Australia & New Zealand
Liver and Intestinal Transplant Registry

Report on liver and intestinal transplantation activity to 31/12/2019

31st
ANNUAL REPORT
ANZLITR

Table of Contents

1 Preface

We are pleased to present the 31st 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 2019 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 were sad to hear that Judie Hanna, New Zealand paediatric liver transplant coordinator and data contributor to the Registry, died in October 2020. The ANZLITR community would like to acknowledge her contribution to the Registry and liver transplantation. Our thoughts are with her family and friends.

We are grateful to the Australian Government and the Organ and Tissue Authority for the ongoing financial support of the Registry. We thank the Australian and New Zealand Organ Donation 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

CITATION
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> Australia and New Zealand Liver and Intestinal Transplant Registry Annual Report 2019
> Melbourne, Victoria, AUSTRALIA
> Editors: Michael Fink, Mandy Byrne

2 Executive Summary

Annual waiting list mortality has decreased from a peak of 12.3% in 2007 to 4.0% in 2019. Two of 27 patients listed as category 1 and none of 20 patients listed as category 2 in 2019 died waiting.

There has been a progressive increase in liver transplantation from deceased donors since 2007, predominantly comprising brain dead donors, including donors aged over 60 years, with a modest increase in donation after circulatory death donors. Living donor liver transplantation accounts for 1.7% of transplants performed.

In 2019, 368 liver transplants were performed in 362 patients. Between 1985 and 2019, 6,627 transplants were performed in 6,126 patients, including 1,167 transplants in 1,024 children and 5,460 transplants in 5,102 adults. Between 2007 and 2019, there was a 97.7% increase in the number of patients transplanted per year. 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 (53% in 2019) and whole liver transplantation is the dominant form of liver transplantation in adults (90% in 2019).

The commonest indication for transplantation in children is biliary atresia and in adults is hepatitis C virus cirrhosis until 2014, after which hepatocellular carcinoma has become the commonest indication. The proportion of patients transplanted primarily for hepatitis C has decreased from 33.8% in 2012 to 12.7% in 2019.

The 1-, 3-, 5- and 10-year patient survival in recent years for paediatric patients was 97%, 96%, 91% and 92%, 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%, 90%, 85% and 73%, respectively. Patient survival in adults reduced progressively with increasing age ($P < 0.001$), varied significantly by primary disease ($P = 0.019$), with poorer outcomes for hepatitis C virus and alcoholic cirrhosis, and has improved over time for hepatitis B ($P < 0.001$) and more recently for hepatitis C virus cirrhosis ($P = 0.004$).

The 1-, 3-, 5- and 10-year graft survival in recent years for paediatric patients was 91%, 88%, 83% and 81%, respectively. The 1-, 3-, 5- and 10-year graft survival in recent years for adult patients was 92%, 86%, 81% and 69%, 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 < 549 mins, $P < 0.001$) and recipient urgency (poorer outcome for category 1 recipients, $P = 0.005$).

The commonest indications for retransplantation were vascular problems (30%), rejection (18%), biliary (16%), primary non-function or initial poor function (14%) and recurrent disease (14%). The commonest causes of death were malignancy (24%), graft-related causes (19%), sepsis (14%), multi-organ failure (8%) and cardiovascular disease (8%).

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. 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
- 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 early, first liver transplant in Australia performed by 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).

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 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.

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.

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 Stephen Munn, 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 are 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); 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 (5,682 listings)

Comprehensive wait list data including listing and delisting date and delisting outcome are available from 1 January 2004. There are data on 5,682 wait listings from this date.

4.4 Liver Transplant Recipient Datasets

In order 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 (6,126 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 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 (6,121 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 (6,627 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 (6,011 deceased donors; 6,389 transplants)

The Australia and New Zealand Organ Donation (ANZOD) Registry provides the ANZLITR with deceased donor data for analysis. A total of 6,515 grafts were sourced from 6,137 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 6,011 donors. A total of 5,631 donated livers were allocated to a single recipient and 380 donated livers were split (one graft was not utilised from each of two livers that were split), resulting in a total of 6,389 grafts with deceased donor data.

4.5.2 Living Liver Donors (112 living donors)

Data on 112 living liver donors are collected in ANZLITR.

4.6 Intestinal Dataset

The intestinal dataset includes data on all 17 wait-listed patients (the first listing was in 2007) and all seven 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 2019) 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 2019) or failed (due to death or re-transplantation).

4.9 Statistical Analysis

Statistical analyses were undertaken using IBM SPSS Statistics 26.

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, listing urgency, listing creatinine, listing albumin and transplant albumin.

P values < 0.05 were considered significant.

5 Liver Transplant Waiting List

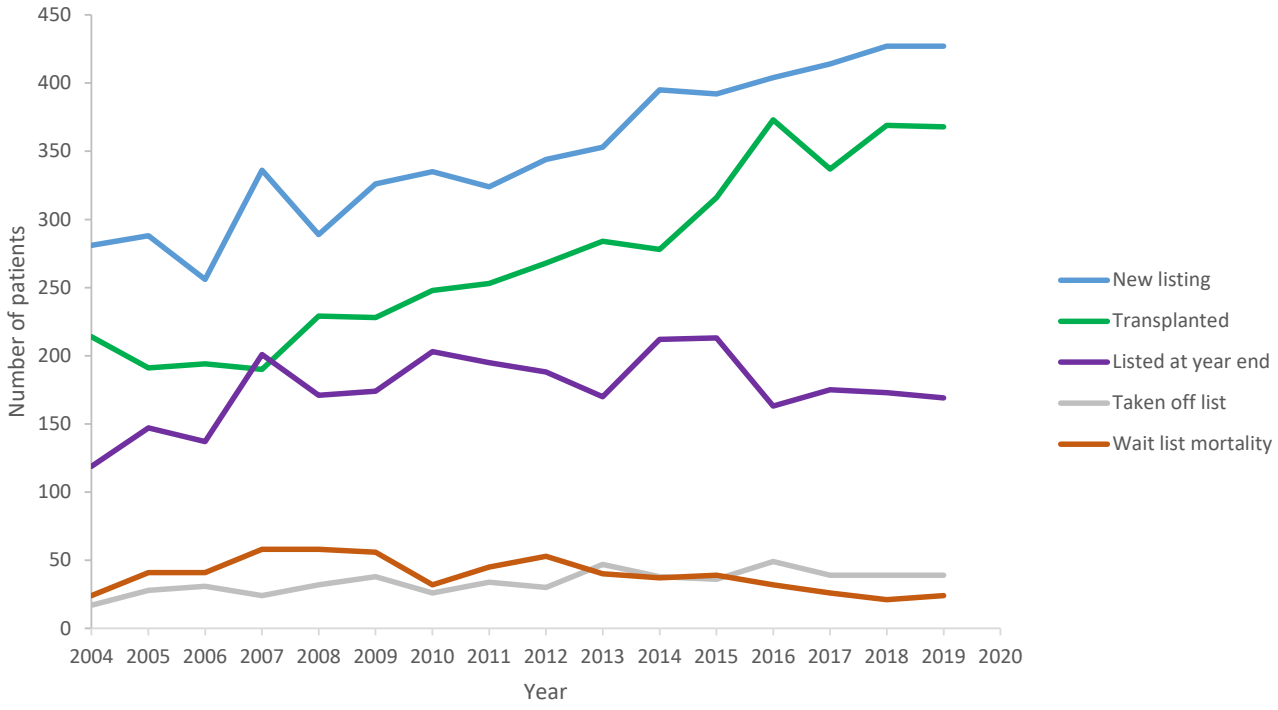
In 2020, a full review of patients listed as alive in the Registry was undertaken to confirm their status. One hundred and sixty-two patients that were delisted without transplant were identified as having died. Three quarters of these patients delisted without transplant died within 12 months, so this has resulted in a small increase in the historical wait list mortality in this year's report.

5.1 Waiting List Activity

There has 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). There has been a 72% increase in the number of liver transplants performed per year over the same time period (214 to 368). There were 169 people on the waiting list for a liver transplant at the end of 2019. This number has remained fairly stable over recent years despite an increase in the number of transplants performed as the number of new patients listed has increased.

The annual waiting list mortality rate has progressively decreased from a peak of 12.3% in 2007 to 4.0% in 2019.

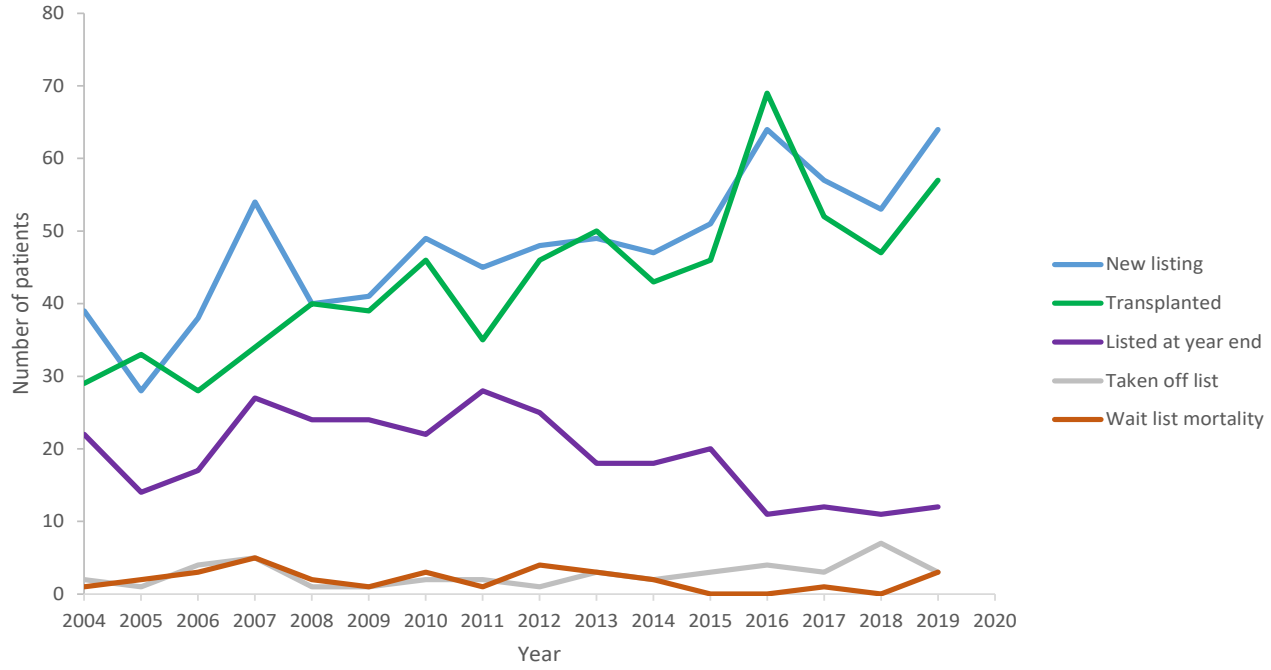
Figure 1. Liver transplant waiting list activity – all patients



5.2 Paediatric Waiting List Activity

There has been an increase in the number of new paediatric listings per year with the number of paediatric transplants following this trend (Figure 2). There has been a 97% increase in paediatric transplants per year from 29 in 2004 to 57 in 2019. The waiting list mortality rate peaked in 2007 at 7.0%, was zero in 2015, 2016 and 2018 and was 4.0% in 2019. The number of patients still listed at the end of each year has gradually decreased from 21 in 2004 to 12 in 2019.

Figure 2. Paediatric liver transplant waiting list activity

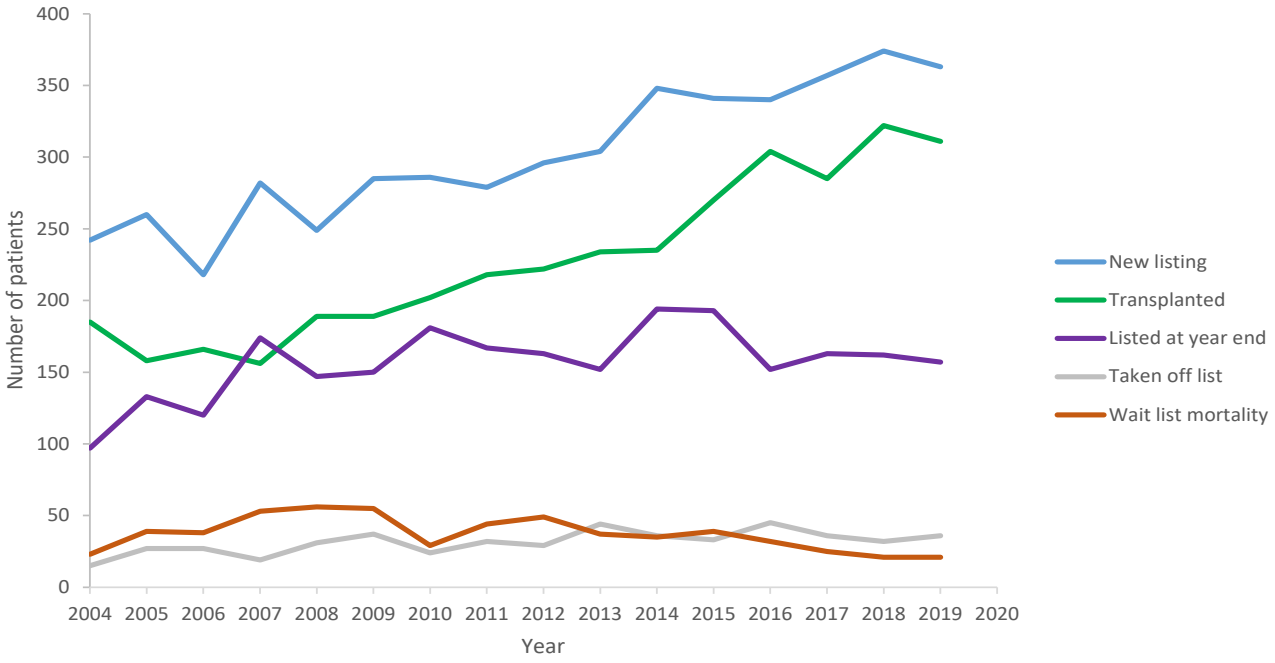


5.3 Adult Waiting List Activity

There has been a 50% increase in the number of adults listed for liver transplant per year from 242 in 2004 to 362 in 2019 (Figure 3). The number of adults transplanted per year has increased 68% from 185 in 2004 to 311 in 2019. The number of adults remaining on the waiting list at the end of the year has stabilised around 160 after peaking at 193 in 2014.

The adult wait list mortality rate peaked at 13.2% in 2008 and has fallen to 4.0% in 2019.

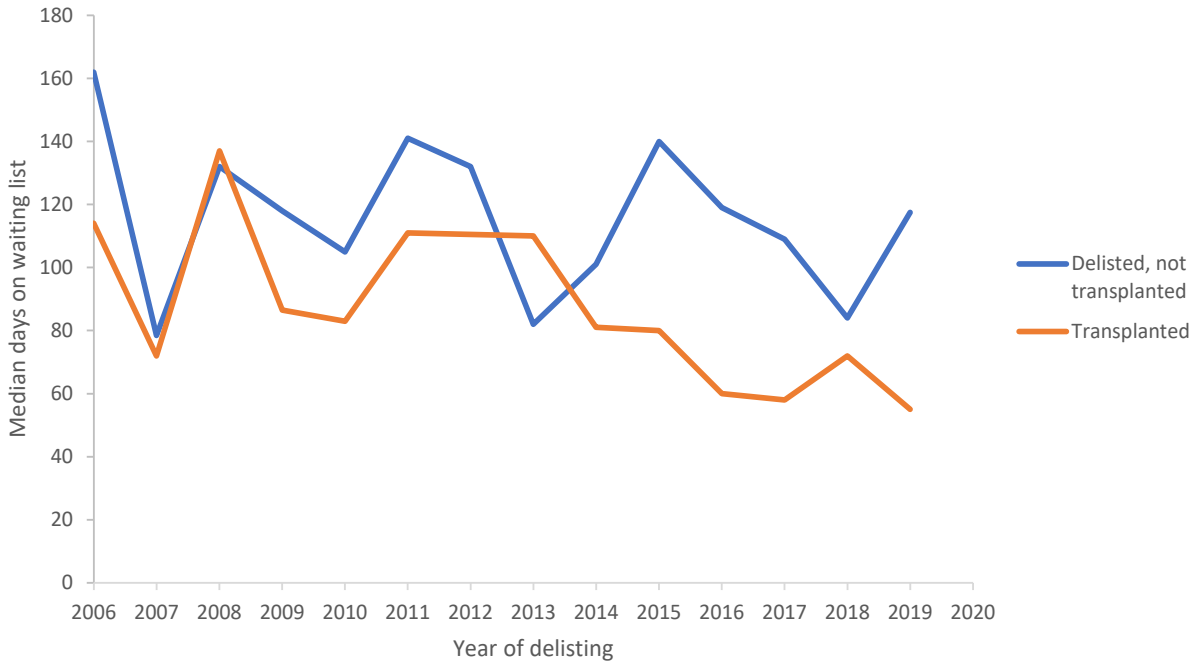
Figure 3. Adult liver transplant waiting list activity



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 55 days in 2019 (Figure 4). The median time from listing to delisting without transplant was 141 days in 2011 and has decreased to 118 days in 2019.

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 (2015 – 2019) was 11.0%. The rate in 2019 was 7.4%.

There were no urgent category 2 wait list mortality deaths in 2015 and between 2017 and 2019. There was one death in 2016. The urgent category 2 wait list mortality rate for the last five years (2015 – 2019) was 1.1%.

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.

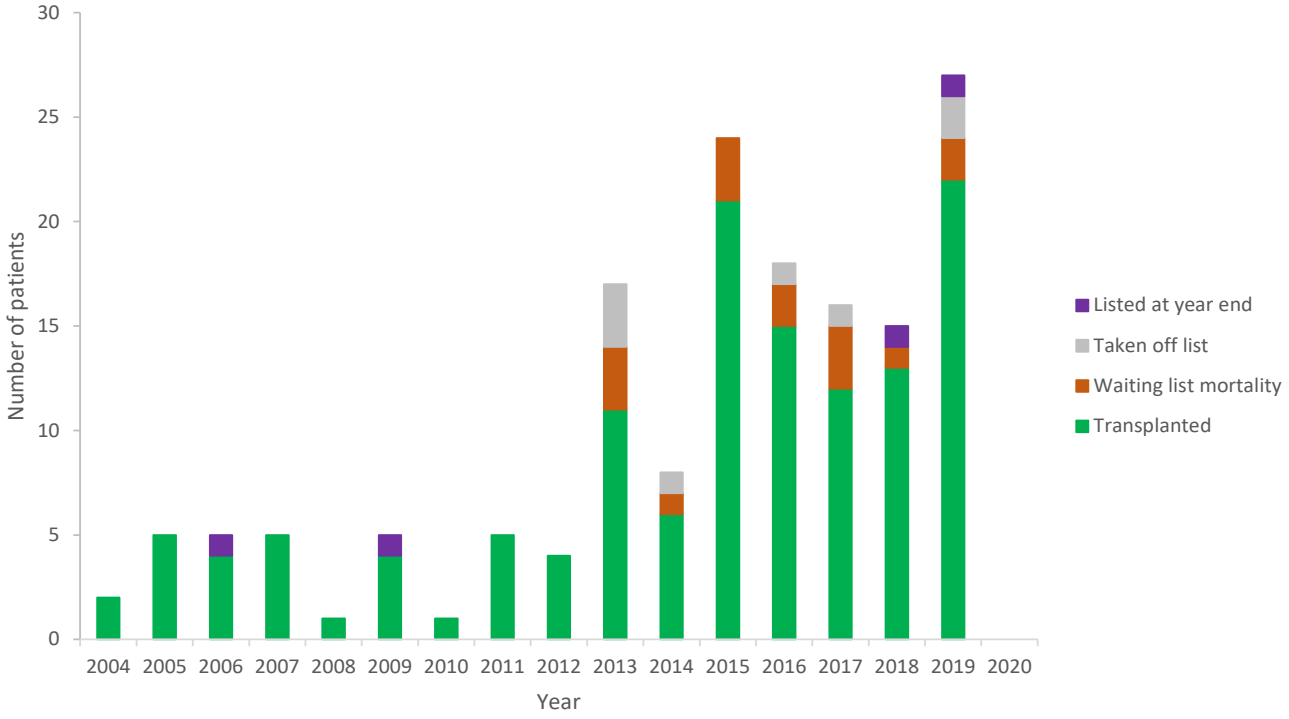
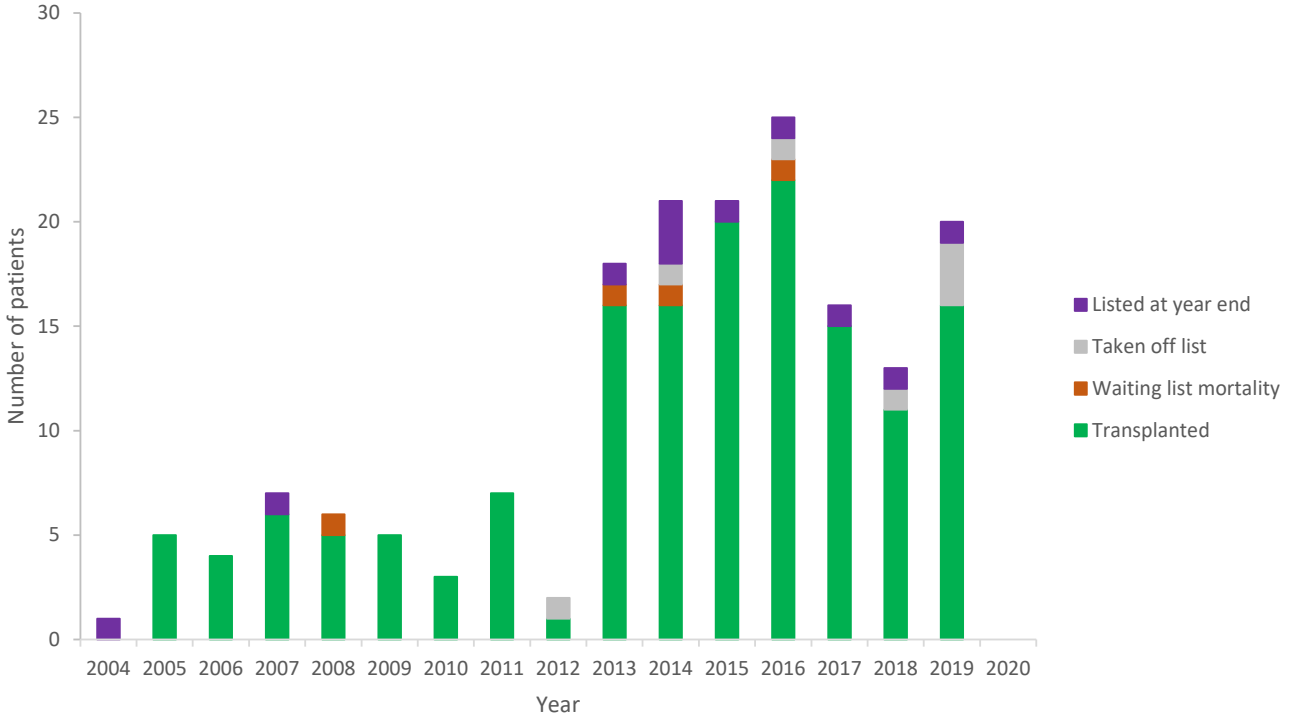


Figure 6. Urgent category 2 waiting list outcomes. Data show the outcome of urgent listings for each year. The outcomes of patients still listed at the end of the year are reported in the subsequent year.

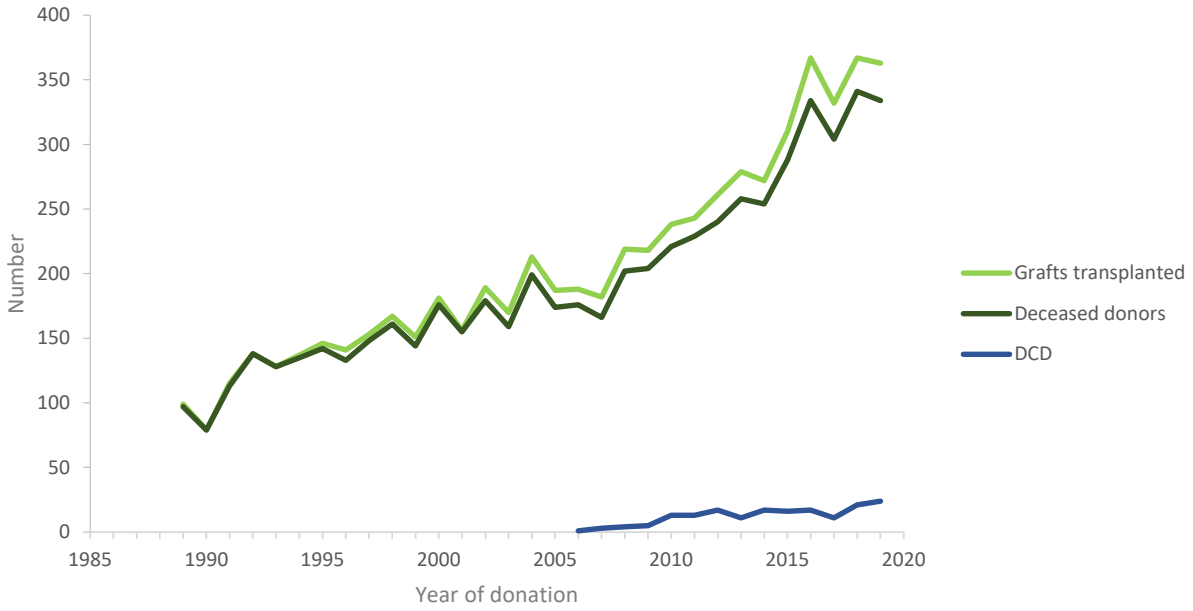


6 Deceased Liver Donors

Of 6,627 liver transplants, 6,515 (98.3%) were sourced from deceased donors, with only a small proportion from living donors (112, 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 6,011 deceased donors from 1989 onwards. Of these, 380 donated livers were split (one graft was not utilised from each of two livers that were split), resulting in a total of 6,389 grafts. The number of deceased donors has grown steadily over the years (Figure 7). Of 334 deceased donors in 2019, 24 (7.2%) were donation after circulatory death donors.

Figure 7. Deceased donors and grafts transplanted by year

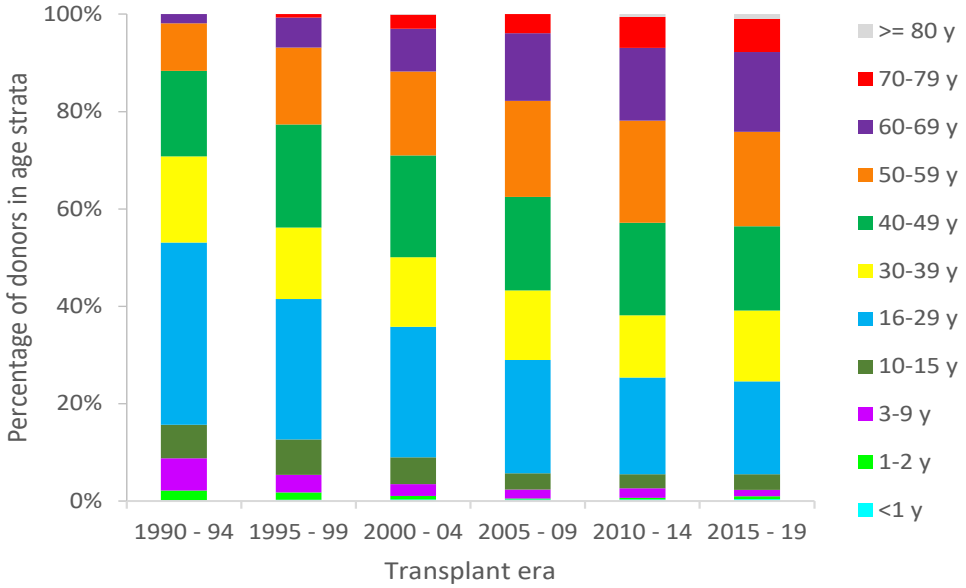


Abbreviation: DCD, donation after circulatory death

There has been a progressive increase in donor age from a median of 28 years in 1990-94 to 46 years in 2015-19.

Figure 8 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 19%, 16%, 7% and 1%, respectively in the 2015-19 era.

Figure 8. Deceased donor age by transplant era



7 Living Liver Donors

Of 6,627 liver transplants, 112 (1.7%) were sourced from living donors (including four domino livers). Paediatric recipients received the majority (81.3%) of living liver donations (Table 1). There have been no deaths of living liver donors.

Table 1. Living liver donor demographics

Living Donors	**Paediatric Recipient** (<16 years)	**Adult Recipient** (≥16 years)	**All Recipients**
Number of living donors	**91**	**21**	**112**
% living donors	81.3%	18.7%	
Gender of living donor			
Female *(% age category)*	42 *(46.2%)*	8 *(38.1%)*	**50** *(44.6%)*
Male *(% age category)*	49 *(53.8%)*	13 *(61.9%)*	**62** *(55.4%)*
Age of living donor (years)			
Median	34	33	**34**
Range	19 – 54	18 – 54	**18 – 54**
Living donor relationship			
Father	39	1	**40**
Mother	23	0	**23**
Aunt	10	0	**10**
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**
Daughter	0	2	**2**
Grandmother	2	0	**2**
Uncle	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 2019

There were 368 liver transplants performed on 362 recipients in 2019. This equates to 12.0 liver transplant recipients per million population (Australia and New Zealand combined population in 2019: 30.6 million).

8.1 Demographic Data for Patients Transplanted in 2019

Of patients receiving a transplant in 2019, 14.9% were children. Females represented 38.9% of paediatric patients but only 29.9% of the adult population (Table 2).

Table 2. Patient demographics by age group (2019)

Patients Transplanted in ANZ in 2019	**Children** (<16 years)	**Adults** (≥16 years)	**Total Patients**
Number of patients *(% total patients)*	54 *(14.9%)*	308 *(85.1%)*	362
Gender			
Female *(% age category)*	21 *(38.9%)*	92 *(29.9%)*	113 *(31.2%)*
Male *(% age category)*	33 *(61.1%)*	216 *(70.1%)*	249 *(68.8%)*
Age at first ANZ transplant in 2019			
Mean ± SD (years)	4 ± 5	53 ± 13	46 ± 21
Median (years)	1	56	54
Range	25 d - 15 y	17 y - 72 y	25 d - 72 y
Interquartile range	8 m - 7 y	46 y - 63 y	36 y - 61 y
Status of patient at 31/12/2019			
Alive *(% age category)*	53 *(98.1%)*	299 *(97.1%)*	352 *(97.2%)*
Deceased *(% age category)*	1 *(1.9%)*	9 *(2.9%)*	10 *(2.8%)*

Abbreviation: ANZ: Australia or New Zealand

8.2 Transplants in 2019

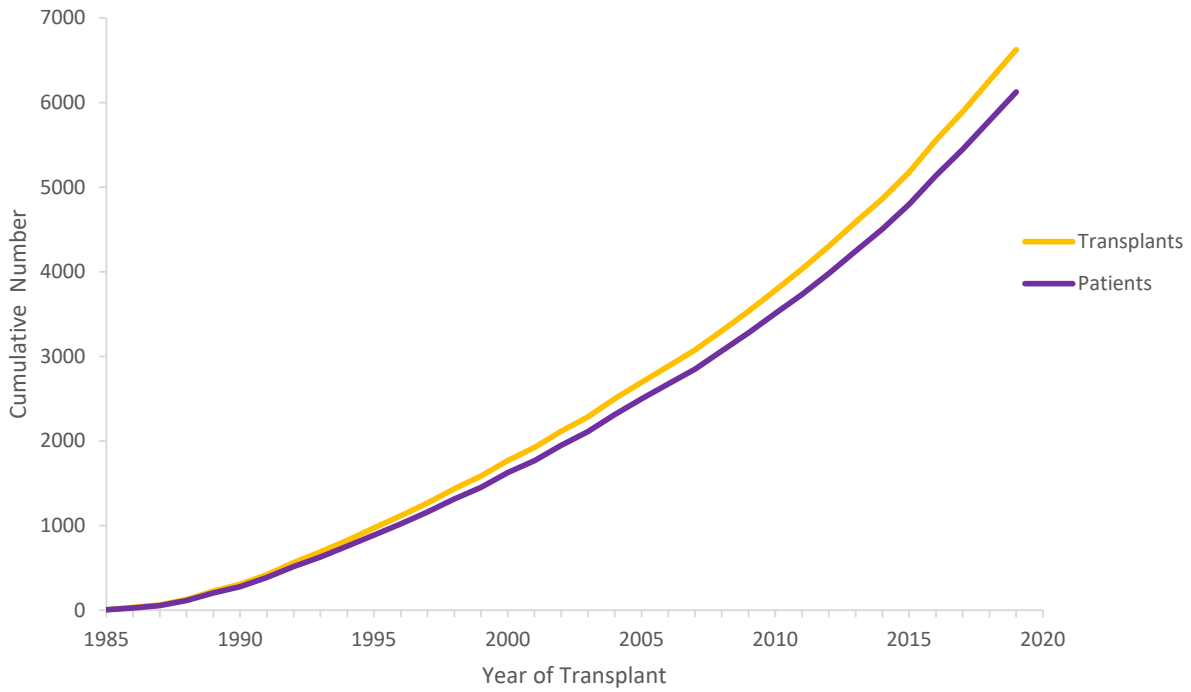
The majority of the 368 transplants were for adult patients (311, 84.5%), whilst 57 (15.5%) transplants were performed on children.

Of the 362 patients, 338 (93.4%) patients had their first transplant in 2019. Of these, four required retransplantation (i.e. two transplant operations in 2019). Twenty patients who had a single transplant prior to 2019 were retransplanted in 2019. Two of these went on to have their third transplant in 2019. Four patients who had two transplants prior to 2019 were retransplanted with their third graft in 2019.

9 Liver Transplantation from 1985 – 2019

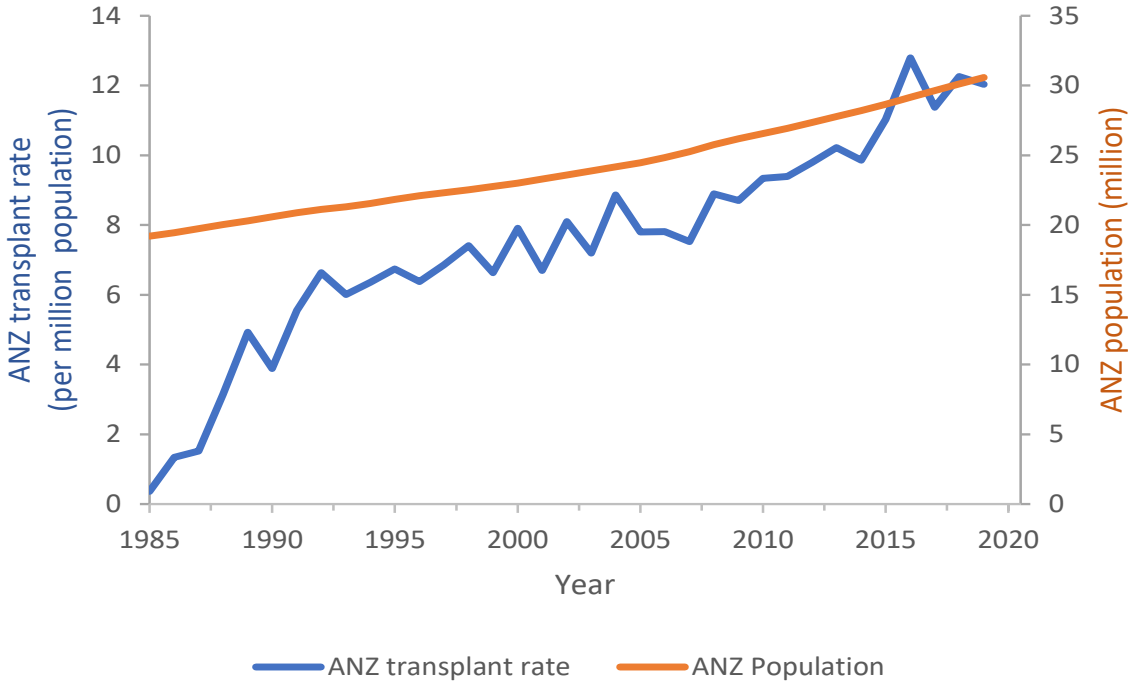
There have been 6,627 liver transplants undertaken on 6,126 patients between 1985 and 2019. Figure 9 shows the cumulative number of patients and transplants.

Figure 9. 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 to 12.0 in 2019, peaking at 12.8 in 2016 (Figure 10, Australia and New Zealand population source: https://www.abs.gov.au/statistics/people/population, https://www.stats.govt.nz/topics/population).

Figure 10. Liver transplant rate and total Australia and New Zealand population



9.1 Demographic Data for Patients Transplanted from 1985 - 2019

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. (6,126 patients, 6,121 graft 1; 5 graft 2).

Of patients receiving a transplant from 1985 to 2019, 16.7% were children. Females comprised 51.2% of paediatric patients but only 33.3% of adult patients (Table 3).

Table 3. Patient demographics by age group (1985 – 2019)

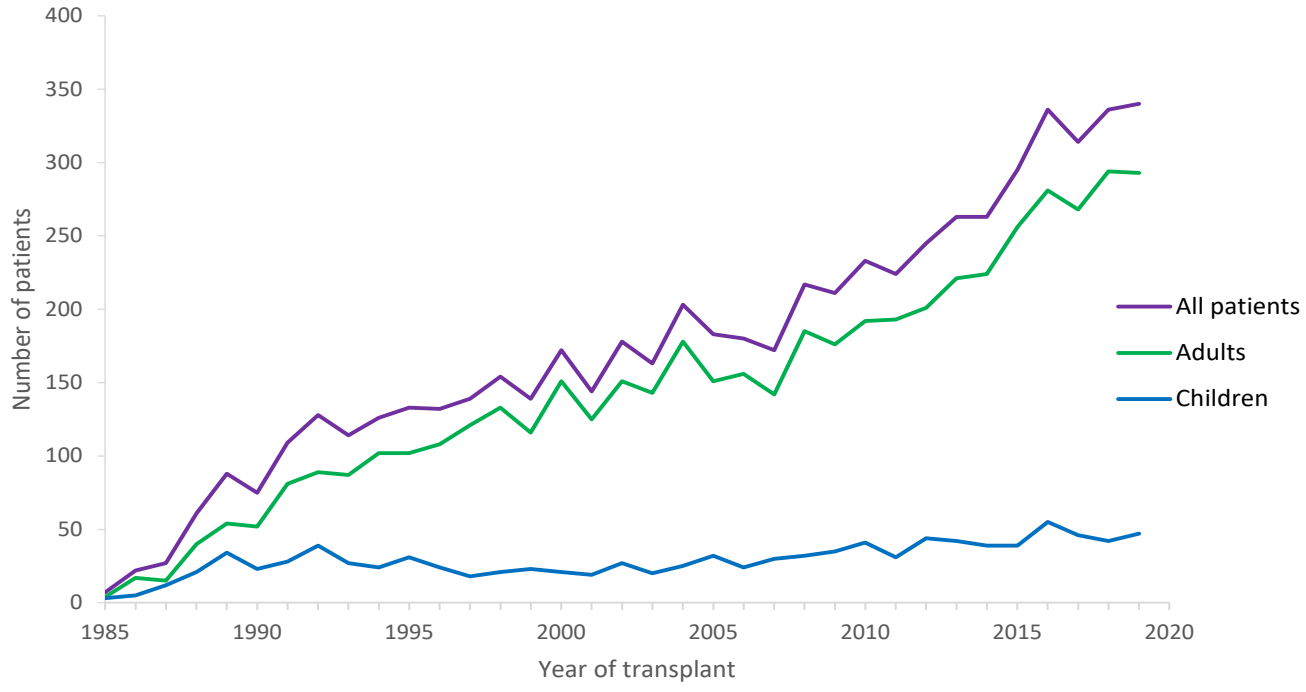
Patients Transplanted in ANZ from 1985 to 2019	**Children** (<16 years)	**Adults** (≥16 years)	**Total Patients**
Number of patients *(% total patients)*	1,024 *(16.7%)*	5,102 *(83.7%)*	6,126
Gender			
Female *(% age category)*	524 *(51.2%)*	1,701 *(33.3%)*	2,225 *(36.3%)*
Male *(% age category)*	500 *(48.8%)*	3,401 *(66.7%)*	3,901 *(63.7%)*
Age at first ANZ transplant			
Mean ± SD (years)	4 ± 4	50 ± 12	42 ± 20
Median (years)	2	52	49
Range	18 d - 15 y	16 y - 73 y	18 d - 73 y
Interquartile range (years)	1 - 7	44 - 59	32 - 57
Status of patient at 31/12/2019			
Alive *(% age category)*	848 *(82.8%)*	3,539 *(69.4%)*	4,387 *(71.6%)*
Deceased *(% age category)*	176 *(17.2%)*	1,563 *(30.6%)*	1,739 *(28.4%)*

Abbreviation: ANZ: Australia or New Zealand

9.1.1 Patients Transplanted by Year of First Transplant

From 2007 to 2019, there was a 97.7% increase in the number of patients transplanted per year, based on the year of their first transplant, from 172 to 340, including a 56.7% increase in the number of children transplanted (30 to 47) and a 106.3% increase in the number of adults transplanted (142 to 293, Figure 11).

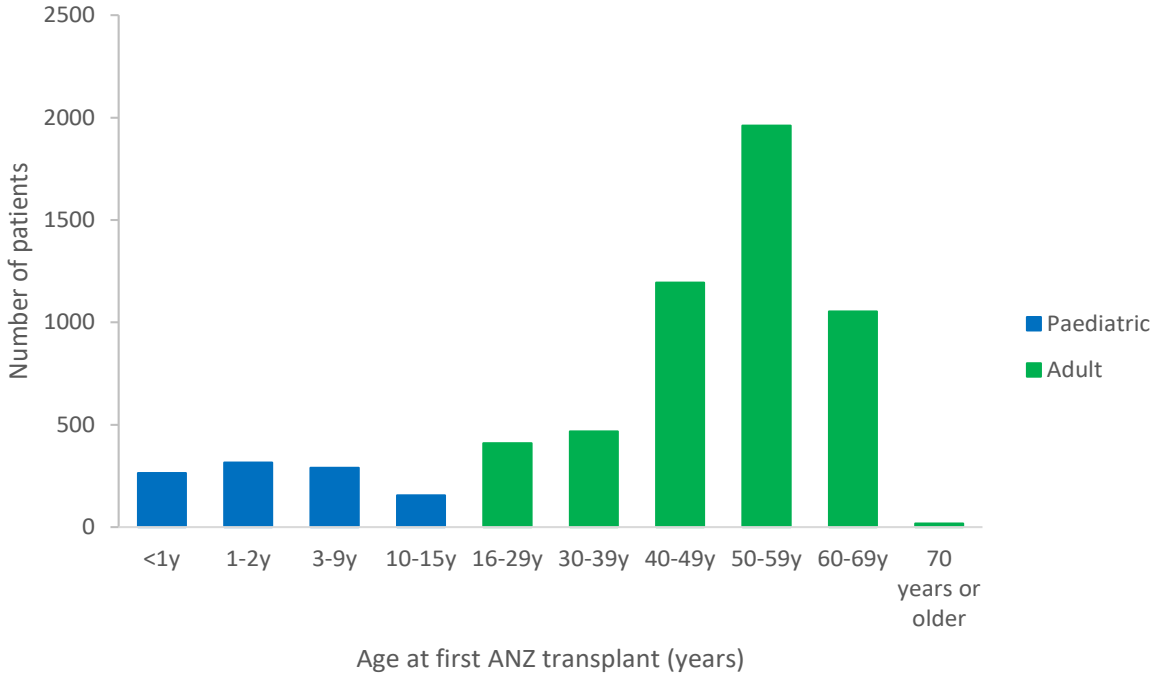
Figure 11. Number of patients transplanted by age group by year of first transplant



9.1.2 Recipient Age at First Transplant (1985 – 2019)

Of the 1,024 paediatric transplant recipients, 25.8% were infants less than one year old and 15.1% were adolescents 10 to 15 years old (Figure 12). Of the 5,102 adult recipients, 38.4% were in their 50s and only 0.3% were in their 70s.

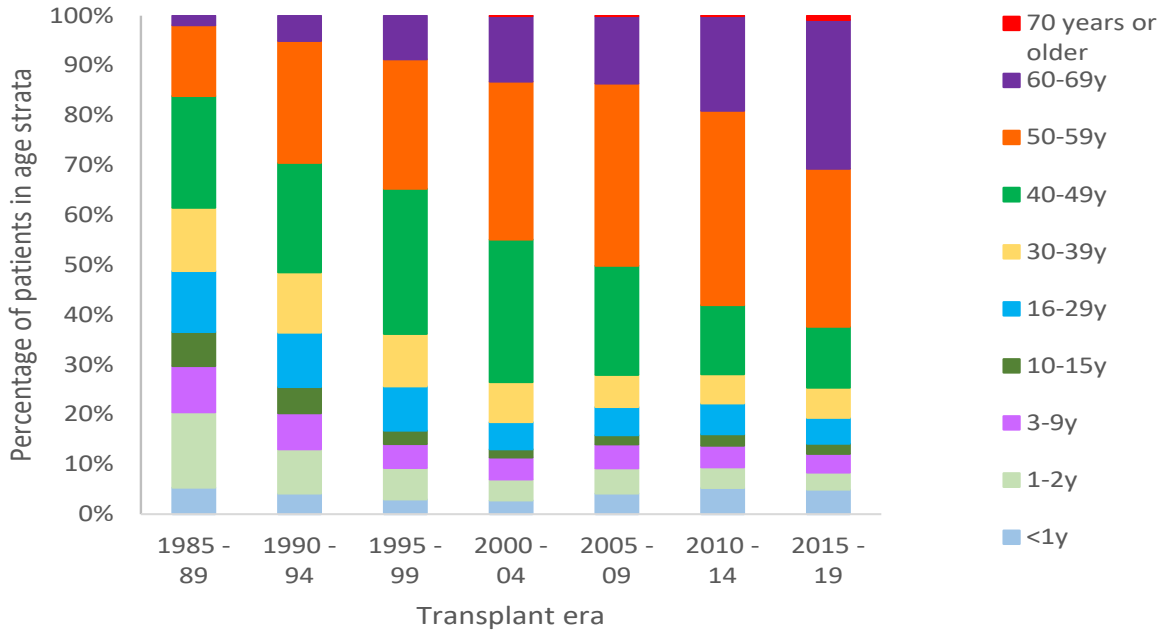
Figure 12. Recipient age strata at first Australian or New Zealand transplant (1985 – 2019)



9.1.3 Recipient Age at First Transplant by Era of Transplant

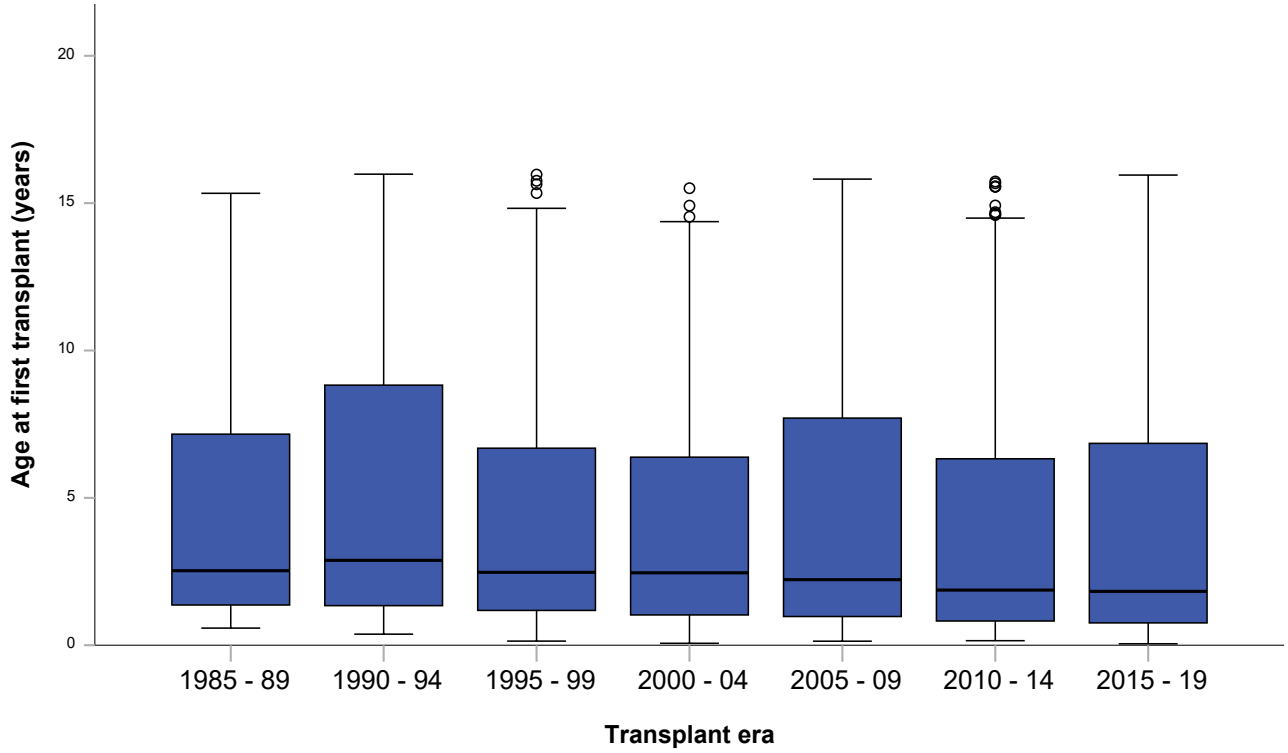
Figure 13 demonstrates the changing recipient age profile over the various transplant eras. There has been a progressive increase in the proportion of recipients aged 50-59, 60-69 and ≥ 70 years from 14%, 2% and 0%, respectively in the 1985-1989 era to 32%, 30% and 1%, respectively in the 2015-2019 era.

