

The International Thoracic Organ Transplant Registry of the International Society for Heart and Lung Transplantation: 2025 Annual Report of Heart and Lung Transplantation

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Abbreviations

1. BMI= Body Mass Index
2. DBD=Donation after brain death
3. DCD=Donation after circulatory death
4. eGFR= Estimated Glomerular Filtration Rate
5. ECMO= Extracorporeal membrane oxygenation

6. Forced HCV= Hepatitis C virus
7. ISHLT= International Society for Heart and Lung Transplantation
8. LVAD: left ventricular assist device
8. MCS: mechanical circulatory support
9. NAT= Nucleic acid test
10. VAD: ventricular assist device

INTRODUCTION

In this 2025 ISHLT Thoracic Organ Transplant Registry Annual Report, we present the first new data since the Registry paused in 2018 to comply with European privacy laws (General Data Protection Regulations). After publishing core heart transplant (HT) and lung transplant (LT) reports in 2019, the reports between 2019 and 2024 analyzed data input through June 2018. These reports focused on changing donor characteristics in 2023(1-4), changing recipient characteristics in 2021(5-8), special populations in 2022(9-12), graft survival in 2023(13), and the impact of early post-transplant renal failure in 2024(14).

The present “ISHLT Registry 2025” consists of data from Registry partners globally who were both successful in signing new Data Sharing Agreements (DSAs) and transferring anonymized data to ISHLT’s secure server. These include transplant recipients from Registry partners in Australia, Brazil, Canada, Hong Kong, Israel, Scandinavia, Spain, South Korea, the United Kingdom, and the United States (e-slides 2,3). This marks the beginning of a successful relaunch with many more partners expected to contribute data in the near future. This core

report includes donor and recipient descriptive data, 1-year survival, and multivariable models for 1-year survival in adult and pediatric HT and LT recipients. Also, in this issue of the *Journal of Heart and Lung Transplantation*, we present two focus theme articles utilizing the “ISHLT Registry 2025” data. These manuscripts report the largest donation after circulatory death (DCD) heart and lung transplant cohorts to date.

STATISTICAL METHODS

Data collection

The ISHLT Thoracic Transplant Registry, founded in 1983, paused in 2018 to ensure compliance with the European General Data Protection Regulations. The ISHLT Registry then began a process of relaunching with anonymized data transfers, encrypted servers, and updates DSAs. As of the Fall of 2024, 12 contributing partners, including collectives and large single centers, had both successfully signed DSAs with the ISHLT and transferred anonymized data. The current “ISHLT TTX Registry 2025” includes data from 182,319 individual transplant recipients between the years 1992 to 2024.

The ISHLT Registry 2025 captures donor, recipient, and transplant variables such as transplant year, organ/procurement type, basic demographics (i.e., age, sex, diagnosis) and follow-up information (dead vs alive). Various quality control and validation measures are utilized to ensure acceptable data values before data can be uploaded, and fields are reviewed to enhance the quality and consistency of data transfers. The mechanical support variables for heart transplant recipients were further categorized based on device brands into temporary or durable ventricular assist (VAD) devices. In addition, temporary left ventricular assist devices

(LVADs) were further categorized into microaxial or extracorporeal. Data elements collected in the Registry through 2024 are available at: https://www.isHLT.org/docs/default-source/uploadedfiles/documents/registries/isHLT-registration-follow-up-data-elements-look-up-tables.xlsx?sfvrsn=90f8302a_0#0.

Analytical Conventions and Statistical Methods

Descriptive Analysis

Unless otherwise noted, the descriptive analysis for adult HTs, pediatric HTs, adult LTs, and pediatric LTs included all transplants performed between 1992 and 2024. When summarizing annual data trends, we included transplants through 2023. Recipient, donor, and transplant characteristics were summarized as percentages for categorical variables and as medians (with 5th to 95th percentiles) for continuous variables. Summary statistics included only transplants with non-missing data. Supplemental Tables 1A and 1B list all the variables included in the summary statistics, along with the number of transplants with known and missing values.

Univariate Survival Analysis

The Kaplan-Meier method was used to estimate time to death (i.e., survival) among primary single organ transplants by era performed between 1992 and 2023, to allow for one year follow-up. This analysis excluded previous transplants, multi-organ transplants, and transplants with missing follow-up time. Cohort subjects were censored at the time of re-transplantation or time of last follow up. Pairwise tests to compare survival curves among transplant eras were conducted and adjusted for multiple comparisons using the Scheffé method.

