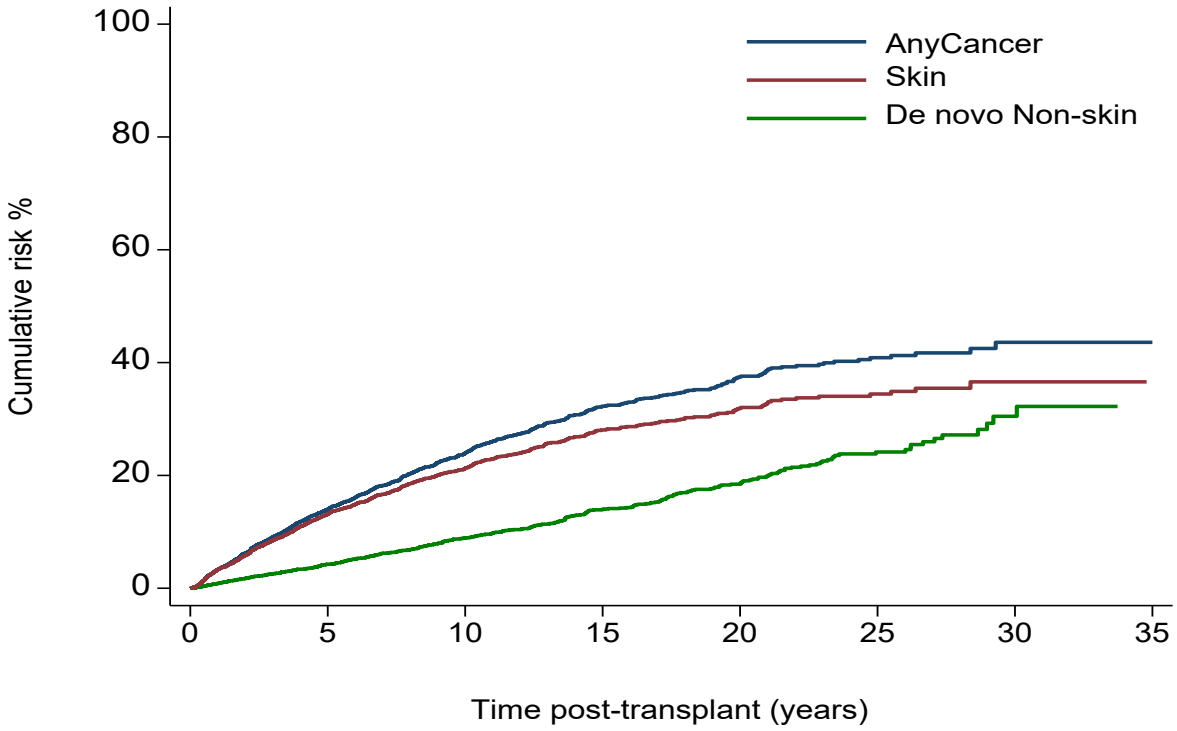


Table 69. Cumulative risk of diagnosis of cancer following liver transplantation

Cancer type	Patient Survival	Time post-transplant (years)								
		0	1	5	10	15	20	25	30	35
Any cancer	No at risk	6,428	5,408	3,460	2,053	1,178	631	280	71	2
	Cumulative risk	0%	3%	14%	24%	32%	37%	41%	44%	44%
Skin cancer	No at risk	6,428	5,071	3,222	1,900	1,086	555	238	48	1
	Cumulative risk	0%	3%	13%	21%	28%	32%	34%	37%	
De novo (non-skin) cancer	No at risk	6,428	5,222	3,590	2,247	1,318	680	287	59	1
	Cumulative risk	0%	1%	4%	9%	14%	18%	24%	30%	