Figure 13. Recipient age strata (percentages) by transplant era



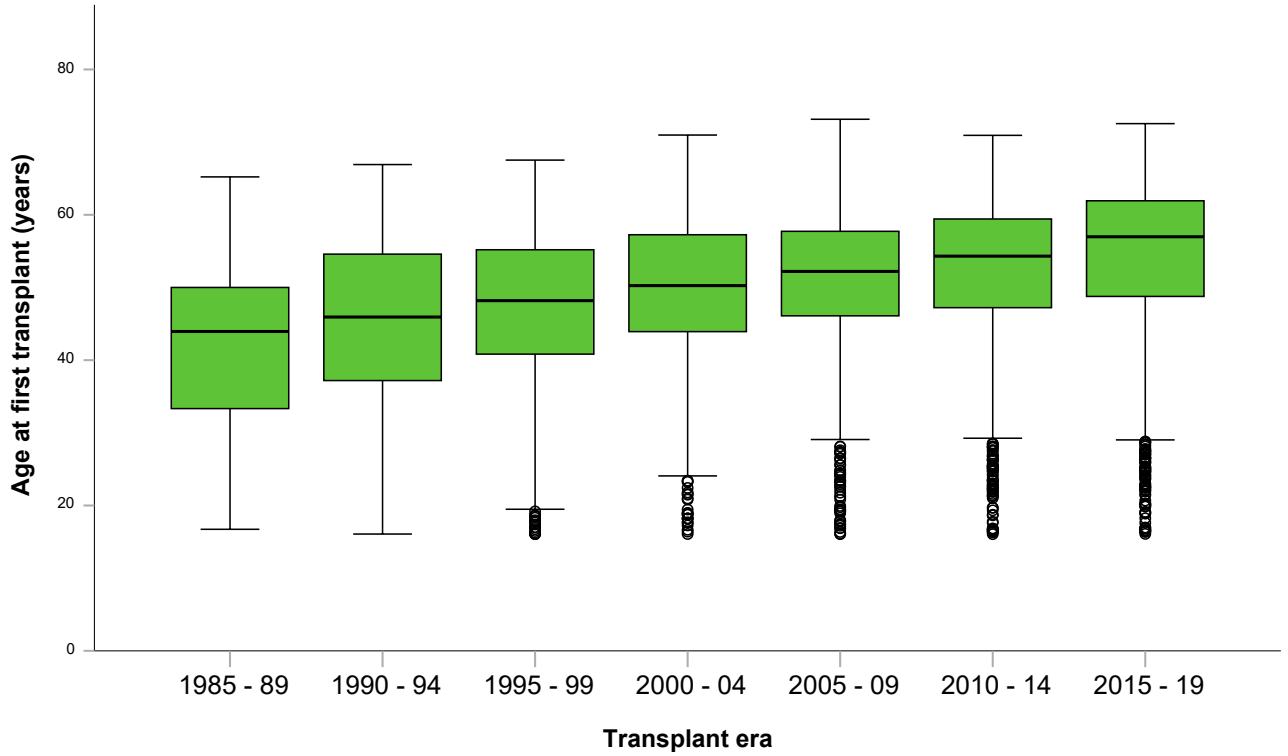
The median paediatric recipient age has been gradually decreasing over the transplant eras, from 2 years and 6 months in 1985-89 to 1 year and 10 months in 2015-19 (P=0.020, Figure 14).

Figure 14. 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 56 years in 2015-19 (P<0.001, Figure 15).

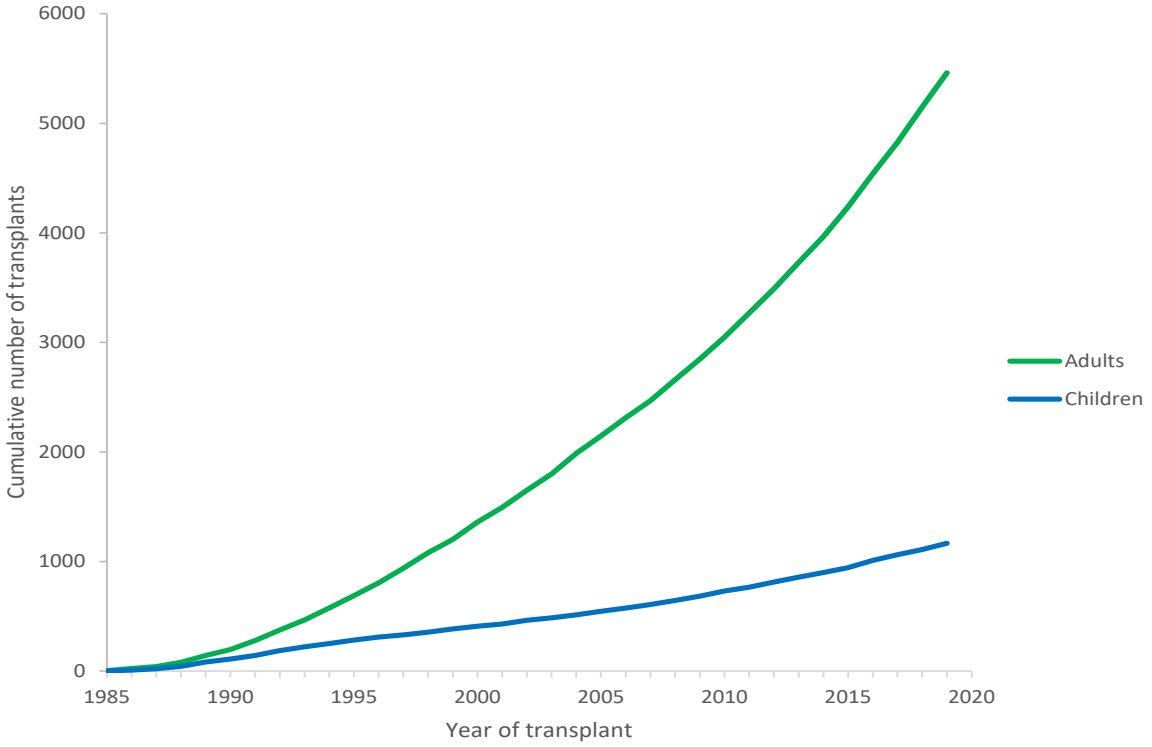
Figure 15. Adult age at first transplant by transplant era
Box and whisker plot: median, interquartile range, 1.5 times interquartile range and outliers shown



9.2 Transplants (1985 – 2019)

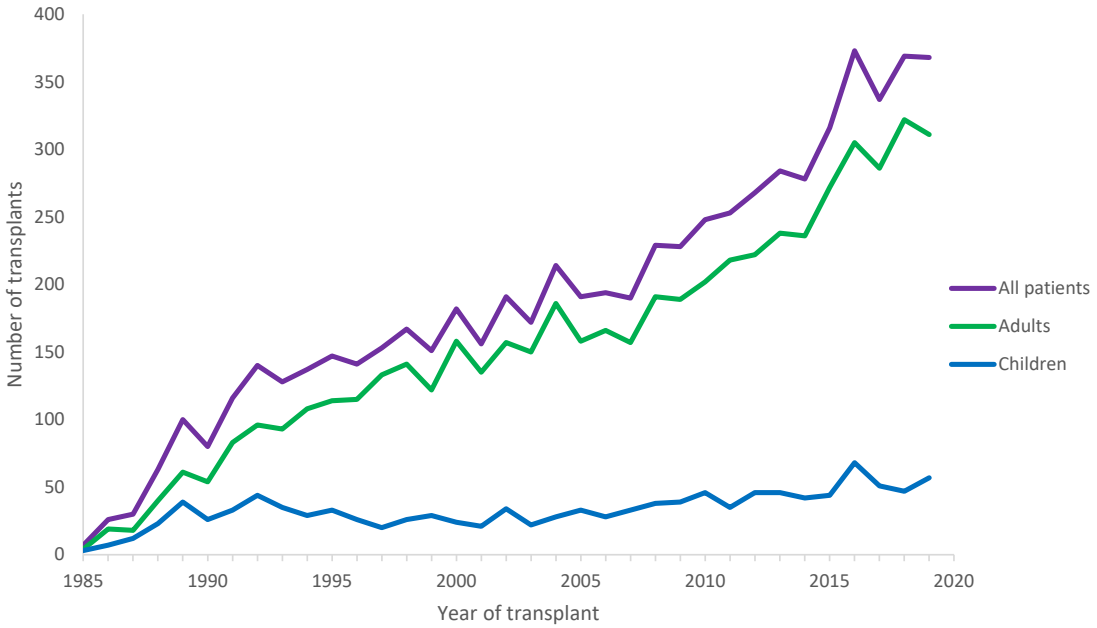
Of the 6,627 transplants, 5,460 (82.4%) were performed in adults and 1,167 (17.6%) in children (<16 years, Figure 16).

Figure 16. Cumulative number of liver transplants per year by age category



From 2007 to 2019, there was a 93.7% increase in the number of transplants performed per year, from 190 to 368, including a 72.7% increase in the number of transplants in children (33 to 57) and a 98.1% increase in the number of transplants in adults (157 to 311, Figure 17).

Figure 17. Number of liver transplants per year by recipient age category

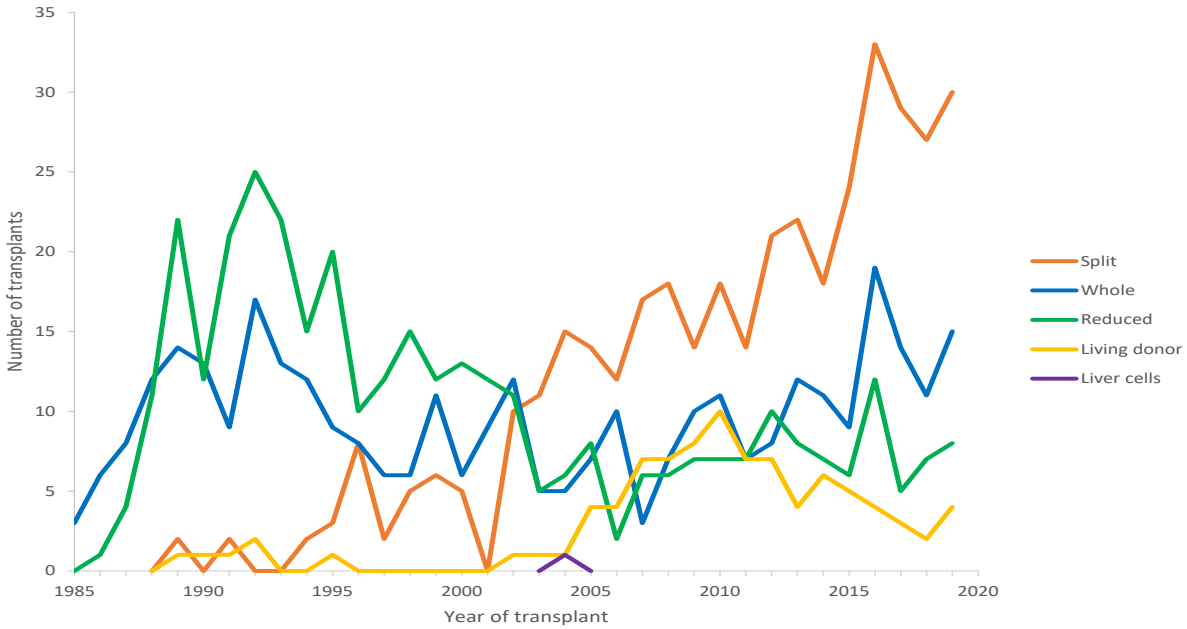


Since the first transplant in 1985, 447 (7.3%) recipients have undergone retransplantation. Of these, 395 patients had one retransplant, 50 patients have required two retransplants and two patients had three retransplants.

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 (53% in 2019, Figure 18). The number of living donors peaked at 10 in 2010 and subsequently this has become an infrequent method of transplantation in children (four transplants in 2019).

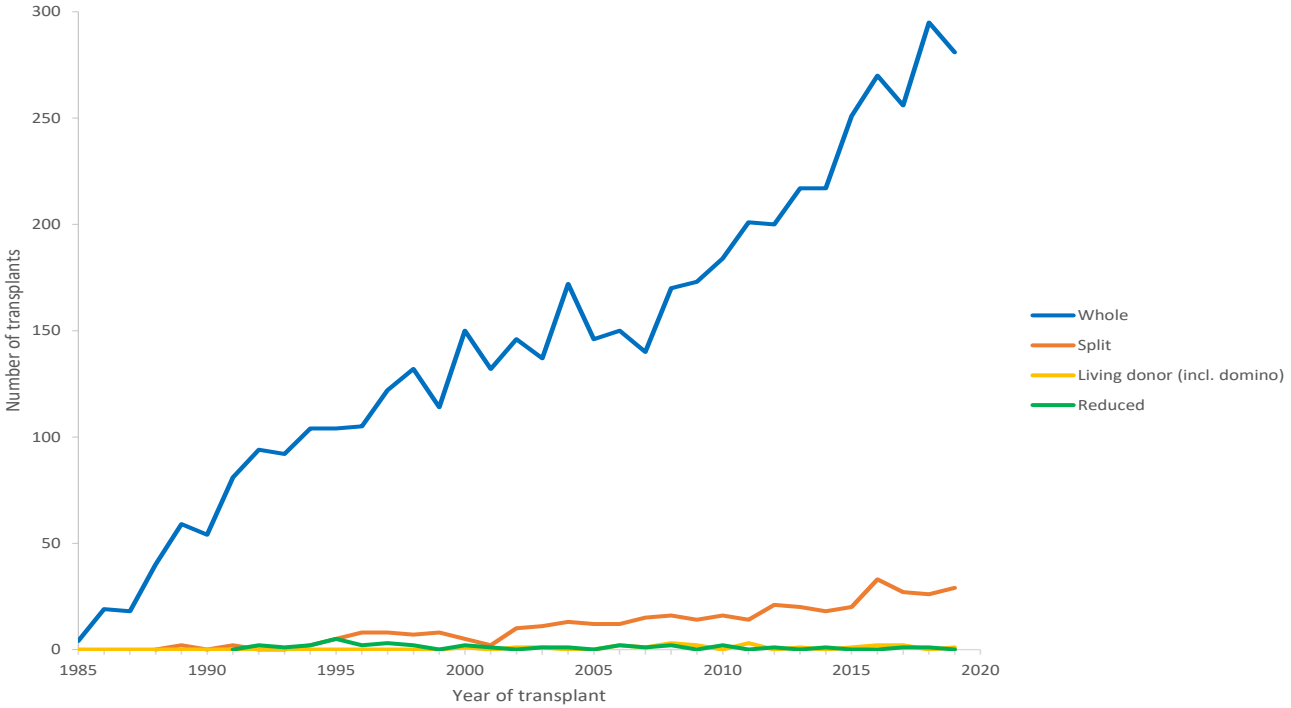
Figure 18. Type of graft for paediatric recipients – all years



9.2.2 Type of Graft – Adult Recipients, All Years

The dominant form of liver transplantation in adults is whole liver transplantation (281 of 311 transplants, 90% in 2019, Figure 19). The number of deceased donor split liver transplants in adults has increased from 5 of 158 transplants (3%) in 2000 to 29 of 311 (9%) in 2019. There has been a total of 21 adult-to-adult living donor liver transplants performed, including four domino liver transplants.

Figure 19. Type of graft for adult recipients – all years



10 Diagnoses at First Transplant

Diagnosis at First Transplant Analysis Population: n = 6,121 patients - first liver transplant in Australia or New Zealand (ie. Graft 1). Excludes five patients who had first graft overseas.

10.1 Primary Diagnosis in Children

Of 1,022 children who underwent their first liver transplant in Australia or New Zealand, the most common primary diagnoses were biliary atresia (54%), metabolic disease (15%) and fulminant hepatic failure, (11%, Table 4).

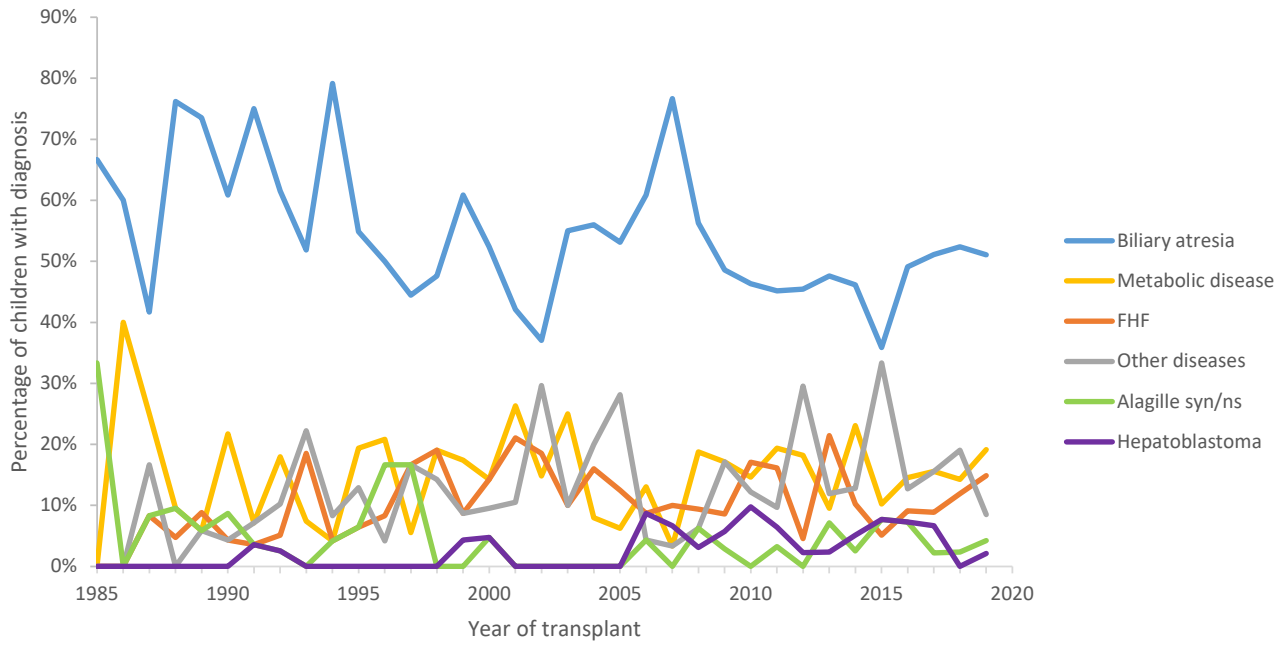
Table 4. Primary diagnosis in children

Primary diagnosis	N	%
Biliary atresia	548	**54%**
Metabolic disorders	150	**15%**
Fulminant hepatic failure	111	**11%**
Alagille syndrome	41	**4%**
Hepatoblastoma	32	**3%**
Progressive familial intrahepatic cholestasis	28	**3%**
Cryptogenic cirrhosis	22	**2%**
Cystic fibrosis	15	**1%**
Autoimmune cirrhosis	12	**1%**
Primary sclerosing cholangitis	8	**1%**
Hepatocellular carcinoma	7	**1%**
Neonatal hepatitis	6	**1%**
Histiocytosis X	5	**0.5%**
Caroli's disease	4	**0.4%**
Choledocal cyst	3	**0.3%**
Ductopenia	3	**0.3%**
Intestinal failure associated liver disease	3	**0.3%**
Secondary biliary cirrhosis	3	**0.3%**
Chronic Budd Chiari	2	**0.2%**
Common variable immune deficiency	2	**0.2%**
Congenital intrahepatic portosystemic shunt	2	**0.2%**
Polycystic liver +/- kidney disease	2	**0.2%**
Arterio-venous malformation	1	**0.1%**
Autoimmune sclerosing cholangitis	1	**0.1%**
Bile salt synthetic defect	1	**0.1%**
Cornelia de Lange syndrome	1	**0.1%**
Enterovirus hepatitis	1	**0.1%**
Established cirrhosis with marked cholestasis	1	**0.1%**
Gestational alloimmune liver disease	1	**0.1%**
Hepatic fibrosis / polycystic kidney disease	1	**0.1%**
Hepatic lymphangiomatosis	1	**0.1%**
Idiopathic copper toxicosis	1	**0.1%**
Ischaemic sclerosing cholangitis	1	**0.1%**
Nodular regenerative hyperplasia	1	**0.1%**
Parvovirus	1	**0.1%**
Total	**1022**	

10.2 Primary Diagnosis Trend in Children

The indications for liver transplantation in children have remained relatively stable over time (Figure 20).

Figure 20. Paediatric primary diagnosis percentages (based on graft 1) all years



Abbreviation: FHF, fulminant hepatic failure; Alagille syn/ns, Alagille syndrome / non-syndromic

10.3 Primary Diagnosis in Adults

Of 5,099 adults who underwent their first liver transplant in Australia or New Zealand, the most common primary diagnoses were hepatitis C virus cirrhosis (21%), alcoholic cirrhosis (13%) and hepatocellular carcinoma (12%, Table 5).

Table 5. Primary diagnosis in adults

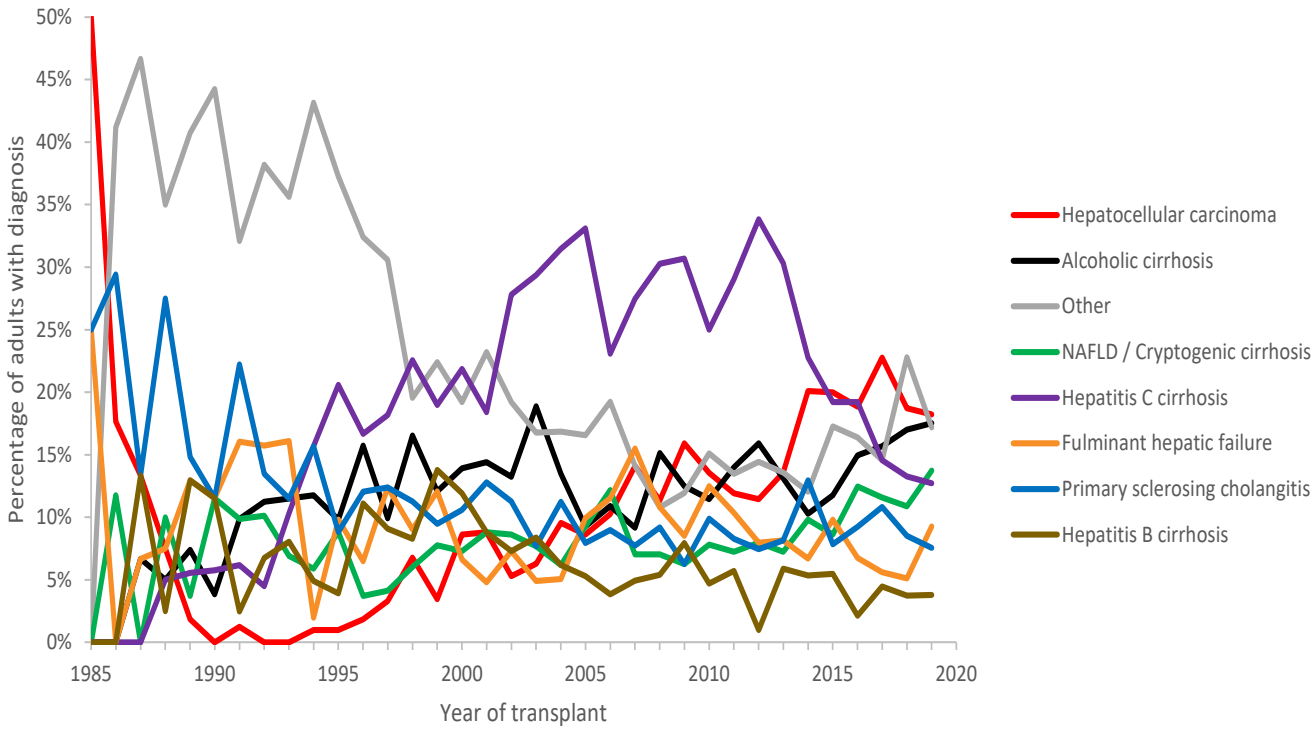
Primary diagnosis	N	%	Primary diagnosis	N	%
Hepatitis C virus cirrhosis	1094	21%	Ductopenia	4	0.1%
Alcoholic cirrhosis	676	13%	Secondary biliary cirrhosis - hepatolithiasis	4	0.1%
Hepatocellular carcinoma	609	12%	Cholestatic cirrhosis / Secondary cholangitis	3	0.1%
Primary sclerosing cholangitis	516	10%	Haemolytic uraemic syndrome	3	0.1%
Fulminant hepatic failure	446	9%	Oriental cholangiohepatitis	3	0.1%
NAFLD / Cryptogenic cirrhosis	445	9%	Post hepatitic cirrhosis - Drug related	3	0.1%
Hepatitis B virus cirrhosis	299	6%	Choledocal cyst	2	0.04%
Primary biliary cirrhosis	276	5%	Congenital biliary fibrosis	2	0.04%
Metabolic disorders	210	4%	Intestinal failure associated liver disease	2	0.04%
Autoimmune cirrhosis	180	4%	Non-cirrhotic portal hypertension	2	0.04%
Polycystic liver +/- kidney disease	58	1%	Recurrent cholangitis	2	0.04%
Biliary atresia	50	1%	Angiosarcoma	1	0.02%
Chronic Budd Chiari	39	1%	Arterio-venous malformation	1	0.02%
Cystic fibrosis	28	1%	Biliary papillomatosis	1	0.02%
Secondary biliary cirrhosis	20	0.4%	Chronic cholestatic liver disease	1	0.02%
Caroli's disease	19	0.4%	COACH syndrome	1	0.02%
Hepatic cholangiocellular carcinoma	15	0.3%	Common variable immune deficiency	1	0.02%
Granulomatous hepatitis / sarcoidosis	11	0.2%	Congenital heart disease	1	0.02%
Alagille syndrome	10	0.2%	Drug induced cholestasis	1	0.02%
Epithelioid hemangioendothelioma	8	0.2%	Fasciola	1	0.02%
Hereditary haemorrhagic telangiectasia	8	0.2%	Graft vs host disease - bone marrow transplant	1	0.02%
Nodular regenerative hyperplasia	7	0.1%	Histiocytosis X	1	0.02%
Progressive familial intrahepatic cholestasis	6	0.1%	Infected hydatid cysts	1	0.02%
Congenital hepatic fibrosis	5	0.1%	Liver trauma	1	0.02%
Haemangioma	5	0.1%	Portal biliopathy	1	0.02%
Metastatic neuroendocrine tumour	5	0.1%	Portal vein thrombosis	1	0.02%
Adenomatosis	4	0.1%	Secondary liver tumours - Gastrinoma	1	0.02%
Drug hepatotoxicity	4	0.1%	**Total**	**5099**	

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

10.4 Primary Diagnosis Trend in Adults

The commonest indication for transplantation in adults was hepatitis C virus cirrhosis until 2014, after which hepatocellular carcinoma has become the commonest indication. The proportion of patients transplanted primarily for hepatitis C has decreased from 33.8% in 2012 to 12.7% in 2019 (Figure 21). Including cases with hepatitis C virus cirrhosis recorded as any of up to four diagnoses, the proportion of patients transplanted primarily for hepatitis C has decreased from 42% in 2012 to 25% in 2019. The proportion of patients transplanted for hepatocellular carcinoma has increased from 11.4% in 2012 to 18.2% in 2019. Over the same time period, the proportion of patients transplanted for non-alcoholic fatty liver disease increased from 8.0% to 13.7%.

Figure 21. Adult primary diagnosis percentages (based on graft 1) all years



Abbreviation: NAFLD, non-alcoholic fatty liver disease

10.5 Fulminant Hepatic Failure

Table 6 lists the detailed breakdown of the causes of fulminant hepatic failure for adults and children.

Table 6. Detailed breakdown of fulminant hepatic failure category by age group

Fulminant hepatic failure	Paediatric	Adult	All patients
Acute - Unknown / unspecified	59	108	**167**
Acute - Hepatitis B	0	82	**82**
Acute - Hepatitis non A-G	17	23	**40**
Acute - Other drugs	3	36	**39**
Subacute - Hepatitis unknown	4	30	**34**
Acute - Wilson's	9	22	**31**
Acute - Paracetamol	4	25	**29**
Subacute - Autoimmune hepatitis	2	22	**24**
Subacute - Hepatitis B	0	22	**22**
Subacute - Drugs	1	16	**17**
Acute - Autoimmune hepatitis	1	13	**14**
Acute - Herbs / mushrooms	0	10	**10**
Subacute - Wilson's	2	7	**9**
Subacute - Hepatitis non A-G	0	6	**6**
Acute - Post-operative	1	4	**5**
Acute - Budd Chiari	0	4	**4**
Acute - Hepatitis A	1	3	**4**
Acute - Toxic (non drug)	1	3	**4**
Subacute - Budd Chiari	1	2	**3**
Acute - Alpha-1-antitrypsin	2	0	**2**
Acute - Other virus	1	1	**2**
Subacute - Hepatitis A	0	2	**2**
Acute - Hepatitis E	0	1	**1**
Acute - Post traumatic	0	1	**1**
Subacute - Hepatitis - giant cell	1	0	**1**
Subacute - Hepatitis - ischaemic	0	1	**1**
Subacute - Hepatitis C	0	1	**1**
Subacute - Herbs	0	1	**1**
Subacute - Post surgical resection	1	0	**1**
Total	**111**	**446**	**557**

10.6 Metabolic Disorders

Alpha-1 antitrypsin deficiency, familial amyloid polyneuropathy and Wilson's disease were the most common primary diagnoses in the metabolic disorders category (Table 7).

Table 7. Detailed breakdown of metabolic disorders category by age group

Metabolic disorders	Paediatric	Adult	Total patients
Alpha-1-antitrypsin deficiency	42	63	**105**
Familial amyloid polyneuropathy	0	45	**45**
Wilsons disease	8	35	**43**
Haemochromatosis	3	33	**36**
Urea cycle disorders	28	4	**32**
- Ornithine transcarbamylase (OTC) deficiency	*17*	*1*	***18***
- Argininosuccinate lyase (ASL) deficiency	*4*	*1*	***5***
- Citrullinaemia, Argininosuccinate synthetase (ASS) deficiency	*4*	*1*	***5***
- Carbamyl phosphate synthetase (CPS) 1 deficiency	*3*	*1*	***4***
Primary hyperoxaluria	12	9	**21**
Glycogen storage disease	5	10	**15**
Crigler-Najjar	12	1	**13**
Homozygous hypercholesterolaemia	7	2	**9**
Maple syrup urine disease	8	1	**9**
Propionic acidaemia	7	0	**7**
Tyrosinaemia	6	0	**6**
Bile acid synthesis / transport disorder	3	0	**3**
Methylmalonic acidaemia	3	0	**3**
Protein C deficiency	1	2	**3**
Protoporphyria	0	3	**3**
Other porphyria	0	2	**2**
Cirrhosis secondary to Niemann-Pick Type C	1	0	**1**
Familial immunodeficiency syndrome	1	0	**1**
Indian childhood cirrhosis	1	0	**1**
Mitochondrial disease	1	0	**1**
Pyridoxamine 5-phosphate oxidase deficiency	1	0	**1**
Total	**150**	**210**	**360**

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

6,121 patients had their first liver transplant in Australia or New Zealand (i.e. Graft 1, Figure 22 and Table 8). 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 75.0%. The median patient survival post-transplant was 24.5 years.

Figure 22. Patient survival curve

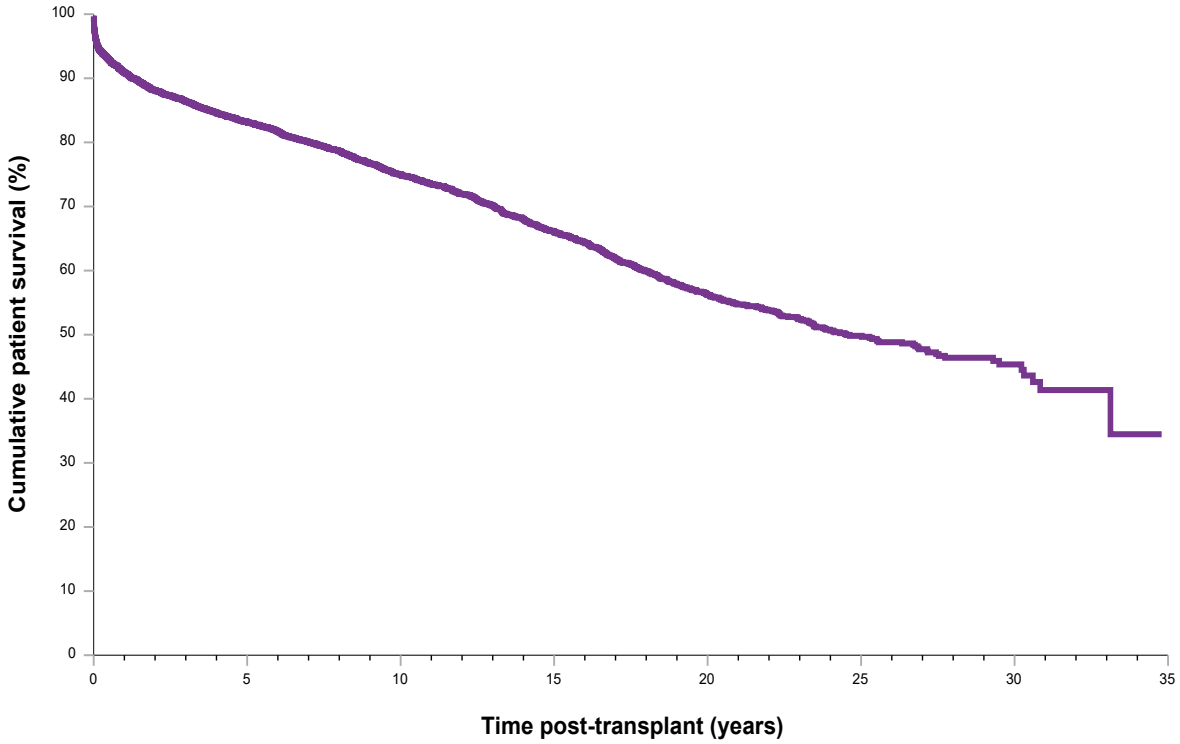


Table 8. Patient survival

Patient Survival	Time post-transplant (years)								
	0	1	3	5	10	15	20	25	30
No. at risk	6,121	5,244	4,399	3,677	2,356	1,423	730	321	67
Survival (%)		91%	86%	83%	75%	66%	56%	50%	45%

11.2 Patient Survival by Age Group

Paediatric cases are defined as less than 16 years at time of first transplant (n = 1,022). Adult cases are defined as greater than or equal to 16 years at time of first transplant (n = 5,099). Post-transplant survival was superior in the paediatric population compared to the adult population (P < 0.001, Figure 23, Table 9). Ten-year patient survival was 84.7% for children and 72.9% for adults. Median patient survival was 33.1 years for children and was 20.4 years for adults.

Figure 23. Patient survival curve by age category

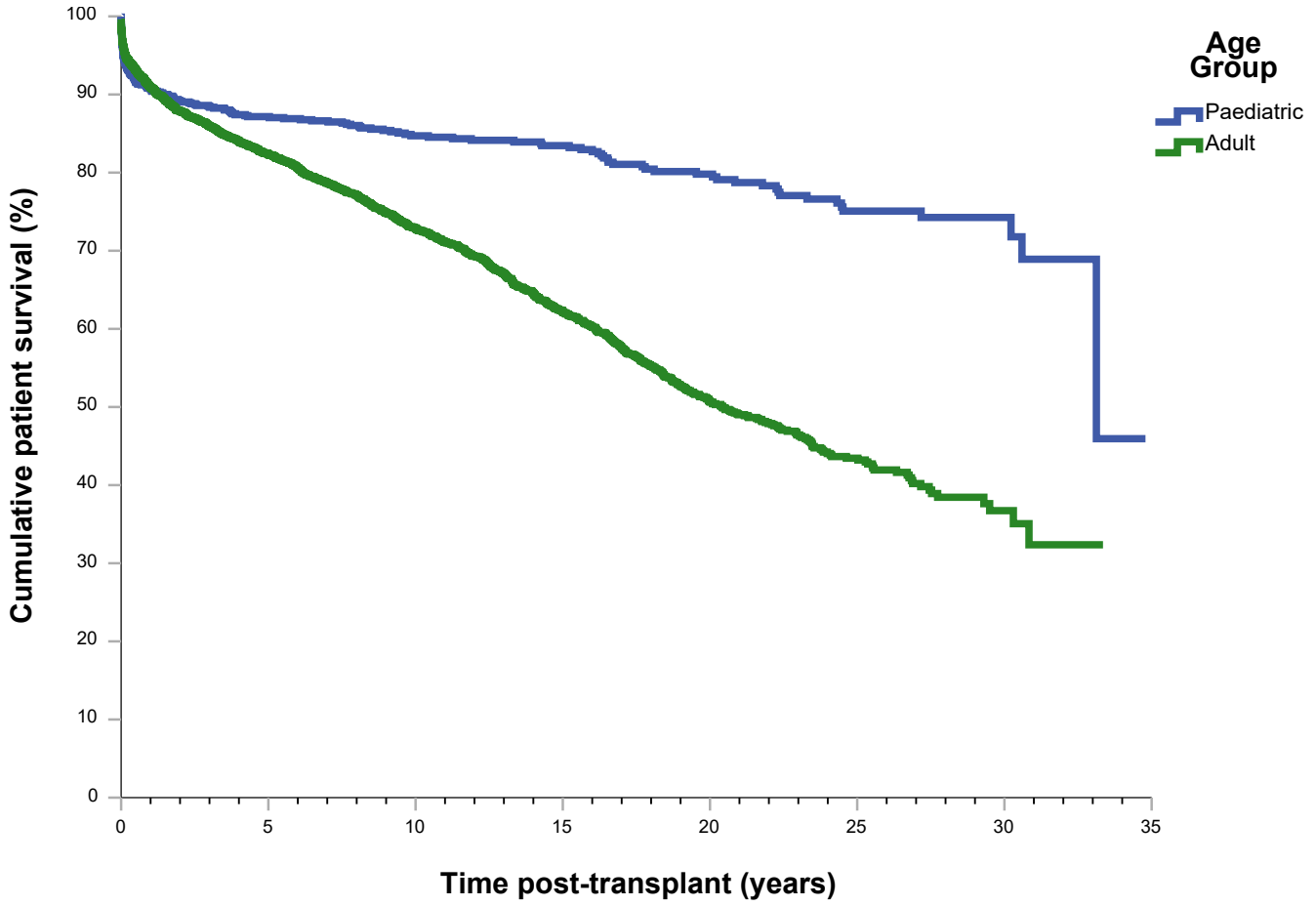


Table 9. Patient survival by age category

Age group	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
Paediatric (<16y)	No. at risk	1,022	882	777	676	481	335	230	133	36
	Survival (%)		91%	89%	87%	85%	84%	80%	75%	74%
Adults (≥16y)	No. at risk	5,099	4,362	3,622	3,001	1,875	1,088	500	188	31
	Survival (%)		91%	86%	82%	73%	62%	51%	43%	37%

11.3 Paediatric Patient Survival by Age Strata

There was no significant difference in patient survival by paediatric age strata (P = 0.276, Figure 24, Table 10). Ten-year patient survival was 85.8% for children less than 1 year, 80.9% for 1 – 2-year-olds, 86.5% for 3 – 9-year-olds and 88.3% 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 24. Paediatric patient survival curve by age strata

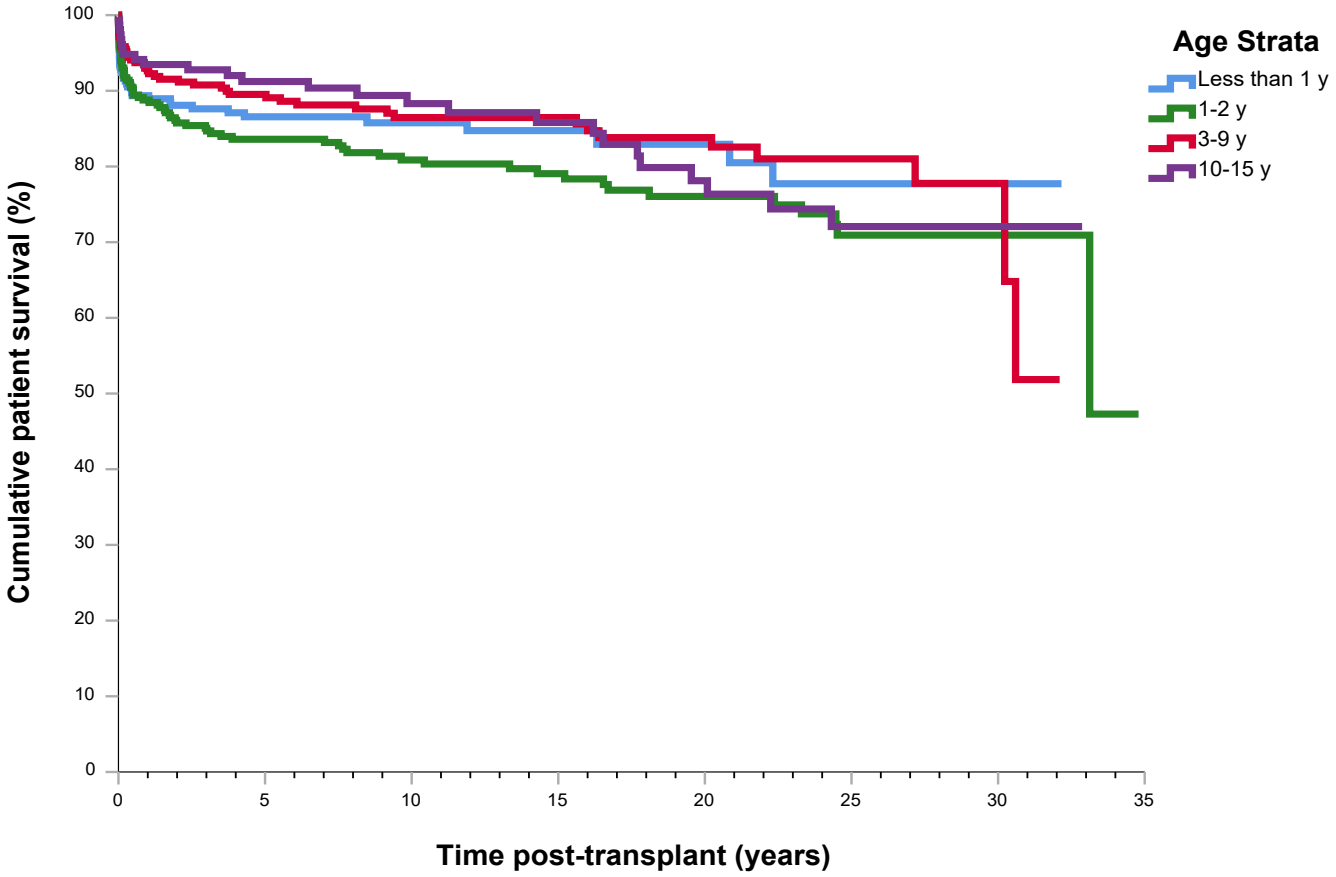


Table 10. Paediatric patient survival by age strata

Age strata	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
< 1 year	No. at risk	264	220	153	143	93	56	37	20	4
	Survival (%)		89%	88%	87%	86%	85%	83%	78%	78%
1 - 2 years	No. at risk	315	267	241	212	161	114	81	48	14
	Survival (%)		89%	85%	84%	81%	79%	76%	71%	71%
3 - 9 years	No. at risk	289	255	231	201	147	103	68	37	9
	Survival (%)		93%	91%	90%	87%	87%	84%	81%	78%
10 – 15 years	No. at risk	154	140	127	110	80	62	44	28	9
	Survival (%)		94%	93%	91%	88%	86%	78%	72%	72%

11.4 Adult Patient Survival by Age Strata

Post-transplant patient survival in adults was significantly worse with increasing patient age (P < 0.001, Figure 25, Table 11). For patients aged 16 to 29, 30 to 39, 40 to 49, 50 to 59, 60 to 69 and 70 to 79 years, 10-year patient survival was 79.5%, 78.0%, 73.7%, 72.6%, 64.9% and 66.7%, respectively. Median patient survival was not reached for patients aged 16 to 29 years. For patients aged 30 to 39, 40 to 49, 50 to 59, 60 to 69 and 70 to 79 years, median patient survival was 25.0, 23.2, 18.1, 15.1 and 11.0 years, respectively.

Figure 25. Adult patient survival curve by age strata

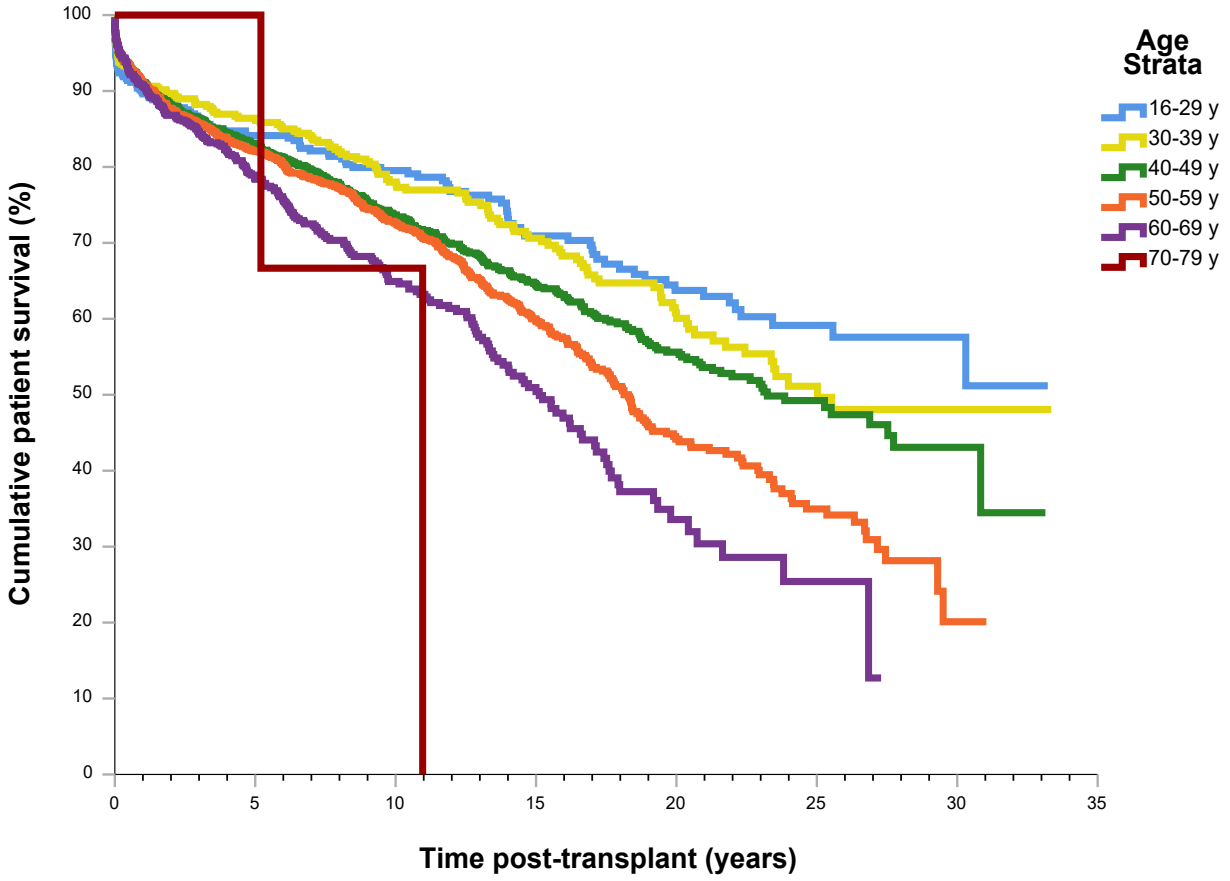


Table 11. Adult patient survival by age strata

Age strata	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
16-29 y	No. at risk	408	352	313	271	186	129	89	43	10
	Survival (%)		90%	86%	84%	80%	71%	64%	59%	58%
30-39 y	No. at risk	466	403	351	313	225	155	86	35	7
	Survival (%)		91%	88%	86%	78%	71%	61%	51%	48%
40-49 y	No. at risk	1,195	1,046	920	816	588	371	175	60	10
	Survival (%)		91%	86%	83%	74%	65%	56%	49%	43%
50-59 y	No. at risk	1,961	1,695	1,417	1,165	673	337	128	46	4
	Survival (%)		91%	86%	82%	73%	60%	44%	35%	20%
60-69 y	No. at risk	1,052	853	616	433	202	96	22	4	0
	Survival (%)		91%	84%	78%	65%	50%	34%	25%	
70-79 y	No. at risk	17	13	5	3	1	0			
	Survival (%)		100%	100%	100%	67%				

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 26, Table 12). Patient survival in the most recent era was 95.4% at 1 year, 91.0% at 3 years, 85.6% at 5 years and 76.1% at 10 years. Median patient survival was 22.0 years for 1995 – 99 era, 20.7 years for 1990 – 94 era and 11.8 years for 1985 – 89 era. Median patient survival was not reached for recent eras from 2000 - 04 onwards.

Figure 26. Patient survival curve by era of transplant

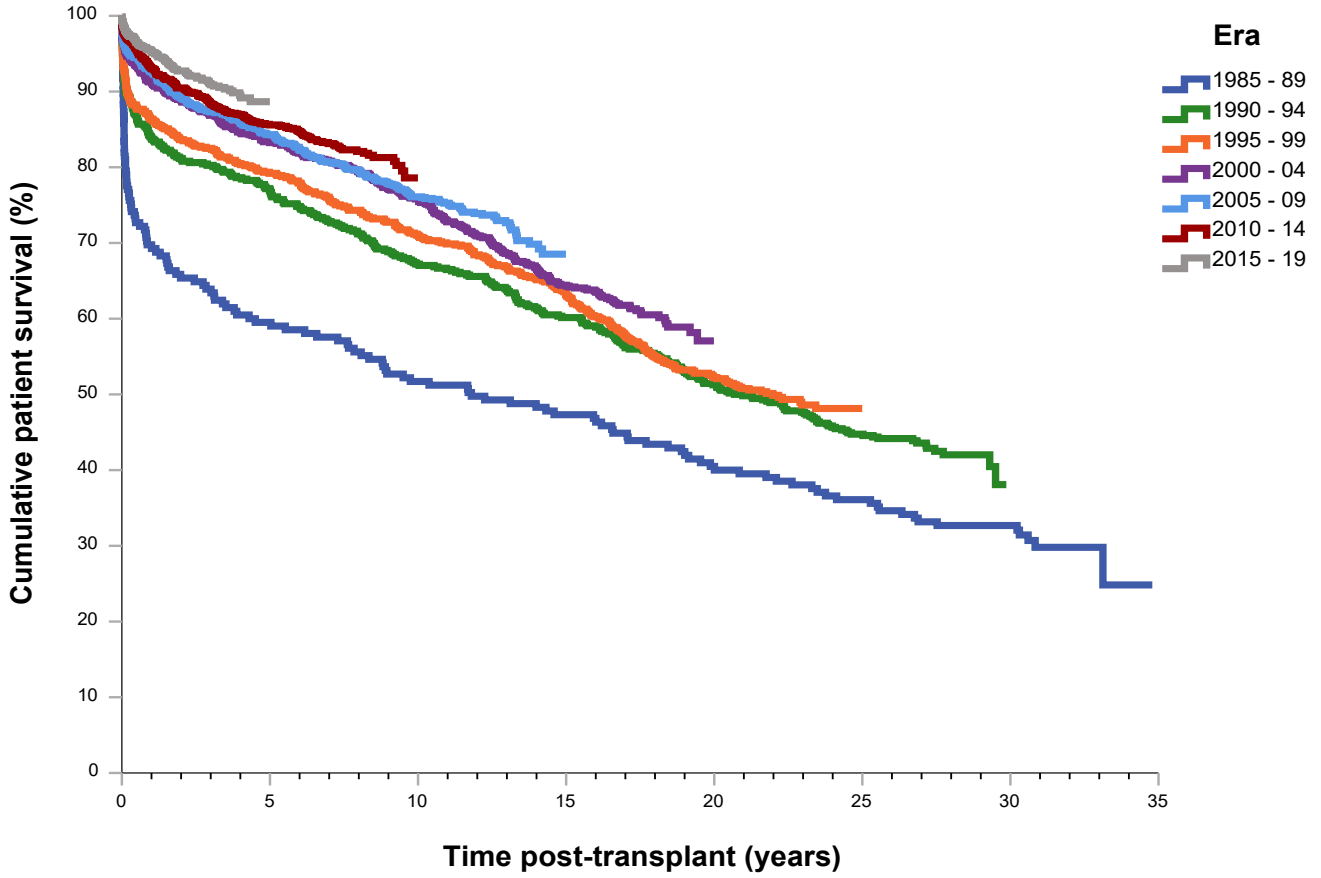


Table 12. Patient survival by transplant era

Transplant Era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
1985 - 89	No. at risk	205	143	131	122	106	97	83	74	67
	Survival (%)		70%	64%	60%	52%	47%	41%	36%	33%
1990 - 94	No. at risk	552	463	443	425	371	332	283	247	0
	Survival (%)		84%	80%	77%	67%	60%	51%	45%	
1995 - 99	No. at risk	697	602	575	552	495	440	364	0	
	Survival (%)		86%	83%	79%	71%	63%	52%		
2000 - 04	No. at risk	860	785	747	716	652	554	0		
	Survival (%)		91%	87%	83%	76%	64%			
2005 - 09	No. at risk	962	891	840	811	732	0			
	Survival (%)		93%	87%	84%	76%				
2010 - 14	No. at risk	1,228	1,143	1,085	1,051	0				
	Survival (%)		93%	88%	86%					
2015 - 19	No. at risk	1,617	1,217	578	0					
	Survival (%)		95%	91%						

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 27, Table 13). Paediatric patient survival in the most recent era was 97.3% at 1 year, 96.1% at 3 years, 90.9% at 5 years and 92.1% at 10 years. Median paediatric patient survival was 20.8 years for 1985 – 89 era and was not reached for all other eras.