Multivariable Survival Analysis

Multivariable Cox regression analyses were performed to identify risk factors for 1-year mortality in each of the cohorts of adult HT, pediatric HT, adult LT, and pediatric LT recipients between 2005-2023 to allow 1 year of follow up. Previous transplants, multi-organ transplants, and transplants with missing follow-up time were excluded. The analyses included 51,392 adult HT recipients, 7,903 pediatric HT recipients, 47,623 adult LT recipients, and 1,026 pediatric LT recipients in each of the Cox models. The cohorts for the multivariable models were smaller than the total registry cohort for the following reasons: 1) the starting time of 2005 was selected to capture a more contemporary cohort; 2) to ensure the majority of the covariates were collected during the analysis period; 3) to also ensure sufficient number of transplants with non-missing covariates.

The variables included in the Cox models were identified *a priori* and reflect patient acuity and donor quality. These are presented in Supplemental Table 2 and include variables with less than 65% missingness. The number of variables in the models varied between pediatric and adult cohorts due to the difference in number of deaths and statistical power. Multiple imputation was performed to allow for retention of cohort subjects with missing covariate data (Supplement). No variable selection methods were utilized, and all selected variables were kept in the models. Schoenfeld residual plots were used to evaluate the assumption of proportional hazards.

The results of the multivariable Cox models for all categorical risk factors included in the models were presented as a forest plot, showing hazard ratios, lower and upper confidence

limits, and p-values, regardless of statistical significance. Statistically significant continuous variables were illustrated with hazard ratio plots and corresponding p-values. Analyses were conducted by the United Network for Organ Sharing, as the Data Coordinating Center for the Registry. Data were analyzed using SAS version 9 (SAS Institute, Inc., Cary, NC) and R version 4.4.3. All tests were two-sided, and a p-value of <0.05 was considered statistically significant.

Heart Transplantation

Transplant Volume

Among currently contributing partners to the ISHLT Registry, on average 2500-3000 HTs were performed yearly, with small year-to-year variability (e-slide 8). Since 2013, there has been a progressive increase in HTs reported annually, with 5,887 HTs reported in 2023 (e-slide 8). This growth in HT volume has occurred in both adult and pediatric age groups (Figure 1, e-slides 9, 10) and has been more pronounced at transplant centers in North America and in Other Parts of the World, and less so in the European countries currently reporting data to the Registry (Figure 1, e-slides 9, 10). While not all European countries and collectives have yet contributed data to the Registry, this trend appears to be fairly consistent across the continent. The opioid crisis in the United States has been associated with increased solid organ transplant volumes for all organs, and is likely a major contributor to the observed increase in HTs in North America.(15, 16) Increase in volume of DCD hearts, described in the special ISHLT Registry report in this issue of the Journal, and new organ preservation techniques have also contributed. Expansion in transplant volume in Other Parts of the World may represent growth in HT infrastructure and expertise to offer this therapy for end stage heart failure.

Recipients and Donor Characteristics

The distributions of select recipient and donor characteristics in adult and pediatric HT recipients who received transplant during 1992-2024 are shown in Table 1 (e-slides 11-13). The median recipient age in adult HT recipients was 55 years, 75.3% were male, 44.2% had undergone prior non-transplant cardiac surgery (including prior HT 2.8%), 3.2% were supported on a ventilator, and 2.4% of recipients received a heart from a DCD (donation after circulatory death) donor. The median donor age was 32 years, 95% of donors were <55 years old, 70.3% of the donors were male, 54.3% of donors had a history of drug use, 13.7% had a history of hypertension and 3.1% had diabetes.

Among pediatric HT recipients, median age was 6 years, 55.6% were male, 16.5% were supported on a ventilator, and 0.4% received a heart from a DCD donor. The median donor age was 8 years, 95% of donors were <35 years old, 58.4% were male, 15.1% had a history of drug use, 1.6% had a history of hypertension, and 1% had diabetes.

For both adult and pediatric HT, approximately 80% of all recipients had blood types A or O, about 13% had blood type B, and nearly 5% had blood type AB (e-Slide 14). These percentages likely represent the population distribution of these blood types where transplants were performed.