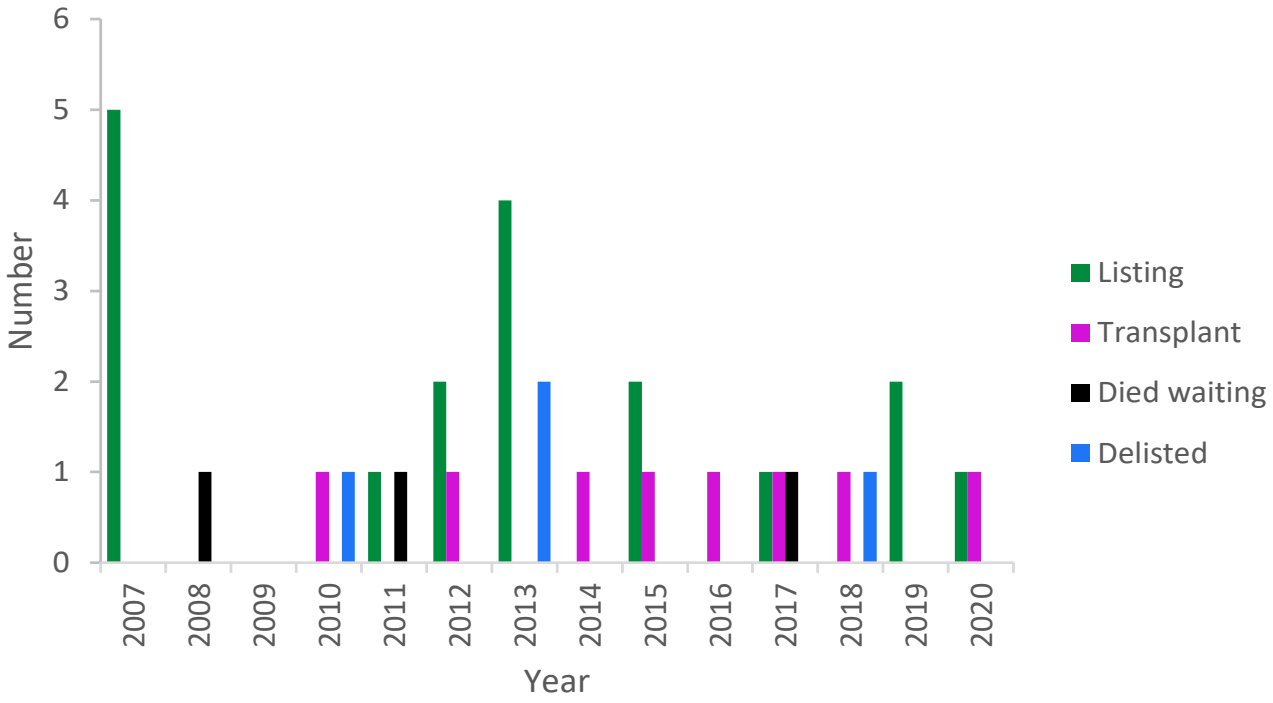
16 Intestinal Transplantation

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

Seventeen patients have been listed for intestinal transplantation, with one patient relisted in 2019, six years after initial delisting (18 listings, see Figure 102). Eight patients were transplanted, three died waiting, three were delisted, and three (including the patient delisted then relisted) were still waiting at the end of 2020.

Figure 102. 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 70. The majority of the seven children listed had short bowel syndrome due to gastroschisis, whilst the 10 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. Four adults have been transplanted, one for short bowel syndrome, two for Hirschsprung's disease and one for liver failure with porto-mesenteric thrombosis.

Table 70. 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	7	10	4	4
Age	8 (4-12)	36 (22-60)	11 (5-13)	29 (24-47)
Gender				
Male	4	7	3	3
Female	3	3	1	1
Diagnosis				
Short bowel syndrome				
- Gastroschisis	5	0	2	0
- Small intestine leiomyoma	0	1	0	0
- Small intestine adenocarcinoma	0	1	0	0
- Volvulus	0	1	0	1
Motor disorder				
- Hirschsprung's disease and variants	1	3	1	2
- Hollow visceral myopathy	0	1	0	0
Other				
- Chronic idiopathic intestinal pseudo-obstruction	1	0	1	0
- Liver failure with porto-mesenteric thrombosis	0	3	0	1

16.3 Organs Transplanted

Four patients underwent liver, pancreas and small intestine transplantation, one underwent multivisceral (liver, stomach, pancreas and small intestine) transplantation, one underwent liver, pancreas, small intestine and kidney transplantation, one underwent intestine and kidney transplantation and one patient underwent small intestine to mid-transverse colon transplantation.