Figure 27. Paediatric patient survival curve by era of transplant

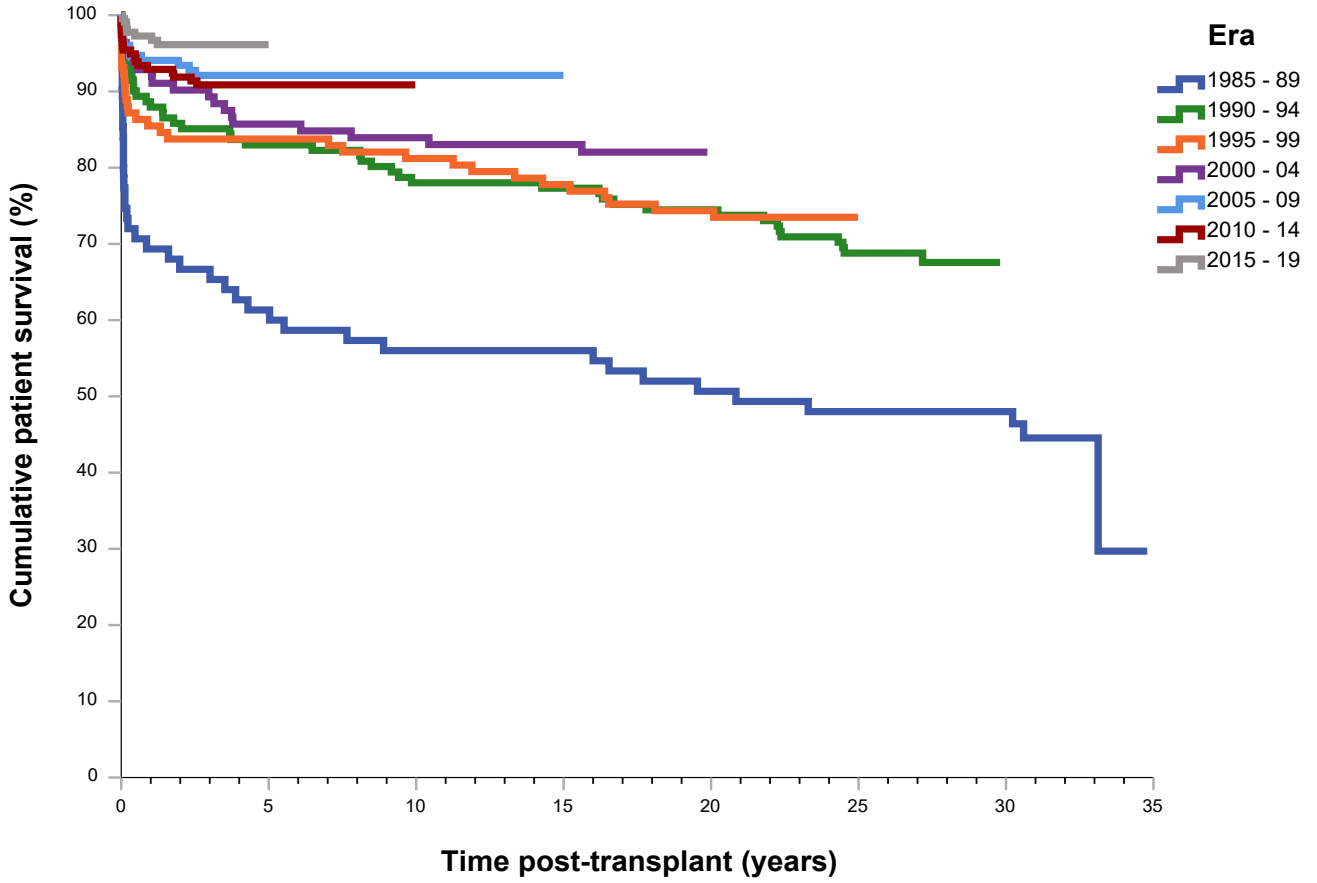


Table 13. Paediatric patient survival by transplant era

Transplant Era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
1985 - 89	No. at risk	75	52	50	46	42	42	38	36	36
	Survival (%)		69%	67%	61%	56%	56%	51%	48%	48%
1990 - 94	No. at risk	141	124	120	117	110	109	105	97	0
	Survival (%)		88%	85%	83%	78%	77%	75%	69%	
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	0		
	Survival (%)		93%	89%	86%	84%	83%			
2005 - 09	No. at risk	152	143	140	140	140	0			
	Survival (%)		94%	92%	92%	92%				
2010 - 14	No. at risk	197	183	179	179	0				
	Survival (%)		93%	91%	91%					
2015 - 19	No. at risk	228	176	90	0					
	Survival (%)		97%	96%						

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 28, Table 14). Patient survival in the most recent era was 95.1% at 1 year, 90.2% at 3 years, 84.6% at 5 years and 73.1% at 10 years. Median adult patient survival was 18.4 years for 1995 – 99 era, 17.0 years for 1990 – 94 era and 9.5 years for 1985 – 89 era. Median adult patient survival was not reached for recent eras from 2000 - 04 onwards.

Figure 28. Adult patient survival curve by era of transplant

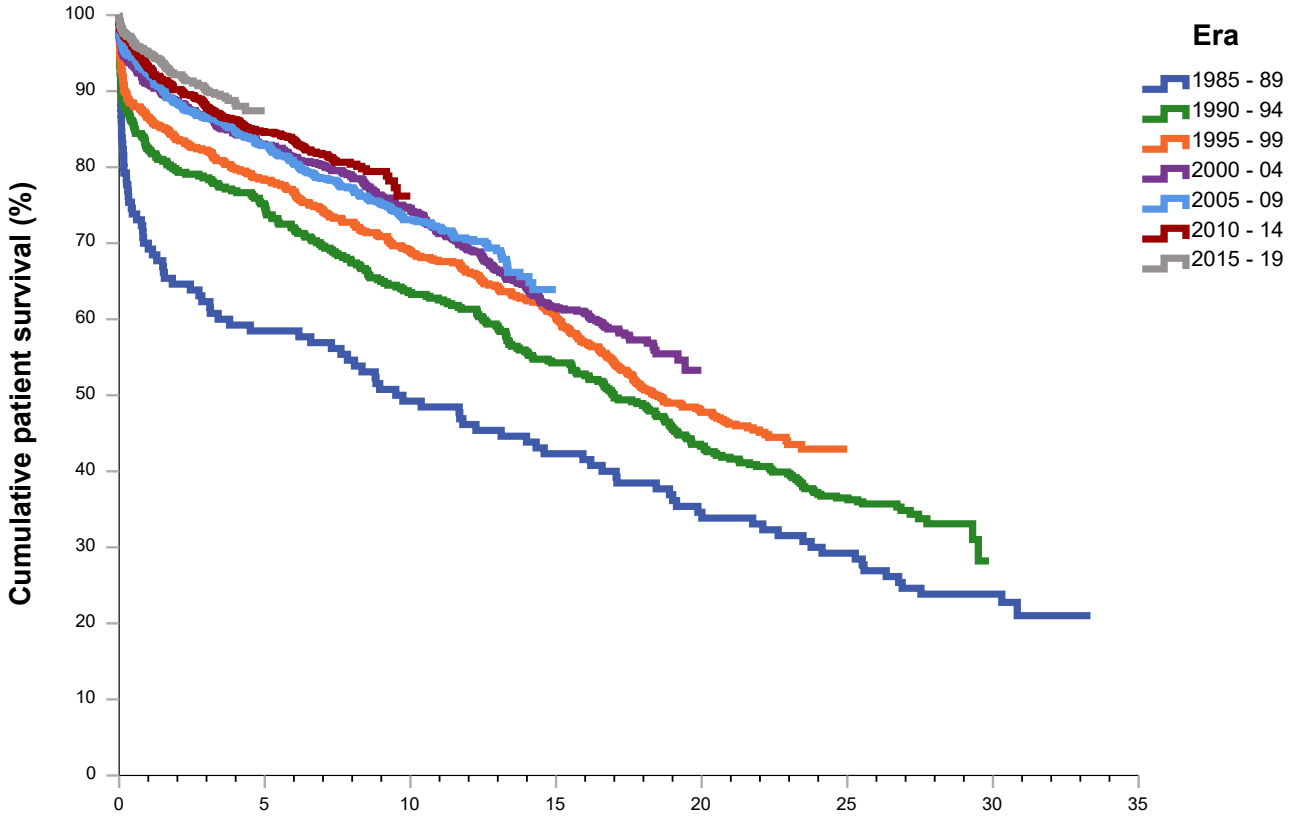


Table 14. Adult patient survival by transplant era

Transplant Era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
1985 - 89	No. at risk	130	91	81	76	64	55	45	38	31
	Survival (%)		70%	62%	59%	49%	42%	35%	29%	24%
1990 - 94	No. at risk	411	339	323	308	261	223	178	150	0
	Survival (%)		83%	79%	75%	64%	54%	43%	37%	
1995 - 99	No. at risk	580	502	477	454	400	349	277	0	
	Survival (%)		87%	82%	78%	69%	60%	48%		
2000 - 04	No. at risk	748	681	647	620	558	461	0		
	Survival (%)		91%	87%	83%	75%	62%			
2005 - 09	No. at risk	810	748	700	671	592	0			
	Survival (%)		92%	86%	83%	73%				
2010 - 14	No. at risk	1,031	960	906	872	0				
	Survival (%)		93%	88%	85%					
2015 - 19	No. at risk	1,389	1,041	488	0					
	Survival (%)		95%	90%						

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 29, Table 15). 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 90.9% for split liver grafts, 89.3% for living donor grafts, 85.4% for whole liver grafts and 76.8% for reduced grafts. Median paediatric patient survival was 33.1 years for reduced grafts but was not reached for other graft types.

Figure 29. Paediatric patient survival curve by type of primary graft

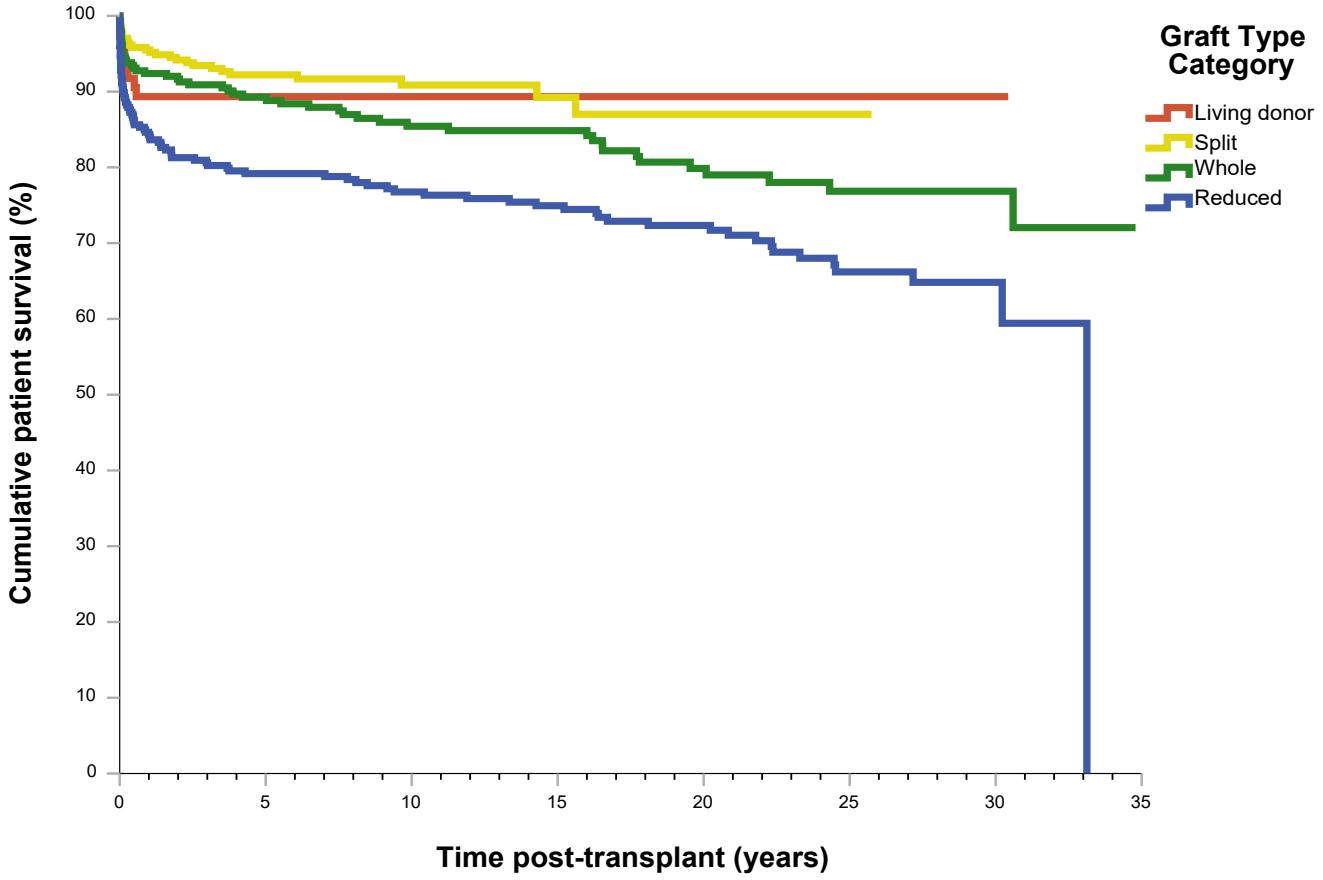


Table 15. Paediatric patient survival by type of primary graft

Graft Type Category	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
Living donor	No. at risk	85	72	68	61	32	6	3	3	1
	Survival (%)		89%	89%	89%	89%	89%	89%	89%	89%
Split	No. at risk	339	298	243	190	109	45	18	1	0
	Survival (%)		96%	93%	92%	91%	89%	87%	87%	
Whole	No. at risk	291	257	232	208	158	130	94	62	19
	Survival (%)		92%	91%	89%	85%	85%	80%	77%	77%
Reduced	No. at risk	306	254	233	216	181	153	115	67	16
	Survival (%)		84%	81%	79%	77%	75%	72%	66%	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 = 0.197, Figure 30, Table 16). Ten-year patient survival was 85.6% for living donor grafts, 76.1% for split grafts, 72.8% for whole grafts, 50.7% 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 30. Adult patient survival curve by type of primary graft

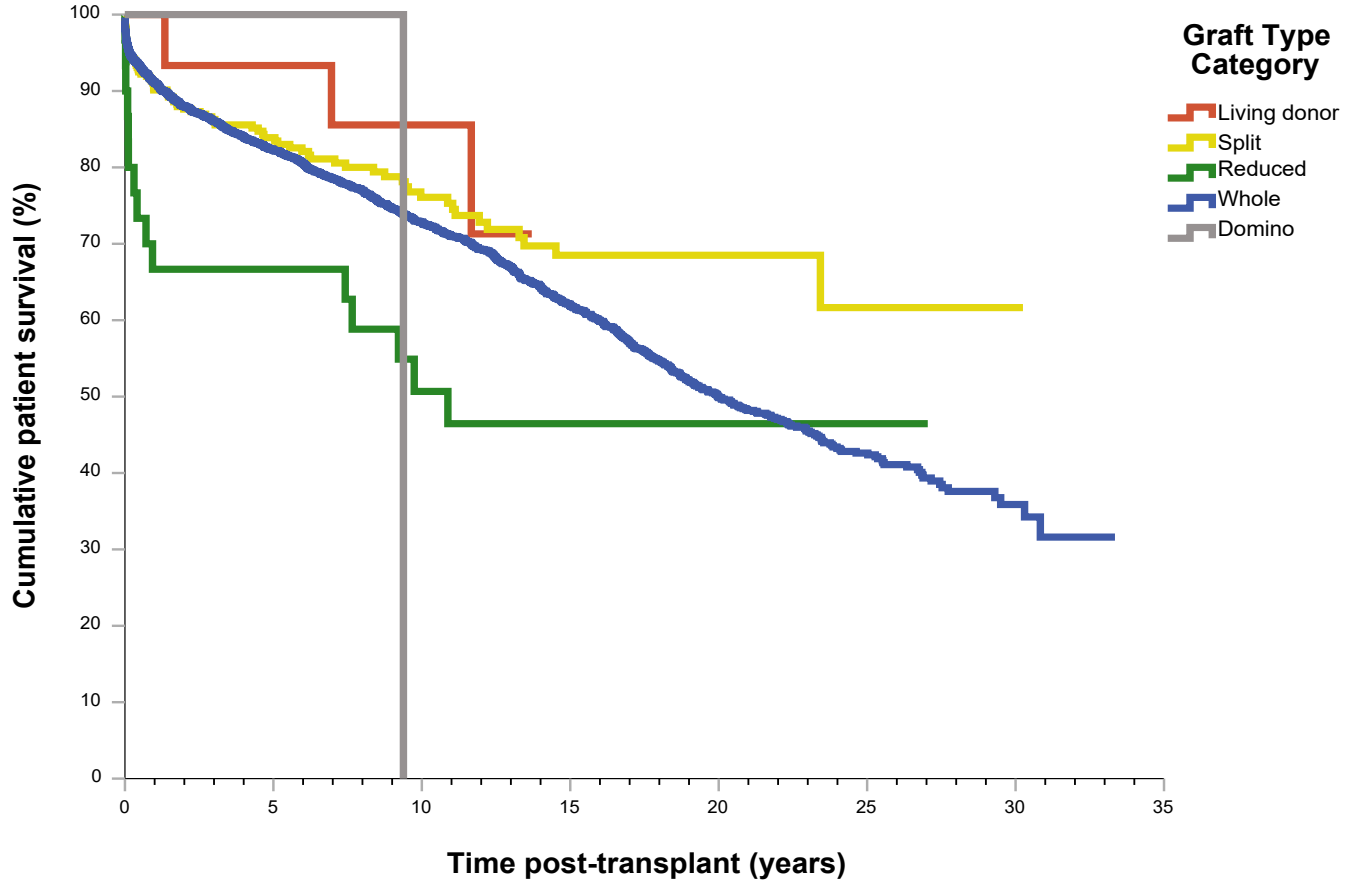


Table 16. Adult patient survival by type of primary graft

Graft Type Category	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
Living donor	No. at risk	16	15	13	12	8	0			
	Survival (%)		100%	93%	93%	86%				
Split	No. at risk	364	301	244	192	108	48	21	3	1
	Survival (%)		90%	86%	84%	76%	69%	69%	62%	62%
Reduced	No. at risk	30	20	19	19	12	10	7	2	0
	Survival (%)		67%	67%	67%	51%	47%	47%	47%	
Whole	No. at risk	4,685	4,022	3,1342	2,776	1,747	1,030	472	183	30
	Survival (%)		91%	86%	82%	73%	62%	50%	43%	36%
Domino	No. at risk	4	4	4	2	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 = 0.293, Figure 31 and Table 17). Ten-year paediatric patient survival was 88.7% for children over 20 kg, 84.3% for children weighing between 8.01 and 20 kg and 81.0% for children between 5 and 8 kg and 80.0% for children under 5 kg. Median paediatric patient survival was 33.1 years for children weighing between 5 and 8 kg and was not reached for other weight categories.

Figure 31. Paediatric patient survival curve by transplant weight

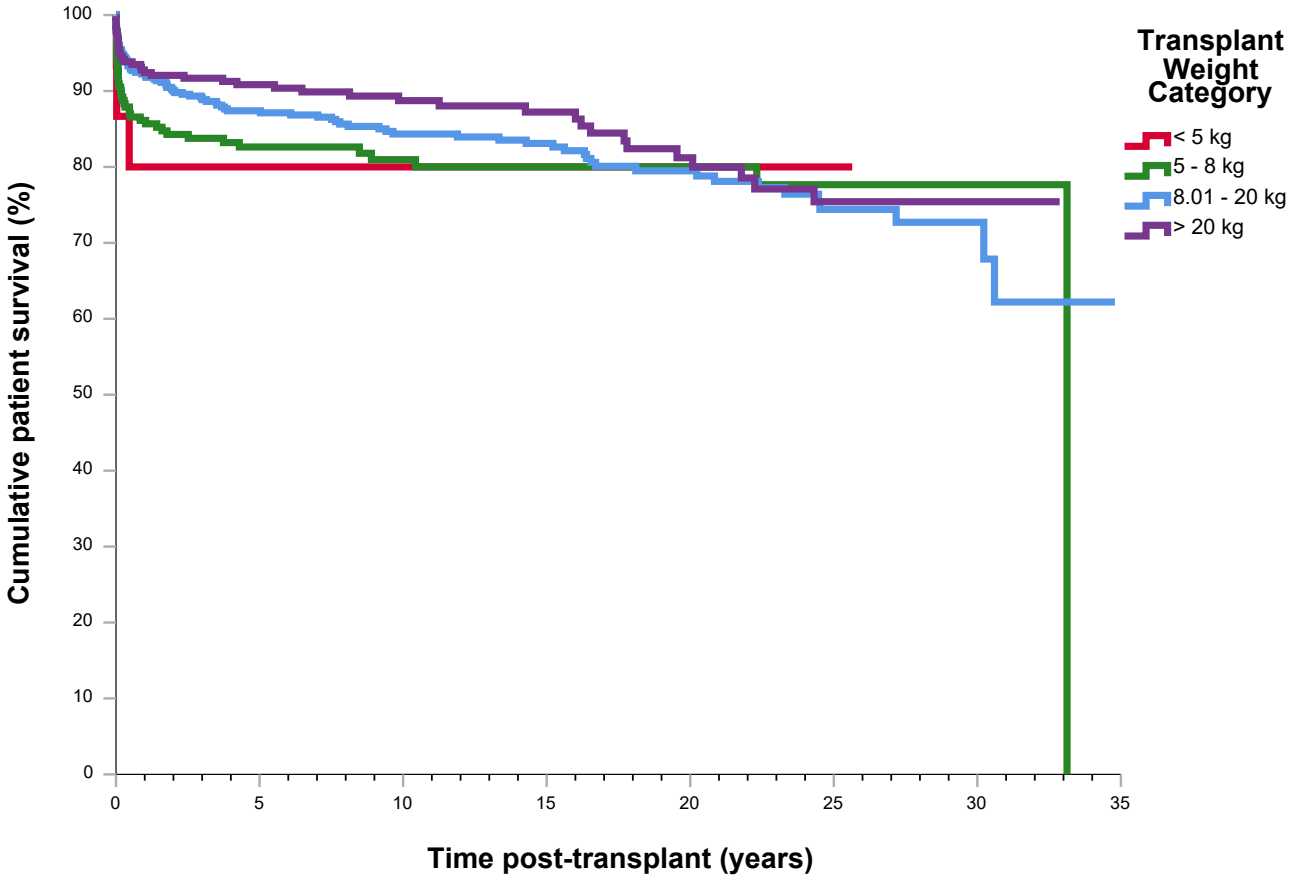


Table 17. Paediatric patient survival by transplant weight

Transplant weight	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
< 5 kg	No. at risk	15	11	7	6	4	3	2	1	0
	Survival (%)		80%	80%	80%	80%	80%	80%	80%	
5 - 8 kg	No. at risk	232	192	158	137	89	58	41	25	8
	Survival (%)		86%	84%	83%	81%	80%	80%	78%	78%
8.01 - 20 kg	No. at risk	481	420	378	332	243	175	120	66	17
	Survival (%)		92%	89%	87%	84%	83%	80%	74%	73%
> 20 kg	No. at risk	294	259	234	201	145	99	67	41	11
	Survival (%)		92%	92%	91%	89%	87%	81%	75%	75%

11.11 Paediatric Patient Survival by Primary Disease

There was a trend to difference in patient survival between different disease categories in children (P = 0.097, Figure 32, Table 18). Children with fulminant hepatic failure had the poorest ten-year survival of 75.6%. Children with hepatoblastoma had a ten-year survival of 78.5%. 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 and was not reached for all other disease groups.

Figure 32. Paediatric patient survival curve by primary disease

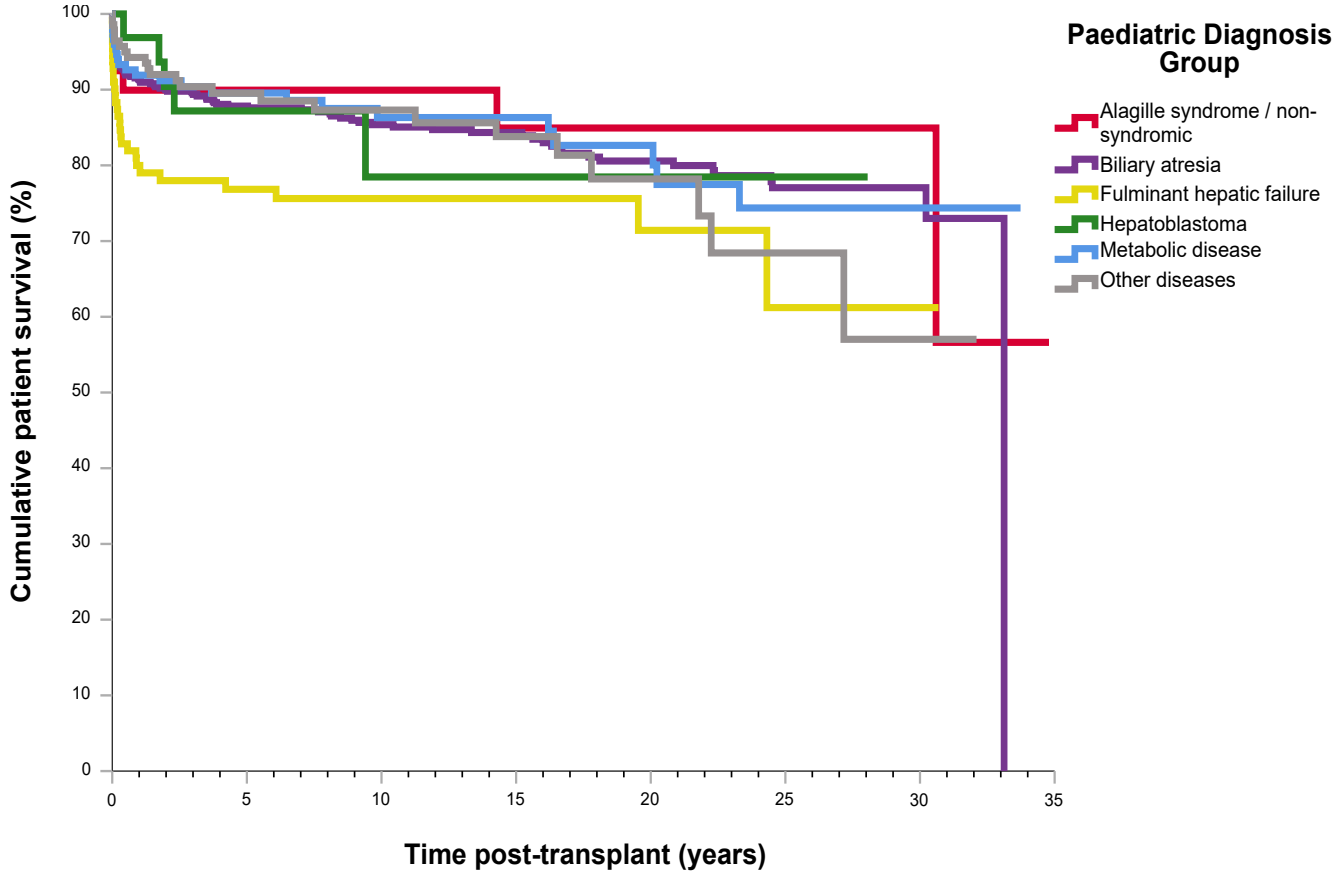


Table 18. Paediatric patient survival by primary disease

Primary Diagnosis	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
Alagille syndrome / non-syndromic	No. at risk	41	35	33	26	21	17	16	8	4
	Survival (%)		90%	90%	90%	90%	85%	85%	85%	85%
Biliary atresia	No. at risk	548	477	425	376	283	195	144	91	24
	Survival (%)		91%	90%	88%	85%	84%	81%	77%	77%
Fulminant hepatic failure	No. at risk	111	82	72	66	43	31	16	6	1
	Survival (%)		80%	78%	77%	76%	76%	71%	61%	61%
Hepatoblastoma	No. at risk	32	30	24	17	7	2	2	2	0
	Survival (%)		97%	87%	87%	79%	79%	79%	79%	
Metabolic Diseases	No. at risk	150	129	114	102	69	51	32	16	5
	Survival (%)		92%	90%	90%	86%	86%	83%	74%	74%
Other Diseases	No. at risk	140	129	109	89	58	39	20	11	2
	Survival (%)		94%	90%	90%	87%	84%	78%	68%	57%

11.12 Adult Patient Survival by Primary Disease

There was a significant difference in the survival between different disease categories in adults (P = 0.019, Figure 33, Table 19). Patients with hepatocellular carcinoma, hepatitis C virus cirrhosis and non-alcoholic fatty liver disease (NAFLD) / cryptogenic cirrhosis had the poorest 10-year patient survival (67.5%, 69.7% and 71.4%, respectively), while those with alcoholic cirrhosis, hepatitis C virus cirrhosis and NAFLD / cryptogenic cirrhosis had the poorest median survival (17.1 years, 18.3 years and 18.8 years, respectively).

Figure 33. Adult patient survival curve by primary disease

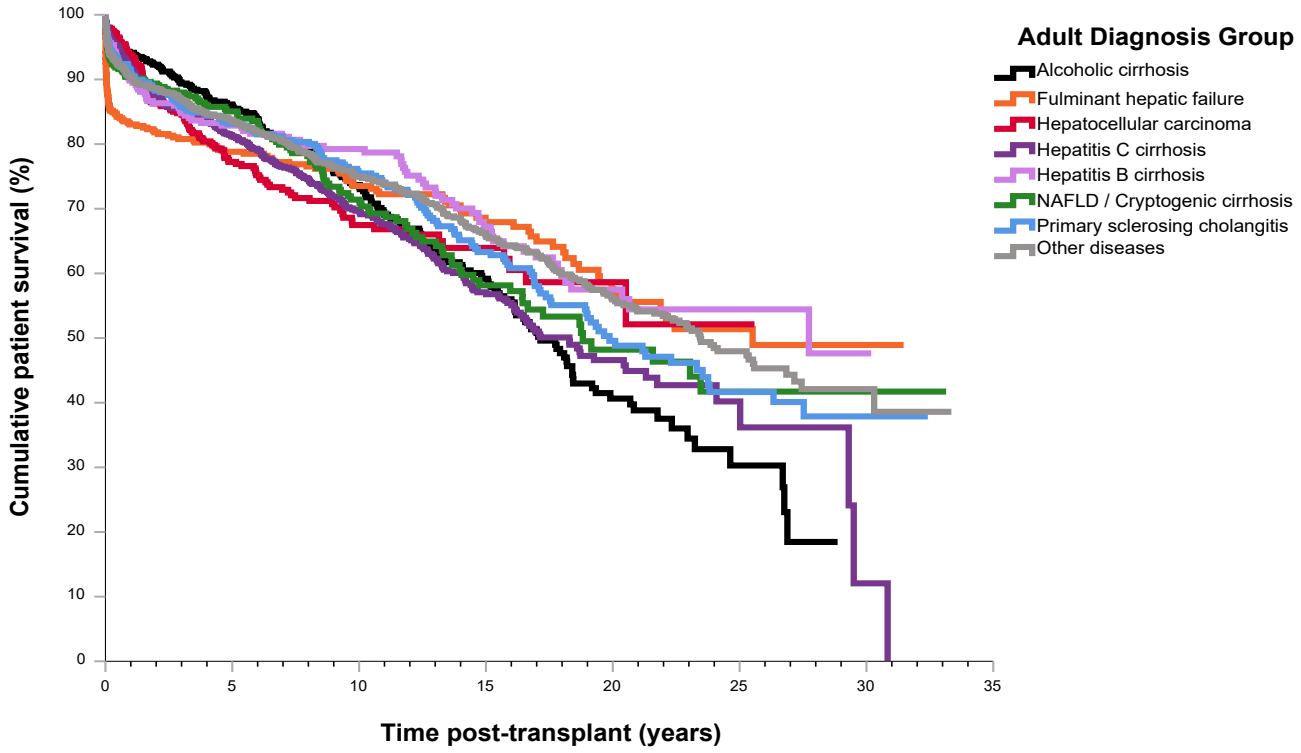


Table 19. Adult patient survival by primary disease

Primary Diagnosis	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
Alcoholic cirrhosis	No. at risk	676	587	475	391	233	135	47	11	0
	Survival (%)		94%	89%	86%	74%	59%	41%	30%	
Fulminant hepatic failure	No. at risk	446	344	310	264	181	100	58	22	5
	Survival (%)		83%	81%	79%	74%	68%	58%	51%	49%
Hepatocellular carcinoma	No. at risk	609	521	367	249	116	47	9	1	0
	Survival (%)		94%	85%	77%	68%	64%	59%	52%	
Hepatitis B virus cirrhosis	No. at risk	299	258	222	200	150	92	42	14	1
	Survival (%)		90%	85%	83%	79%	67%	58%	54%	48%
Hepatitis C virus cirrhosis	No. at risk	1,094	969	833	700	390	189	58	10	1
	Survival (%)		92%	85%	81%	70%	57%	47%	40%	12%
NAFLD / Cryptogenic cirrhosis	No. at risk	445	364	298	236	135	70	32	14	1
	Survival (%)		90%	88%	85%	71%	58%	48%	42%	42%
Primary sclerosing cholangitis	No. at risk	516	450	376	324	217	136	66	33	7
	Survival (%)		91%	86%	83%	76%	63%	50%	42%	38%
Other disease	No. at risk	1,014	869	741	637	453	319	188	83	16
	Survival (%)		90%	76%	84%	75%	66%	56%	48%	42%

Abbreviation: NAFLD, non-alcoholic fatty liver disease

11.13 Patient Survival by Age Group with Primary Diagnosis of Fulminant Hepatic Failure

There was no significant difference in the survival between adults and children with a primary diagnosis of fulminant hepatic failure (FHF) (P = 0.328, Figure 34 and Table 20). Ten-year patient survival was 75.6% for children and 73.5% for adults. Median patient survival was not reached for children and was 25.5 years for adults.

Figure 34. Patient survival curve by age group with primary diagnosis of fulminant hepatic failure

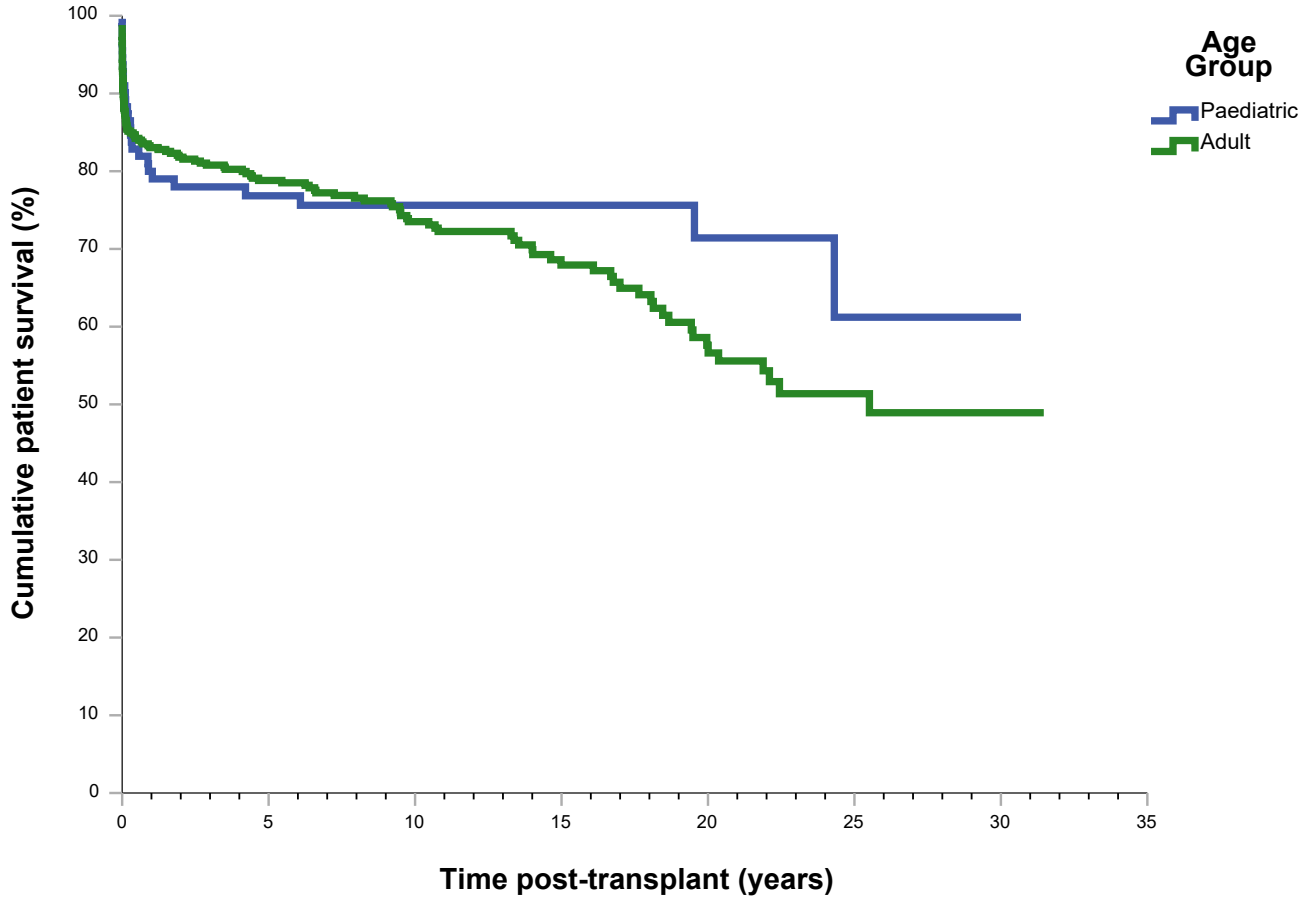


Table 20. Patient survival by age group with primary diagnosis of fulminant hepatic failure (FHF)

Primary Diagnosis	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
Paediatric FHF	No. at risk	111	82	72	66	43	31	16	6	1
	Survival (%)		80%	78%	77%	76%	76%	71%	61%	61%
Adult FHF	No. at risk	446	344	310	264	181	100	58	22	5
	Survival (%)		83%	81%	79%	74%	68%	58%	51%	49%

11.14 Adult Patient Survival by Transplant Era with Chronic Viral Hepatitis B

There has been an improvement in patient survival over the transplant eras for patients with a primary diagnosis of hepatitis B (P < 0.001, Figure 35, Table 21). Median adult patient survival was 0.6 years for the 1985 – 89 era, 13.3 years for the 1990 – 94 era, 20.4 years for the 1995 – 99 era and was not reached for the recent eras.

Figure 35. Adult patient survival curve by transplant era with primary diagnosis of chronic viral hepatitis B

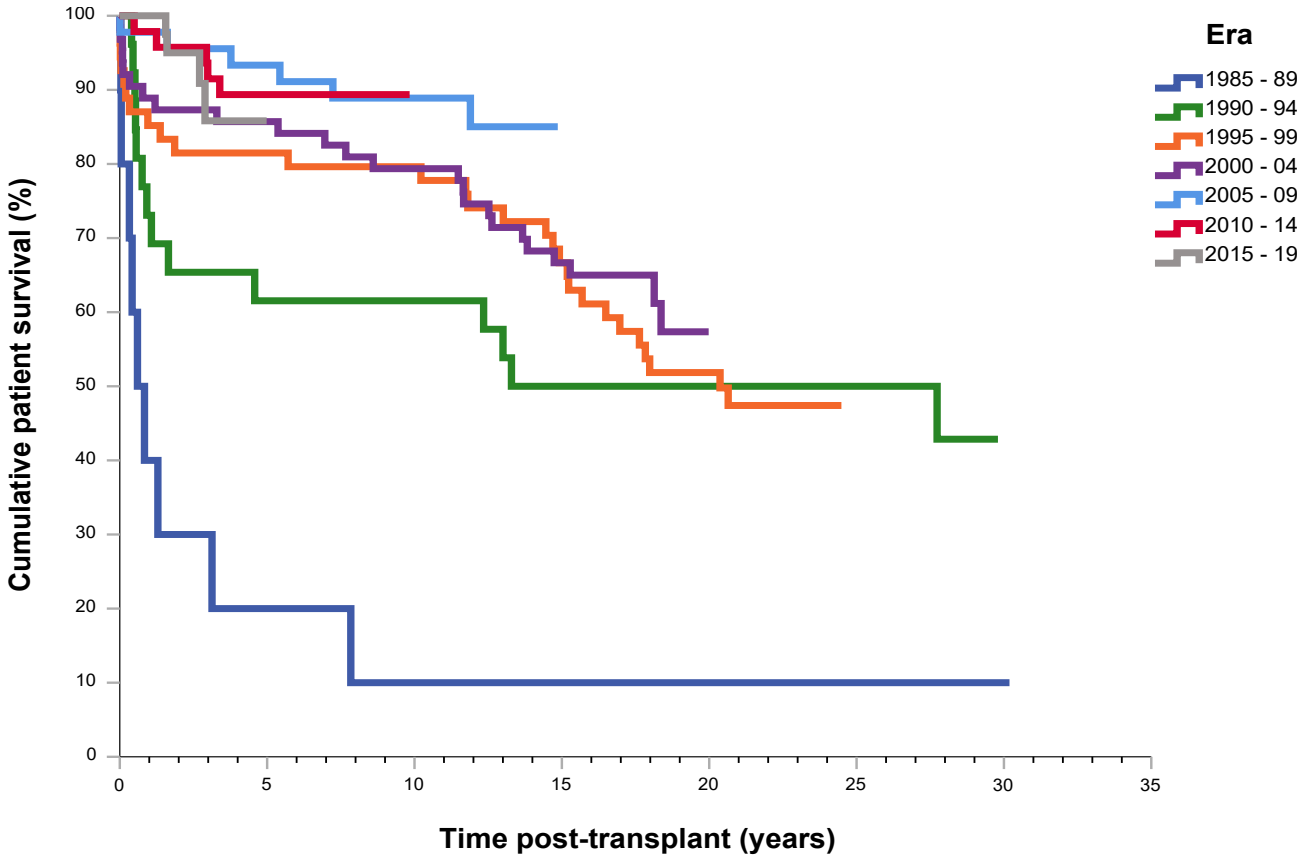


Table 21. Patient survival by transplant era with primary diagnosis of chronic viral hepatitis B

Transplant era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
1985 - 89	No. at risk	10	4	3	2	1	1	1	1	1
	Survival (%)		40%	30%	20%	10%	10%	10%	10%	10%
1990 - 94	No. at risk	26	19	17	16	16	13	13	13	0
	Survival (%)		73%	65%	62%	62%	50%	50%	50%	
1995 - 99	No. at risk	54	46	44	44	43	36	28	0	
	Survival (%)		85%	82%	82%	80%	67%	52%		
2000 - 04	No. at risk	63	56	55	54	50	42	0		
	Survival (%)		90%	87%	86%	79%	67%			
2005 - 09	No. at risk	45	44	43	42	40	0			
	Survival (%)		98%	96%	93%	89%				
2010 - 14	No. at risk	47	46	43	42	0				
	Survival (%)		98%	92%	89%					
2015 - 19	No. at risk	54	43	17	0					
	Survival (%)		100%	86%						

11.15 Adult Patient Survival by Transplant Era with Hepatitis C Virus Cirrhosis

Patient survival after transplantation for hepatitis C virus cirrhosis varied over transplant eras with the best 3-year survival (91.0%) occurring in the period 2015-2019 (P = 0.004, Figure 36 and Table 22). Median adult patient survival was 17.1 years for the 1985 – 89 era, 13.5 years for the 1990 – 94 era, 12.7 years for the 1995 – 99 era and was not reached for the recent eras.

Figure 36. Adult patient survival curve by transplant era with primary diagnosis of chronic viral hepatitis C

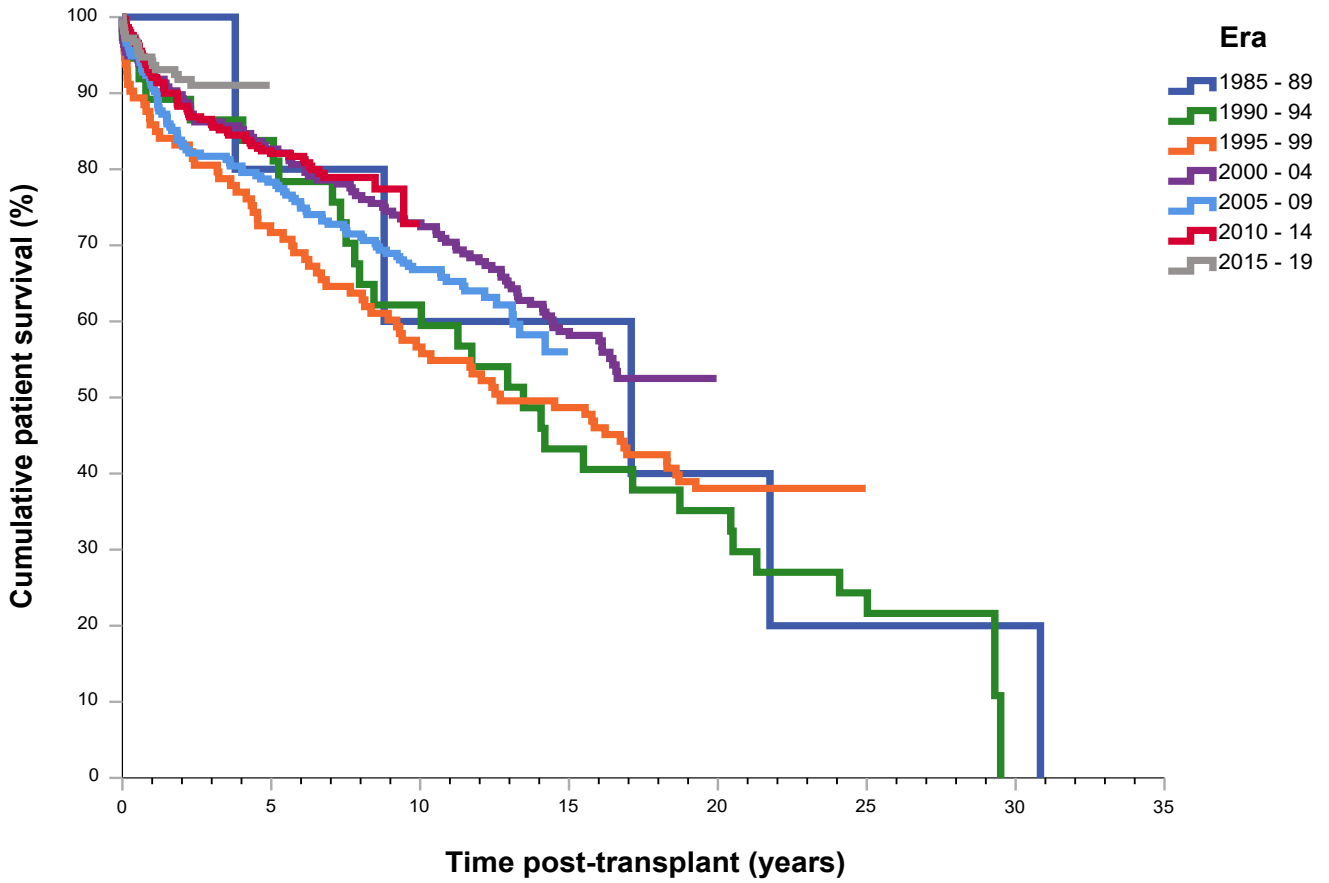


Table 22. Adult patient survival curve by transplant era with primary diagnosis of chronic viral hepatitis C

Transplant era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
1985 - 89	No. at risk	5	5	5	4	3	3	2	1	1
	Survival (%)		100%	100%	80%	60%	60%	40%	20%	20%
1990 - 94	No. at risk	37	33	31	30	23	16	13	9	0
	Survival (%)		89%	84%	83%	62%	43%	35%	24%	
1995 - 99	No. at risk	113	97	91	81	64	55	43	0	
	Survival (%)		86%	81%	72%	57%	49%	38%		
2000 - 04	No. at risk	196	181	169	162	143	115	0		
	Survival (%)		92%	86%	83%	73%	59%			
2005 - 09	No. at risk	235	214	192	184	157	0			
	Survival (%)		91%	82%	78%	67%				
2010 - 14	No. at risk	290	268	249	238	0				
	Survival (%)		92%	86%	82%					
2015 - 19	No. at risk	218	171	95	0					
	Survival (%)		94%	91%						

11.16 Patient Survival with Primary Diagnosis of Malignancy by Era of Transplant

There has been an improvement in patient survival over the transplant eras for patients with a diagnosis of malignancy (P<0.001, Figure 37, Table 23). Median patient survival was 1.5 years for the 1985 – 89 era, 5.0 years for the 1990 – 94 era, 7.2 years for the 1995 – 99 era and was not reached for the recent eras.