Indication

Among adult HT recipients during 1992-2024, non-ischemic cardiomyopathy (44% of recipients) and ischemic cardiomyopathy (34% of recipients) were the most frequent underlying

cardiac diagnoses (Figure 2, e-slide 15). The remaining diagnostic categories had 3% or fewer recipients in each group, with 10% of patients not reported under any of the defined diagnostic categories. The percentage of adult HT recipients with a diagnosis of non-ischemic cardiomyopathy increased from 43.5% of recipients in 1992 to 46.8% of recipients in 2023, whereas the percentage of recipients with ischemic cardiomyopathy has decreased from 43.4% of recipients in 1992 to 24.4% of recipients in 2023 (Figure 3, e-slide 16). This decline may be related to advances in primary and secondary prevention of ischemic heart disease, improved risk stratification, advances in catheter-based interventions, and wide availability of highly effective medications for treating risk factors such as hyperlipidemia, diabetes and hypertension.(17-19)

Among pediatric HT recipients, congenital heart disease (CHD, 42%) and dilated cardiomyopathy (38%) represented 80% of all recipients (Figure 2, e-slide 15). The percentage of patients with CHD was 53.7% of recipients in 1992, when most infants born with lethal, unrepaired single ventricle hearts had few options. The percentage decreased over time to 36.0% in 2007 with progress in repair of CHD and then increased to 47.0% of recipients in 2023 following development of ventricular dysfunction after initial surgical repair (Figure 4, e-slide 17). The percentage of recipients with dilated cardiomyopathy has been more stable, representing 35.2% of recipients in 1992, 41.9% of recipients in 2007 and 32.4% of recipients in 2023 (Figure 4, e-slide 17).

Overall, 26% of adult HT recipients and 35% of pediatric HT recipients had peak circulating panel reactive antibody (antibody to human leukocyte antigen) level >20% prior to transplant (e-slide 18). These high percentages may be explained by a high proportion of HT

recipients with prior history of cardiac surgery. Previous Registry reports have shown both an increase in the percentage of HT recipients over time with history of cardiac surgery, and a corresponding increase in percentage of recipients who are highly sensitized.(7, 8)

Pre-transplant Mechanical Support

The proportion of adult HT candidates bridged to HT on mechanical circulatory support (MCS) has increased progressively over time. During 2005-2008, 20-30% of recipients were on MCS at transplant, which increased gradually to approximately 50% of recipients during 2013-2018, and to 60% of recipients during 2019-2024 (Figure 5A, e-slide 19). This trend was initially due to an increasing number of patients supported by a durable left ventricular assist device (LVAD) from 17.3% of recipients in 2005 to 42.4% of recipients in 2017 (Figure 6, e-slides 20, 21). Since 2018, the percentage of adult HT recipients supported by a durable LVAD has progressively declined to 14.8% of recipients in 2024, whereas those supported by a temporary MCS have increased from 11.1% of recipients in 2018 to 39.1% of recipients in 2024. The percentage of adult HT recipients supported by extracorporeal membrane oxygenation (ECMO) has increased from 3.4% in 2018 to 8.0% in 2024 (Figure 6, e-slides 20, 21). These trends in clinical practice for bridging HT candidates to transplant appear to be limited to North America (e-slides 25-27). This trend followed a change in donor heart allocation in the United States in 2018 with new system prioritizing heart allocation to candidates supported with temporary MCS and ECMO.(20)

The proportion of pediatric HT recipients bridged to transplant using MCS has also increased progressively from <20% of HT recipients during 2005-2008, to 43.2% of recipients in

2024 (Figure 5B, e-slide 22). This increase has been driven primarily by the availability and use of durable LVAD support in children; 75% of all pediatric HT candidates requiring MCS in the current era are supported by a durable LVAD (Figure 7, e-slides 23, 24, 26). In contrast, ECMO and temporary MCS are less frequently employed in pediatric HT candidates, with approximately 5% being on ECMO and 7% being on temporary MCS at the time of transplant in the current era (e-slides 24, 27).

Additional Donor Characteristics

Hearts from hepatitis C virus (HCV) seropositive donors have been used in Europe for adult HT candidates for more than two decades. HCV seropositive donors began to be used in adult HT candidates in 2017 in North America. In the present ISHLT Registry cohort, approximately 150 HT recipients per year in Europe and 200 HT recipients per year in North America had donors that were HCV seropositive (e-slide 28). Using hearts from HCV seropositive donors remains rare in pediatric HT candidates (e-slide 28).