16.4 Survival

Six of the eight 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 87.5% and the 5-year and 10-year patient and graft survival are 70.0% (Figure 103, Table 71, Figure 104, Table 72).

Figure 103. Patient survival after intestinal transplantation

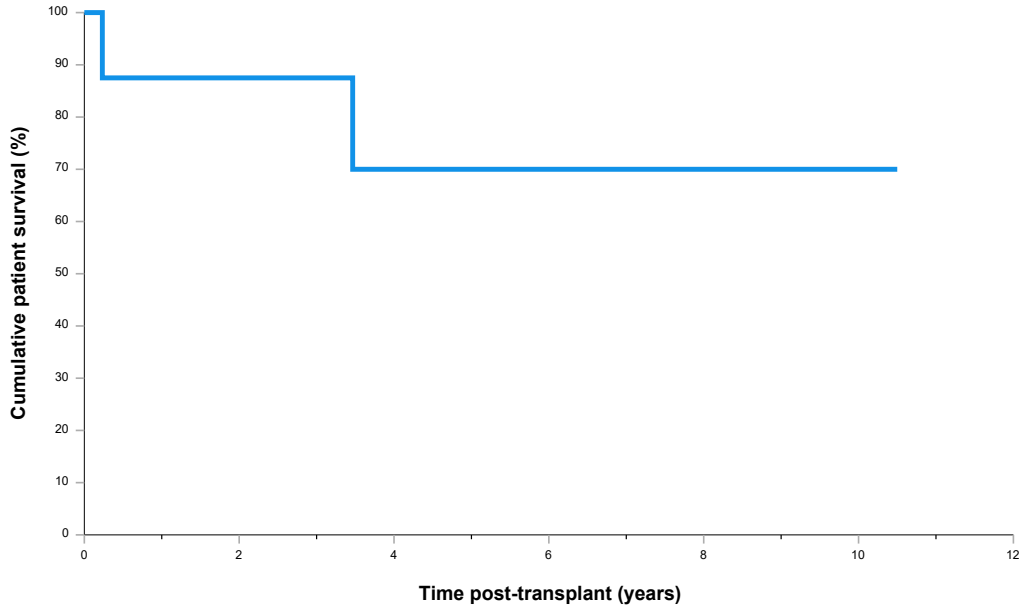


Table 71. Intestinal patient survival

Patient Survival	Time post-transplant (years)					
	0	1	3	5	10	15
No. at risk	8	6	5	4	1	0
Survival (%)		88%	88%	70%	70%	