Figure 37. Patient survival curve with primary diagnosis of malignancy by era of transplant

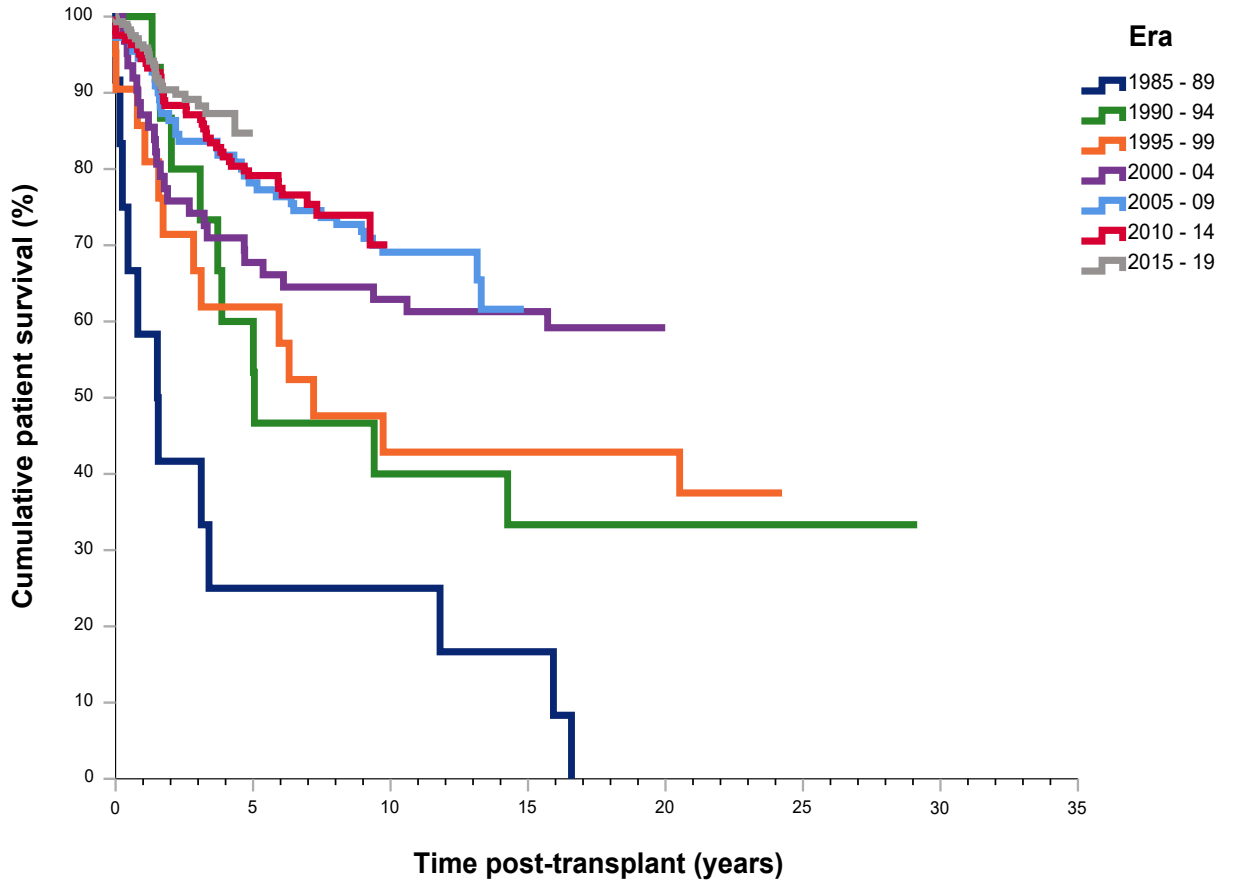


Table 23. Patient survival curve with primary diagnosis of malignancy by transplant era

Transplant era	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
1985 - 89	No. at risk	12	7	5	3	3	2	0		
	Survival (%)		58%	42%	25%	25%	17%			
1990 - 94	No. at risk	15	14	12	9	6	5	5	5	0
	Survival (%)		100%	80%	60%	40%	33%	33%	33%	
1995 - 99	No. at risk	21	18	14	13	9	9	9	0	
	Survival (%)		86%	67%	62%	43%	43%	43%		
2000 - 04	No. at risk	62	54	46	42	39	38	0		
	Survival (%)		87%	74%	68%	63%	61%			
2005 - 09	No. at risk	110	104	92	86	76	0			
	Survival (%)		95%	84%	78%	69%				
2010 - 14	No. at risk	163	154	142	129	0				
	Survival (%)		95%	87%	79%					
2015 - 19	No. at risk	301	233	104	0					
	Survival (%)		96%	89%						

11.17 Paediatric Patient Survival with Primary Diagnosis of Malignancy

Children transplanted for histiocytosis X had the best survival. Hepatoblastoma had a better survival than those transplanted for hepatocellular carcinoma (P = 0.008, Figure 38 and Table 24). Ten-year paediatric patient survival was 100% for histiocytosis X, 78.5% for hepatoblastoma and 53.6% for hepatocellular carcinoma. Median paediatric patient survival for hepatocellular carcinoma was 14.3 years and was not reached for hepatoblastoma and other malignancies.

Figure 38. Paediatric patient survival curve with primary diagnosis of malignancy

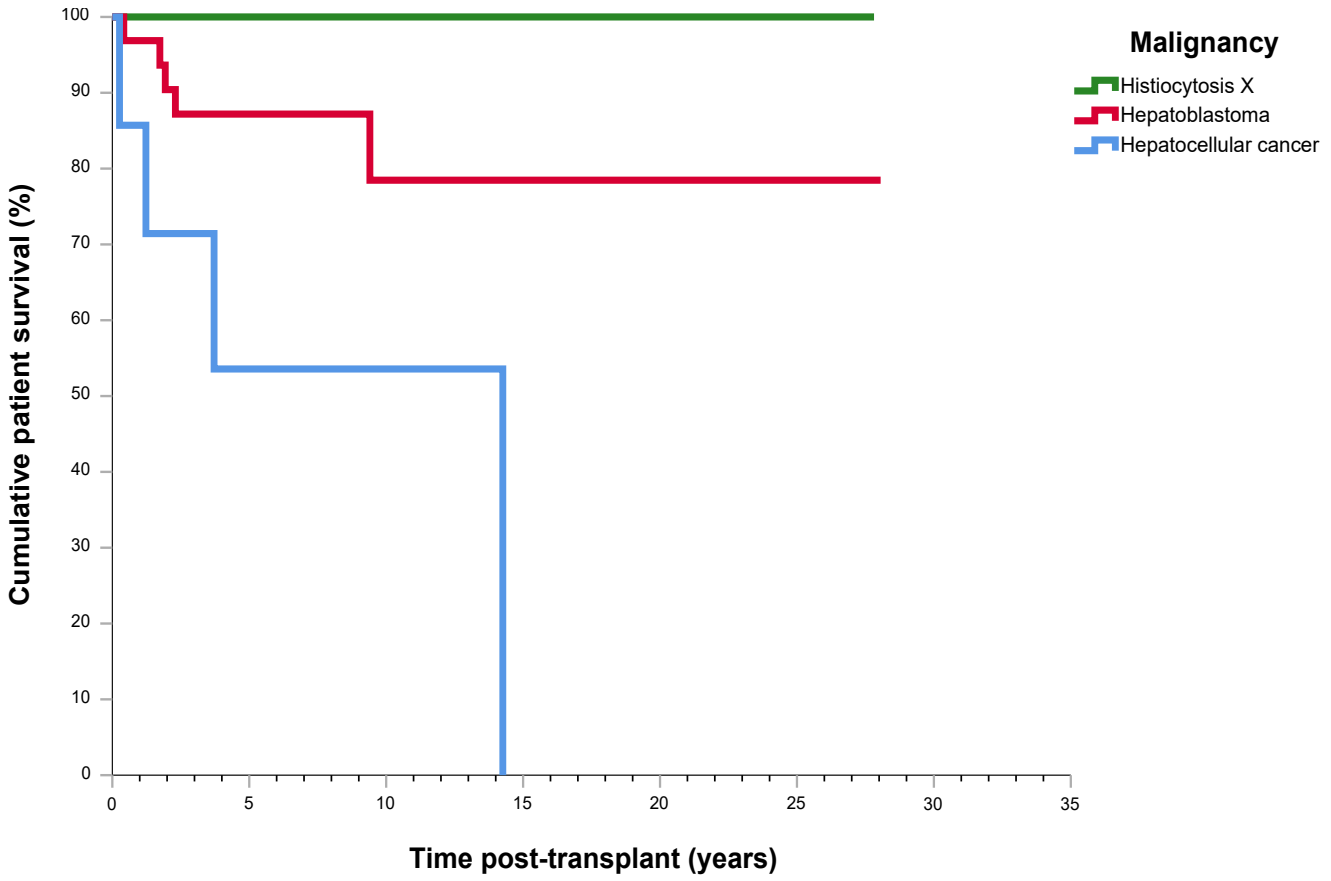


Table 24. Paediatric patient survival with primary diagnosis of malignancy

Primary Diagnosis	Patient Survival	Time post-transplant (years)							
		0	1	3	5	10	15	20	25
Histiocytosis X	No. at risk	5	4	4	4	4	3	2	2
	Survival (%)		100%	100%	100%	100%	100%	100%	100%
Hepatoblastoma	No. at risk	32	30	24	17	7	2	2	1
	Survival (%)		97%	87%	87%	79%	79%	79%	79%
Hepato-cellular carcinoma	No. at risk	7	6	4	2	1	0		
	Survival (%)		86%	71%	54%	54%			

11.18 Adult Patient Survival with Primary Diagnosis of Malignancy

Adult patient survival after transplantation for malignancy varied by diagnosis (P <0.001, Figure 39 and Table 25). Ten-year patient survival was 100% for histiocytosis X (only one patient), 75.0% for epithelioid haemangio-endothelioma, 67.5% for hepatocellular carcinoma, 61.4% for cholangiocarcinoma and 0 for secondary liver tumours and angiosarcoma (only one patient). Median adult patient survival was 2.0 years for secondary liver tumours, 0.8 years for angiosarcoma and was not reached for other types of malignancy.

Figure 39. Adult patient survival curve with primary diagnosis of malignancy

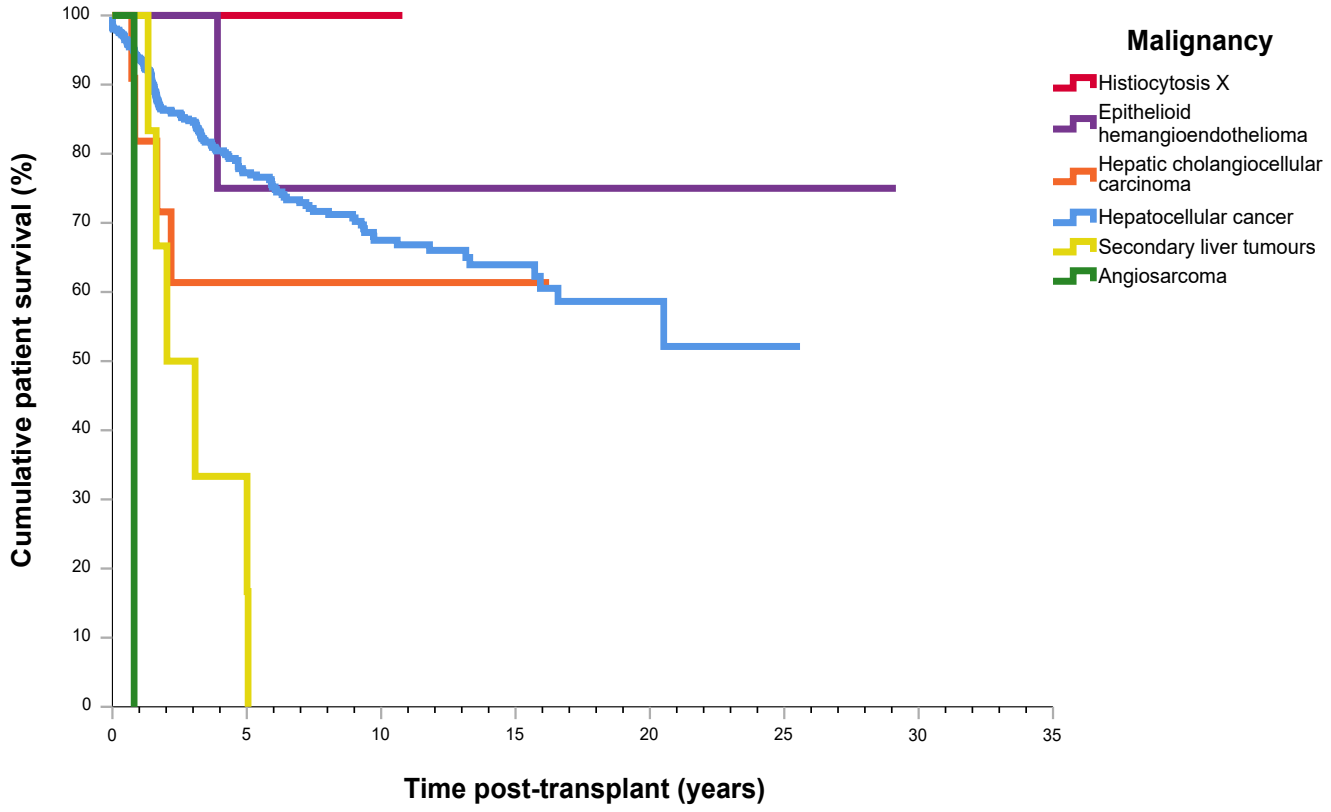


Table 25. Adult patient survival curve with primary diagnosis of malignancy

Primary Diagnosis	Patient Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
Histiocytosis X	No. at risk	1	1	1	1	1	0			
	Survival (%)		100%	100%	100%	100%				
Epithelioid haemangio-endothelioma	No. at risk	8	7	5	3	2	1	1	1	0
	Survival (%)		100%	100%	75%	75%	75%	75%	75%	
Cholangiocarcinoma	No. at risk	15	9	6	4	2	1	0		
	Survival (%)		82%	61%	61%	61%	61%			
Hepatocellular carcinoma	No. at risk	609	521	367	249	116	47	9	1	0
	Survival (%)		94%	85%	77%	68%	64%	59%	52%	
Secondary liver tumours	No. at risk	6	6	3	2	0				
	Survival (%)		100%	50%	33%					
Angiosarcoma	No. at risk	1	0							
	Survival (%)		0%							

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 6,627 grafts in 6,126 patients (Figure 40 and Table 26). Ten-year graft survival was 69.0% across all grafts. The median graft survival was 20.0 years.

Figure 40. Graft survival curve for all grafts

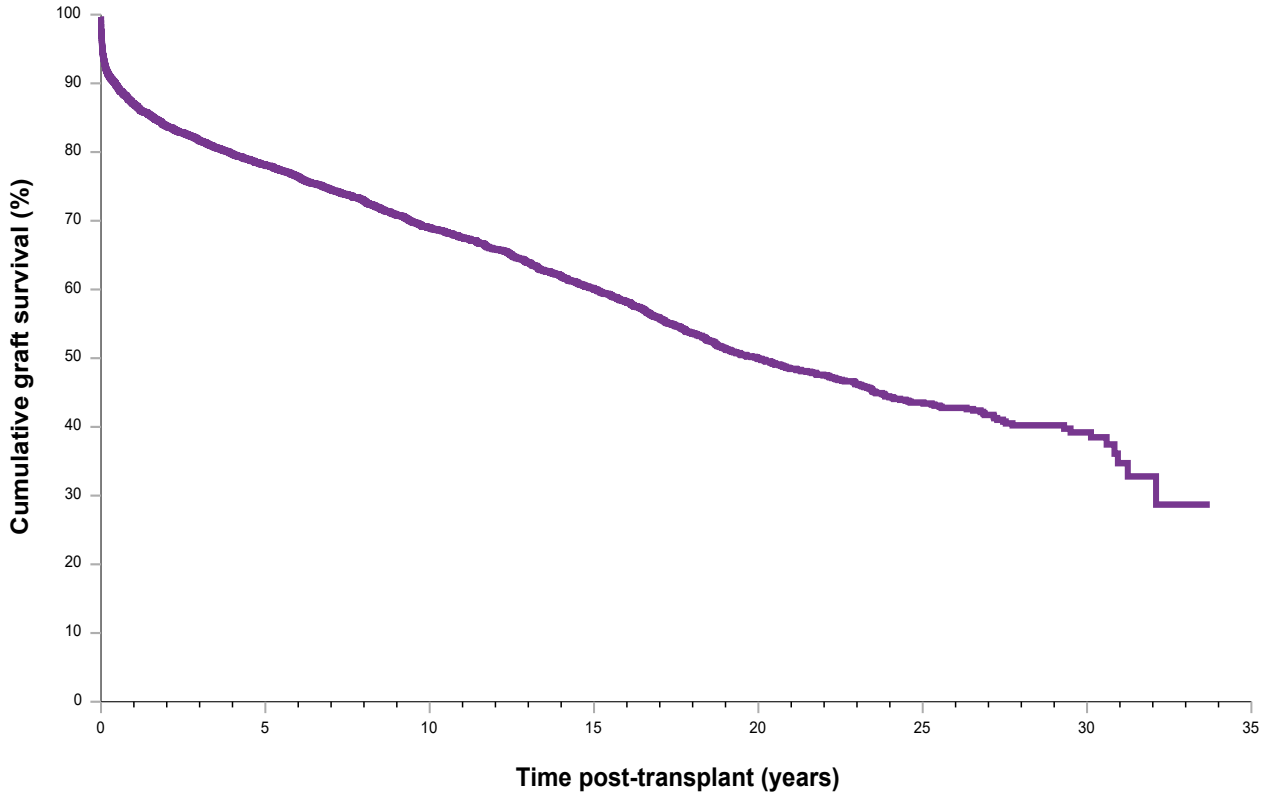


Table 26. Graft survival - all grafts

Graft Survival	Time post-transplant (years)								
	0	1	3	5	10	15	20	25	30
No. at risk	6,627	5,424	4,488	3,724	2,321	1,384	690	301	58
Survival (%)		87%	82%	78%	69%	60%	50%	44%	39%

12.2 Outcome of All Grafts by Age Group

A total of 1,167 transplants were performed in children and 5,460 in adults. Post-transplant graft survival was superior in the paediatric population (P < 0.001, Figure 41, Table 27). Ten-year graft survival was 72.4% for children and 68.2% for adults. Median graft survival was 31.2 years in children and 18.3 years in adults. Although 1-year survival was slightly worse in children (84.3% vs 87.6%), the survival curve for children was subsequently flatter. However, there were several late graft losses occurring over 30 years after paediatric transplantation.

Figure 41. Graft survival curve for all grafts by age group

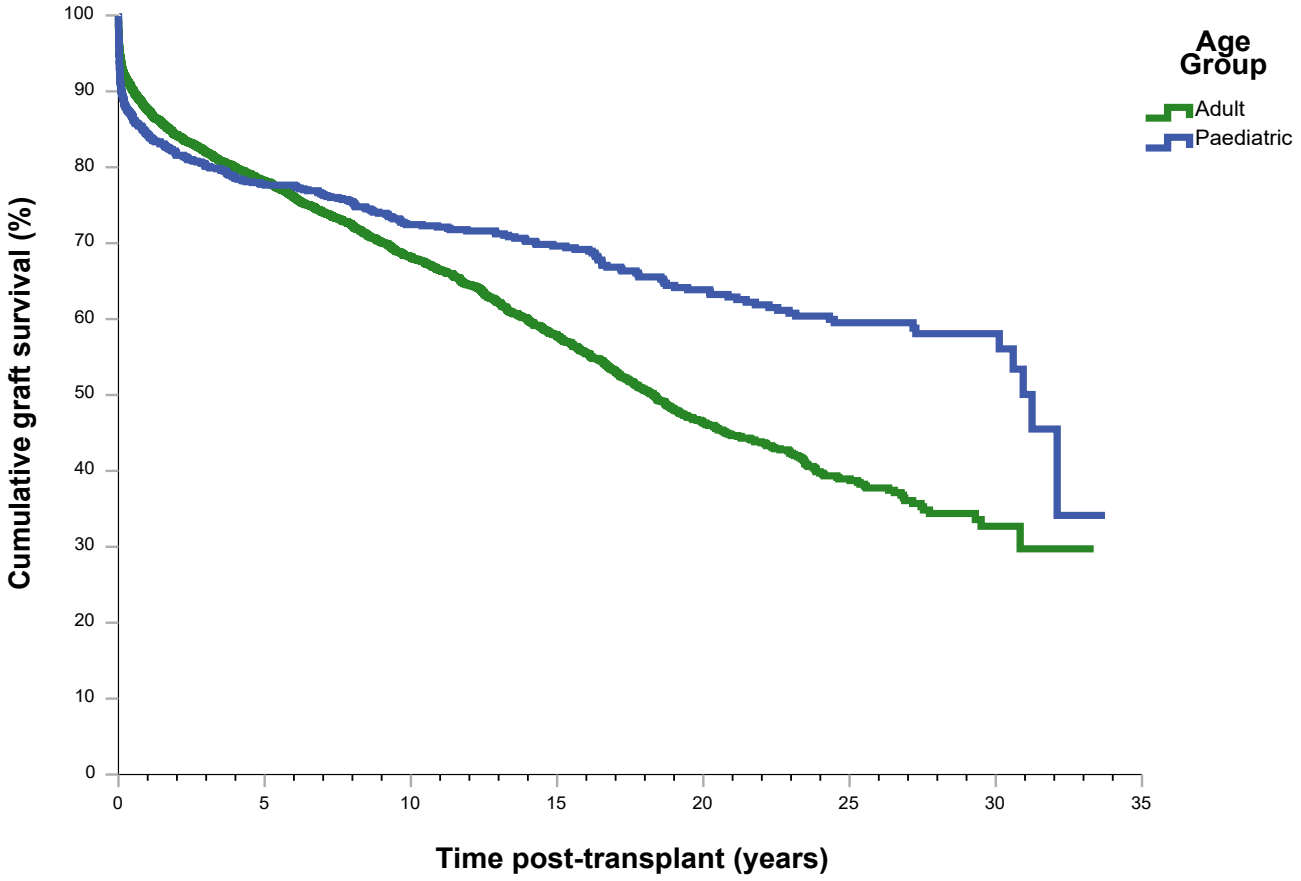


Table 27. Graft survival by age group - all grafts

Age Group	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
Adult ≥16 years	No. at risk	5,460	4,492	3,689	3,042	1,854	1,067	480	177	28
	Survival (%)		88%	82%	78%	68%	58%	46%	39%	33%
Paediatric <16 years	No. at risk	1,167	932	799	682	467	317	210	124	30
	Survival (%)		84%	80%	78%	72%	70%	64%	60%	58%

12.3 Outcome by Graft Number

There was a significant difference in graft survival by graft number (P < 0.001, Figure 42 and Table 28). Ten-year graft survival was 70.1% for the first graft, 55.0% for the second graft, 59.7% for the third graft and not reached for the fourth graft. Median graft survival was 20.5 years for the first graft, 12.9 years for the second graft, 21.1 years for the third graft and not reached for the fourth graft.

Figure 42. Graft survival curve for all grafts by graft number

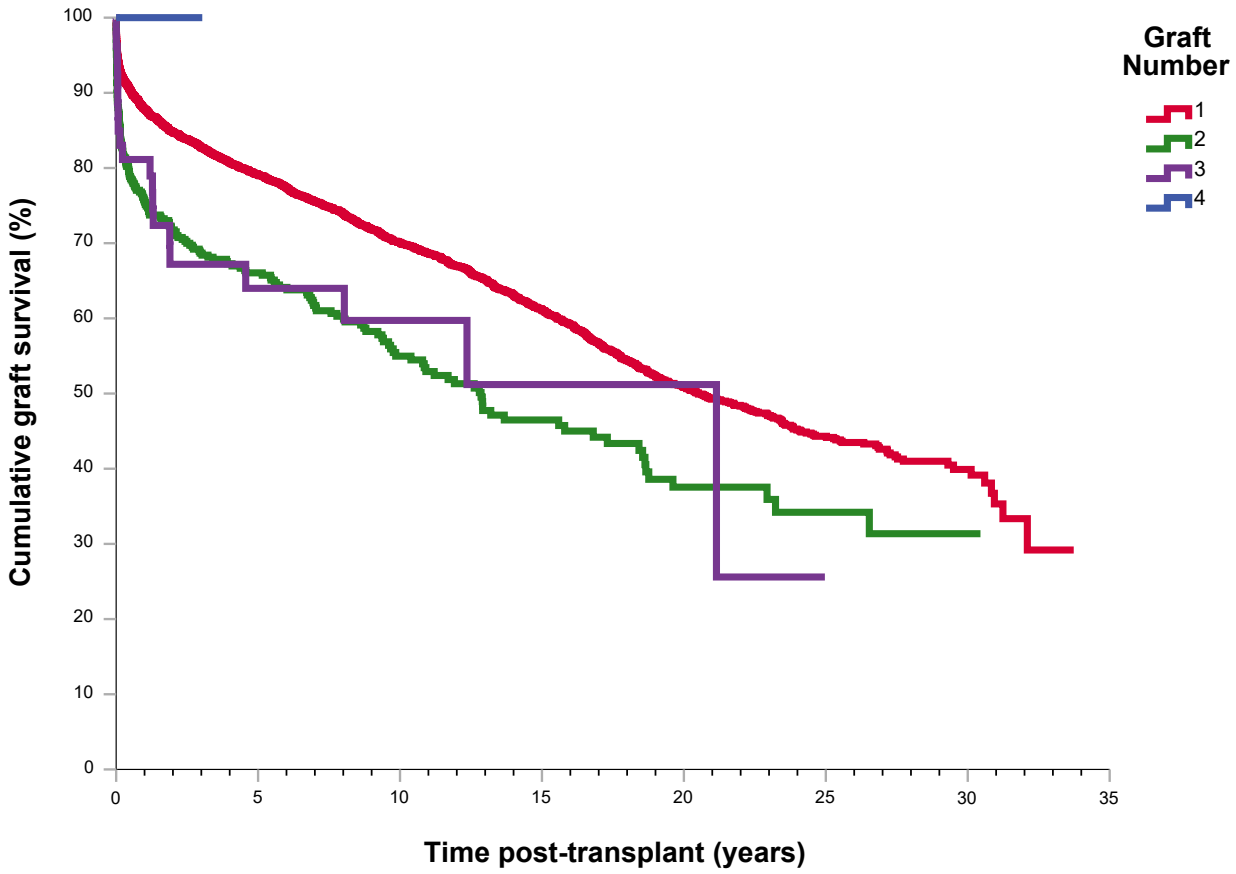


Table 28. Graft survival - all grafts

Graft Number	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
1	No. at risk	6,121	5,062	4,203	3,493	2,195	1,314	654	287	56
	Survival (%)		88%	83%	79%	70%	61%	51%	44%	40%
2	No. at risk	451	322	258	211	113	66	34	14	2
	Survival (%)		76%	69%	66%	55%	47%	38%	34%	31%
3	No. at risk	53	38	26	20	13	4	2	0	
	Survival (%)		81%	67%	64%	60%	51%	51%		
4	No. at risk	2	2	0						
	Survival (%)		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 43 and Table 29). Ten-year graft survival was 75.4% for the first graft, 49.5% for the second graft and 60.6% for the third graft. Median graft survival was 31.2 years for the first graft, 9.8 years for the second graft and 21.1 years for the third graft.

Figure 43. Graft survival curve for paediatric recipients by graft number

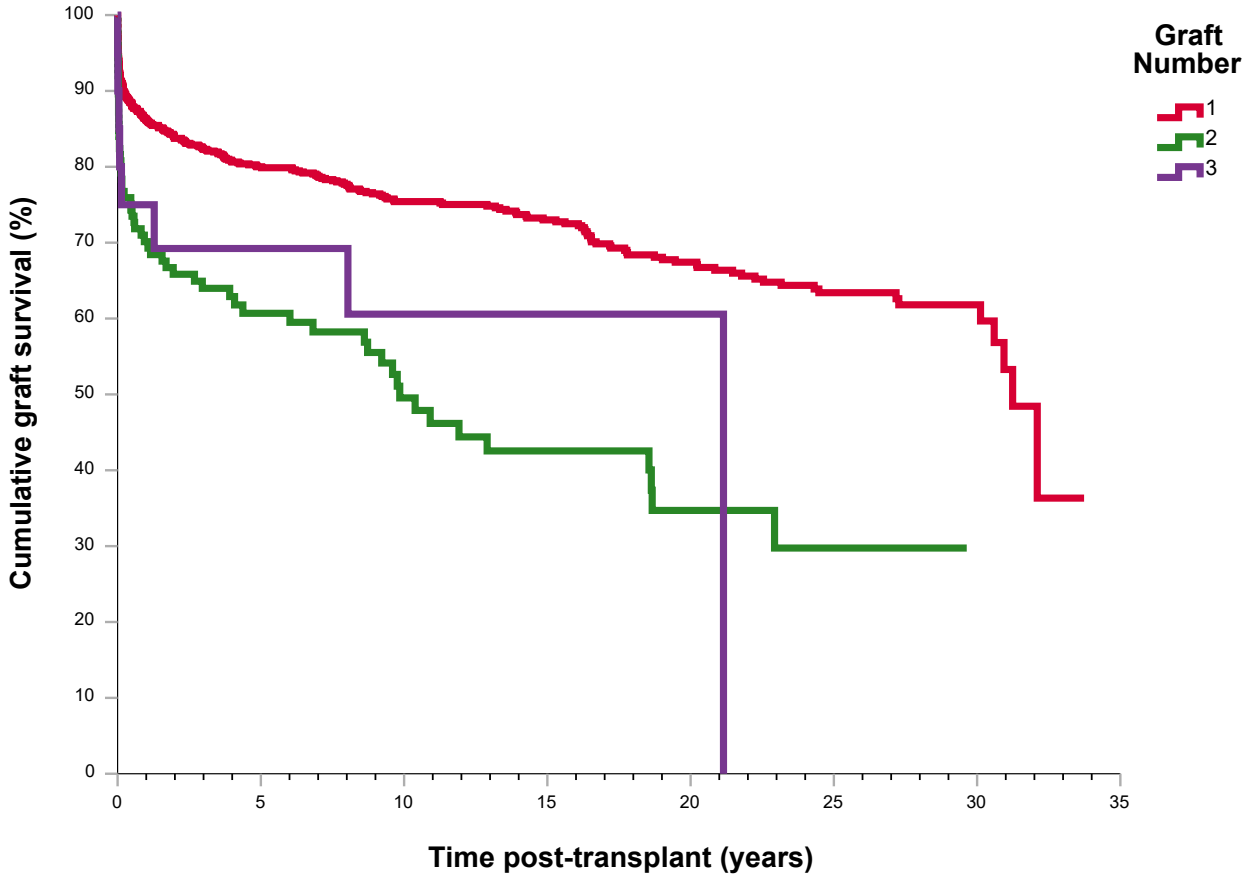


Table 29. Graft survival - paediatric by graft number

Graft Number	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
1	No. at risk	1,022	837	721	622	428	294	197	119	30
	Survival (%)		86%	82%	80%	75%	73%	67%	63%	62%
2	No. at risk	125	82	68	52	32	20	12	5	0
	Survival (%)		70%	64%	61%	50%	43%	35%	30%	
3	No. at risk	20	13	10	8	7	3	1	0	
	Survival (%)		75%	69%	69%	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 44 and Table 30). Ten-year graft survival 68.9% for the first graft, 57.3% for the second graft, 60.9% for the third graft and not reached for the fourth graft. Median graft survival was 18.4 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 44. Graft survival curve for adults by graft number

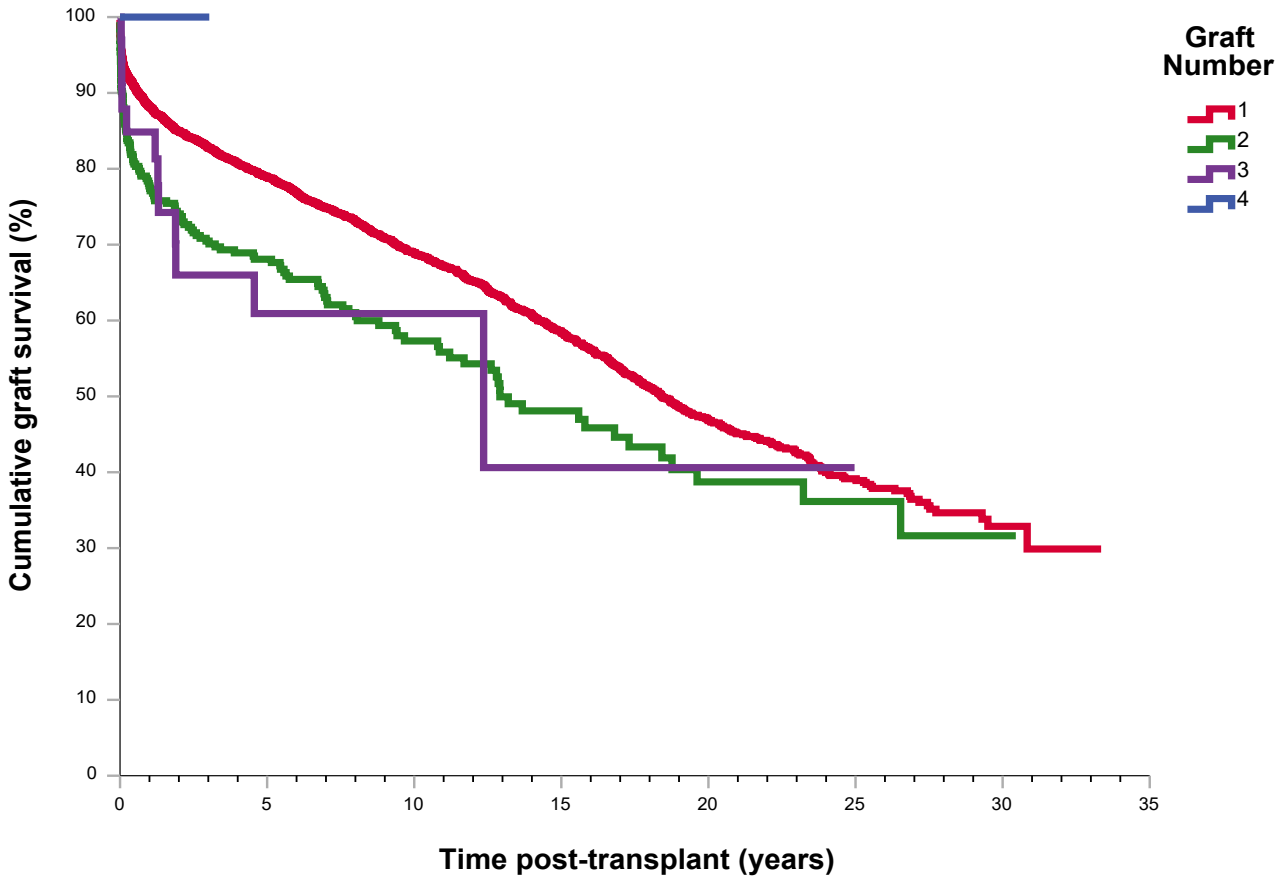


Table 30. Graft survival – adults by graft number

Graft Number	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
1	No. at risk	5,099	4,225	3,482	2,871	1,767	1,020	457	168	26
	Survival (%)		88%	83%	79%	69%	59%	47%	39%	33%
2	No. at risk	326	240	190	159	81	46	22	9	2
	Survival (%)		78%	71%	68%	57%	48%	39%	36%	32%
3	No. at risk	33	25	16	12	6	1	1	0	
	Survival (%)		85%	66%	61%	61%	41%	41%		
4	No. at risk	2	2	0						
	Survival (%)		100%							

12.6 Graft Survival by Type of Graft

There was no significant difference in graft survival by graft type, although there was a trend to improved survival in living donor transplants after 10 years and worse survival in reduced liver transplants up to 15 years (P = 0.106, Figure 45 and Table 31). Ten-year graft survival was 78.4% for living donor grafts, 71.1% for split grafts, 69.2% for whole grafts, 60.1% for reduced grafts and 0 for domino grafts. Median graft survival was 23.1 years for reduced grafts, 18.8 years for whole grafts, 9.4 years for domino grafts, and not reached for split and living donor grafts.

Figure 45. Graft survival curve for type of graft, all grafts

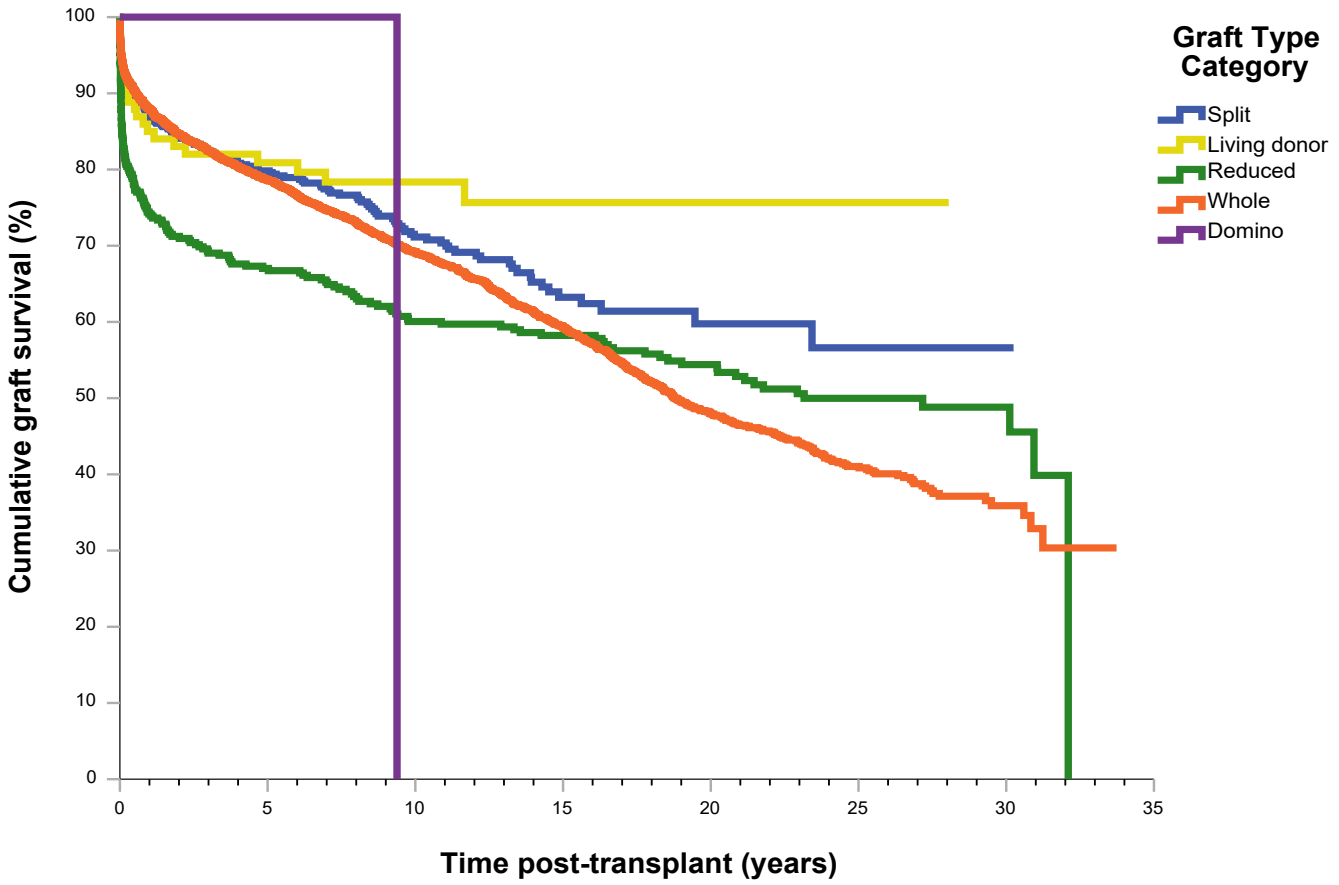


Table 31. Graft survival by type of graft - all grafts

Graft Type	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
Domino	No. at risk	4	4	4	2	0				
	Survival (%)		100%	100%	100%					
Living donor	No. at risk	108	87	79	71	40	5	2	2	0
	Survival (%)		85%	82%	81%	78%	76%	76%	76%	
Split	No. at risk	758	604	481	373	198	83	36	5	1
	Survival (%)		87%	83%	80%	71%	63%	60%	57%	57%
Reduced	No. at risk	388	282	250	228	179	151	107	64	16
	Survival (%)		74%	69%	67%	60%	58%	54%	50%	49%
Whole	No. at risk	5,368	4,446	3,674	3,050	1,904	1,145	545	230	41
	Survival (%)		88%	82%	79%	69%	59%	48%	41%	36%

12.7 Graft Survival by Graft Type in Children

Graft survival in children differed significantly by graft type, with worse survival after reduced liver transplantation (P < 0.001, Figure 46 and Table 32). Ten-year graft survival was 79.5% for living donor liver transplantation, 78.8% for whole liver transplantation, 75.5% for split liver transplantation and 61.4% for reduced liver transplantation. Median graft survival was 31.2 years for whole grafts, 27.2 years for reduced grafts and not reached for the other graft types.

Figure 46. Paediatric graft survival curve for type of graft, all grafts

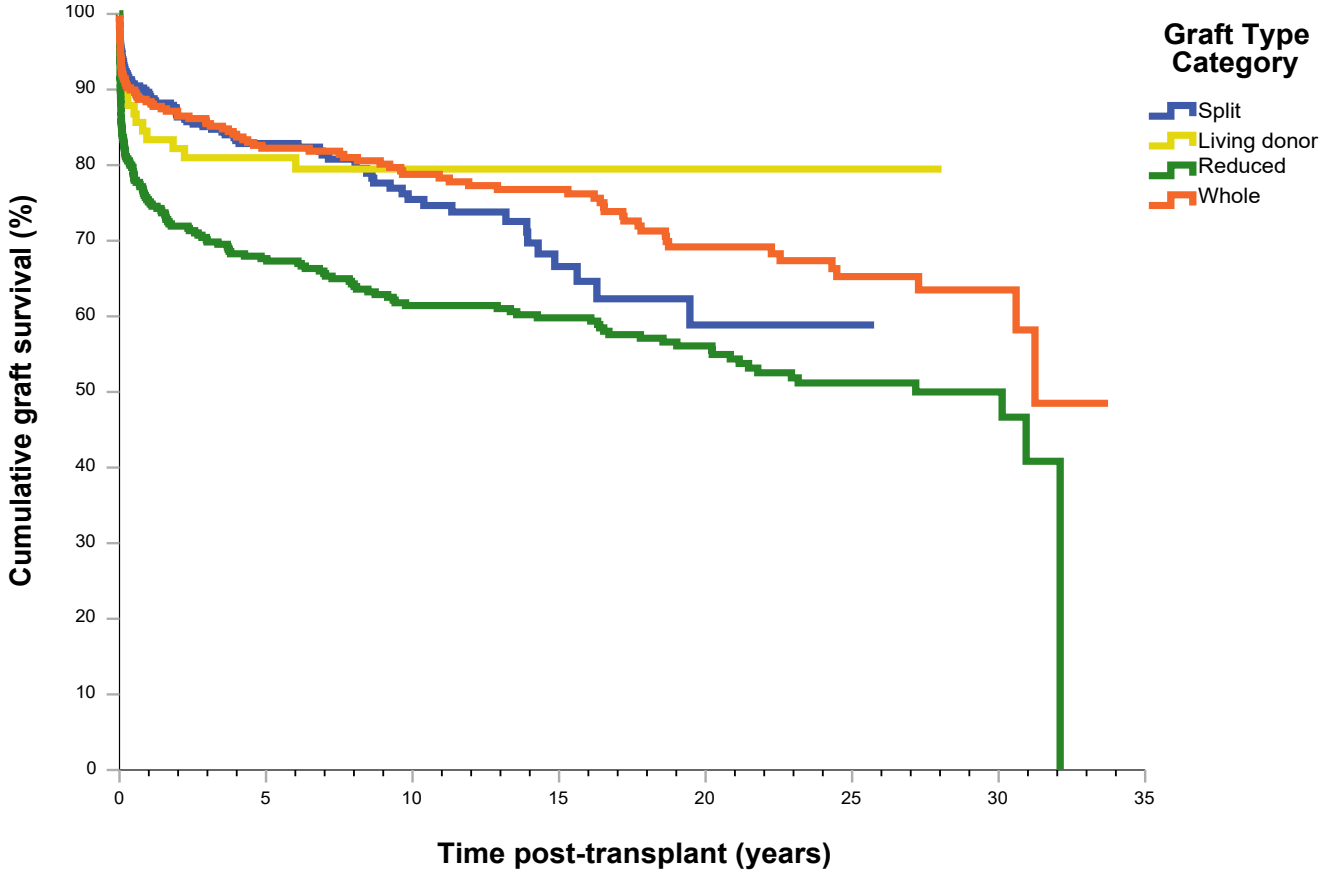


Table 32. Paediatric Recipient Graft survival by type of graft - all grafts

Graft Type	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
Living donor	No. at risk	91	72	66	60	31	5	2	2	0
	Survival (%)		83%	81%	81%	80%	80%	80%	80%	
Whole	No. at risk	338	284	252	220	169	134	91	59	14
	Survival (%)		88%	86%	82%	79%	77%	69%	65%	64%
Split	No. at risk	382	314	249	192	100	37	17	2	0
	Survival (%)		89%	85%	83%	76%	67%	59%	59%	
Reduced	No. at risk	355	261	232	210	167	141	100	61	16
	Survival (%)		75%	70%	68%	61%	60%	56%	51%	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 = 0.492, Figure 47 and Table 33). Ten-year graft survival was 72.9% for living donor liver transplantation, 68.5% for whole liver transplantation, 66.9% for split liver transplantation, 45.3% for reduced liver transplantation and 0 for domino liver transplantation. Median graft survival was 18.2 years for whole liver transplantation, 9.4 years for domino liver transplantation, 9.2 years for reduced liver transplantation and was not reached for split liver and living donor liver transplantation.

Figure 47. Adult graft survival curve for type of graft, all grafts

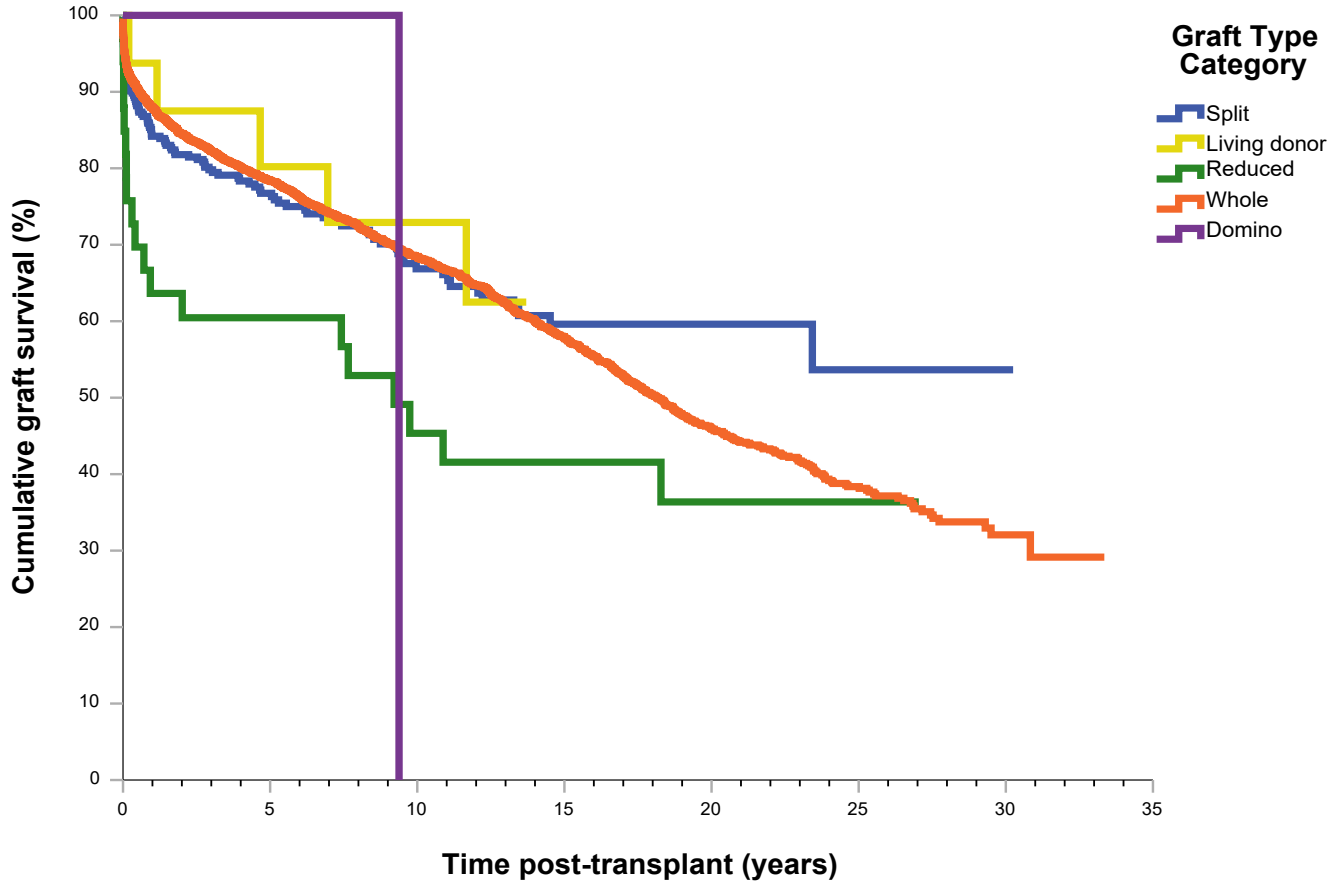


Table 33. Adult graft Survival for type of graft, all grafts

Graft Type	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
Domino	No. at risk	4	4	4	2	0				
	Survival (%)		100%	100%	100%					
Living donor	No. at risk	17	15	13	11	9	0			
	Survival (%)		94%	88%	80%	73%				
Split	No. at risk	376	290	232	181	98	46	19	3	1
	Survival (%)		84%	80%	77%	67%	60%	60%	54%	54%
Whole	No. at risk	5,030	4,162	3,422	2,830	1,735	1,011	454	171	27
	Survival (%)		88%	82%	78%	69%	58%	46%	38%	32%
Reduced	No. at risk	33	21	18	18	12	10	7	3	0
	Survival (%)		64%	61%	61%	45%	42%	36%	36%	

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 48, Table 34). Graft survival in the most recent era was 91.4% at 1 year, 86.4% at 3 years, 81.4% at 5 years and 70.6% at 10 years. Median graft survival was 17.2 years for 1995 – 99 era, 17.0 years for 1990 – 94 era, 7.7 years for 1985 – 89 era and was not reached for recent eras.

Figure 48. Graft (deceased and living donors) survival curve by era of transplant

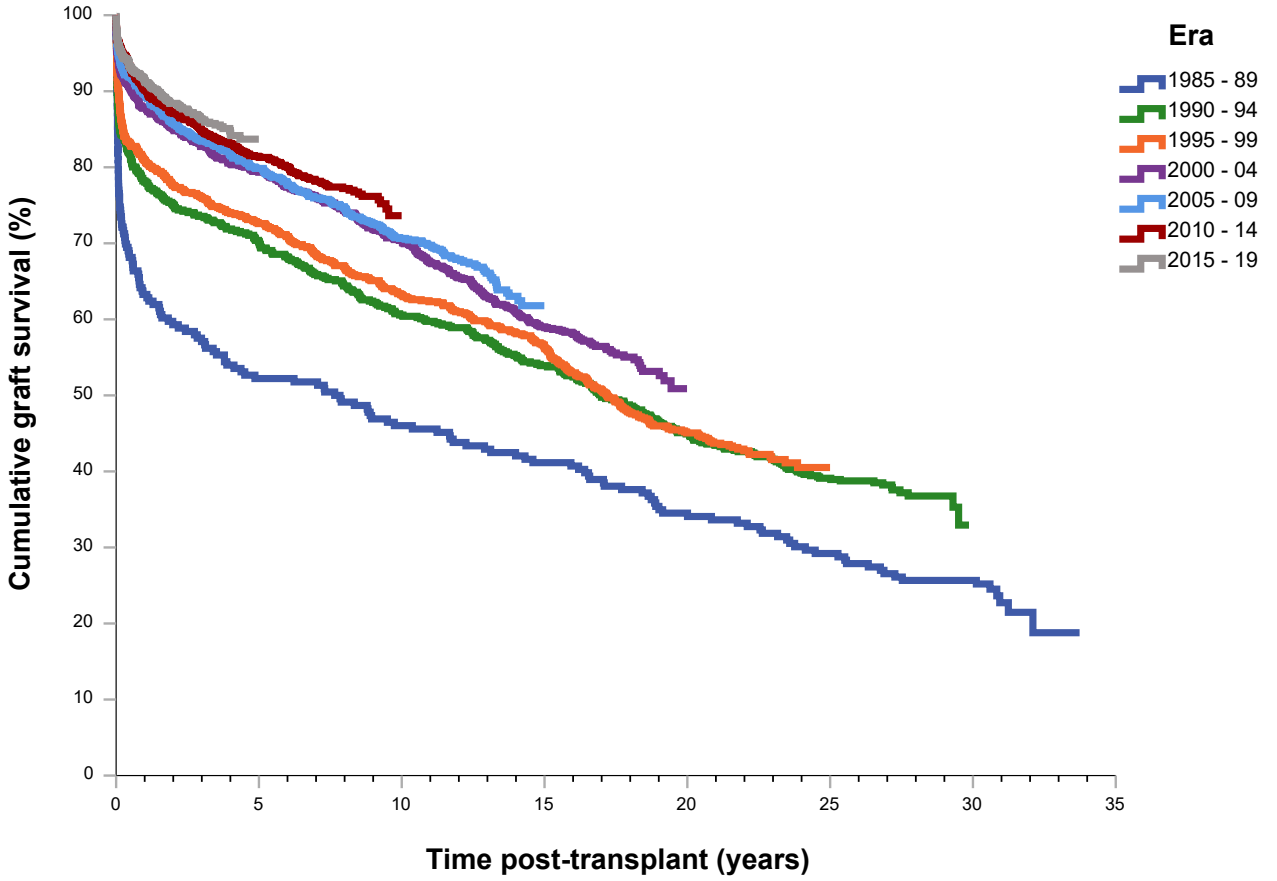


Table 34. Graft (deceased and living donors) survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
1985 - 89	No. at risk	226	143	129	118	104	93	78	66	58
	Survival (%)		63%	57%	52%	46%	41%	35%	29%	26%
1990 - 94	No. at risk	601	470	442	422	364	324	270	235	0
	Survival (%)		78%	74%	70%	61%	54%	45%	39%	
1995 - 99	No. at risk	759	614	577	551	480	427	342	0	
	Survival (%)		81%	76%	73%	63%	56%	45%		
2000 - 04	No. at risk	915	803	757	726	644	540	0		
	Survival (%)		88%	83%	79%	70%	59%			
2005 - 09	No. at risk	1,032	925	861	824	729	0			
	Survival (%)		90%	83%	80%	71%				
2010 - 14	No. at risk	1,331	1,201	1,128	1,083	0				
	Survival (%)		90%	85%	81%					
2015 - 19	No. at risk	1,763	1,268	594	0					
	Survival (%)		91%	86%						

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, although outcomes since 2005 have been similar (P < 0.001, Figure 49, Table 35). Graft survival in the most recent era was 90.7% at 1 year, 87.9% at 3 years, 83.3% at 5 years and 81.3% at 10 years. Median paediatric graft survival was 7.7 years for 1985 – 89 era and was not reached for all other transplant eras.

Figure 49. Paediatric graft (deceased and living donors) survival curve by era of transplant

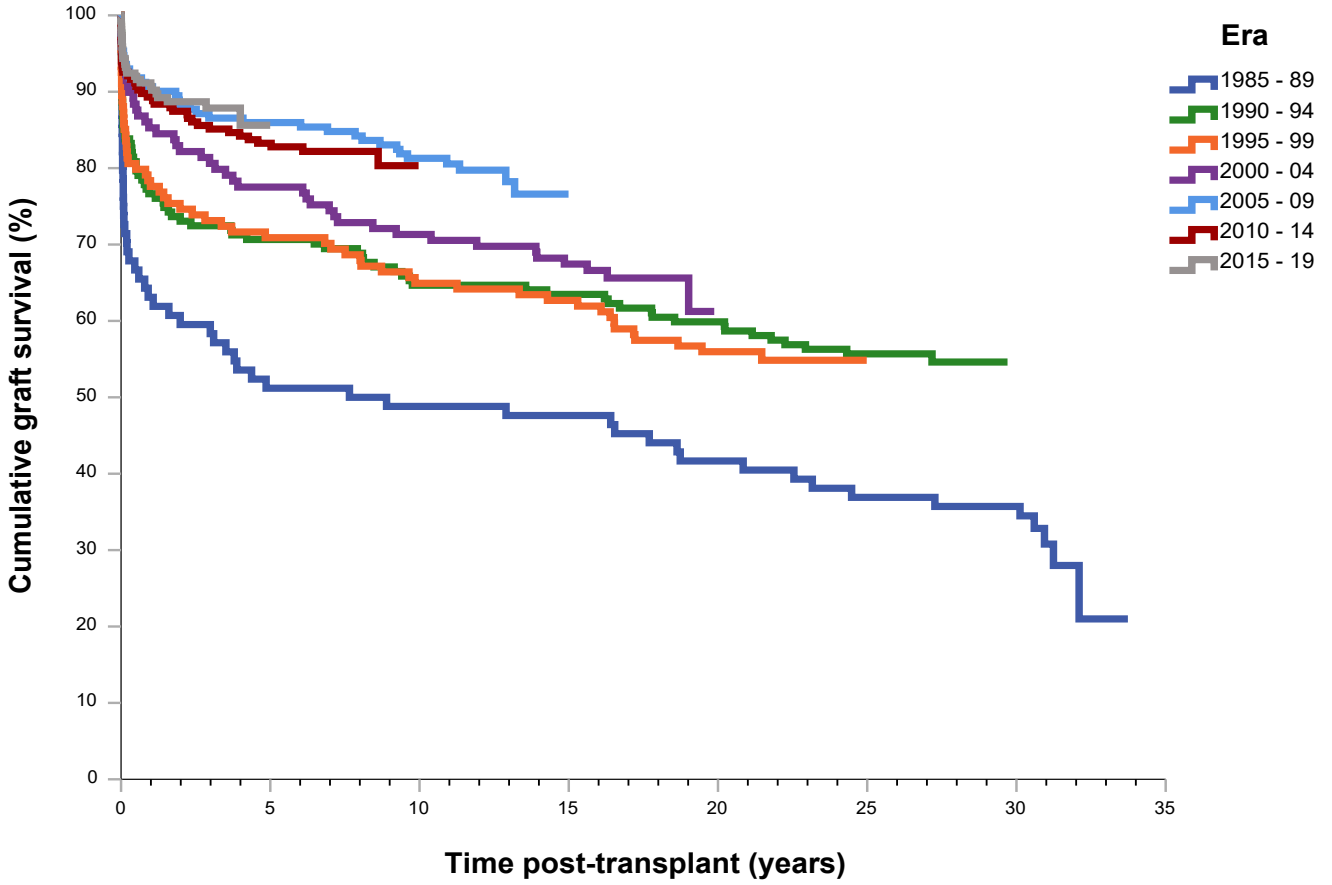


Table 35. Paediatric graft (deceased and living donors) survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
1985 - 89	No. at risk	84	53	49	43	41	40	35	31	30
	Survival (%)		63%	58%	51%	49%	48%	42%	37%	36%
1990 - 94	No. at risk	167	128	121	118	108	106	100	93	0
	Survival (%)		77%	73%	71%	65%	64%	60%	56%	
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	0		
	Survival (%)		85%	81%	78%	71%	67%			
2005 - 09	No. at risk	171	155	148	147	139	0			
	Survival (%)		91%	87%	86%	81%				
2010 - 14	No. at risk	215	192	183	179	0				
	Survival (%)		89%	85%	83%					
2015 - 19	No. at risk	267	190	96	0					
	Survival (%)		91%	88%						

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 50, Table 36). Graft survival in the most recent era was 91.6% at 1 year, 86.1% at 3 years, 81.0% at 5 years and 68.5% at 10 years. Median adult graft survival was 19.4 years for 2000 – 04 era, 16.5 years for 1995 – 99 era, 15.1 years for 1990 – 94 era, 7.3 years for 1985 – 89 era and not reached for other transplant eras.

Figure 50. Adult graft (deceased and living donors) survival curve by era of transplant

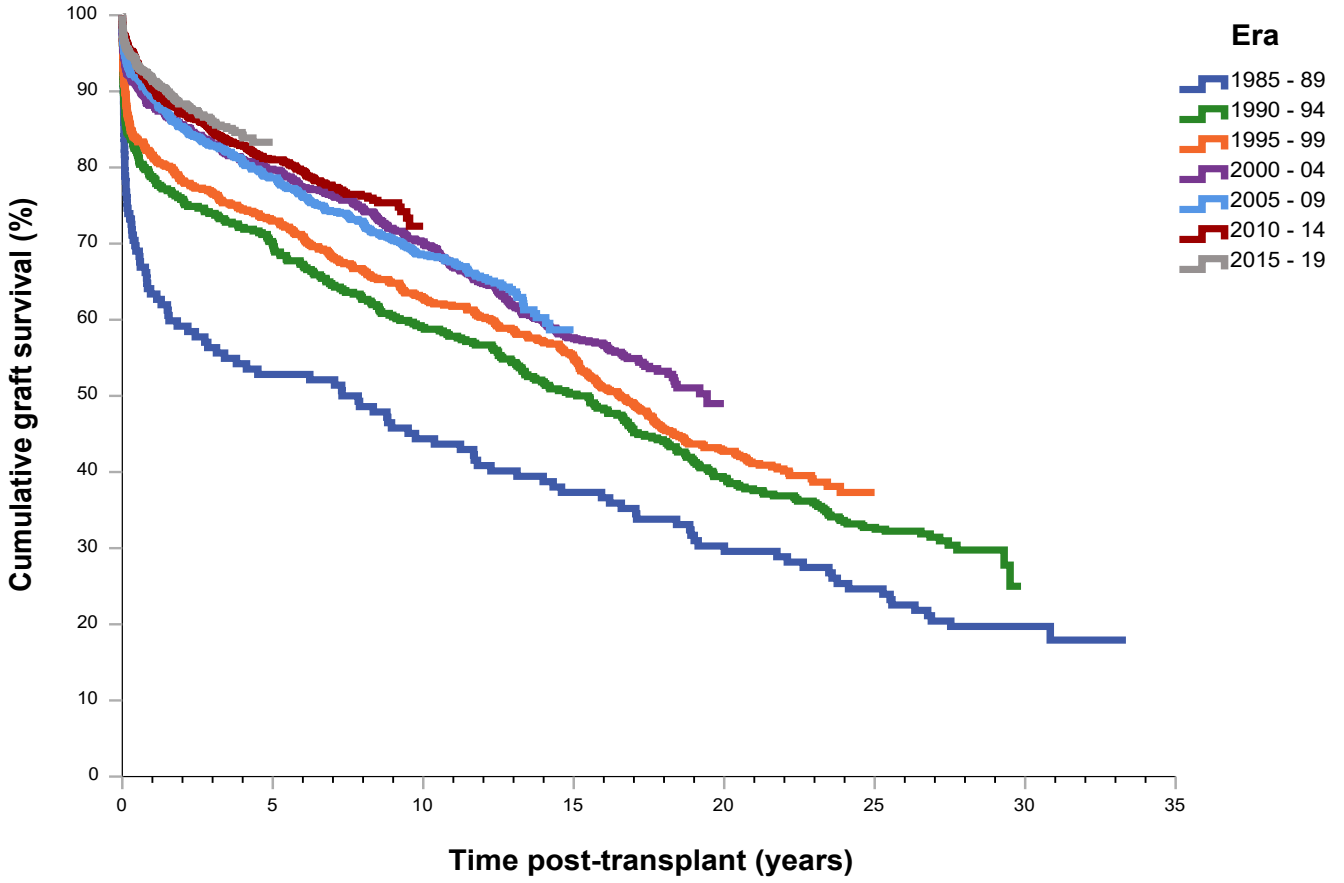


Table 36. Adult graft (deceased and living donors) survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years) 0	1	3	5	10	15	20	25	30
1985 - 89	No. at risk	142	90	80	75	63	53	43	35	28
	Survival (%)		63%	56%	53%	44%	37%	30%	25%	20%
1990 - 94	No. at risk	434	342	321	304	256	218	170	142	0
	Survival (%)		79%	74%	70%	59%	50%	39%	33%	
1995 - 99	No. at risk	625	510	479	456	393	343	267	0	
	Survival (%)		82%	77%	73%	63%	55%	43%		
2000 - 04	No. at risk	786	693	653	626	552	453	0		
	Survival (%)		88%	83%	80%	70%	58%			
2005 - 09	No. at risk	861	770	713	677	590	0			
	Survival (%)		89%	83%	79%	69%				
2010 - 14	No. at risk	1,116	1,009	945	904	0				
	Survival (%)		90%	85%	81%					
2015 - 19	No. at risk	1,496	1,078	498	0					
	Survival (%)		92%	86%						

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 51,Table 37). Graft survival in the most recent era was 92.0% at 1 year, 86.7% at 3 years, 82.0% at 5 years and 69.4% at 10 years. Median graft survival was 17.4 years for 1995 – 99 era, 16.7 years for 1990 – 94 era, 8.3 years for 1985 – 89 era and not reached for other eras.

Figure 51. Whole graft survival curve by era of transplant

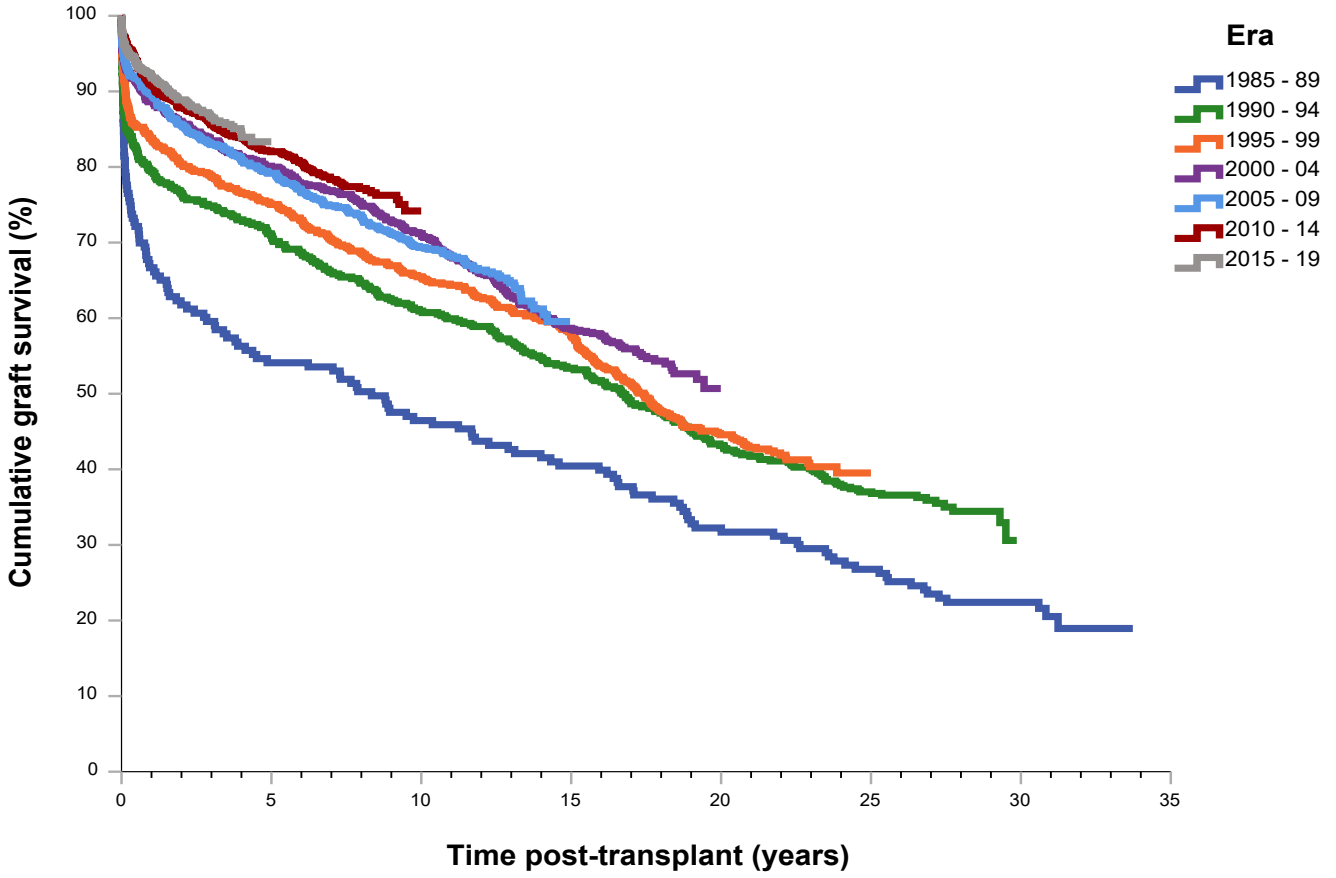


Table 37. Whole graft survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
1985 - 89	No. at risk	183	122	109	99	85	74	59	49	41
	Survival (%)		68%	60%	54%	46%	40%	32%	27%	22%
1990 - 94	No. at risk	489	389	366	347	298	261	211	181	0
	Survival (%)		80%	75%	71%	61%	53%	43%	37%	
1995 - 99	No. at risk	617	517	486	463	404	356	275	0	
	Survival (%)		84%	79%	75%	66%	58%	45%		
2000 - 04	No. at risk	774	686	646	619	551	454	0		
	Survival (%)		89%	84%	80%	71%	59%			
2005 - 09	No. at risk	816	732	677	646	566	0			
	Survival (%)		90%	83%	79%	69%				
2010 - 14	No. at risk	1,068	971	914	876	0				
	Survival (%)		91%	86%	82%					
2015 - 19	No. at risk	1,421	1,029	476	0					
	Survival (%)		92%	87%						

12.13 Reduced Graft Survival by Era of Transplant

Graft survival after reduced liver transplantation varied over transplant eras without a clear trend (P = 0.022, Figure 52, Table 38). Graft survival in the most recent era was 87.4% at 1 year, 83.9% at 3 years, 67.4% at 5 years and 70.6% at 10 years. Median graft survival was 21.1 years for 1990 – 94 era, 9.2 years for 1995 – 99 era, 3.0 years for 1985 – 89 era and not reached for other eras.

Figure 52. Reduced graft survival curve by era of transplant

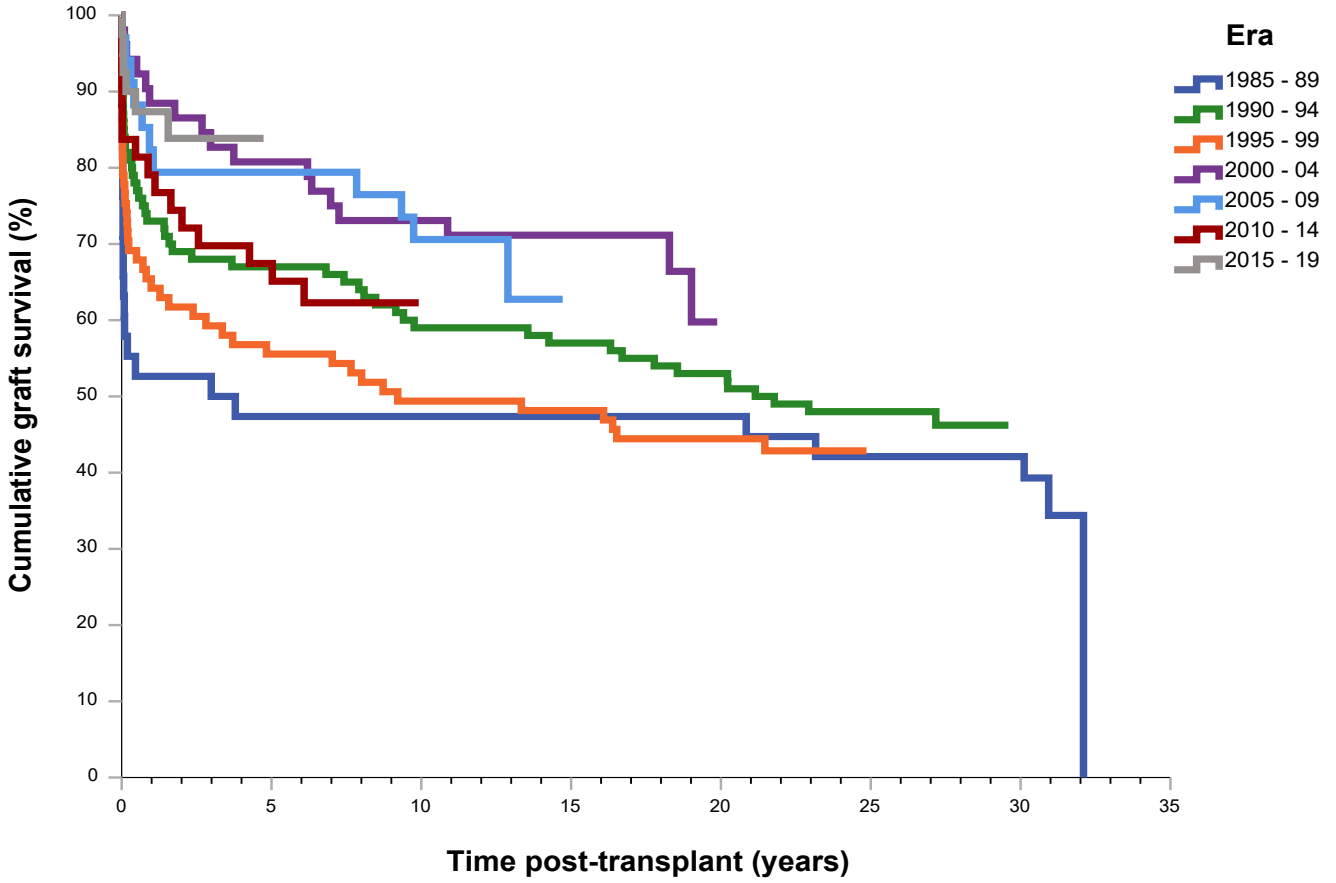


Table 38. Reduced graft (deceased donor) survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
1985 - 89	No. at risk	38	20	19	18	18	18	18	16	16
	Survival (%)		53%	50%	47%	47%	47%	47%	42%	42%
1990 - 94	No. at risk	100	73	68	67	59	57	53	48	0
	Survival (%)		73%	68%	67%	59%	57%	53%	48%	
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	0		
	Survival (%)		89%	83%	81%	73%	71%			
2005 - 09	No. at risk	34	28	27	27	24	0			
	Survival (%)		82%	79%	79%	71%				
2010 - 14	No. at risk	43	34	30	29	0				
	Survival (%)		79%	70%	67%					
2015 - 19	No. at risk	40	29	15	0					
	Survival (%)		87%	84%						

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 = 0.006, Figure 53, Table 39). Graft survival in the most recent era was 89.9% at 1 year, 86.0% at 3 years, 81.3% at 5 years and 72.9% at 10 years. Median graft survival was 23.4 years for 1995 – 99 era, 5.0 years for 1985 – 94 era and not reached for other transplant eras.

Figure 53. Split graft (deceased donor) survival curve by era of transplant

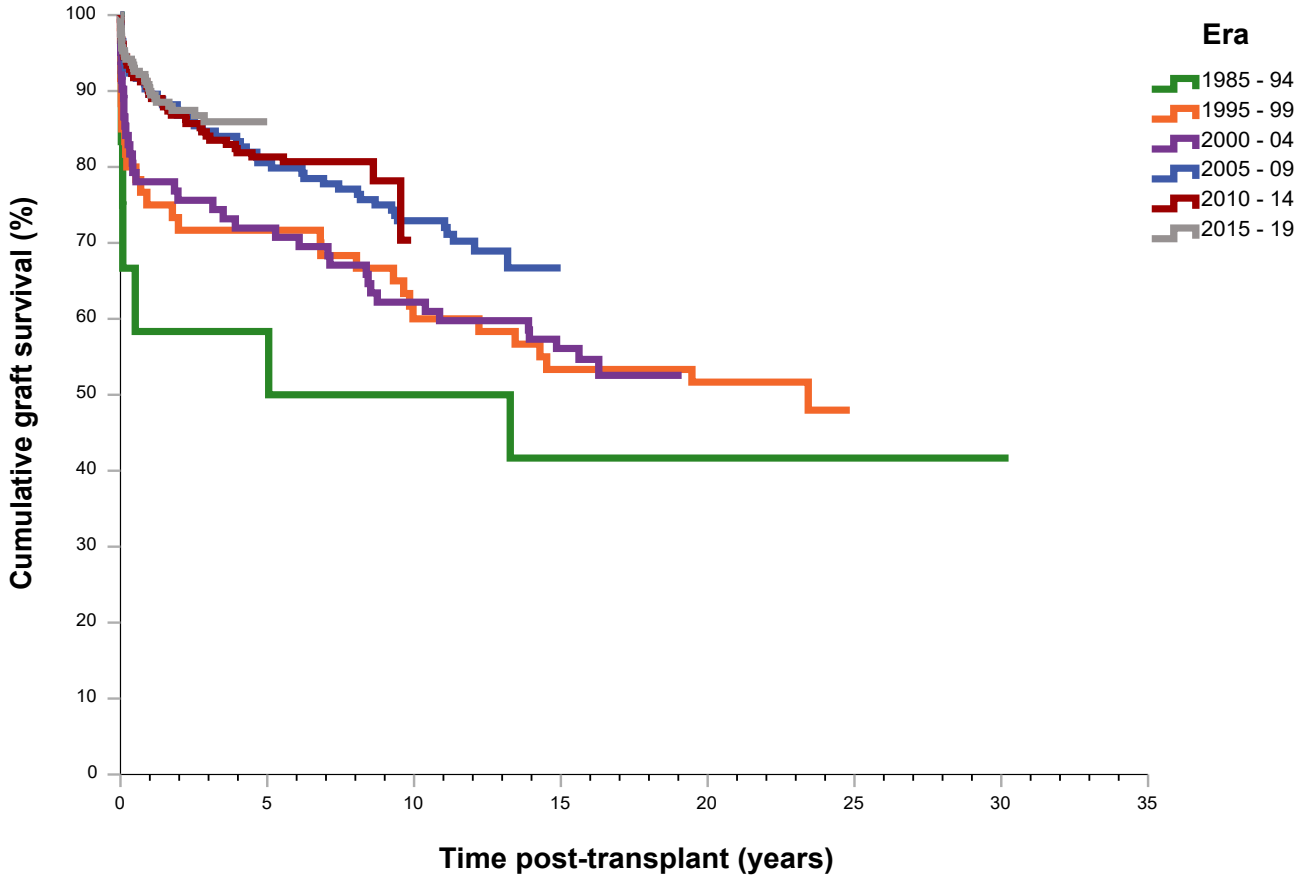


Table 39. Split graft (deceased donor) survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
1985 - 94	No. at risk	12	7	7	7	6	5	5	5	1
	Survival (%)		58%	58%	58%	50%	42%	42%	42%	42%
1995 - 99	No. at risk	60	45	43	43	36	32	31	0	
	Survival (%)		75%	72%	72%	60%	53%	52%		
2000 - 04	No. at risk	82	64	62	59	51	46	0		
	Survival (%)		78%	76%	72%	62%	56%			
2005 - 09	No. at risk	144	129	122	116	105	0			
	Survival (%)		90%	85%	81%	73%				
2010 - 14	No. at risk	182	163	153	148	0				
	Survival (%)		90%	84%	81%					
2015 - 19	No. at risk	278	196	94	0					
	Survival (%)		90%	86%						

12.15 Living Donor Graft Survival by Era of Transplant

There were 108 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 (P = 0.007, Figure 54 and Table 40). Graft survival in the most recent era was 76.5% at 1 year (2015-2019 era), 76.5% at 3 years (2015-2019 era), 78.4% at 5 years (2010-2014 era) and 89.5% at 10 years (2005-2009 era). Median graft survival was 0.8 years for 1985 – 99 era and not reached for other transplant eras. Multivariate analysis determined that transplant era was not independently associated with graft survival.

Figure 54. Living donor (excluding domino) graft survival curve by era of transplant

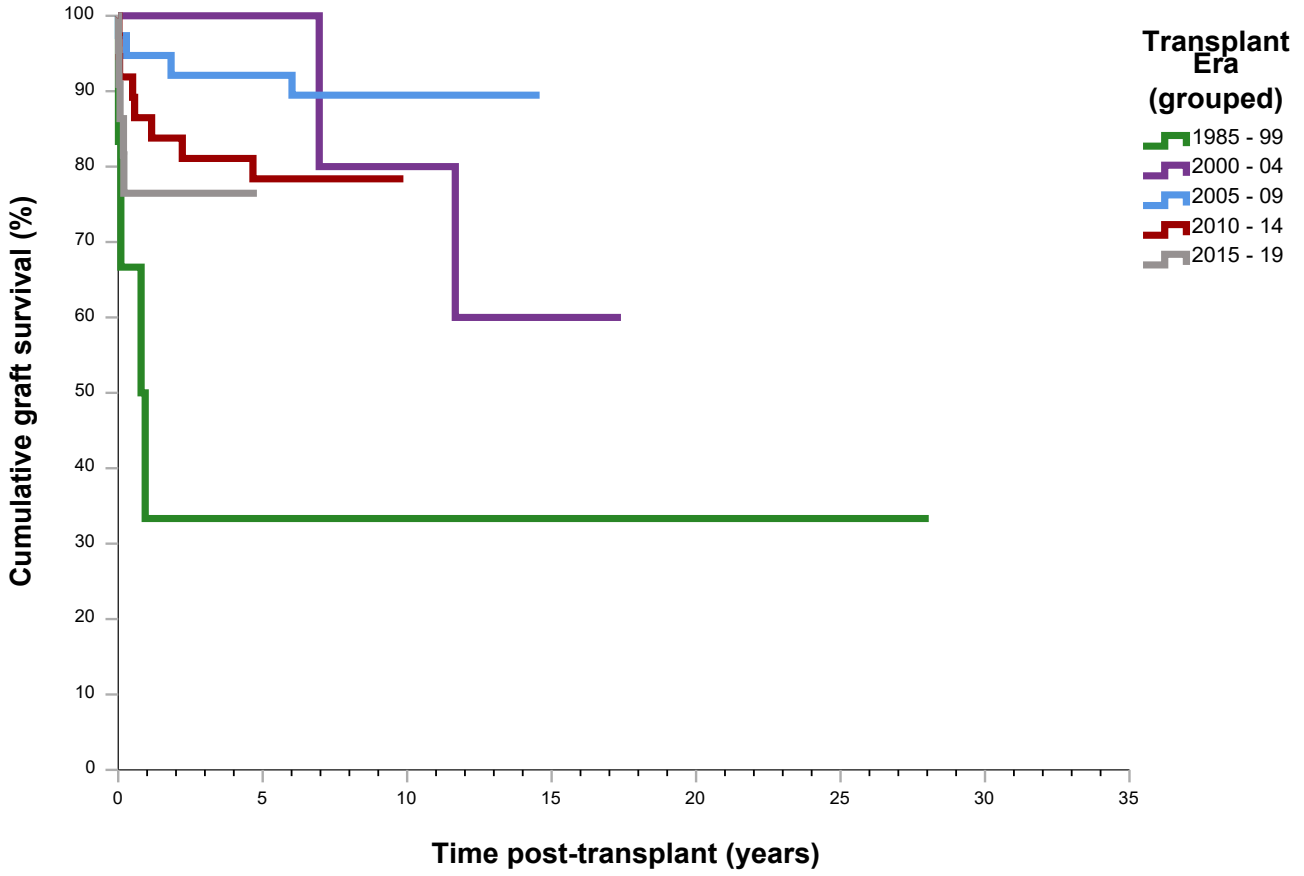


Table 40. Living donor (excluding domino) graft survival by era of transplant

Transplant Era	Graft Survival	Time post-transplant (years)							
		0	1	3	5	10	15	20	25
1985 - 99	No. at risk	6	2	2	2	2	2	2	2
	Survival (%)		33%	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	0		
	Survival (%)		95%	92%	92%	90%			
2010 - 14	No. at risk	37	32	30	29	0			
	Survival (%)		87%	81%	78%				
2015 - 19	No. at risk	22	12	7	0				
	Survival (%)		77%	77%					

12.16 Graft Survival by Deceased Donor Age

6,515 grafts were sourced from deceased donors however there is no deceased donor information on 126 grafts from 1985 to 1988. This survival analysis is limited to 6,389 grafts (from 6,011 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 55 and Table 41). Ten-year graft survival was 80.9% for donors aged 10 – 15 years, 77.2% for donors aged 0 – 9 years, 71.9% for donors aged 16 – 29 years, 68.4% for donors aged 30 – 39 years, 67.8% for donors aged 40 – 49 years, 68.0% for donors aged 70 years and older, 66.5% for donors aged 60 – 69 years and 63.9% for donors aged 50 – 59 years. Median graft survival was 27.2 years for donors aged 10 – 15 years, 22.6 years for donors aged 16 – 29 years, 18.3 years for donors aged 30 – 39 years, 18.4 years for donors aged 40 – 49 years, 15.9 years for donors aged 50 - 59 years, 17.1 years for donors aged 60 – 69 years and was not reached for donors aged 0 – 9 years and 70 years and older.

Figure 55. Graft survival curve by deceased donor age

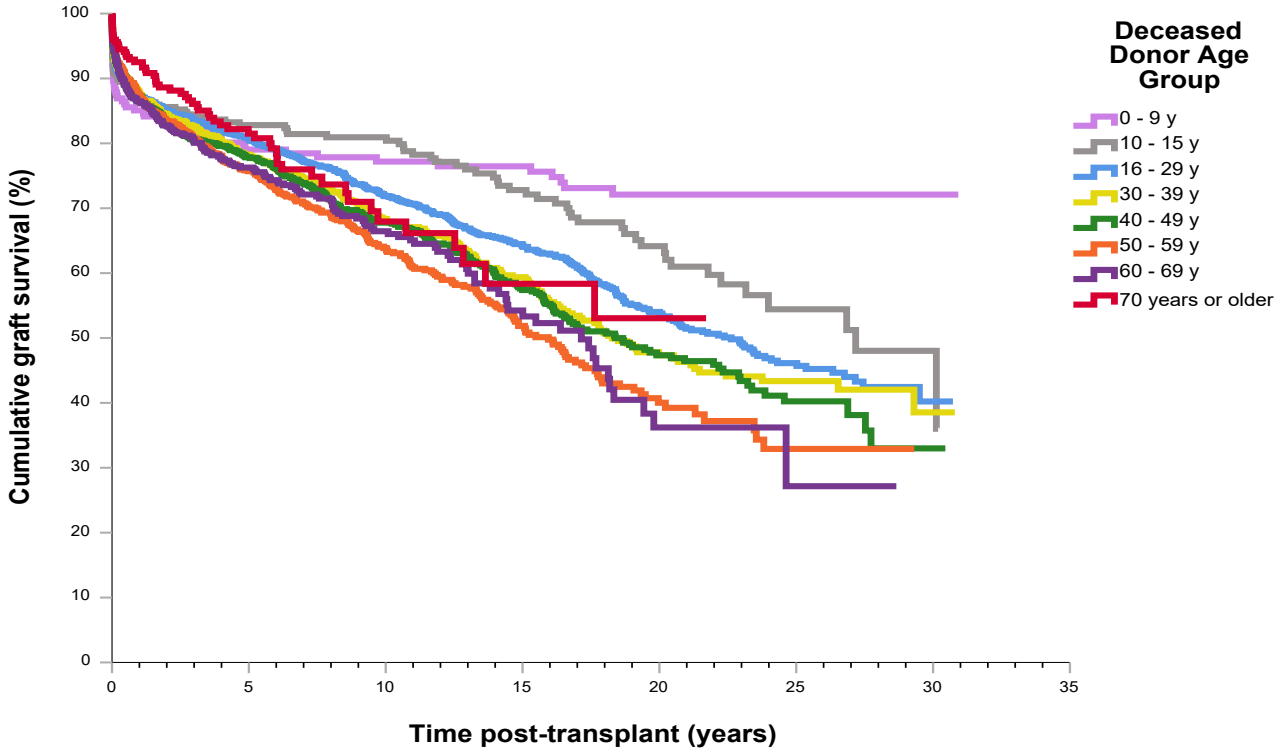


Table 41. Graft survival by deceased donor age

	Graft Survival	Time post-transplant (years)							
		0	1	3	5	10	15	20	25
0 – 9 y	No. at risk	222	182	164	146	114	94	65	39
	Survival (%)		85%	82%	79%	77%	77%	72%	72%
10 – 15 y	No. at risk	295	245	217	186	152	109	63	20
	Survival (%)		86%	84%	83%	81%	73%	64%	54%
16 – 29 y	No. at risk	1,640	1,368	1,186	1,016	690	446	239	110
	Survival (%)		87%	84%	81%	72%	64%	54%	46%
30 – 39 y	No. at risk	944	782	634	520	328	199	97	43
	Survival (%)		88%	83%	78%	68%	59%	47%	43%
40 – 49 y	No. at risk	1,214	966	809	695	428	254	110	38
	Survival (%)		87%	81%	78%	68%	57%	47%	40%
50 – 59 y	No. at risk	1,094	890	724	577	317	156	57	14
	Survival (%)		87%	81%	76%	64%	52%	40%	33%
60 – 69 y	No. at risk	706	562	433	327	155	59	16	3
	Survival (%)		87%	80%	76%	67%	54%	36%	27%
70 years and older	No. at risk	274	225	166	118	41	16	2	0
	Survival (%)		93%	86%	82%	68%	58%	53%	

12.17 Graft Survival by Donor Type

There was a trend to better graft survival for transplantation from living donors and worse graft survival for transplantation from donation after circulatory death donors in comparison to transplantation from donation after brain death donors (P = 0.100, Figure 56 and Table 42). Ten-year graft survival was 77.4% for transplantation from living donors, 68.9% for transplantation from donation after brain death donors and 64.1% for transplantation from donation after circulatory death donors. Median survival for transplantation from donation after brain death donors was 19.8 years and was not reached for transplantation from living donors and donation after circulatory death donors.

Figure 56. Graft survival curve by donor type – all grafts

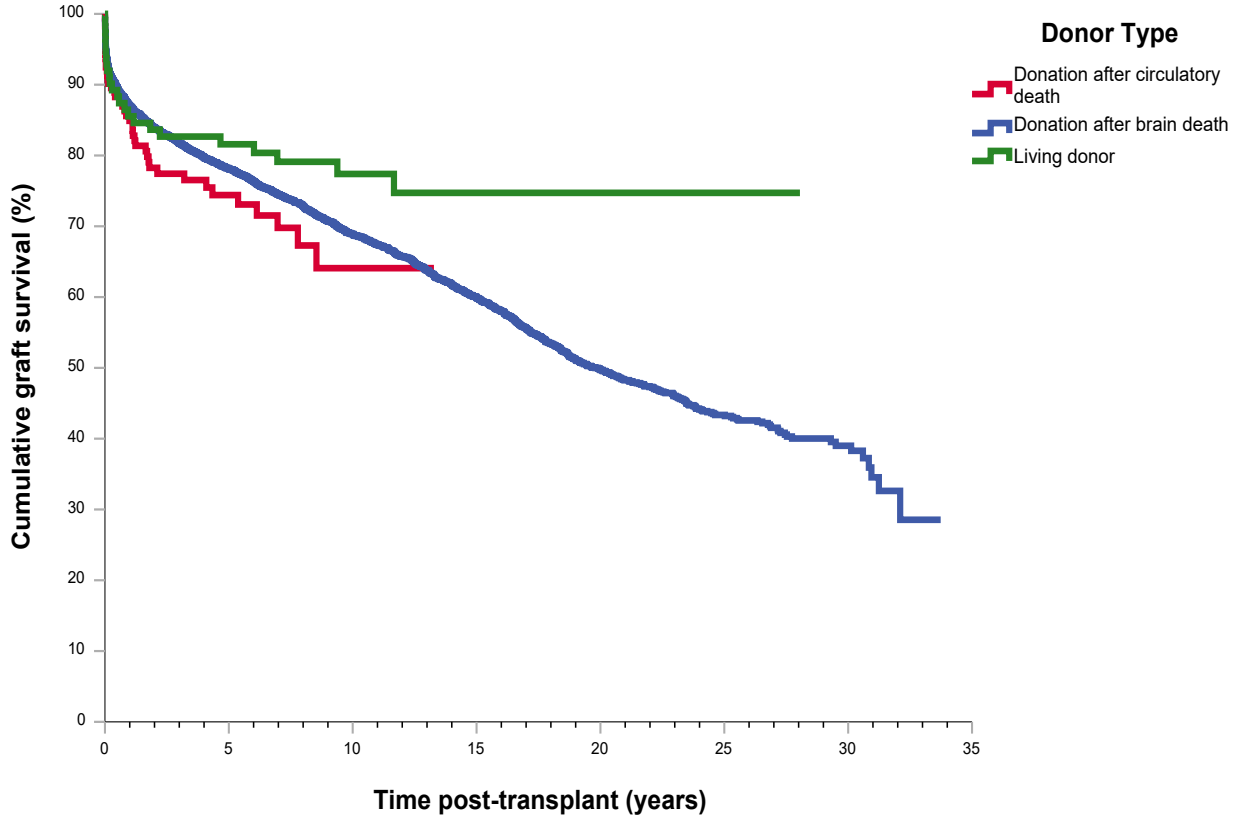


Table 42. Graft survival by donor type – all grafts

Donor Type	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
Living donor	No. at risk	112	91	83	73	40	5	2	2	0
	Survival (%)		86%	83%	82%	77%	75%	75%	75%	
DBD	No. at risk	6,342	5,209	4,381	3,589	2,272	1,379	688	299	58
	Survival (%)		87%	82%	78%	69%	60%	50%	43%	39%
DCD	No. at risk	173	124	87	62	9	0			
	Survival (%)		85%	77%	74%	64%				

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 57, Table 43). Ten-year graft survival was 75.6% for other cause, 72.1% for anoxia, 70.3% for trauma and 66.8% for stroke. Median survival was 27.4 years for other cause, 21.8 years for trauma, 20.7 years for anoxia and 17.9 years for stroke.

Figure 57. Graft survival curve by donor cause of death

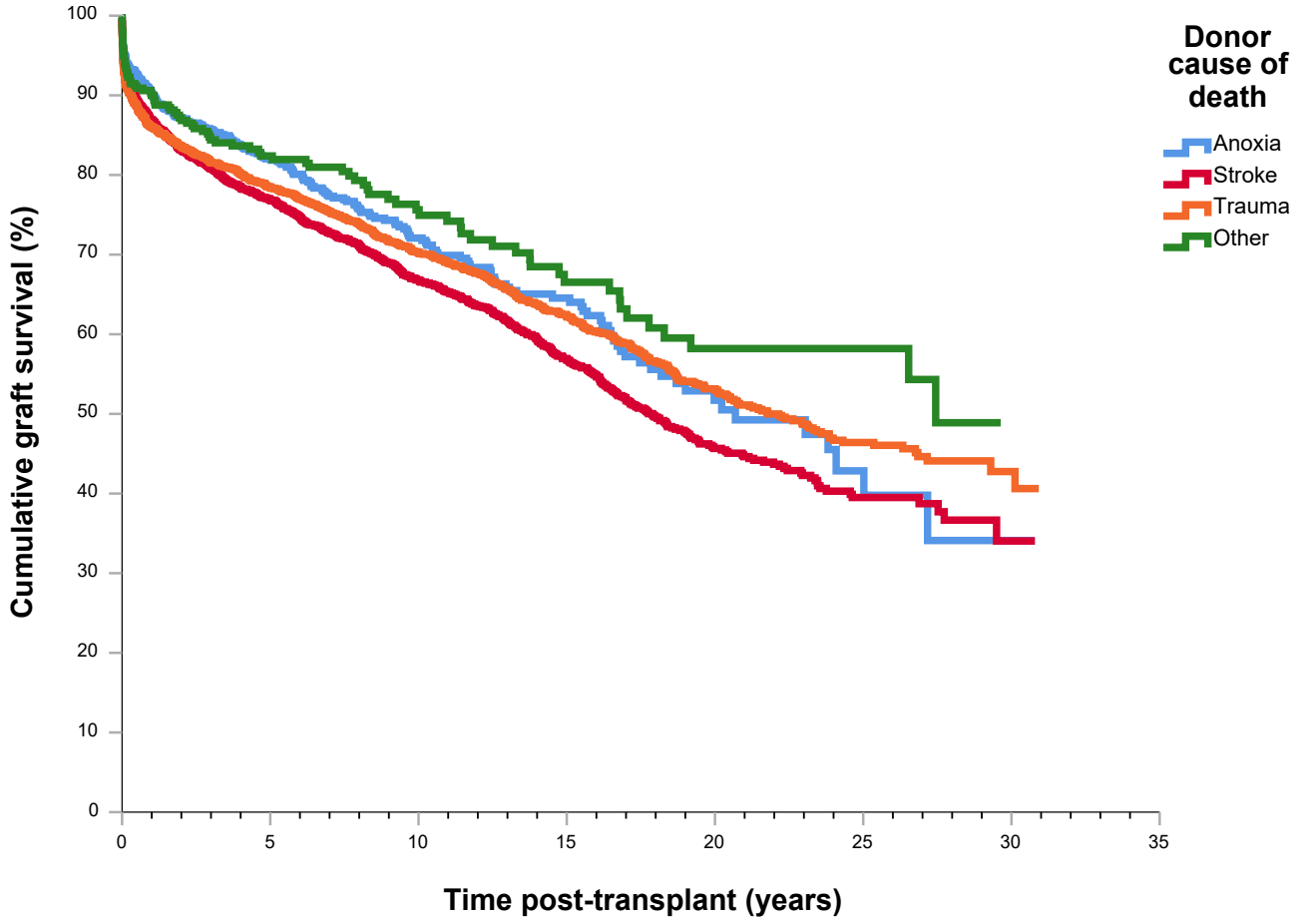


Table 43. Graft survival by donor cause of death

Donor cause of death	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
Other	No. at risk	377	299	238	186	109	68	41	18	0
	Survival (%)		90%	84%	82%	76%	67%	58%	58%	
Trauma	No. at risk	1,885	1,568	1,393	1,229	874	591	327	147	22
	Survival (%)		86%	82%	79%	70%	62%	53%	46%	43%
Stroke	No. at risk	2,954	2,440	2,004	1,678	998	552	237	88	6
	Survival (%)		87%	81%	77%	67%	57%	46%	40%	34%
Anoxia	No. at risk	1,173	943	698	492	244	123	44	14	2
	Survival (%)		90%	86%	82%	72%	65%	52%	43%	34%

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 58, Table 44). Ten-year graft survival was 70.8% for transplants performed with a non-shipped liver and 65.2% for a liver shipped from another unit. Median graft survival was 20.1 years for transplants performed with a local donor liver and 19.2 years for a liver shipped from another unit.