Figure 104. Graft survival after intestinal transplantation

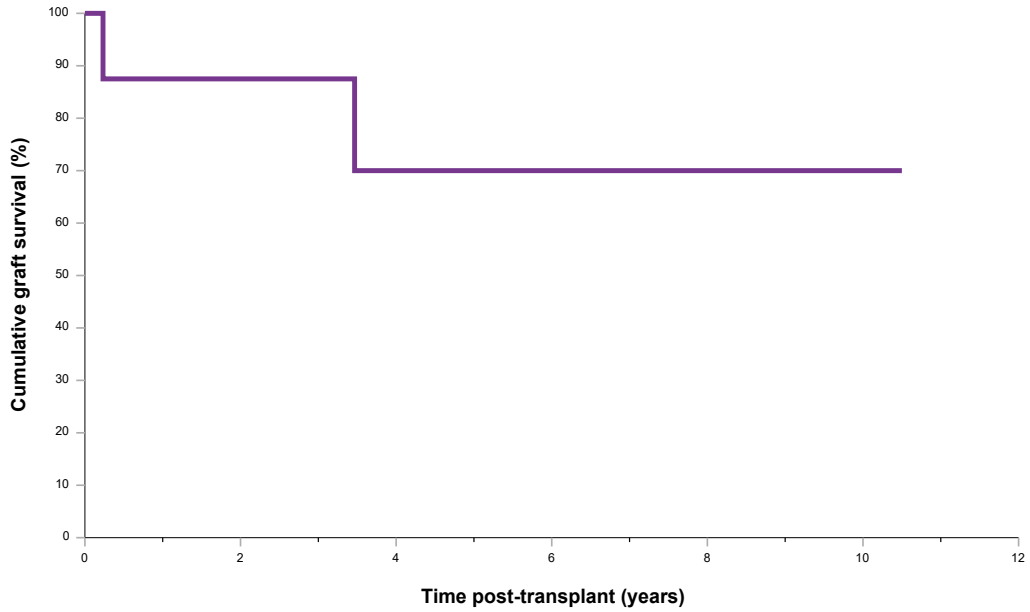


Table 72. Intestinal graft survival

Graft Survival	Time post-transplant (years)					
	0	1	3	5	10	15
No. at risk	8	6	5	4	1	0
Survival (%)		88%	88%	70%	70%	

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 restoration of blood flow in the recipient.
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, 2020 for this report) for patients who have not been retransplanted or died by that date.

Graft number	The number of liver transplants the patient previously undergone plus 1. 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.
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, 2020 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 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.
Stormon MO, Hardikar W, Evans HM, Hodgkinson P. 1985-2018. Journal Paediatrics and Child Health 2020 Nov;56(11):1739-1746.

18.2 Publications in 2019

Increasing incidence of nonalcoholic steatohepatitis as an indication for liver transplantation in Australia and New Zealand.
Calzadilla-Bertot L., Jeffrey, G.P., 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, L.A.
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.
Angus W. Jeffrey, Luc Delriviere, Geoff McCaughan, Michael Crawford, Peter Angus, Robert Jones, Graeme A. Macdonald, Jonathan Fawcett, Alan Wigg, John Chen, Ed Gane, Stephen Munn, and Gary P. Jeffrey.
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.

18.3 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; D M Allen R; Hawthorne WJ; Pleass HC.
Liver Transplantation. 24(11):1536-1544, 2018 11.

18.4 Publications in 2016

Additive impact of pre-liver transplant metabolic factors on survival post-liver transplant.
Leon A Adams, Oscar Arauz, Peter W Angus, Marie Sinclair, Graeme A MacDonald, Utti Chelvaratnam, Alan J Wigg, Sze Yeap, Nicholas Shackel, Linda Lin, Spiro Raftopoulos, Geoffrey W McCaughan, Gary P Jeffrey, 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.
Su Yin Lau, Richard J. Woodman, Mauricio F. Silva, Kate Muller, John Libby, John W. Chen, Robert Padbury, Alan J. Wigg.
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.

18.5 Publications in 2015

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.

18.6 Publications in 2014

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.

18.7 Publications in 2013

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, A.E., Meagher, N.S., McCaughan, G.W., Keogh, A.M., Vajdic, C.M., 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.

18.8 Publications in 2012 and Earlier

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.
John W.C. Chen, Lilian Kow, Deborah J. Verran, John L. McCall, Stephen Munn, Glenda A. Balderson, Jonathan W. Fawcett, Paul J. Gow, Robert M. Jones, Gary P. Jeffrey, Anthony K. House & Simone I. Strasser. HPB 2009, 11, 81–89.

Minimal but significant improvement in survival for non-hepatitis C-related adult liver transplant patients beyond the one-year posttransplant mark.
McCaughan, Geoffrey W; Shackel, Nicholas A; Strasser, Simone I; Dilworth, Pamela; Tang, Patrick for Australian and New Zealand Liver Transplant Study Group. Liver Transplantation 16: 130-137, 2010.

The epidemiology of hepatitis C in Australia: Notifications, treatment uptake and liver transplantations, 1997–2006.
Heather F Gidding, Libby Topp, Melanie Middleton, Kate Robinson, Margaret Hellard, Geoffrey McCaughan, Lisa Maher, John M Kaldor, Gregory J Dore and Matthew G Law. Journal of Gastroenterology and Hepatology 24 (2009) 1648–1654.

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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