Figure 58. Graft survival curve by organ shipping

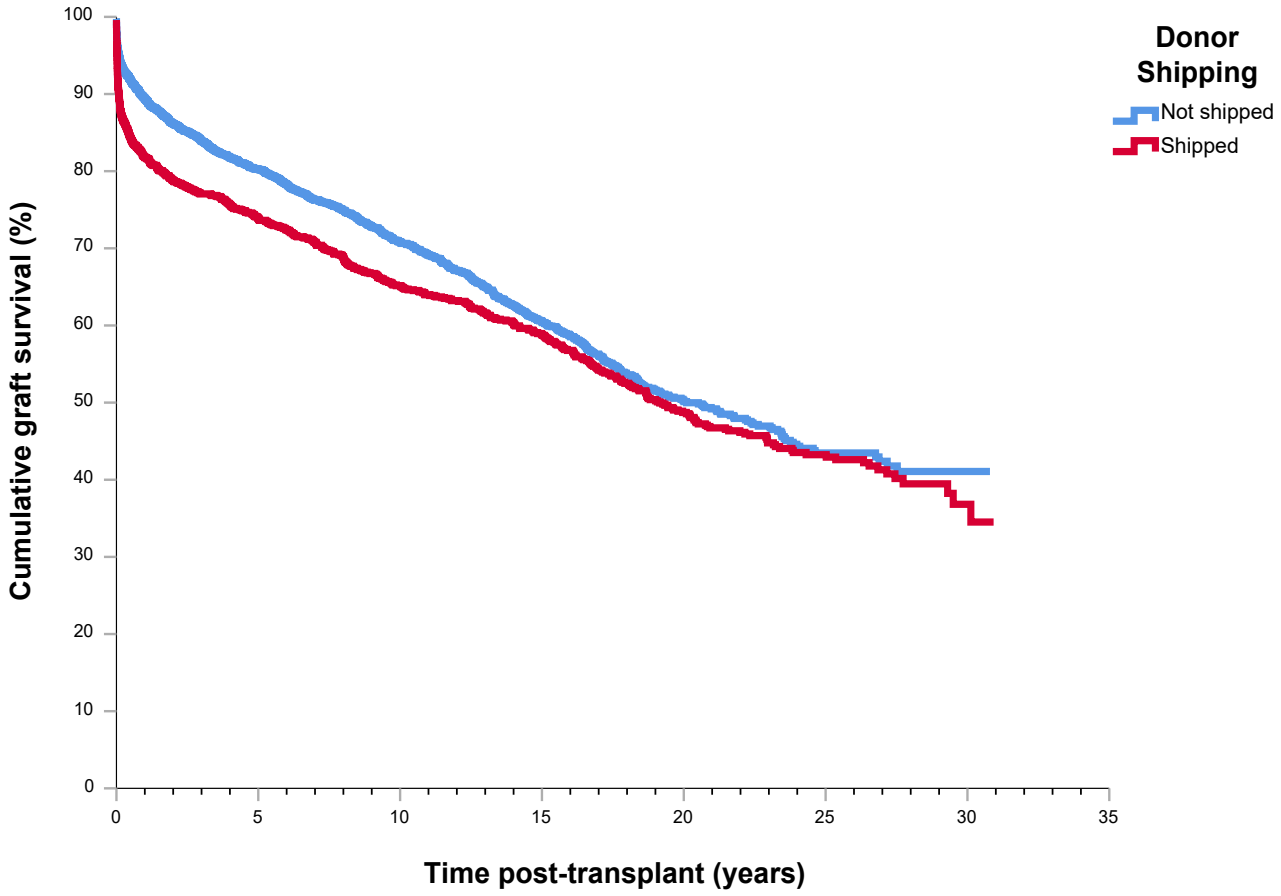


Table 44. Graft survival by organ shipping

Organ Shipping	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
Not shipped	No. at risk	4,716	3,936	3,184	2,582	1,497	813	344	128	11
	Survival (%)		89%	84%	80%	71%	60%	50%	44%	41%
Shipped	No. at risk	1,673	1,314	1,149	1,003	728	520	305	139	19
	Survival (%)		82%	77%	74%	65%	59%	49%	43%	37%

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 549 minutes compared to transplants performed with a cold ischaemia time 549 minutes or greater (P < 0.001, see Figure 59 and Table 45). Ten-year graft survival was 72.1% for transplants with a cold ischaemia time less than 549 minutes and 67.8% for transplants with a cold ischaemia time greater than or equal to 549 minutes. Median survival was 18.5 years for transplants with a cold ischaemia time less than 549 minutes and 15.8 years for transplants with a cold ischaemia time greater than or equal to 549 minutes.

Figure 59. Graft survival curve by cold ischaemia time

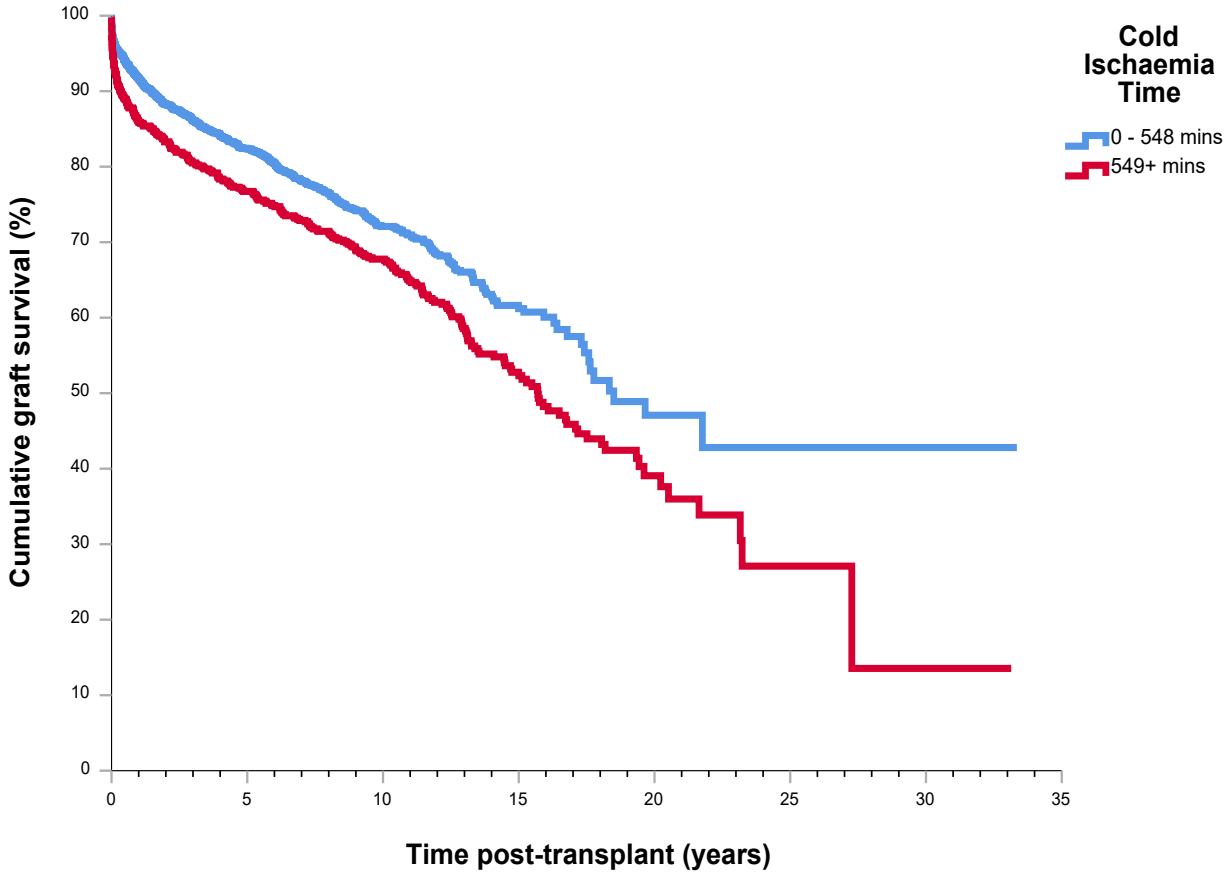


Table 45. Graft survival by cold ischaemia time

Cold Ischaemia Time	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
0 – 548 min	No. at risk	3,598	2,997	2,292	1,680	666	143	24	3	1
	Survival (%)		92%	86%	82%	72%	61%	47%	43%	43%
549+ min	No. at risk	865	716	621	545	346	115	28	4	1
	Survival (%)		86%	81%	77%	68%	52%	39%	27%	14%

2,164 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=0.006, Figure 60 and Table 46). Ten-year graft survival was 71.7% 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), 70.3% for blood group-compatible transplants, 69.7% for blood group-incompatible transplants (excluding A2 donors) and 69.2% for blood group-identical transplants. Median graft survival was not reached for blood group-incompatible transplants and incompatible "A2" transplants, 20.8 years for transplants in which the donor and recipient blood groups were compatible and 20.0 years for transplants between identical blood groups.

Figure 60. Graft survival curve by blood group compatibility

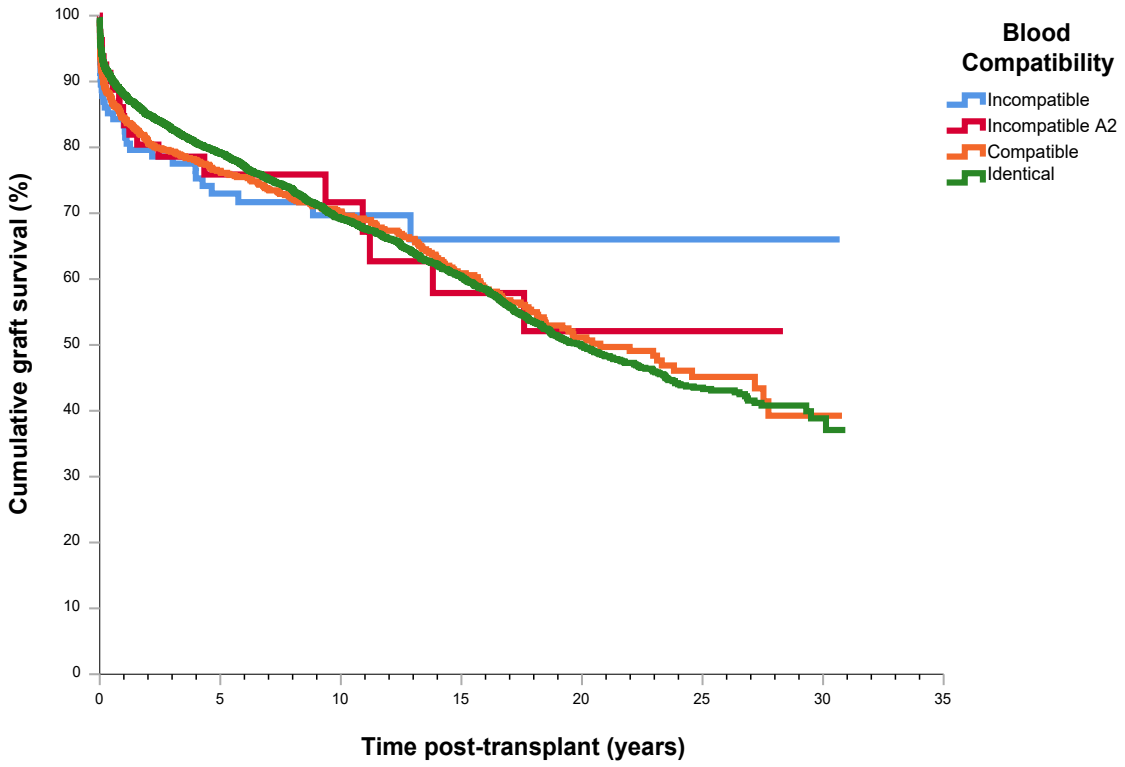


Table 46. Graft survival by blood group compatibility

Compatibility	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
Incompatible	No. at risk	115	90	73	59	30	12	6	3	1
	Survival (%)		83%	79%	73%	70%	66%	66%	66%	66%
Incompatible A2	No. at risk	81	62	42	25	17	11	4	2	0
	Survival (%)		85%	79%	76%	72%	58%	52%	52%	
Compatible	No. at risk	894	719	592	493	337	210	109	46	5
	Survival (%)		85%	79%	76%	70%	61%	51%	45%	39%
Identical	No. at risk	5,299	4,379	3,626	3,008	1,841	1,099	529	216	24
	Survival (%)		88%	83%	79%	69%	60%	50%	44%	39%

238 cases missing

12.22 Graft Survival by Recipient Urgency

Graft survival varied significantly by recipient urgency (P = 0.005, Figure 61 and Table 47). Ten-year graft survival was 78.1% for category 2, 68.9% for non-urgent and 64.2% for category 1 patients. Median graft survival was not reached for category 2, 19.8 years for non-urgent and 23.2 years for category 1 patients.

Figure 61. Graft survival curve by recipient urgency

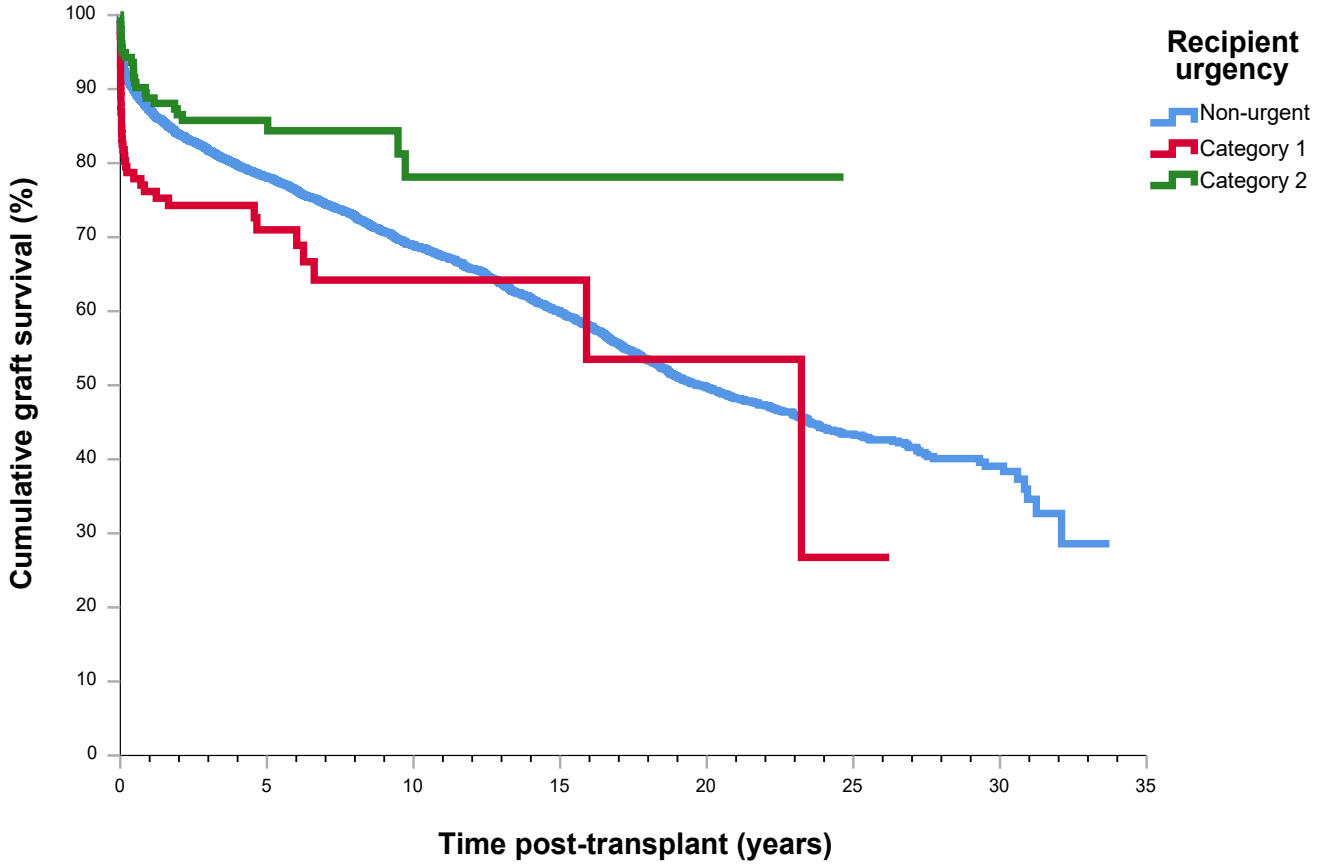


Table 47. Graft survival by recipient urgency

Urgency	Graft Survival	Time post-transplant (years)								
		0	1	3	5	10	15	20	25	30
Category 2	No. at risk	157	124	100	61	25	3	2	0	
	Survival (%)		89%	86%	86%	78%	78%	78%		
Non-urgent	No. at risk	6,332	5,214	4,321	3,623	2,279	1,373	684	300	58
	Survival (%)		87%	82%	78%	69%	60%	50%	43%	39%
Category 1	No. at risk	138	86	67	40	17	8	4	1	0
	Survival (%)		76%	74%	71%	64%	64%	54%	27%	

13 Indication for Retransplantation

13.1 All Retransplants

There were 500 retransplants after the previous graft failed. There have been 445 second grafts, 53 third grafts and two fourth grafts. The commonest indications for retransplantation were vascular complications (30%), rejection (18%), biliary complications (16%), primary non-function or initial poor function (14%) and recurrent disease (14%, Table 48).

Table 48. Reason for retransplantation

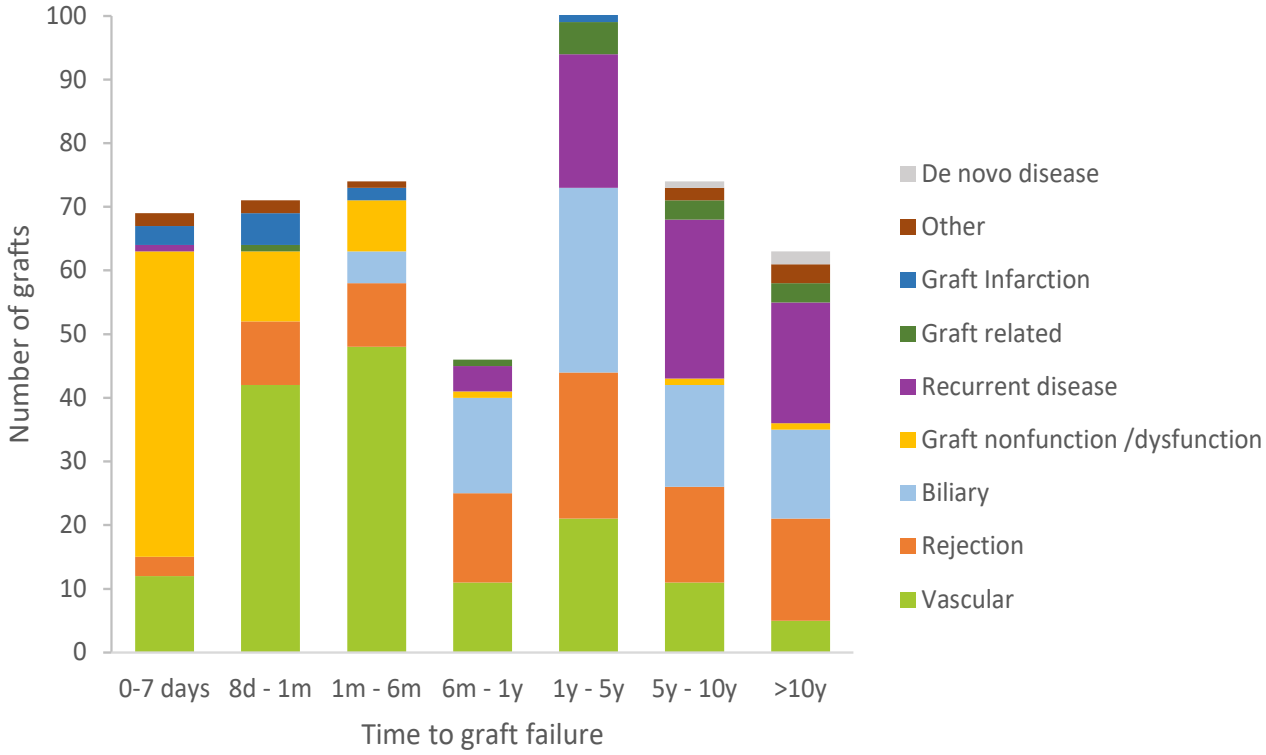
Reason for retransplantation	Graft 2	Graft 3	Graft 4	Total grafts	% total
Vascular	**133**	**17**		**150**	**30%**
- Hepatic artery thrombosis	*101*	*12*		*113*	*23%*
- Portal vein thrombosis	*10*			*10*	*2%*
- Hepatic vein thrombosis	*5*	*1*		*6*	*1%*
- Unspecified	*5*			*5*	*1%*
- Haemorrhage (Hepatic artery)	*4*			*4*	*0.8%*
- Hepatic artery stenosis	*3*			*3*	*0.6%*
- Hepatic artery pseudoaneurysm	*2*			*2*	*0.4%*
- Hepatic vein stenosis		*2*		*2*	*0.4%*
- Arterio-portal vein fistula	*1*			*1*	*0.2%*
- Budd Chiari	*1*			*1*	*0.2%*
- Hepatic artery injury	*1*			*1*	*0.2%*
- Recurrent bleeds		*1*		*1*	*0.2%*
- Ruptured hepatic artery anastomosis		*1*		*1*	*0.2%*
Rejection	**79**	**11**	**1**	**91**	**18%**
- Chronic rejection	*56*	*10*		*66*	*13%*
- Acute rejection	*16*	*1*	*1*	*18*	*4%*
- ABO incompatible	*4*			*4*	*0.8%*
- Hyperacute rejection	*2*			*2*	*0.4%*
- Donor antibody mediated	*1*			*1*	*0.2%*
Biliary	**76**	**3**		**79**	**16%**
- Unspecified	*25*	*2*		*27*	*5%*
- Biliary strictures type unspecified	*15*			*15*	*3%*
- Non anastomotic	*9*			*9*	*2%*
- Cholangiopathy	*8*			*8*	*2%*
- Anastomotic	*6*			*6*	*1%*
- Biliary cirrhosis / fibrosis	*6*			*6*	*1%*
- Cholangitis	*2*			*2*	*0.4%*
- Cholestatic disease	*2*			*2*	*0.4%*
- Ductopenia	*2*			*2*	*0.4%*
- Biliary necrosis		*1*		*1*	*0.2%*
- Biliopathy caused by ABO incompatible transplant	*1*			*1*	*0.2%*
Primary graft nonfunction /dysfunction	**63**	**7**		**70**	**14%**
- Primary nonfunction (ReTx or death <= 7 days)	*45*	*7*		*52*	*10%*
- Primary dysfunction (ReTx or death > 7 days)	*16*	*2*		*18*	*4%*
Recurrent disease	**63**	**7**		**70**	**14%**
- Primary sclerosing cholangitis	*23*	*5*		*28*	*6%*
- Hepatitis C	*22*			*22*	*4%*
- Autoimmune hepatitis	*6*	*1*		*7*	*1%*
- Primary biliary cirrhosis	*6*	*1*		*7*	*1%*
- Hepatitis B	*4*			*4*	*0.8%*
- Crigler-Najjar	*1*			*1*	*0.2%*
- Erythropoietic protoporphyria	*1*			*1*	*0.2%*
Graft related	**10**	**3**		**13**	**3%**
- Post necrotic cirrhosis	*5*	*3*		*8*	*2%*
- Nodular regenerative hyperplasia	*3*			*3*	*0.6%*
- Immune/nonviral hepatitis	*2*			*2*	*0.4%*

(table continued on next page)

Reason for retransplantation	Graft 2	Graft 3	Graft 4	Total grafts	% total
Graft Infarction	**11**		**1**	**12**	**2%**
- Non thrombotic	*5*		*1*	*6*	*1%*
- Thrombotic	*6*			*6*	*1%*
De novo disease	**4**			**4**	**0.8%**
- Hepatitis C	*2*			*2*	*0.4%*
- Hepatitis B	*1*			*1*	*0.2%*
- Hepatitis D	*1*			*1*	*0.2%*
Other	**8**	**3**		**11**	**2.2%**
- Unspecified	*3*	*1*		*4*	*1%*
- Cryptogenic cirrhosis	*2*	*1*		*3*	*0.6%*
- Donor derived malignancy	*2*	*1*		*3*	*0.6%*
- Acute hepatic failure - Drug related: interferon	*1*			*1*	*0.2%*
Total	**445**	**53**	**2**	**500**	

Forty-three percent of graft failures occurred within the first six months' post-transplant (13.8% 0 – 7 days, 14.2% day 8 to 1 month, 14.8% 1 month to 6 months). Primary graft non-function (69.6%) was the main reason for retransplantation in the first 7 days post-transplant whilst vascular causes were the main type for 8 days to 1 month (59.2%) and 1 month to 6 months (64.9% Figure 62). Recurrent disease was the leading cause of graft failure after five years post-transplant.

Figure 62. Time to graft failure by reason for retransplantation



13.2 Paediatric Retransplantation

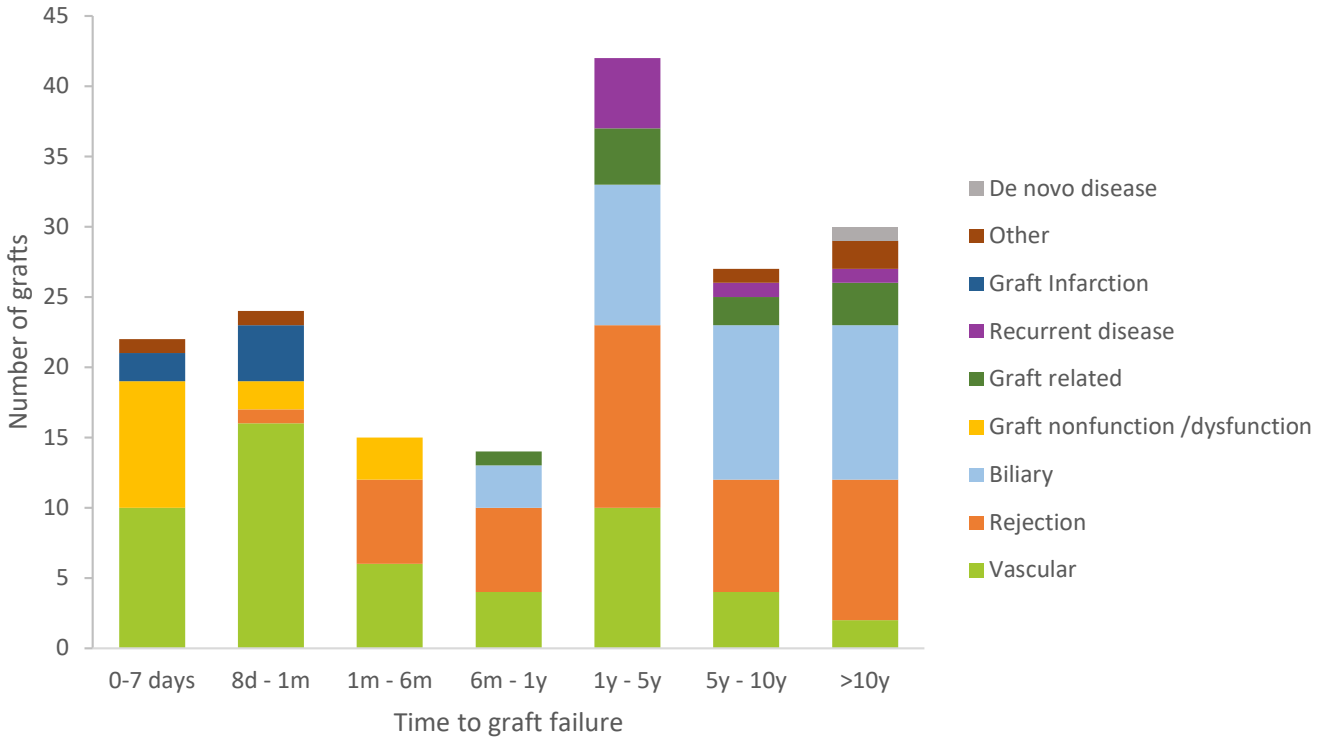
There were 174 retransplants following paediatric graft failure. There have been 147 second grafts and 27 third grafts. The commonest indications for retransplantation were vascular complications (30%), rejection (25%) and biliary complications (20%, Table 49).

Table 49. Reason for retransplantation following paediatric graft failure

Reason for retransplantation	Graft 2	Graft 3	Total grafts	% total
Vascular	**43**	**9**	**52**	**30%**
- Hepatic artery thrombosis	*28*	*6*	***34***	*20%*
- Portal vein thrombosis	*7*		***7***	*4%*
- Hepatic vein thrombosis	*2*	*1*	***3***	*2%*
- Unspecified	*3*		***3***	*2%*
- Hepatic vein stenosis		*1*	***1***	*1%*
- Recurrent bleeds		*1*	***1***	*1%*
- Arterio-portal vein fistula	*1*		***1***	*1%*
- Budd Chiari	*1*		***1***	*1%*
- Hepatic artery stenosis	*1*		***1***	*1%*
Rejection	**35**	**9**	**44**	**25%**
- Chronic rejection	*34*	*8*	***42***	*24%*
- Acute rejection	*1*	*1*	***2***	*1%*
Biliary	**33**	**2**	**35**	**20%**
- Unspecified	*7*	*1*	***8***	*5%*
- Biliary strictures type unspecified	*7*		***7***	*4%*
- Anastomotic	*4*		***4***	*2%*
- Biliary cirrhosis / fibrosis	*4*		***4***	*2%*
- Non anastomotic	*3*		***3***	*2%*
- Cholangiopathy	*2*		***2***	*1%*
- Cholangitis	*2*		***2***	*1%*
- Ductopenia	*2*		***2***	*1%*
- Biliary necrosis		*1*	***1***	*1%*
- Cholestatic disease	*1*		***1***	*1%*
- Biliopathy caused by ABO incompatible transplant	*1*		***1***	*1%*
Graft nonfunction /dysfunction	**11**	**4**	**15**	**9%**
- Primary nonfunction (ReTx or death <= 7 days)	*6*	*3*	***9***	*5%*
- Primary dysfunction (ReTx or death > 7 days)	*5*		***5***	*3%*
Graft related	**9**	**1**	**10**	**6%**
- Post necrotic cirrhosis	*5*	*1*	***6***	*3%*
- Immune/nonviral hepatitis	*2*		***2***	*1%*
- Nodular regenerative hyperplasia	*2*		***2***	*1%*
Recurrent disease	**6**	**1**	**7**	**4%**
- Autoimmune hepatitis	*2*	*1*	***3***	*2%*
- Primary biliary cirrhosis	*2*		***2***	*1%*
- Crigler-Najjar	*1*		***1***	*1%*
- Primary sclerosing cholangitis	*1*		***1***	*1%*
Graft Infarction	**6**		**6**	**3%**
- Thrombotic	*4*		***4***	*2%*
- Non thrombotic	*2*		***2***	*1%*
De novo disease	**1**		**1**	**1%**
- Hepatitis C	*1*		***1***	*1%*
Other	**3**	**1**	**4**	**2%**
- Cryptogenic cirrhosis	*2*	*1*	***3***	*2%*
- Donor derived malignancy		*1*	***1***	*1%*
- Unspecified	*1*		***1***	*1%*
Total	**147**	**27**	**174**	

Thirty-five percent of graft failures occurred within the first six months' post-transplant (12.6% 0 – 7 days, 13.8% day 8 to 1 month, 8.6% 1 month to 6 months). Vascular causes were the main reason for retransplantation in the first month post-transplant (Figure 63). Rejection, biliary and vascular causes were the leading causes of graft failure after one-year post-transplant.

Figure 63. Paediatric time to graft failure by reason for retransplantation



13.3 Adult Retransplantation

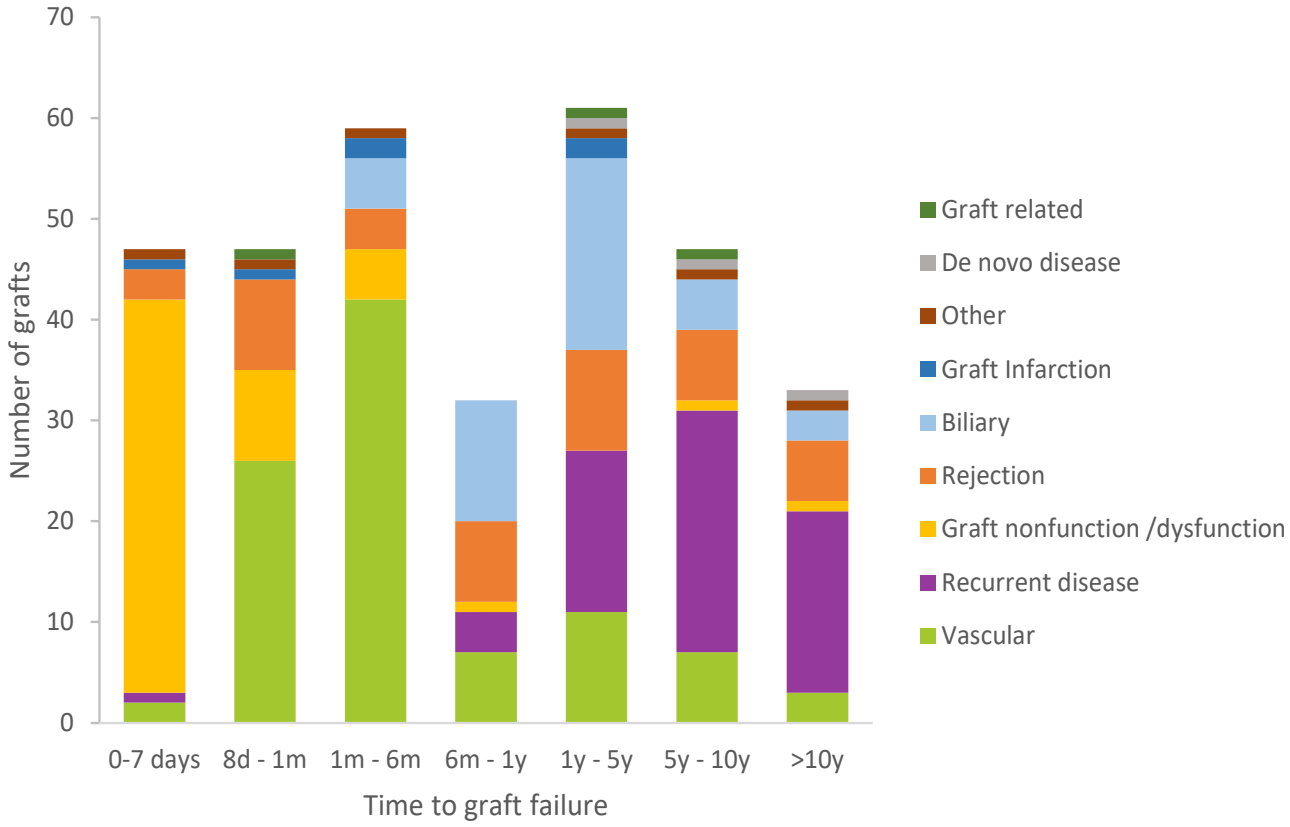
There were 326 retransplants following adult graft failure. There have been 298 second grafts, 26 third grafts and two fourth grafts. The commonest indications for retransplantation were vascular (30%), disease recurrence (19%) and primary non-function or initial poor function (17%, Table 50).

Table 50. Reason for retransplantation following adult graft failure

Reason for retransplantation	Graft 2	Graft 3	Graft 4	All grafts	% total
Vascular	**90**	**8**		**98**	**30%**
- Hepatic artery thrombosis	*73*	*6*		*79*	*24%*
- Haemorrhage (hepatic artery)	*4*			*4*	*1%*
- Hepatic vein thrombosis	*3*			*3*	*1%*
- Portal vein thrombosis	*3*			*3*	*1%*
- Hepatic artery pseudoaneurysm	*2*			*2*	*1%*
- Hepatic artery stenosis	*2*			*2*	*1%*
- Unspecified	*2*			*2*	*1%*
- Hepatic artery injury	*1*			*1*	*0.3%*
- Hepatic vein stenosis		*1*		*1*	*0.3%*
- Ruptured hepatic artery anastomosis		*1*		*1*	*0.3%*
Recurrent disease	**57**	**6**		**63**	**19%**
- Primary sclerosing cholangitis	*22*	*5*		*27*	*8%*
- Hepatitis C	*22*			*22*	*7%*
- Primary biliary cirrhosis	*4*	*1*		*5*	*2%*
- Autoimmune hepatitis	*4*			*4*	*1%*
- Hepatitis B	*4*			*4*	*1%*
- Erythropoietic protoporphyria	*1*			*1*	*0.3%*
Primary graft nonfunction /dysfunction	**50**	**6**		**56**	**17%**
- Primary nonfunction (ReTx or death <= 7 days)	*39*	*4*		*43*	*13%*
- Primary dysfunction (ReTx or death > 7 days)	*11*	*2*		*13*	*4%*
Rejection	**44**	**2**	**1**	**47**	**14%**
- Chronic rejection	*22*	*2*		*24*	*7%*
- Acute rejection	*15*		*1*	*16*	*5%*
- ABO incompatible	*4*			*4*	*1%*
- Hyperacute rejection	*2*			*2*	*1%*
- Donor antibody mediated	*1*			*1*	*0.3%*
Biliary	**43**	**1**		**44**	**13%**
- Unspecified	*18*	*1*		*19*	*6%*
- Biliary strictures type unspecified	*8*			*8*	*2%*
- Cholangiopathy	*6*			*6*	*2%*
- Non anastomotic	*6*			*6*	*2%*
- Anastomotic	*2*			*2*	*1%*
- Biliary cirrhosis / fibrosis	*2*			*2*	*1%*
- Cholestatic disease	*1*			*1*	*0.3%*
Graft Infarction	**5**		**1**	**6**	**2%**
- Non thrombotic	*3*		*1*	*4*	*1%*
- Thrombotic	*2*			*2*	*1%*
De novo disease	**3**			**3**	**1%**
- Hepatitis B	*1*			*1*	*0.3%*
- Hepatitis C	*1*			*1*	*0.3%*
- Hepatitis D	*1*			*1*	*0.3%*
Graft related	**1**	**2**		**3**	**1%**
- Post necrotic cirrhosis		*2*		*2*	*1%*
- Nodular regenerative hyperplasia	*1*			*1*	*0.3%*
Other	**5**	**1**		**6**	**2%**
- Unspecified	*2*	*1*		*3*	*1%*
- Donor derived malignancy	*2*			*2*	*1%*
- Acute hepatic failure - Drug related: interferon	*1*			*1*	*0.3%*
Total	**298**	**26**	**2**	**326**	

Forty-seven percent of graft failures occurred within the first six months' post-transplant (14.4% 0 – 7 days, 14.4% day 8 to 1 month, 18.1% 1 month to 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 6 months (Figure 64). Recurrent disease was the leading cause of graft failure after five years post-transplant.

Figure 64. Adult time to graft failure by reason for retransplantation



14 Cause of Patient Death

14.1 Cause of Death – All Patients

1,740 liver transplant patients (176 children and 1,564 adults based on age at first transplant) have died. The commonest causes of death were malignancy (24%), graft-related causes (19%), sepsis (14%), cardiovascular disease (8%) and multi-organ failure (8%, Figure 65, Table 51).

Figure 65. Cause of death by categories

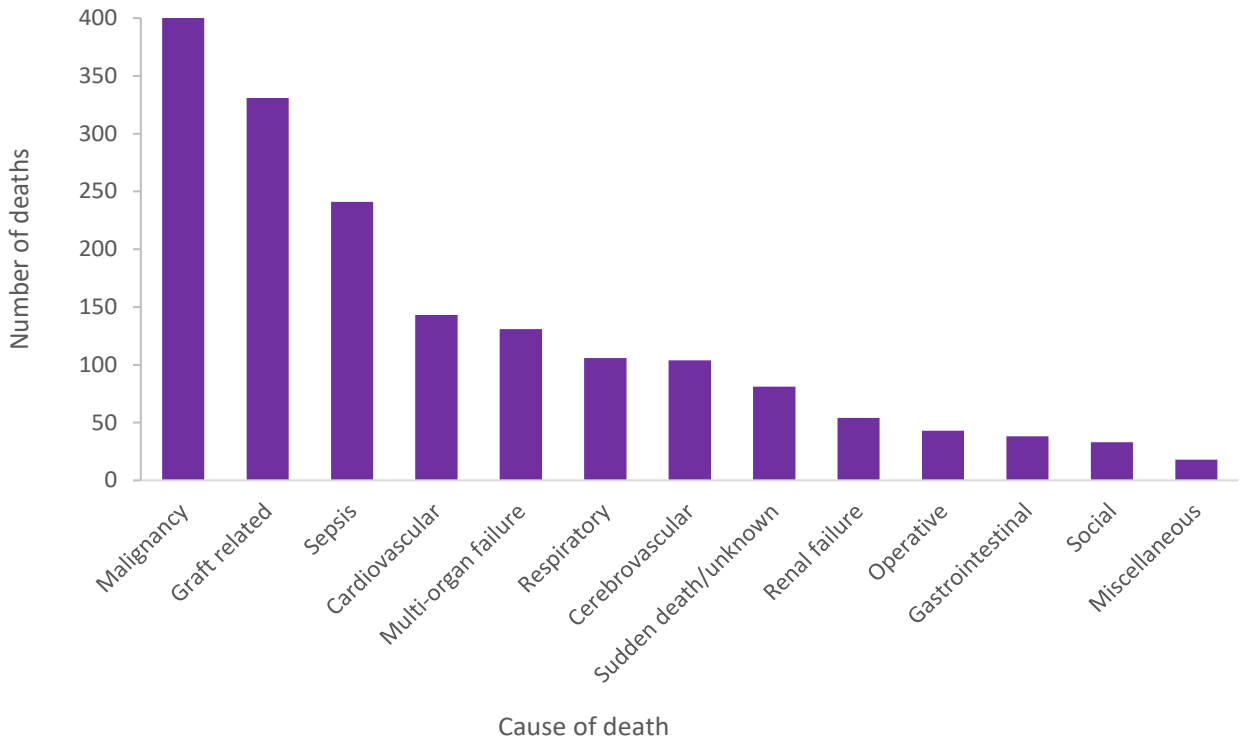


Table 51. Cause of death by age group

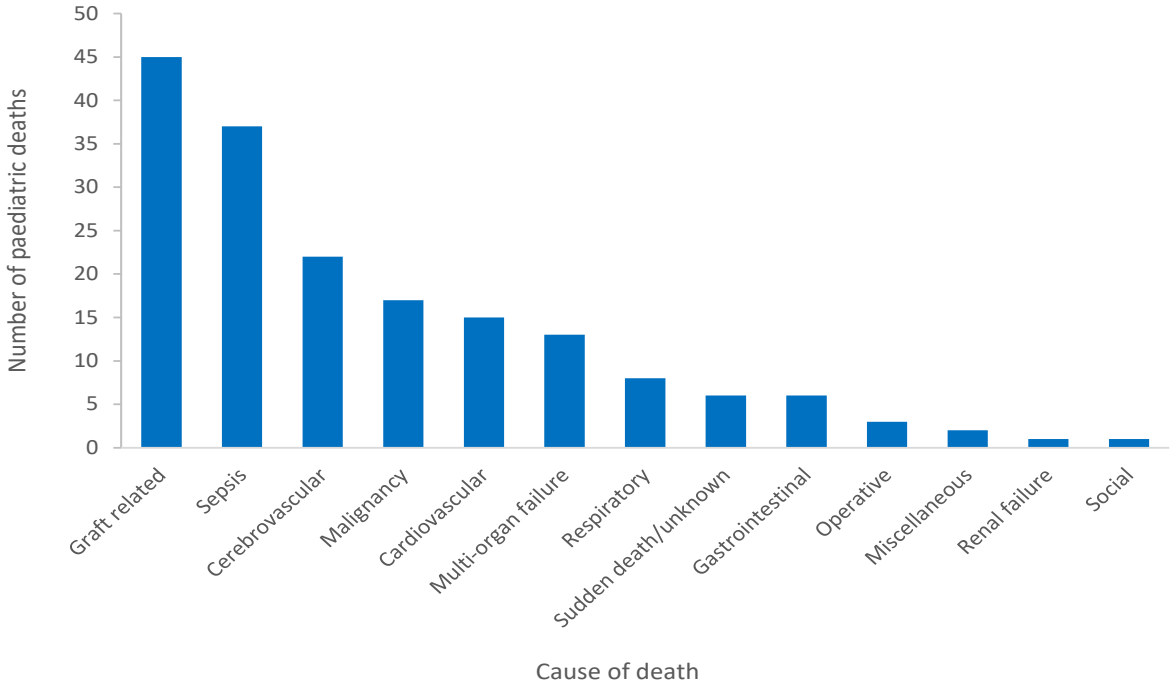
Cause of death	Paediatric	Adult	Total deaths	% of all deaths
Malignancy	**17**	**400**	**417**	**24%**
- De novo malignancy	10	211	221	13%
- Recurrent malignancy	7	187	194	11%
- Donor transmitted malignancy	0	2	2	0.1%
Graft related	**45**	**286**	**331**	**19%**
Other graft related	32	103	135	8%
- Rejection	*15*	*71*	*86*	*5%*
- Primary non-function / dysfunction	*4*	*20*	*24*	*1%*
- Biliary complications	*3*	*15*	*18*	*1%*
- Graft vs host disease	*0*	*7*	*7*	*0.4%*
- Non-thrombotic infarction	*3*	*1*	*4*	*0.2%*
- Hepatitis	*4*	*0*	*4*	*0.2%*
- Massive haemorrhagic necrosis	*4*	*0*	*4*	*0.2%*
- Unspecified	*2*	*2*	*4*	*0.2%*
- Late graft failure	*0*	*3*	*3*	*0.2%*
- De novo hepatitis C	*0*	*2*	*2*	*0.1%*
- Hepato-renal syndrome	*0*	*1*	*1*	*0.1%*
- Outflow obstruction	*1*	*0*	*1*	*0.1%*
- Post necrotic cirrhosis	*1*	*0*	*1*	*0.1%*
Disease recurrence	2	163	165	9%
- Hepatitis C	*0*	*95*	*95*	*5%*
- Hepatitis B	*0*	*18*	*18*	*1%*
- Alcoholic cirrhosis	*0*	*12*	*12*	1%
- Primary sclerosing cholangitis	*0*	*8*	*8*	*0.5%*
- Autoimmune hepatitis	*0*	*4*	*4*	*0.2%*
- NASH	*0*	*2*	*2*	*0.1%*
- Primary biliary cirrhosis	*0*	*2*	*2*	*0.1%*
- Progressive familial amyloid polyneuropathy	*0*	*2*	*2*	*0.1%*
- Erythropoietic protoporphyria	*0*	*1*	*1*	*0.1%*
- Type not specified	*0*	*1*	*1*	*0.1%*
Vascular complications	11	20	31	2%
- Hepatic artery thrombosis	*4*	*9*	*13*	*1%*
- Portal vein thrombosis	*2*	*10*	*12*	*1%*
- Hepatic vein thrombosis	*2*	*0*	*2*	*0.1%*
Sepsis	**37**	**204**	**241**	**14%**
- Bacterial	14	78	92	5%
- Fungal	6	41	47	3%
- Mixed	5	25	30	2%
- Viral	6	16	22	1%
- Unspecified infection	6	44	50	3%
Cardiovascular	**15**	**128**	**143**	**8%**
Multi-organ failure	**13**	**118**	**131**	**8%**
Respiratory	**8**	**98**	**106**	**6%**
Cerebrovascular	**22**	**82**	**104**	**6%**
Sudden death / unknown	**6**	**75**	**81**	**5%**
Renal failure	**1**	**53**	**54**	**3%**
Operative	**3**	**40**	**43**	**2%**
Gastrointestinal	**6**	**32**	**38**	**2%**
Social (accident, suicide, non-compliance, treatment withdrawal)	**1**	**32**	**33**	**2%**
Miscellaneous	**2**	**16**	**18**	**1%**
- Neurological	0	6	6	0.3%
- Haematological	1	3	4	0.2%
- Metabolic	1	2	3	0.2%
- Allergy	0	1	1	0.1%
- Donor transferred OTC deficiency	0	1	1	0.1%
- Veno-occlusive disease	0	1	1	0.1%
- Dementia	0	2	2	0.1%
Total	**176**	**1564**	**1740**	

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

14.2 Paediatric Patients - Cause of Death

Graft-related causes (26%) are the leading cause of death in children, with sepsis being the cause of death in a further 21% of paediatric patients (Figure 66).

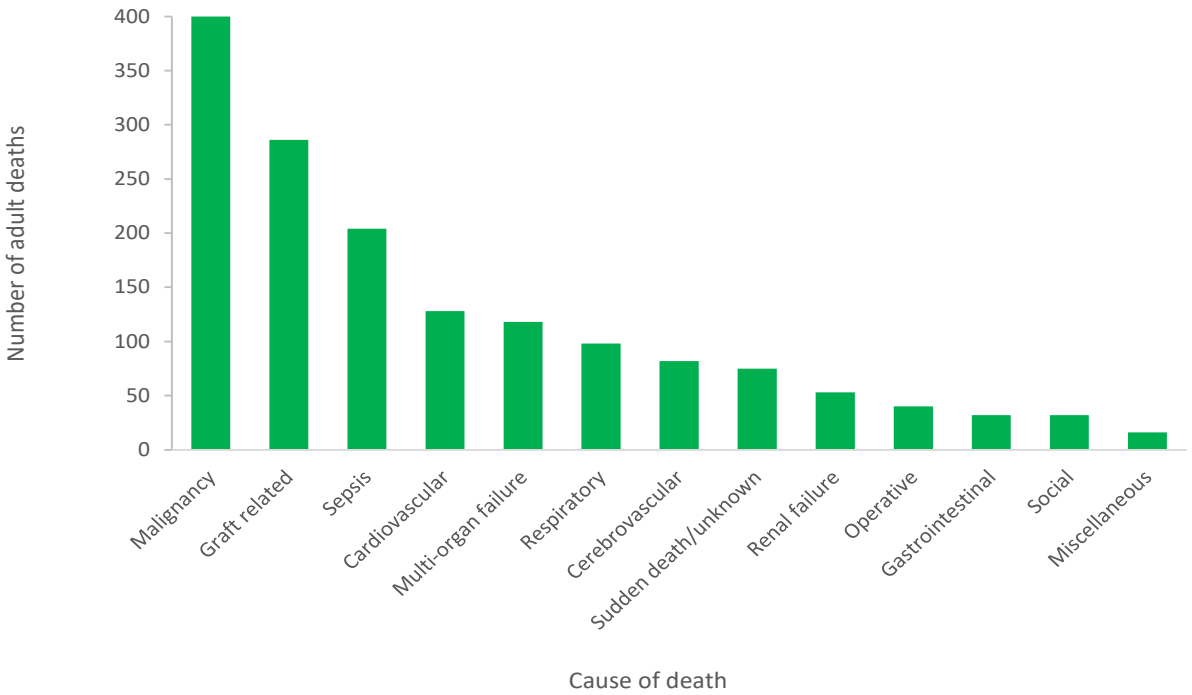
Figure 66. Paediatric cause of death



14.3 Adult Patients – Cause of Death

Malignancy (25.6% total: de novo malignancy 13.5%; recurrent malignancy 12.0%; donor transmitted malignancy 0.1%) is the most frequent cause of death in adult patients. Graft-related causes (18%) and sepsis (13%) are the next largest categories of adult deaths (Figure 67).

Figure 67. Adult cause of death

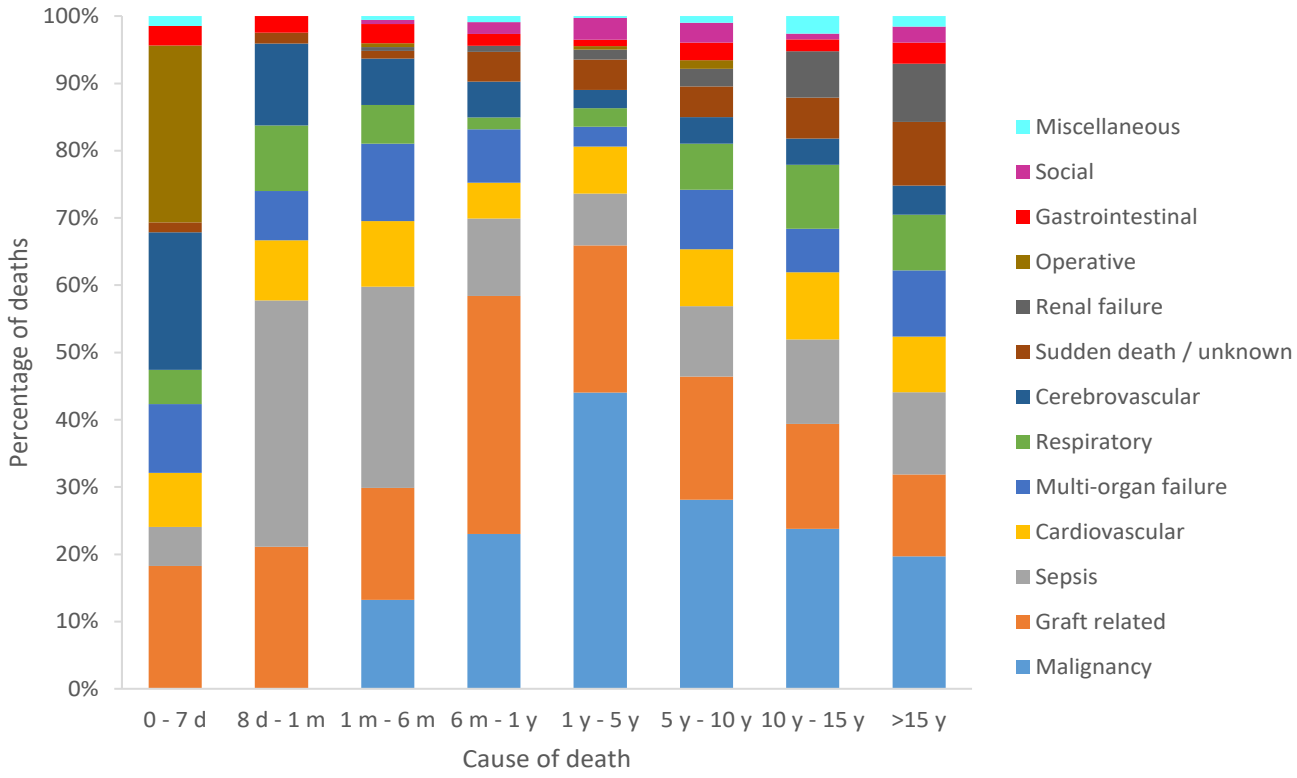


14.4 Cause of Death by Time to Death

Just under a third of all deaths occurred within the first year of transplant. In the first 7 days post-transplant, 8% deaths occurred, a further 7% from day 8 to the end of the first month and 16% after the first month and before the end of the first year. Twenty-three percent of deaths occurred between years 1 and 5, 18% between years 5 and 10 and 28% after 10 years.

The cause of death profile changes over the different post-transplant time periods (Figure 68). 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 68. Cause of death by time to death post-transplant – all patients

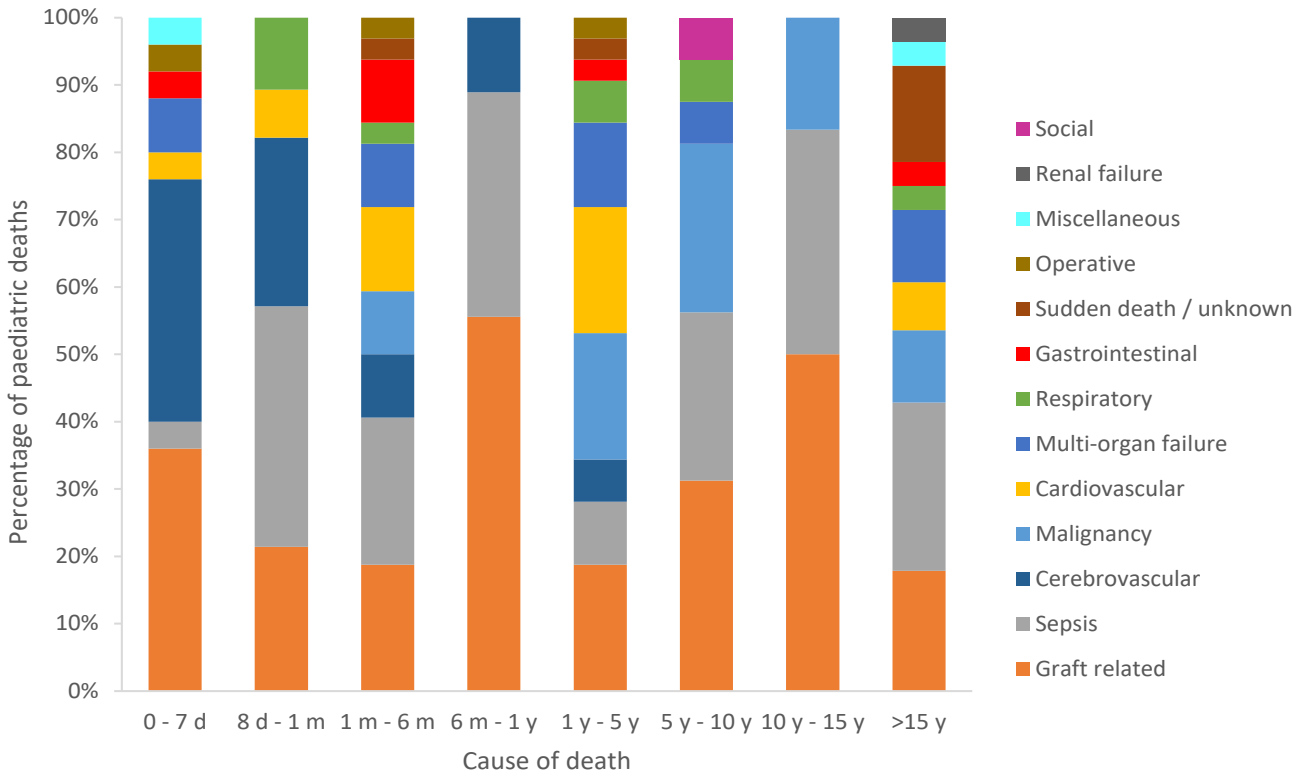


14.5 Paediatric Cause of Death by Time to Death

In children, 53% of deaths occurred within the first year of transplant. In the first 7 days post-transplant, 14% deaths occurred, a further 16% from day 8 to the end of the first month, 23% after the first month and before the end of the first year, 18% between years 1 and 5, 9% between years 5 and 10 and 19% after 10 years.

Cerebrovascular and graft-related causes of death predominated in the first week post-transplant (Figure 69). 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 69. Paediatric cause of death by time to death post-transplant

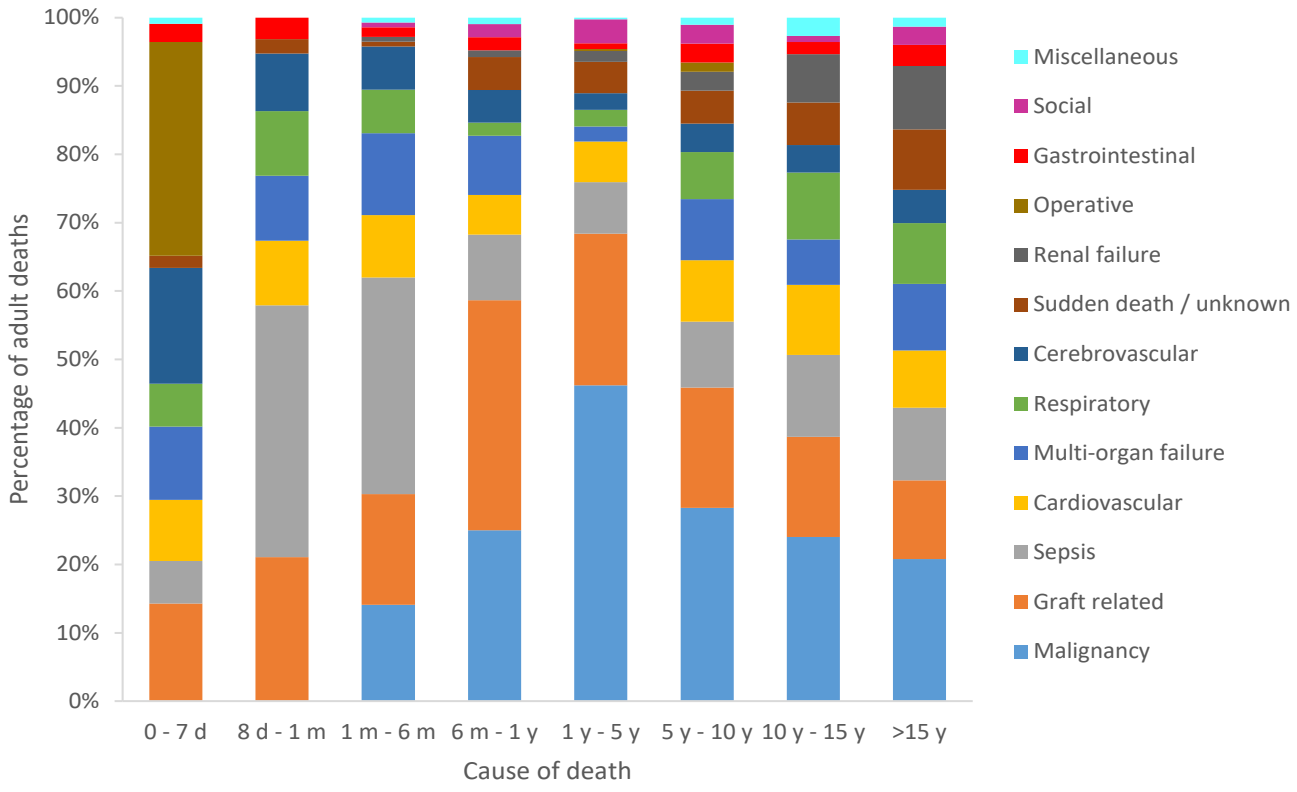


14.6 Adult Cause of Death by Time to Death

In adults, 29% of deaths occurred within the first year of transplant. In the first 7 days post-transplant, 7% deaths occurred, a further 6% from day 8 to the end of the first month, 16% after the first month and before the end of the first year, 24% between years 1 and 5, 19% between years 5 and 10 and 28% after 10 years.

Operative, cerebrovascular and graft-related causes and multi-organ failure were prominent in the first week post-transplant (Figure 70). Sepsis was the predominant cause from 8 days to 6 months, graft-related causes from 6 months to 1 year and malignancy and graft related causes from 1 year.

Figure 70. 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, 1,526 (25%) patients were transplanted with a liver malignancy, 616 (10%) as a primary diagnosis and 913 (15%) as a secondary diagnosis or incidental tumour (Table 52). Three patients had liver cancer types as their primary and secondary diagnosis.

Table 52. Cancer in liver transplant recipients

	Number patients	% of all transplant patients (n = 6,126)	
At Transplant			
Liver cancer as indication for transplant	616	10%	616 cancers
Liver cancer as a secondary/incidental diagnosis	913	15%	918 cancers (5 patients had 2 cancer types)
Total unique patients*	**1,526**	**25%**	
Post-transplant			
Recurrent liver cancer	175	3%	11% patients with cancer at transplant
De novo non-skin cancer	496	8%	8537 cancers
Skin cancer	952	16%	
Total	**1,623**	**26%**	
Multiple non-skin cancers	**137**	**2%**	
Developed non-skin cancer < 90 days	**10**	**0.2%**	

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

Post-transplant 175 (12%) patients with a primary diagnosis of liver cancer, secondary diagnosis of liver cancer or incidental liver cancer developed a recurrent cancer and in 154 of these (10% of liver cancer patients and 88% of patients with recurrent liver cancer), death was related to their initial cancer. Post-transplant 496 (8%) of all patients developed a non-skin (de novo) cancer and 227 (42%) died of their cancer. A total of 137 (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

Hepatocellular cancer was the most common type of liver cancer as a primary diagnosis (89.1%, Table 53). Whilst 22% of patients with hepatocellular carcinoma as a primary diagnosis have died, only 12% died as a result of this cancer.

Table 53. Type of liver cancers as a primary diagnosis

Type of cancer as a primary diagnosis	Number cancers	% of liver cancer patients	Deaths	% deaths for this cancer type	Died of this cancer	% patients died of this cancer
Hepatocellular cancer	549	89.1%	120	22%	64	12%
Hepatoblastoma	33	5.4%	5	15%	4	12%
Cholangiocarcinoma	11	1.8%	3	27%	2	18%
Fibrolamellar	6	1.0%	5	83%	2	33%
Epithelioid haemangioendothelioma	7	1.1%	0	0%	0	0%
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%
Erythroid leukaemia	1	0.2%	1	100%	1	100%
Gastrinoma	1	0.2%	1	100%	1	100%
Pancreatic islet cell	1	0.2%	1	100%	1	100%
Total primary liver cancers	**616**		**142**		**81**	
Percentage all liver transplant patients (n = 6,126)	10%		2%		1%	
Percentage primary liver cancer patients (n = 616)			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 67% (Figure 71, Table 54).

Figure 71. Patient survival curve for patients with a primary diagnosis of liver cancer

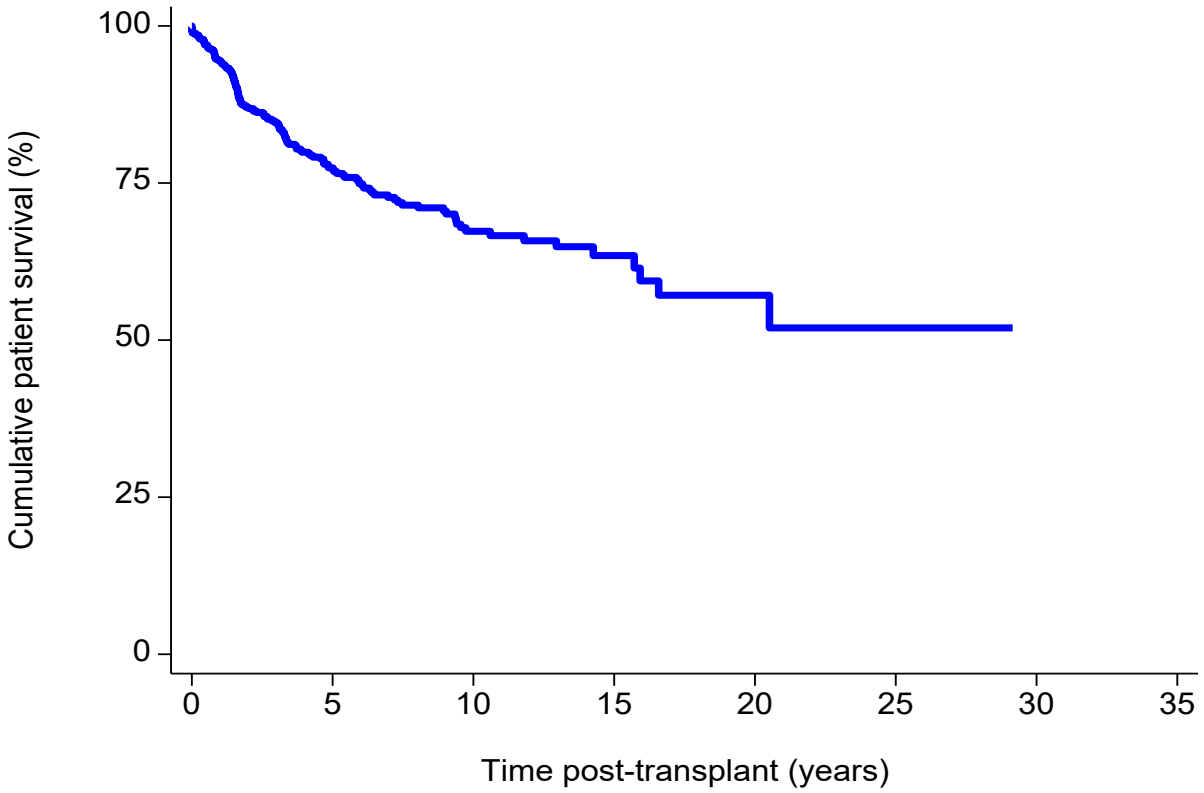
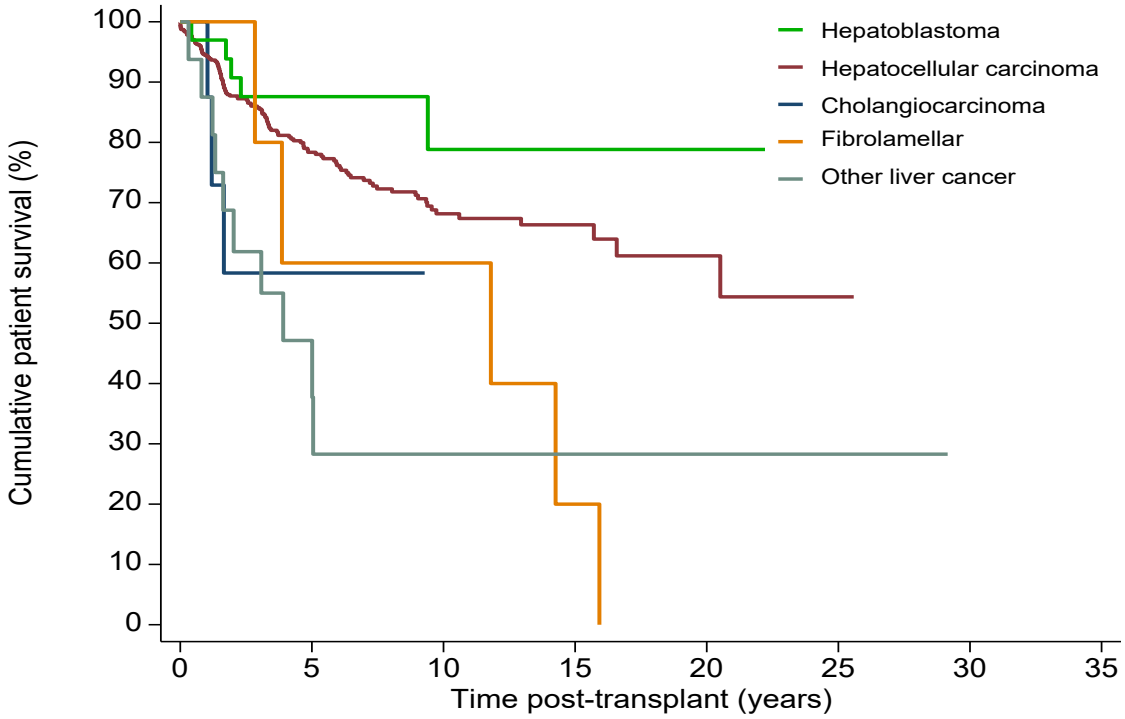


Table 54. Patient survival for patients with a primary diagnosis of liver cancer

Patient Survival	Time post-transplant (years)						
	0	1	5	10	15	20	25
No. at risk	616	529	262	115	41	13	4
Survival (%)		95%	77%	67%	63%	57%	52%

Of patients with a primary diagnosis of liver cancer, there was a significant difference in patient survival between different liver cancers (P<0.0001). Ten-year patient survival for those with hepatoblastoma, hepatocellular carcinoma, fibrolamellar variant, cholangiocarcinoma and other liver cancers was 79%, 68%, 67%, 58% and 28% respectively (Figure 72, Table 55).

Figure 72. 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

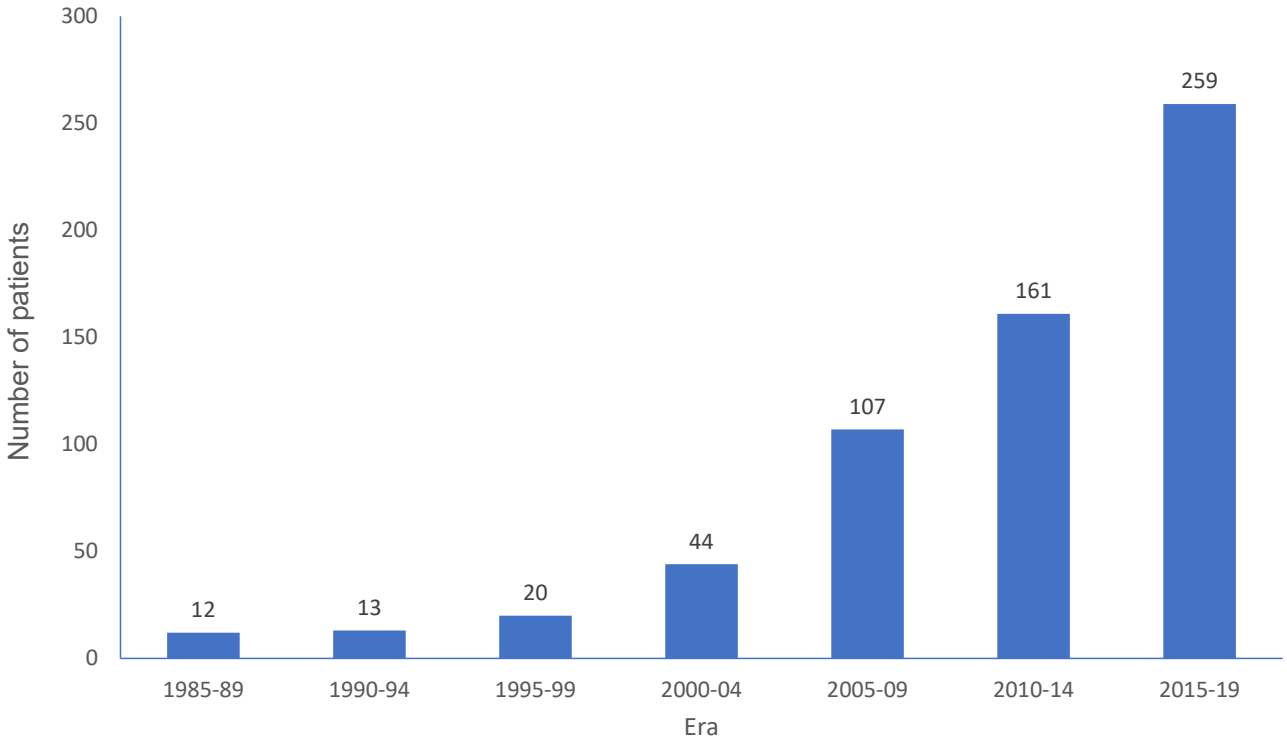
Table 55. Patient survival for patients with a primary diagnosis of liver cancer by type of cancer

Cancer type	Patient Survival	Time post-transplant (years)							
		0	1	5	10	15	20	25	30
Hepatoblastoma	No. at risk	33	32	19	8	3	3	2	0
	Survival (%)		97%	88%	79%	79%	79%	79%	
HCC	No. at risk	551	470	234	103	37	10	2	0
	Survival (%)		94%	78%	68%	66%	61%	54%	
Cholangiocarcinoma	No. at risk	11	9	2	1	0			
	Survival (%)		100%	100%	58%				
Fibrolamellar	No. at risk	5	5	4	2	1	0		
	Survival (%)		100%	67%	67%	22%			
Other liver cancer	No. at risk	17	15	6	3	2	2	2	0
	Survival (%)		88%	47%	28%	28%	28%	28%	

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

There has been a substantial increase in numbers of transplant procedures for patients with liver cancer (Figure 73).

Figure 73. Incidence of patients with liver cancer as a primary diagnosis by era



15.3 Liver Cancer as a Secondary / Incidental Diagnosis

913 patients with 918 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 (93.4%, Table 56). Whilst 26% of patients with hepatocellular carcinoma as a secondary / incidental diagnosis have died, only 8% died as a result of this cancer.

Table 56. 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	% patient died of this cancer
Hepatocellular cancer*	857	93.4%	223	26%	69	8%
Cholangiocarcinoma*	47	5.1%	34	72%	22	47%
Adenocarcinoma	4	0.4%	3	75%	0	0%
Fibrolamellar	4	0.4%	0	0%	0	0%
Hepatoblastoma*	3	0.3%	2	67%	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	**918**		**264**		**93**	
Percentage all liver transplant patients (n = 6,126)		15%		4%		2%
Percentage liver cancer patients as a secondary / incidental diagnosis (n = 913)				29%		10%

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

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

Ten-year patient survival for patients with a secondary diagnosis of liver cancer was 69% (Figure 74, Table 57). The median survival was 16 years.

Figure 74. Patient survival curve for patients with a secondary / incidental diagnosis of liver cancer

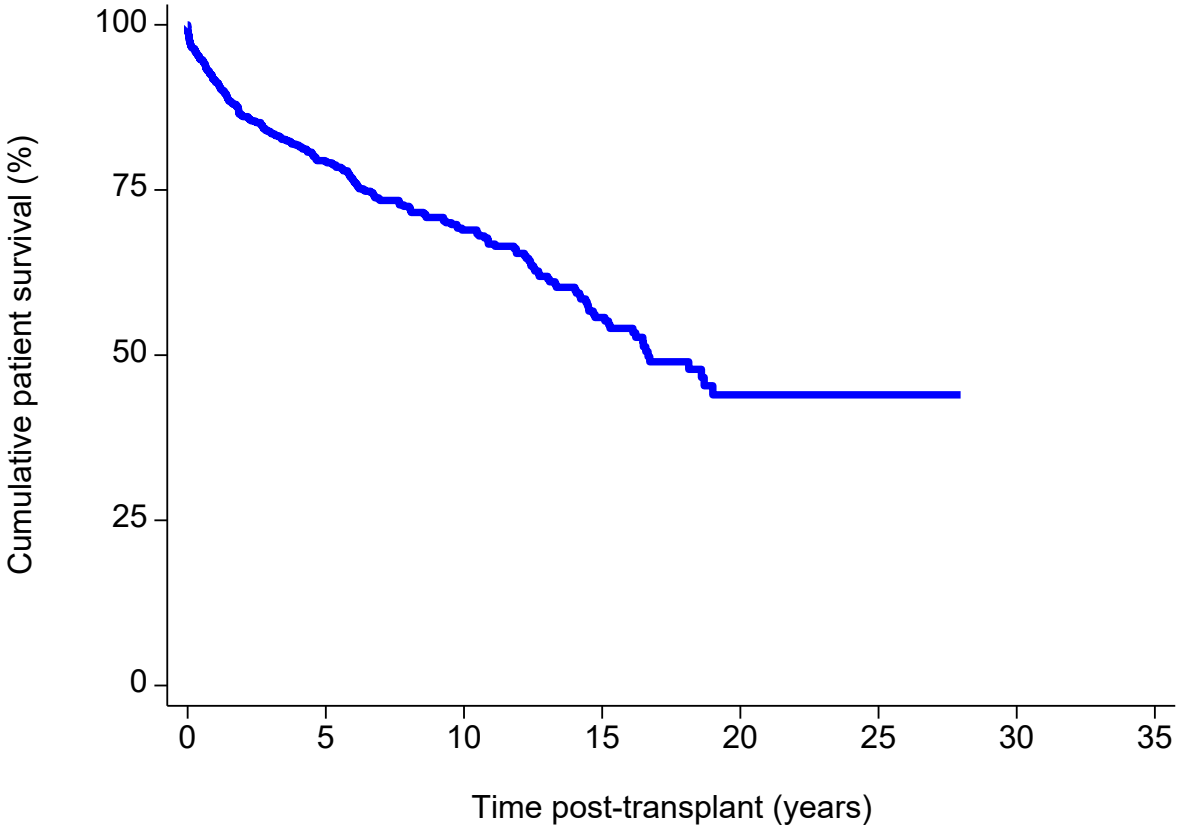
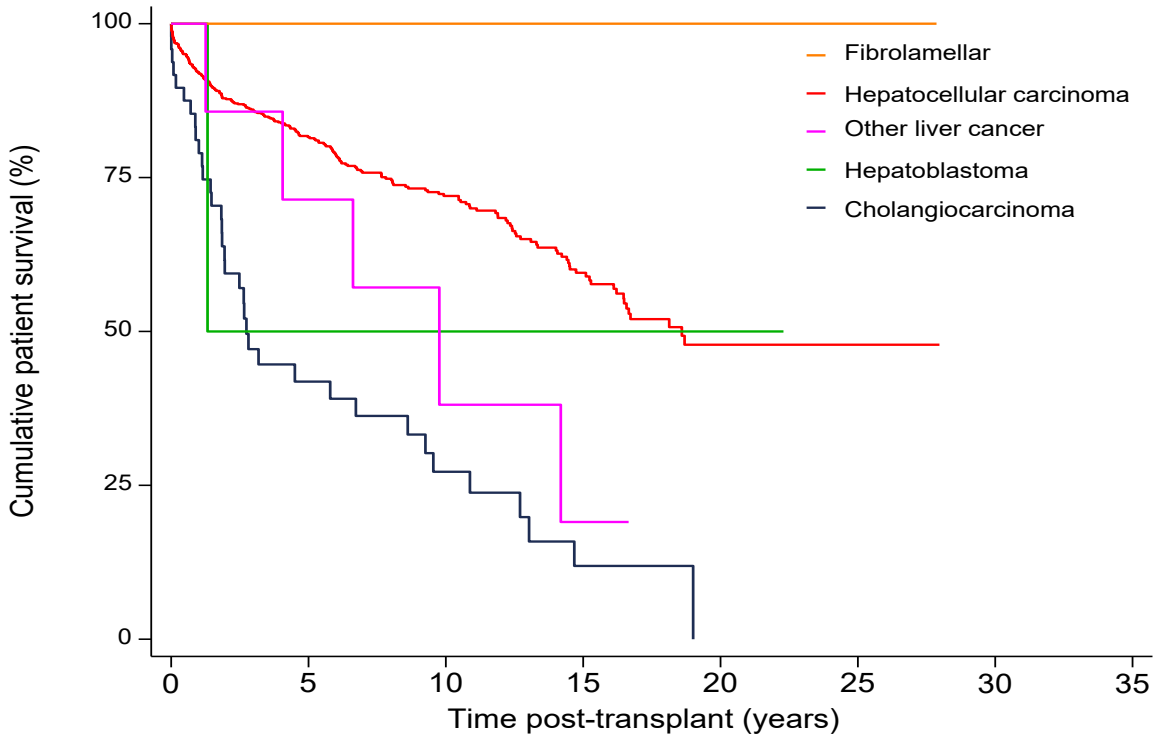


Table 57. Patient survival for patients with a secondary / incidental diagnosis of liver cancer

Patient Survival	Time post-transplant (years)						
	0	1	5	10	15	20	25
No. at risk	913	791	478	243	107	25	5
Survival (%)		92%	79%	69%	56%	44%	44%

There was a significant difference in survival between patients with different liver cancers as a secondary / incidental diagnosis (P<0.0001, Figure 75, Table 58). Ten-year patient survival for those with fibrolamellar variant, hepatocellular carcinoma, other liver cancers, hepatoblastoma and cholangiocarcinoma was 100%, 72%, 38%, 33% and 28% respectively.

Figure 75. 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 58. 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
Fibrolamellar	No at risk	4	4	2	2	2	2	2
	Survival %		100%	100%	100%	100%	100%	100%
Hepatocellular carcinoma	No at risk	860	740	452	228	101	23	4
	Survival %		92%	81%	72%	60%	48%	48%
Other liver cancer	No at risk	7	6	3	2	1	0	
	Survival %		100%	71%	38%	19%		
Hepatoblastoma	No at risk	2	3	2	2	2	1	0
	Survival %		100%	67%	33%	33%	33%	
Cholangiocarcinoma	No at risk	48	38	16	10	4	0	
	Survival %		81%	43%	28%	12%		

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

Of 6,126 transplanted patients, 1,526 (25%) patients had 1,534 liver cancers as a primary or secondary/incidental diagnosis (Table 59). Three patients had two liver cancer types as their primary and secondary diagnoses . Five patients had two liver cancers as secondary/incidental diagnoses.

Table 59. Types of liver cancer (primary or secondary / incidental diagnosis)

Type of liver cancer as a diagnosis	Number cancers	% of liver cancer patients	Deaths	% deaths for this cancer type	Died of this cancer	% patients died of this cancer
Hepatocellular cancer*	1406	91.7%	343	24%	133	9%
Cholangiocarcinoma*	58	3.8%	37	64%	24	41%
Hepatoblastoma*	36	2.3%	7	19%	4	11%
Fibrolamellar	10	0.7%	5	50%	2	20%
Epithelioid haemangioendothelioma	9	0.6%	1	11%	1	11%
Adenocarcinoma	4	0.3%	3	75%	0	0%
Carcinoid	4	0.3%	4	100%	4	100%
Angiosarcoma	2	0.1%	2	100%	2	100%
Hepatocellular malignant neoplasm (nos)	2	0.1%	1	50%	1	50%
Erythroid leukaemia	1	0.1%	1	100%	1	100%
Gastrinoma	1	0.1%	1	100%	1	100%
Pancreatic islet cell	1	0.1%	1		1	
Total liver cancers*	**1534**		**406**		**174**	
Percentage all liver transplant patients (n = 6,126)		25%		7%		3%
Percentage all liver cancer patients (n = 1,526)				27%		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, 4,595 had benign liver disease and 1,531 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 78% and 27 years, compared to 69% and 19 years for those with liver malignancy (Figure 76, Table 60).

Figure 76. Patient survival – pretransplant benign disease versus pretransplant liver malignancy

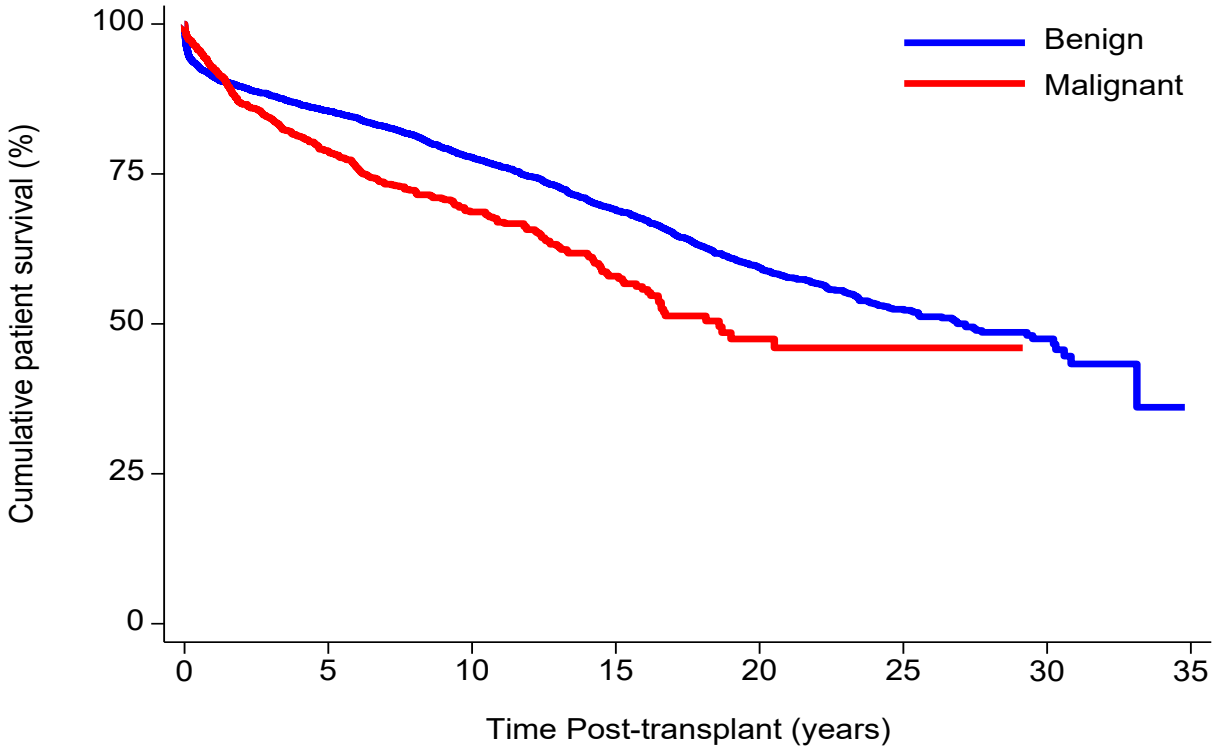


Table 60. Patient survival – pretransplant benign disease versus pretransplant liver malignancy

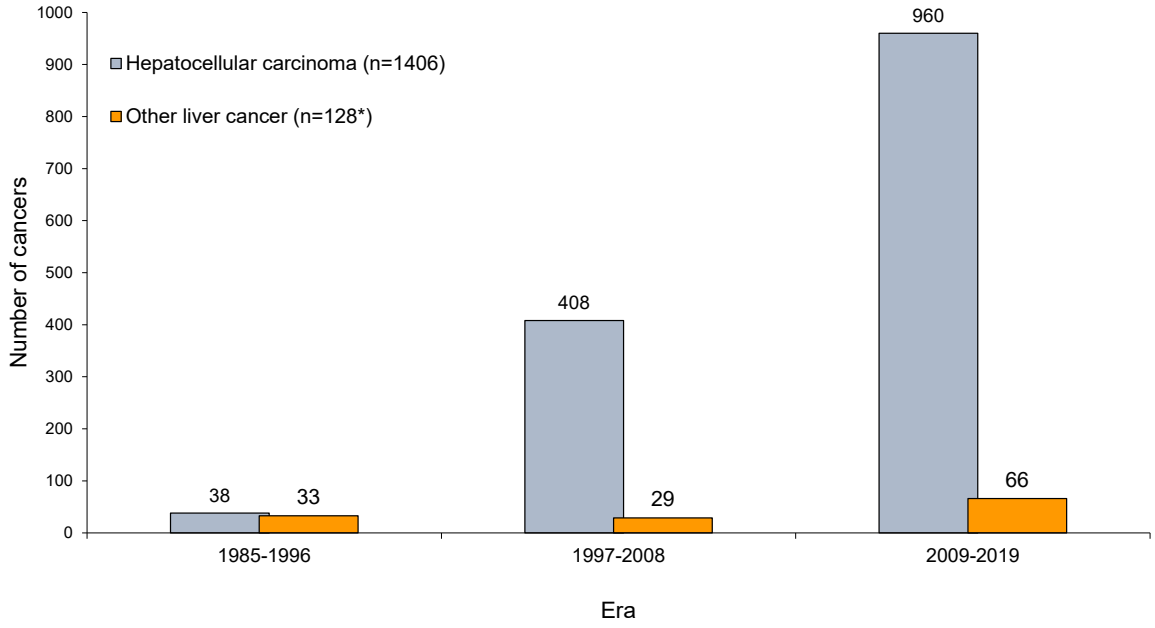
Cancer type	Patient Survival	Time post-transplant (years)							
		0	1	5	10	15	20	25	30
Benign	No at risk	4595	3935	2945	2008	1278	697	318	68
	Survival %		91%	85%	78%	69%	59%	52%	48%
Malignant	No at risk	1531	1314	737	355	146	37	8	0
	Survival %		93%	79%	69%	58%	47%	46%	

15.6 Hepatocellular Carcinoma Diagnosis Versus Other Liver Cancers at Transplantation

15.6.1 Hepatocellular Carcinoma Versus Other Liver Cancers at Transplantation by Era

1406 (23%) patients were transplanted with hepatocellular carcinoma as a primary diagnosis, secondary diagnosis or incidental disease. The incidence of hepatocellular carcinoma has increased over the years (Figure 77).

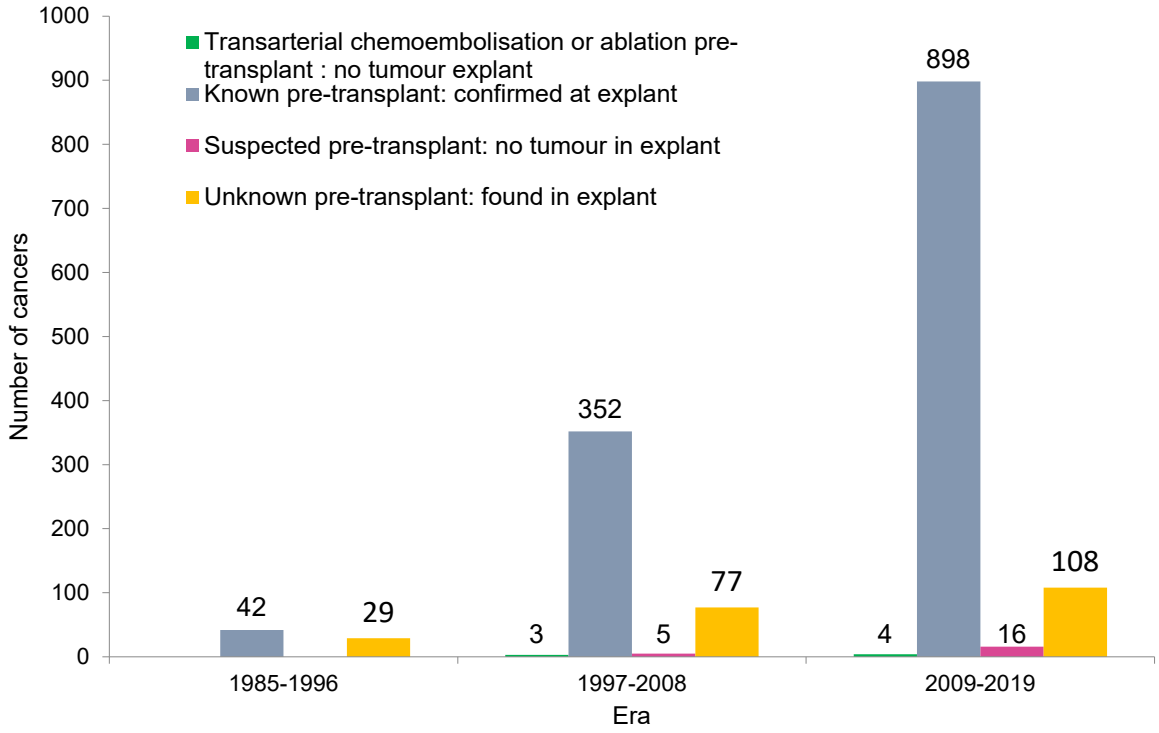
Figure 77. Hepatocellular carcinoma versus other liver cancers at transplantation by era



15.6.2 Hepatocellular Carcinoma Status at Transplant by Era

Most patients had hepatocellular carcinoma (HCC) known prior to transplant. Seven patients had treatment prior to transplant (transarterial chemoembolisation or ablation) resulting in no HCC detected at explant. Twenty-one 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 78).

Figure 78. 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 those transplanted since 2009 is 75%, whilst for those transplanted between 1997 and 2008 it was 67% and for those transplanted between 1985 and 1996 it was 36% (Figure 79, Table 62). Median survival in the 1985-1996 era was 5 years, 19 years in the 1997-2008 era and not reached in the 2009-2019 era.

Figure 79. Patient survival of hepatocellular carcinoma by era

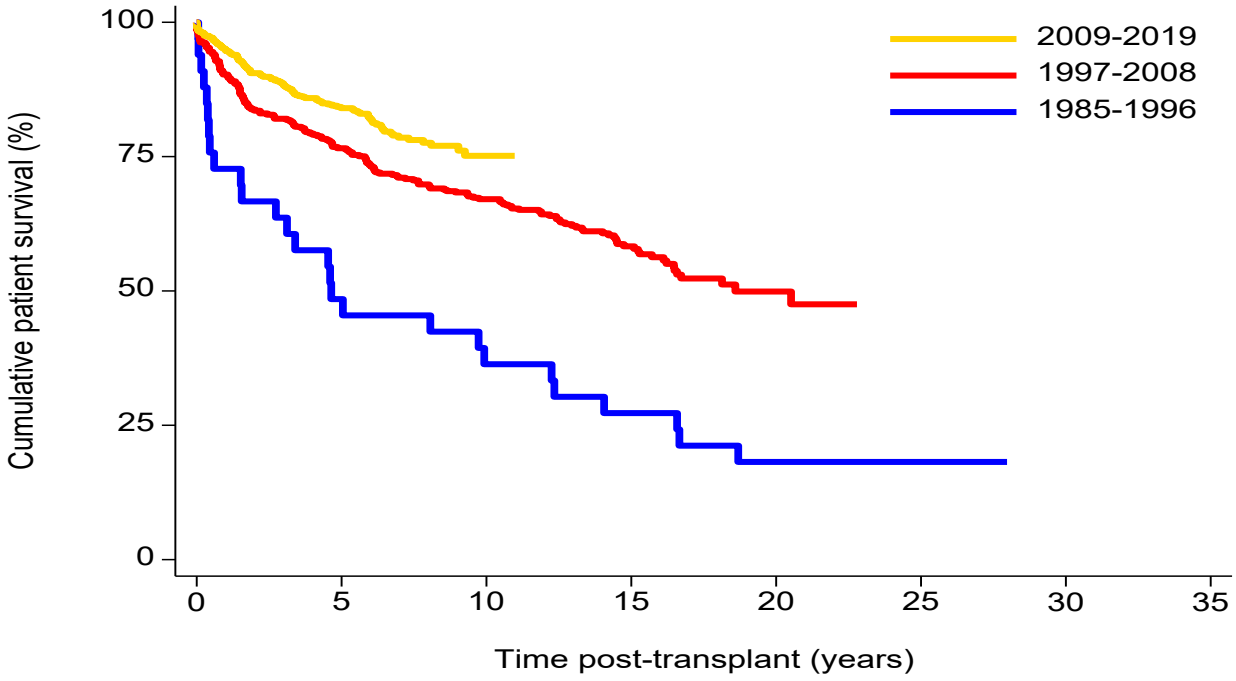


Table 61. Patient survival of hepatocellular carcinoma by era

Cancer type	Patient Survival	Time post-transplant (years)						
		0	1	5	10	15	20	25
2009-2019	No at risk	960	815	361	47	0		
	Survival %		95%	84%	75%			
1997-2008	No at risk	408	363	308	270	127	25	0
	Survival %		90%	77%	67%	58%	50%	
1985-1996	No at risk	38	25	17	13	10	7	4
	Survival %		73%	48%	36%	27%	18%	18%

15.7 De Novo Non-Skin Cancer

15.7.1 De Novo Non-Skin Cancer Types

Four hundred and ninety-six patients (8%) developed 537 de novo non-skin cancers with twenty-eight patients developing more than one non-skin cancer type (Table 62). The three most common types cancers were cancers of the alimentary tract (177, 34%), lymphoma (126, 23%) and genitourinary tract (85, 23%, Table 62, Figure 80). Lower GI cancers account for 60% of alimentary tract cancers and 20% of all de novo non-skin cancers. Sixty-one patients (38%) have died from this cancer.

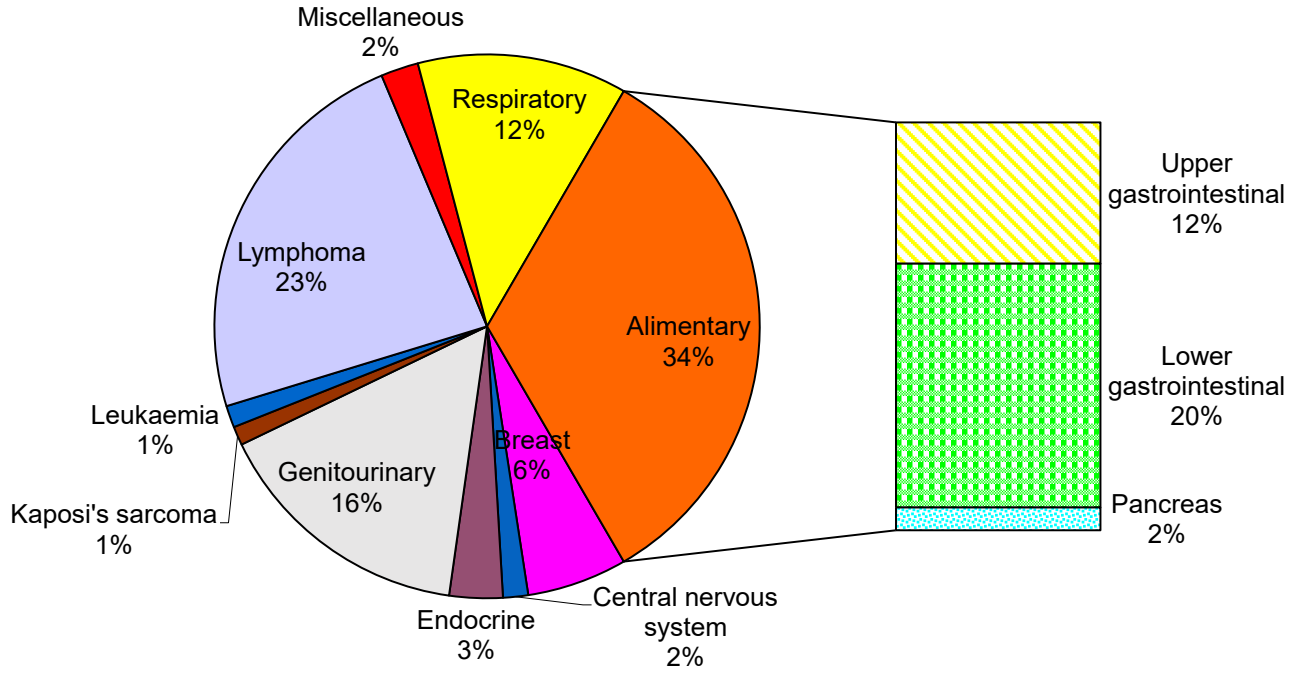
Median time from first transplant to development of a non-skin cancer post-transplant ranged from 23 to 125 months.

Table 62. 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*	177	127	50	5 - 84	61	1 - 330	87	85	48%
Lymphoma*	126	74	52	1 - 79	50	1 - 283	64	52	41%
Genitourinary*	85	55	30	21 - 82	62	2 - 363	104	10	12%
Respiratory*	66	51	15	29 - 80	61	7 - 282	103	48	73%
Breast*	32	1	31	30 - 74	58	11 - 291	100	14	44%
Endocrine	18	9	9	32 - 77	56	6 - 346	64	3	17%
Miscellaneous*	12	7	5	49 - 82	65	41 - 301	125	7	58%
Central nervous system*	8	5	3	16 - 75	65	14 - 212	89	6	75%
Leukaemia*	7	5	2	3 – 66	59	15 - 157	30	2	29%
Kaposi's	6	4	2	31 - 76	56	2 - 254	23	0	0%
Total cancers	***537**	**338**	**199**	**1 - 84**	**59**	**1 - 363**	84		
Total patients	**496**	**316**	**180**					**227**	**46%**

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

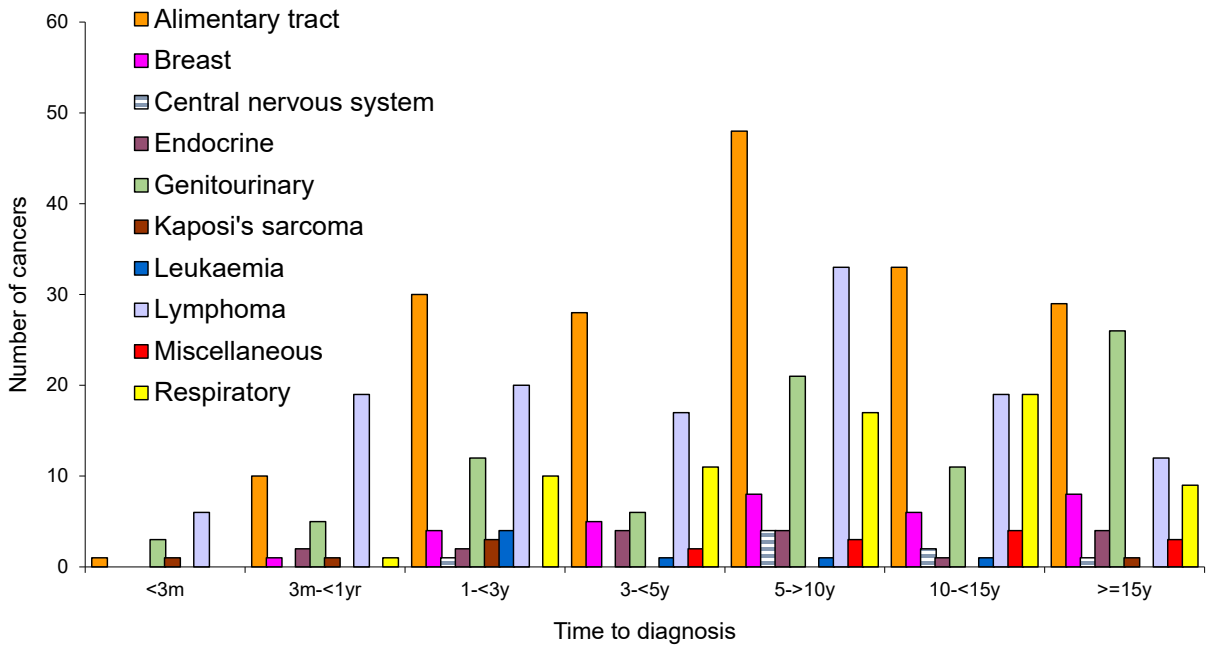
Figure 80. De novo non-skin cancer types



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 (Time to diagnosis of de novo non-skin cancer Figure 81).

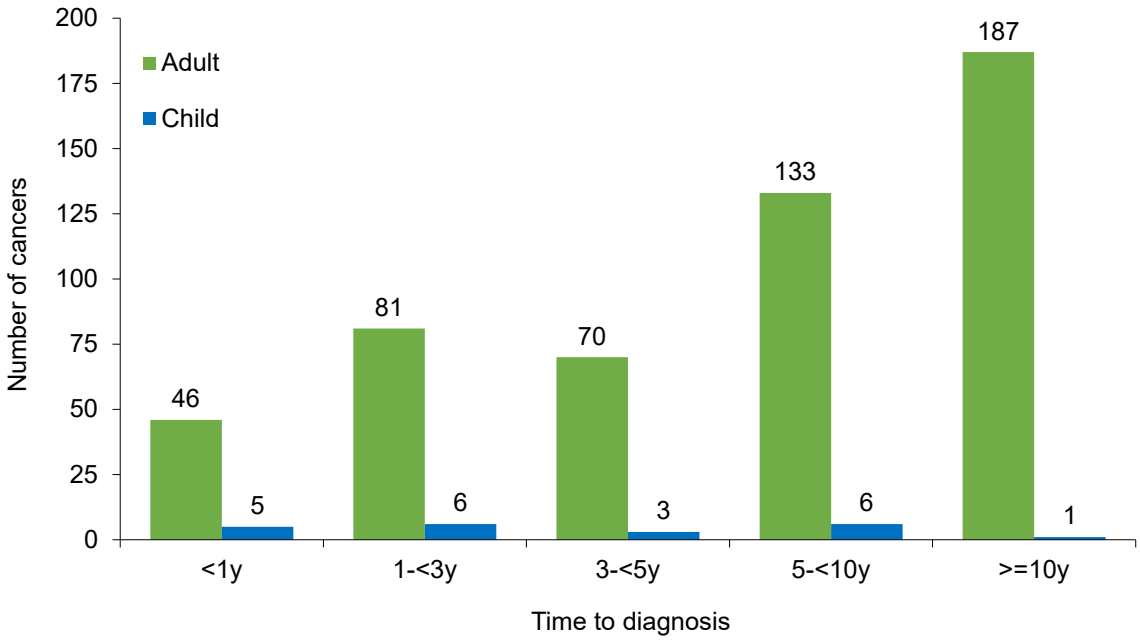
Figure 81. Time to diagnosis of de novo non-skin cancer



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 197 in the first 5 years, 133 from five to ten years post-transplant and 187 cases ten years or more post-transplant (Figure 82).

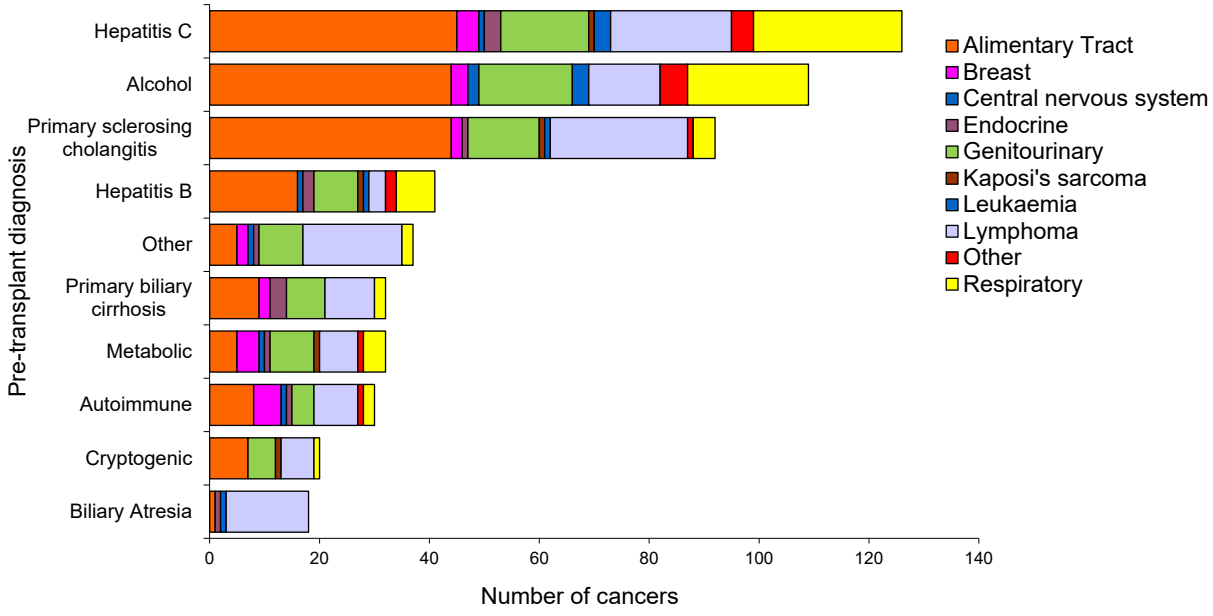
Figure 82. Time to diagnosis of any non-skin cancer by age category



15.7.4 Pretransplant Diagnosis and De Novo Non-Skin Cancer Types

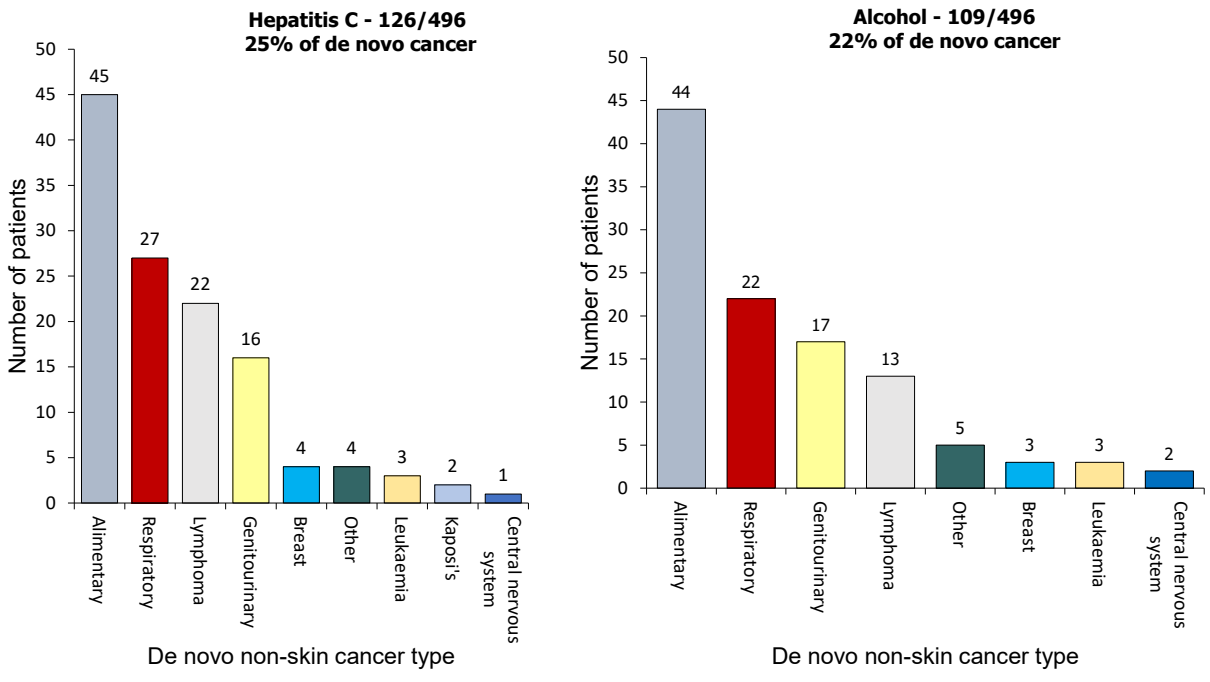
The incidence of de novo non-skin cancers appears to be related to the type of pretransplant underlying disease. Most notable is the incidence of de novo non-skin cancers in patients with underlying hepatitis C virus, alcohol and primary sclerosing cholangitis, being statistically significant (p<0.0001, Figure 83).

Figure 83. 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 84).

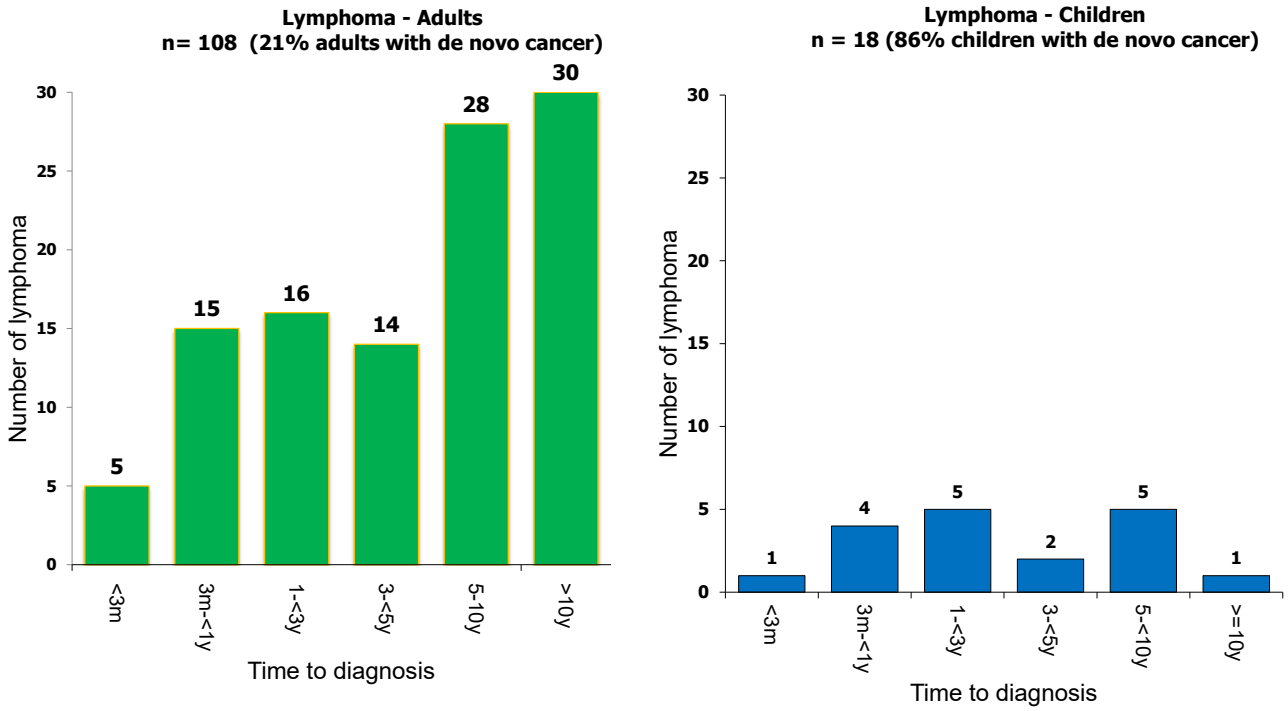
Figure 84. Hepatitis C virus and alcohol diagnosis and types of de novo skin cancer



15.7.5 Time to Diagnosis of De Novo Lymphoma by Age Category

Lymphoma was the third most prevalent non-skin cancer to develop post-transplant affecting 108 adults and 18 children. Time to development ranged from 3 months to >10 years with 54% developing after 5 years in adults and 33% after 5 years in children (Figure 85). Median time to diagnosis was 66 months.

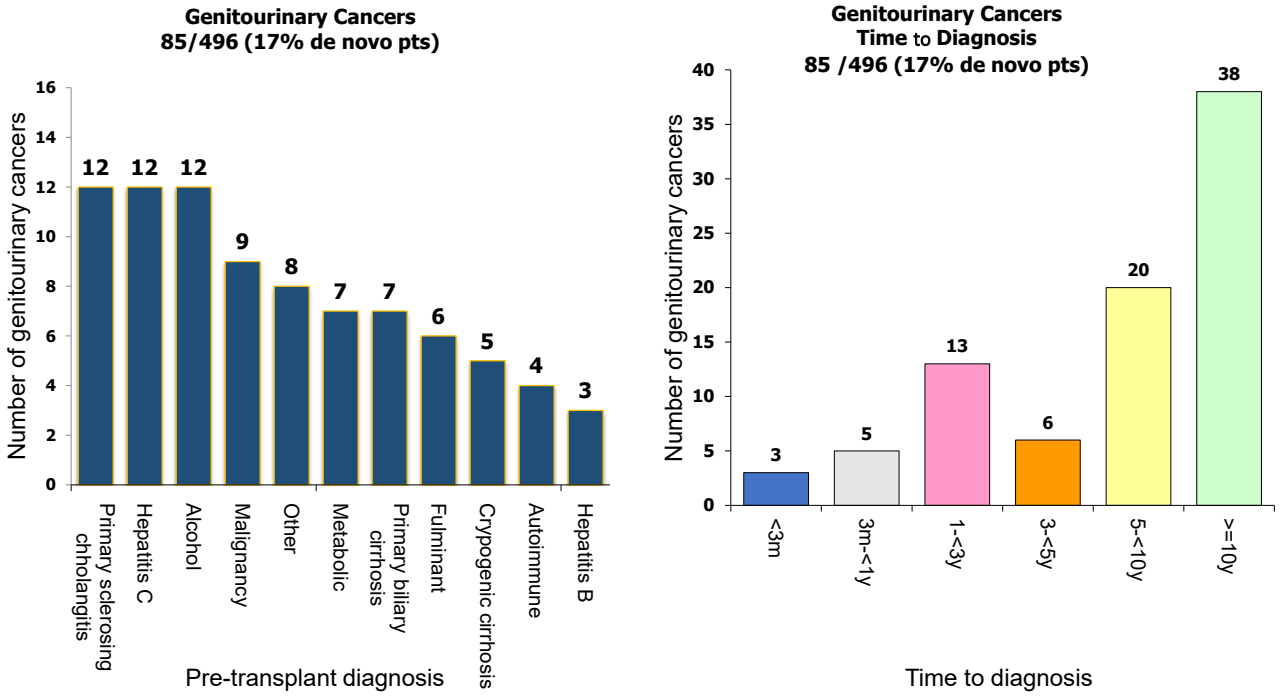
Figure 85. Time to diagnosis of de novo lymphoma by age category



15.7.6 Pretransplant Diagnosis and De Novo Genitourinary Cancers

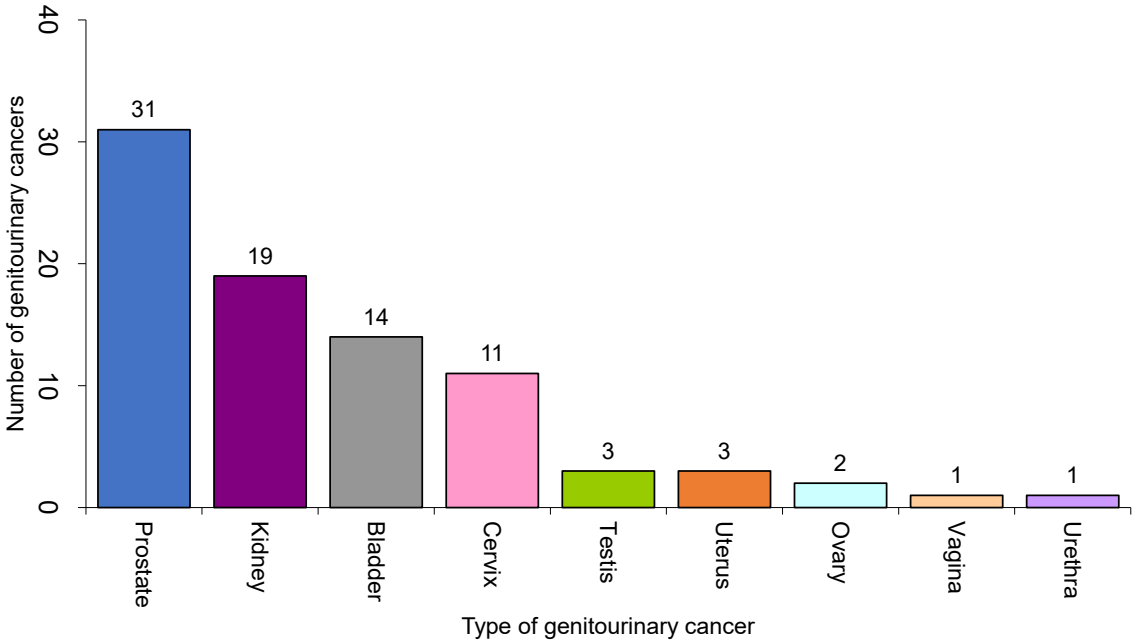
Cancers of the genitourinary tract consisted of 17% of all de novo non-skin cancers. Thirty-five (42%) of these patients were transplanted for primary sclerosing cholangitis, hepatitis C infection or alcoholic liver disease (Figure 86). Time to development ranged from <3 months to >10 years with 68% developing after 5 years. Median time to diagnosis was 104 months.

Figure 86. Pretransplant diagnosis and de novo genitourinary cancers



Thirty-one (36%) of genitourinary tract cancers were cancers of the prostate (Figure 87).

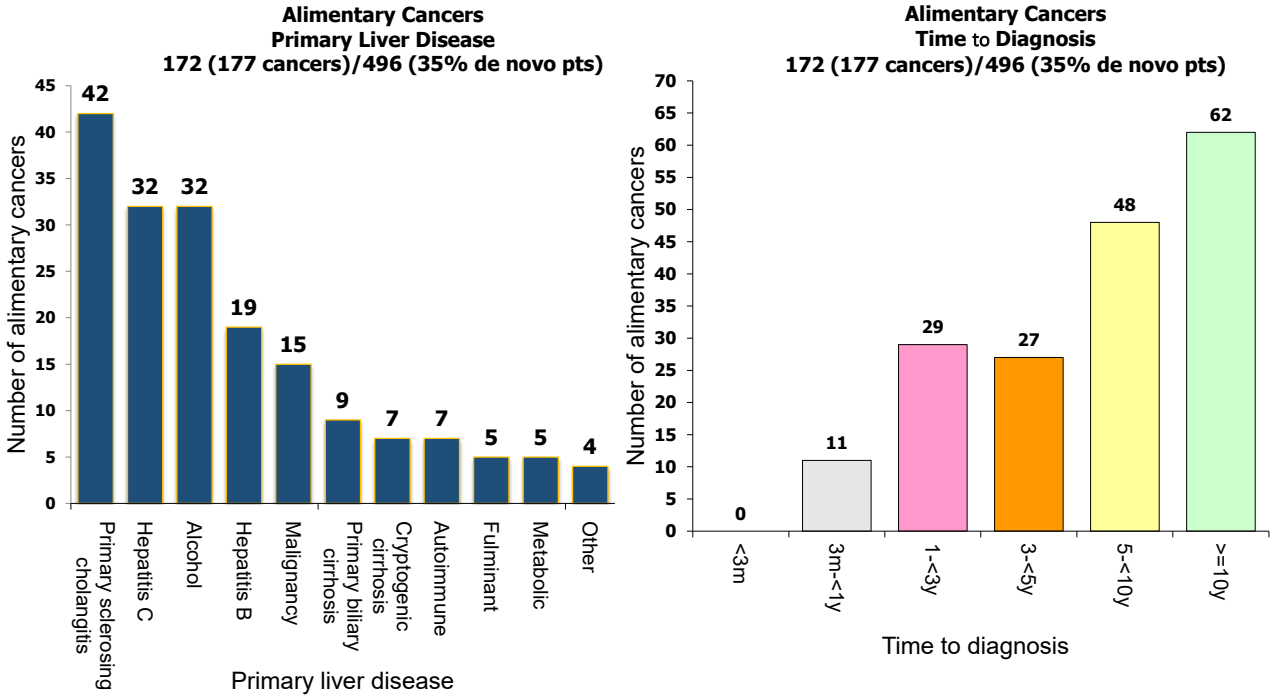
Figure 87. Incidence of de novo genitourinary tract cancers by type



15.7.7 Pretransplant Diagnosis and De Novo Alimentary Cancers

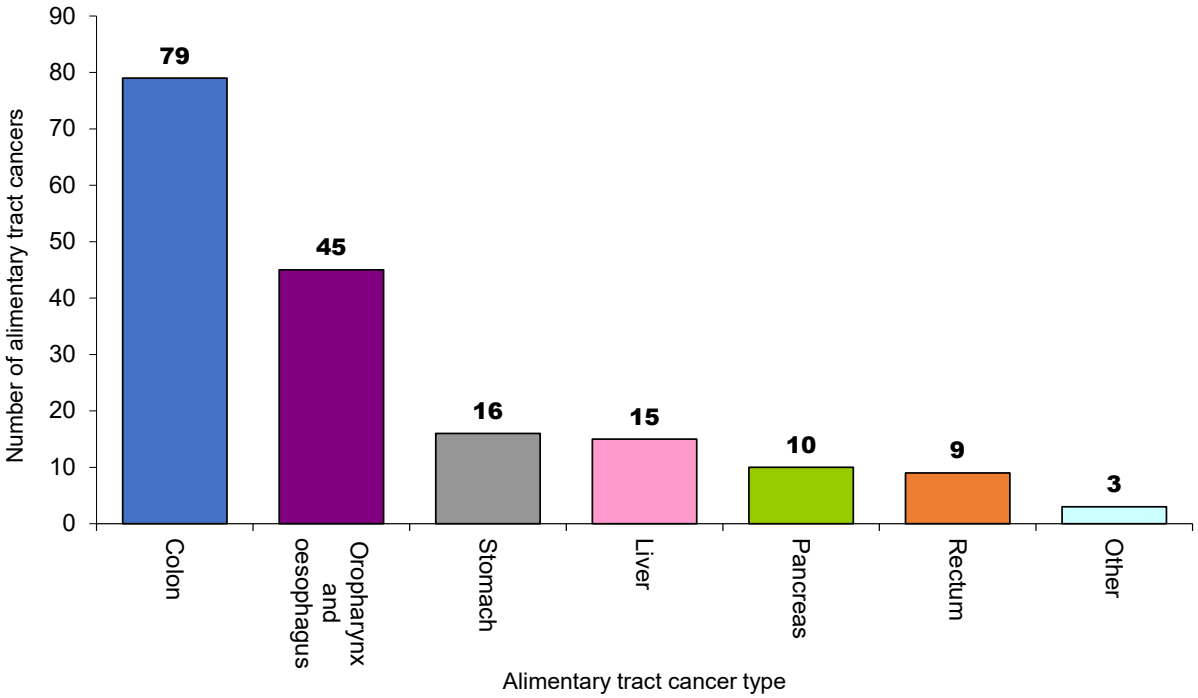
Cancer of the alimentary tract was the most prevalent non-skin cancer to develop post-transplant affecting 172 patients. Time to development ranged from 3 months to >10 years with 62% being diagnosed after 5 years (Figure 88). Median time to diagnosis was 87 months. Pretransplant liver disease was predominantly primary sclerosing cholangitis, hepatitis C infection and alcoholic liver disease.

Figure 88. Pretransplant diagnosis and de novo alimentary cancers



45% of alimentary cancers were of the colon; 25% were oropharynx and oesophagus (Figure 89).

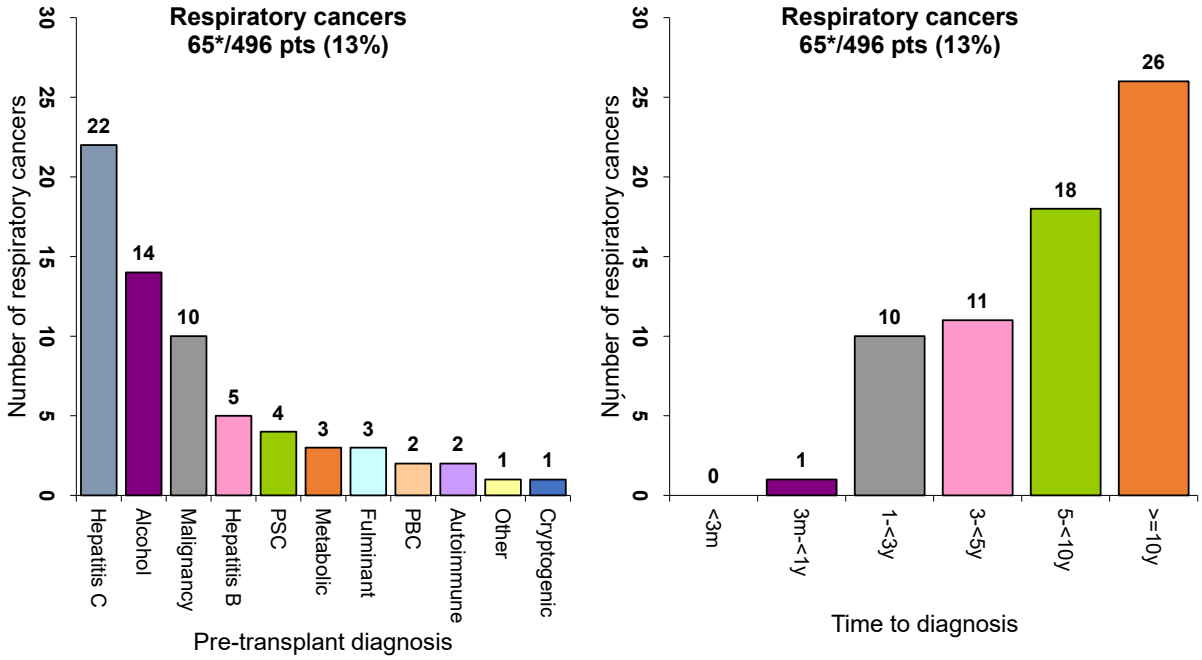
Figure 89. Incidence of de novo alimentary tract cancers by type



15.7.8 Pretransplant Diagnosis and De Novo Respiratory Cancers

Respiratory cancers consisted of 13% of all de novo non-skin cancers. Forty-six (71%) of these patients were transplanted for either hepatitis C infection, alcoholic liver disease or pretransplant liver cancer (Figure 90). Time to development ranged from 3 months to >10 years with 61% developing after 5 years. Median time to diagnosis was 103 months. 92% of respiratory cancers were of the lung (Figure 91).

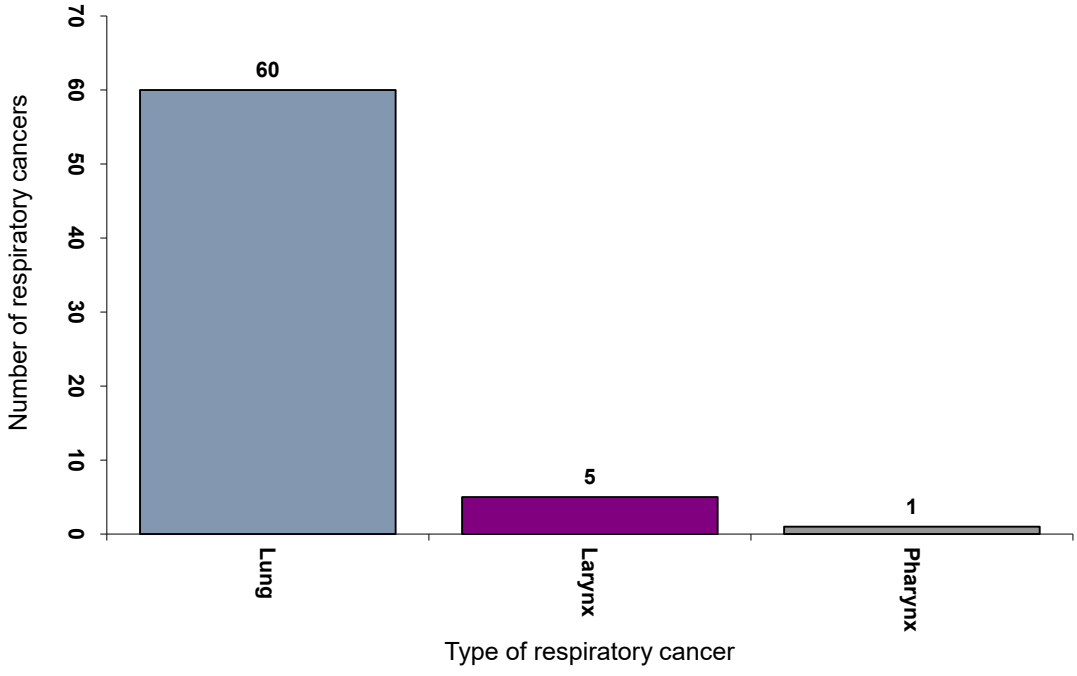
Figure 90. Pretransplant diagnosis and de novo respiratory cancers



*1 patient had 2 respiratory cancers

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

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



*1 patient had 2 respiratory cancers

15.8 Skin Cancer Development

Nine hundred and fifty-two patients (16%) developed a first skin cancer post-transplant with 451 going on to develop multiple skin cancer types. Sixty-nine (1% of all patients) developed melanoma (Figure 92, Figure 93).

Figure 92. Time to first skin cancer development post-transplant by type of skin cancer

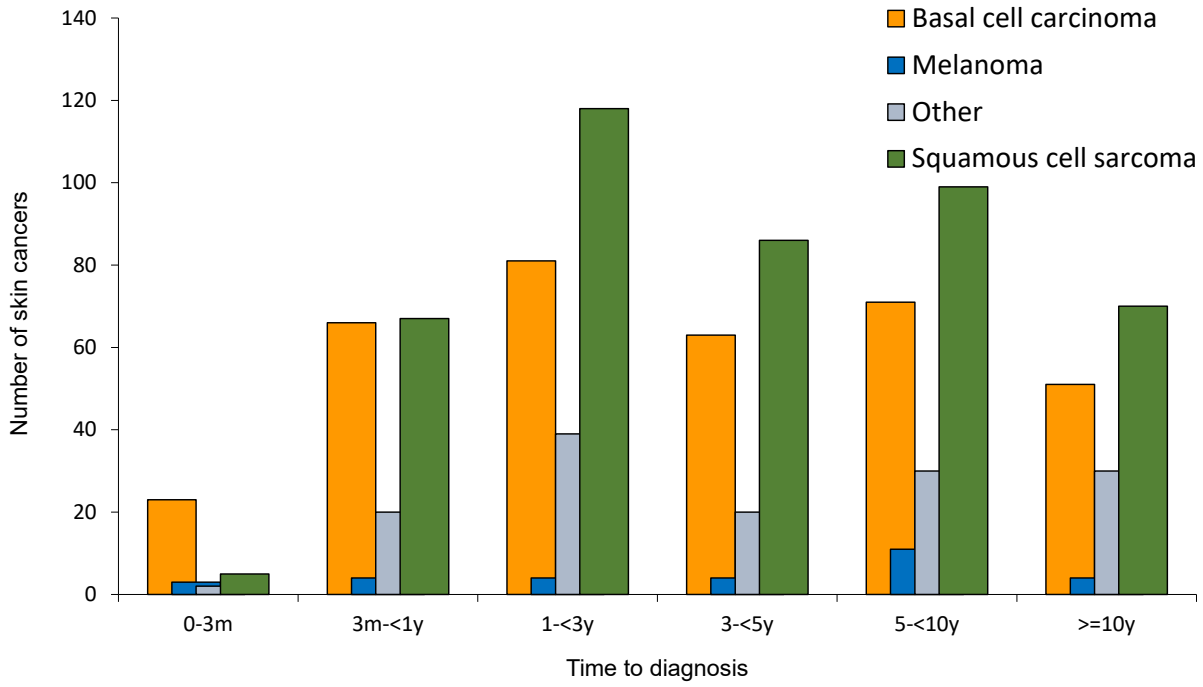
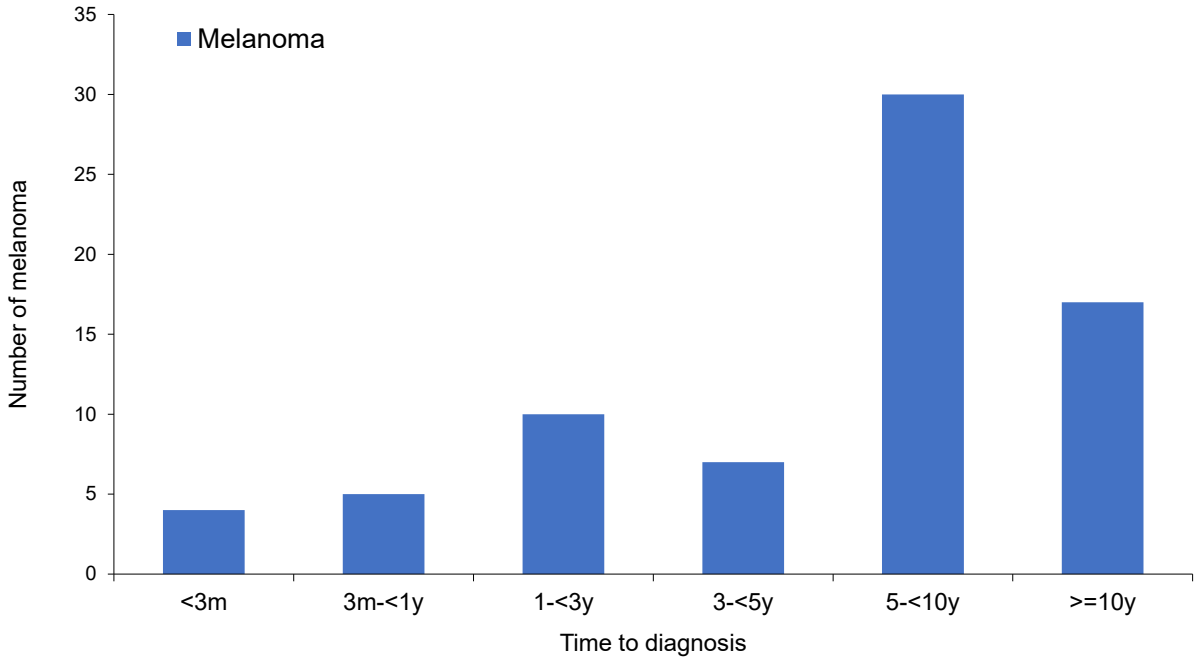


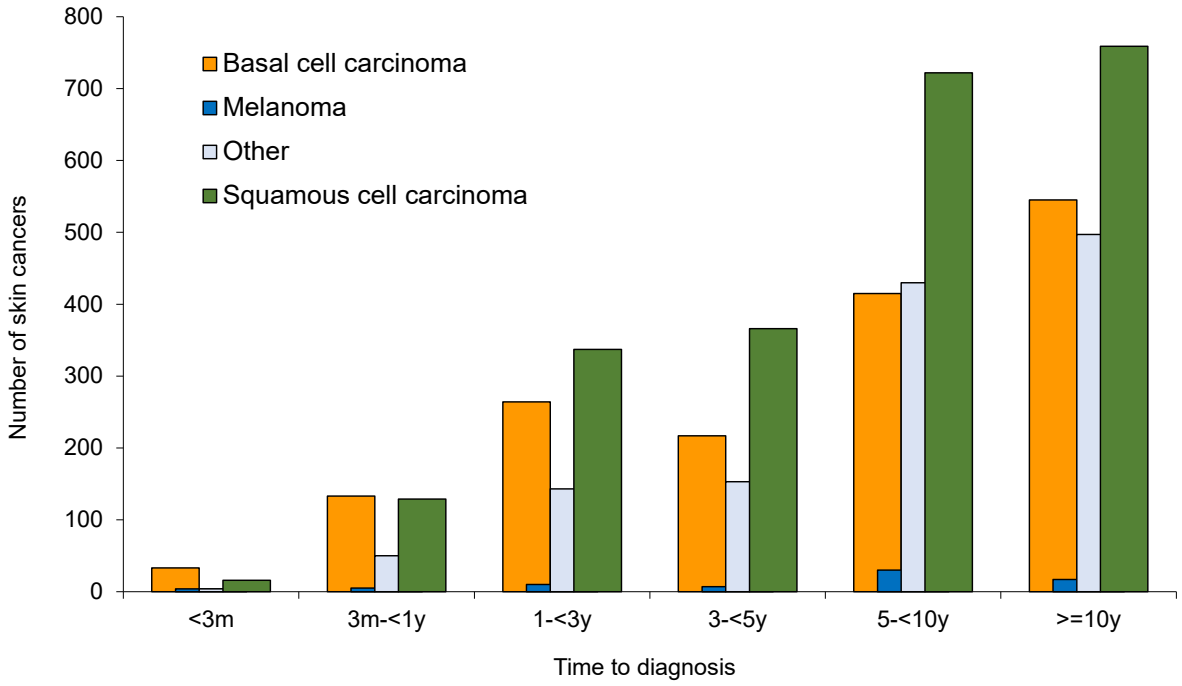
Figure 93. Time to first melanoma development post-transplant
Note: This includes patients who developed melanoma after a non-melanoma skin cancer (first skin cancer)



* 2 patients developed 2 melanoma

Skin cancers increased over time (Figure 94).

Figure 94. Time to any skin cancer development post-transplant



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

The cumulative risk of diagnosis of a de novo non-skin cancer post-transplant is approaching 20% by 20 years (Figure 95, Table 63).

Figure 95. Cumulative risk of diagnosis of skin or non-skin cancer following liver transplantation

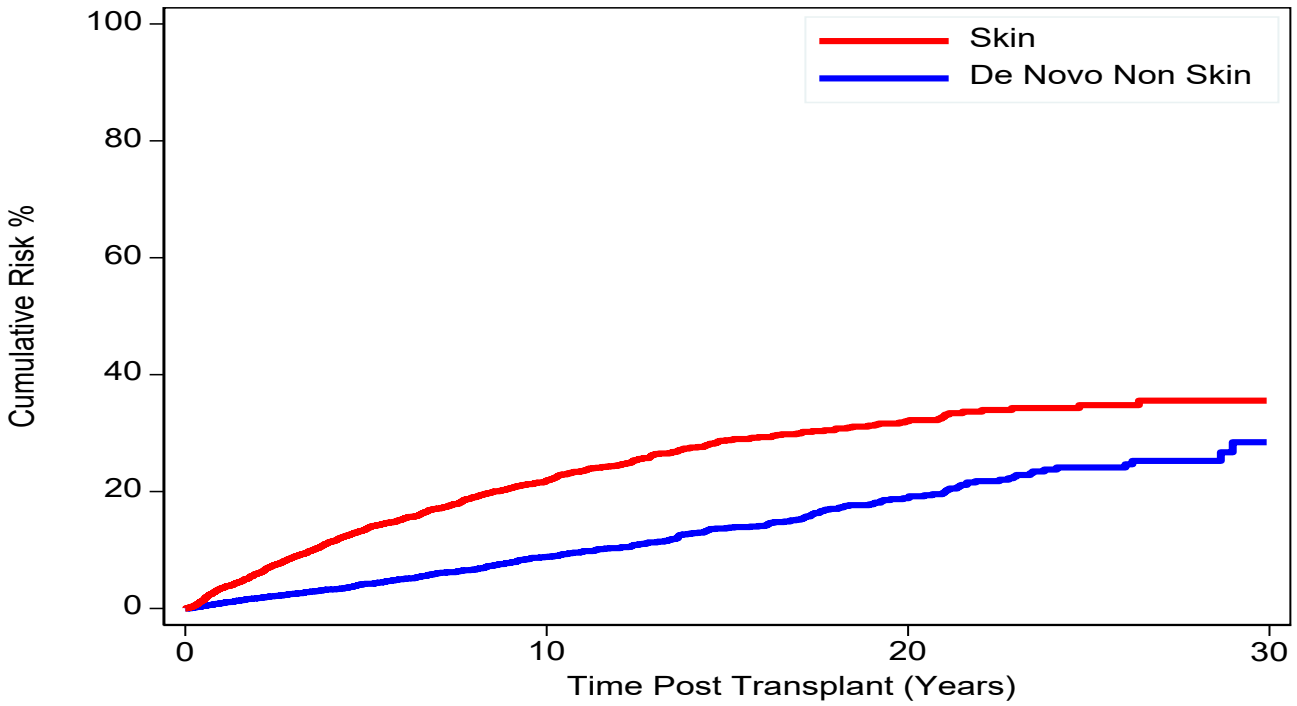


Table 63. Cumulative risk of diagnosis of skin or non-skin cancer following liver transplantation

Cancer type	Patient Survival	Time post-transplant (years)							
		0	1	5	10	15	20	25	30
De novo non-skin	No at risk	6126	5222	3590	2247	1318	680	287	59
	Survival %		1%	4%	9%	14%	18%	24%	30%
Skin	No at risk	6126	5071	3222	1900	1086	555	238	48
	Survival %		3%	13%	21%	28%	32%	34%	37%

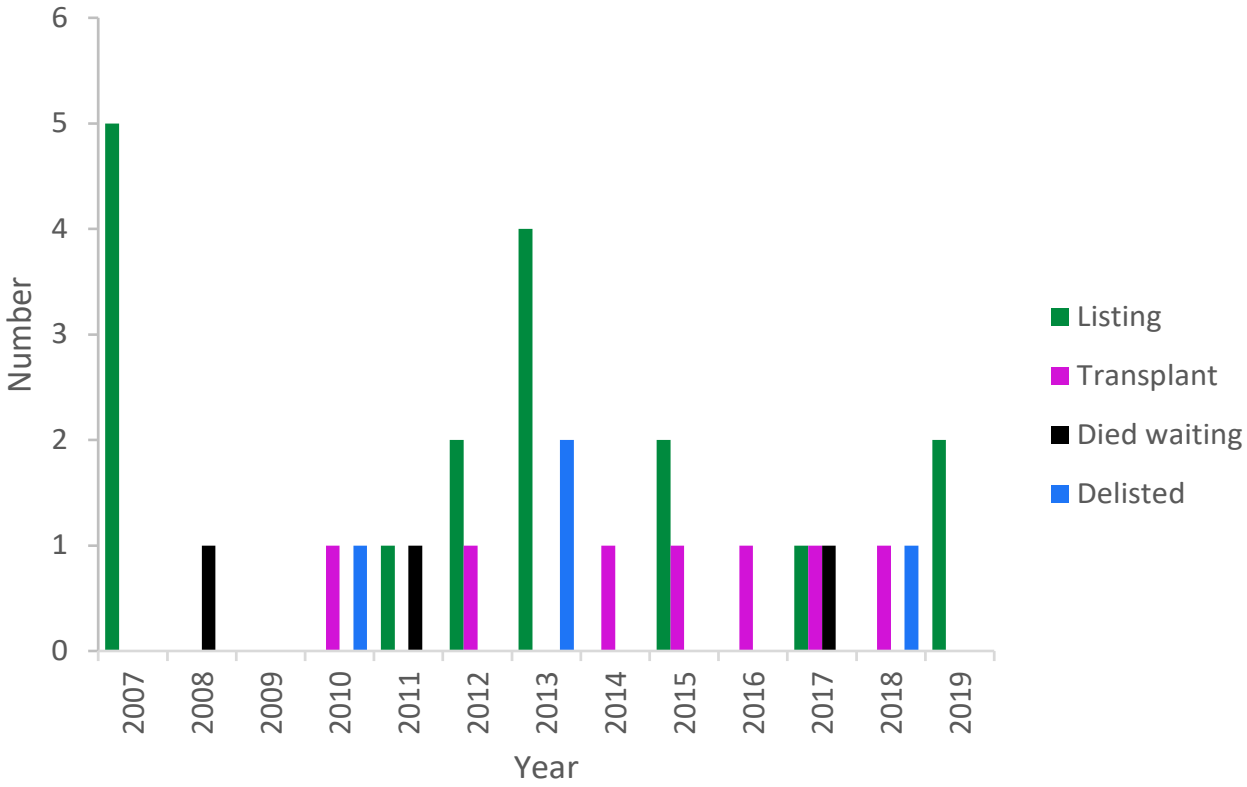
16 Intestinal Transplantation

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

Sixteen patients have been listed for intestinal transplantation, with one patient relisted in 2019, six years after initial delisting (17 listings, see Figure 96). Seven patients were transplanted, three died waiting, three were delisted, and three (including the patient delisted then relisted) were still waiting at the end of 2019.

Figure 96. 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 is shown in Table 64. The majority of the six 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. Three children have been transplanted, two for short bowel syndrome 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 64. 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	6	10	3	4
Age	8 (4-12)	36 (22-60)	10 (5-13)	29 (24-47)
Gender				
Male	4	7	3	3
Female	2	3	0	1
Diagnosis				
Short bowel syndrome				
- Gastroschisis	4	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	0	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 and one patient underwent intestine and kidney transplantation.

16.4 Survival

Five of the seven 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 85.7% and the 5-year patient and graft survival are 68.6% (Figure 97, Table 65, Figure 98, Table 66).

Figure 97. Patient survival after intestinal transplantation

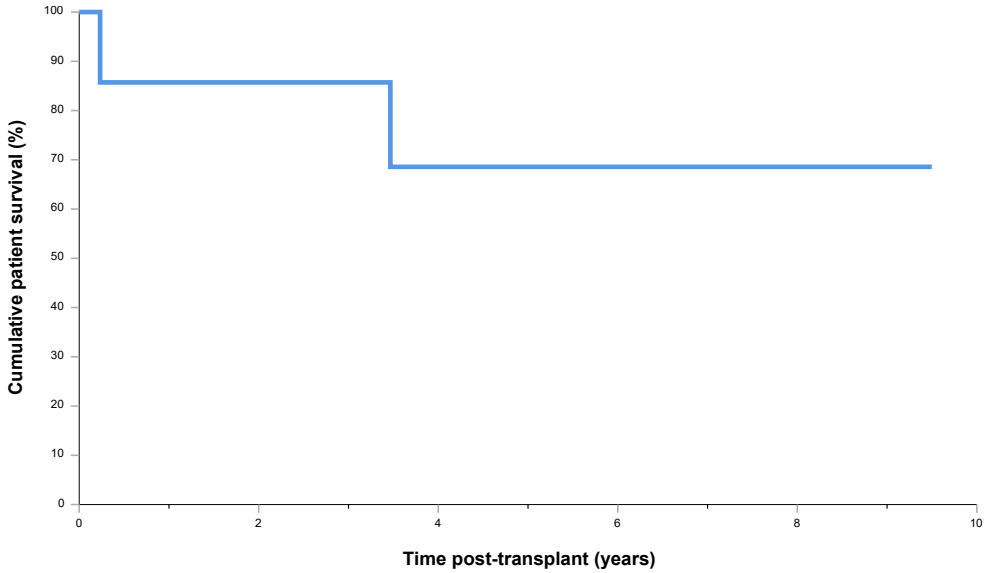


Table 65. Intestinal patient survival

Patient Survival	Time post-transplant (years)				
	0	1	3	5	10
No. at risk	7	6	5	3	0
Survival (%)		86%	86%	69%	

Figure 98. Graft survival after intestinal transplantation

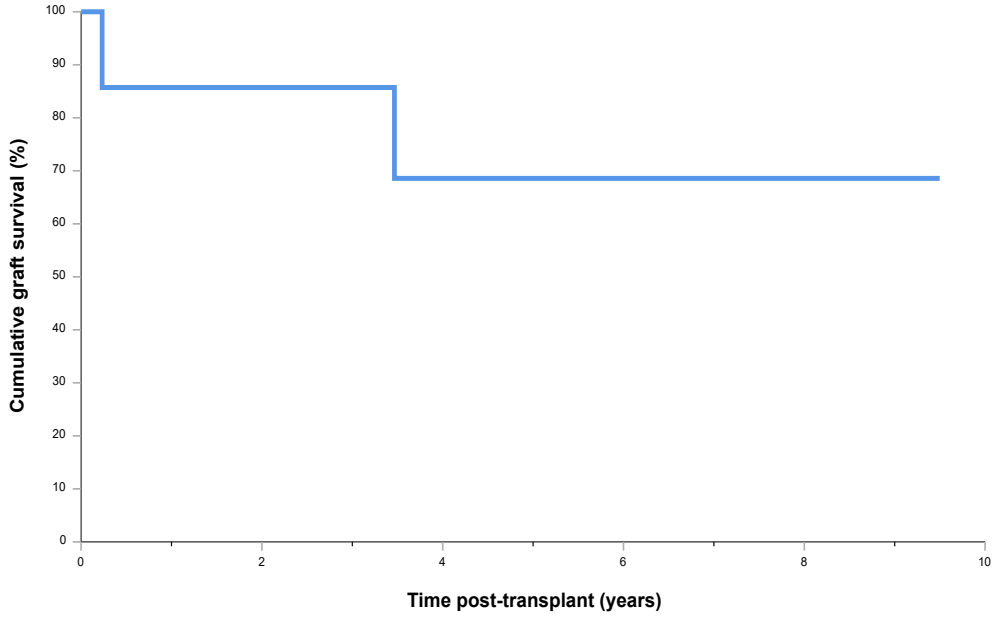


Table 66. Intestinal graft survival

Graft Survival	Time post-transplant (years)				
	0	1	3	5	10
No. at risk	7	6	5	3	0
Survival (%)		86%	86%	69%	

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, 2019 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, 2019 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 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.

18.2 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.

18.3 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.

18.4 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.

18.5 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.

18.6 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.

18.7 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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