There has been a progressive increase in the number of donors with history of drug use in North America between 2005 and 2022, followed by a decline in 2023 in both adult and pediatric HT recipients (e-slide 29). Whether this is the beginning of a trend, and its potential effect on thoracic transplant volume in North America is unclear. The number of donors in Europe and Other Parts of the World with a history of drug use is consistently lower than in North America. Head trauma is the most common cause of donor death among adult HT recipients, present in 42% of donors, followed by anoxia (21%) and stroke (21%). The donor

causes of death in pediatric HT recipients include head trauma (45%), anoxia (32%), and stroke (10%) (e-slide 30).

Post-Transplant 1-year Survival

The unadjusted short-term survival estimates have continued to improve over time in adult HT recipients. The 1-year post-transplant survival was 85.5% during 1992-2000 and increased to 88.7% during 2001-2009, 91.4% during 2010-2017, and 92.1% during 2018-2023 (Figure 8, e-slide 31). Each pairwise comparison was statistically significant ($p < 0.001$) except for the two most recent eras.

Similarly, the estimated 1-year post-transplant survival has improved over time in pediatric HT recipients. One-year survival was 81.4% in pediatric recipients during 1992-2000, improved to 88.9% during 2001-2009, 93.2% during 2010-2017, and 93.1% during 2018-2023 (Figure 9, e-slide 32). The last two time periods, however, were not statistically different from one another.

Multivariable Cox Models for 1-year Mortality

Adult HT recipients

The Cox model for adult HT recipients included 51392 transplants from 2005 and 2023. Statistically significant categorical risk factors associated with higher 1-year mortality in adult HT recipients (Figure 10, e-slide 34) were female sex, diagnosis of congenital heart disease, restrictive cardiomyopathy, other diagnosis, prior cardiac surgery, patient support with any MCS (temporary MCS, durable MCS or ECMO), and ventilator support. Cerebrovascular

accident/stroke (versus head trauma) as the donor cause of death was associated with a higher risk of recipient 1-year mortality, whereas other cause of death and donor history of drug use were associated with a lower risk. Transplants during recent eras (2012-2017, 2018-2023) were associated with lower recipient risks of 1-year mortality when compared to the time period between 2005 and 2011.

Continuous variables associated with higher 1-year mortality included older recipient age, lower estimated glomerular filtration rate (GFR), higher recipient bilirubin, higher pulmonary vascular resistance (PVR) value, older donor age, and longer organ preservation time (Figure 11, Figure 12, e-slides 35-41).

Pediatric HT recipients

The Cox model for pediatric HT recipients included 7903 transplants from 2005 and 2023. Statistically significant categorical risk factors associated with higher 1-year mortality in pediatric HT recipients were diagnosis of congenital heart disease and recipient support with ECMO or ventilator support (Figure 13, e-slide 43). Continuous risk factors associated with higher 1-year mortality were lower recipient GFR, higher peak PRA, and longer organ preservation time (Figure 14, e-slides 45-47).

LUNG TRANSPLANTATION

Transplant Volume

The annual LT recipients reported to the Registry grew 6-fold from ~600/year in 1992 to ~3800/year in 2019, with similar growth in LT volume in North America and Europe (e-slide 49).

There was an 11% decline in the total number of LTs performed in 2020, likely related to the COVID pandemic and its strained effect on health care systems also affecting transplantation. Since 2020, there has been a gradual recovery of transplant volume (e-slide 49). The trend in adult LT recipient volume over time was the key driver for global LT volume with a recent reduction in pediatric LT volume (Figure 15, e-slide 50). Notably, there has been a decline in the number of pediatric LTs from 60-80/year during 2010s to approximately 40 LTs per year during 2020-2023 (Figure 15, e-slide 51). This is best explained by advances in the treatment of cystic fibrosis (CF) with cystic fibrosis transmembrane conductance regulator (CFTR) modulators, which have markedly reduced the need for LT in all age groups with this condition (e-slide 59).(21)

Recipient and Donor Characteristics

Select recipient and donor characteristics in adult and pediatric LT recipients during 1992-2024 are presented in Table 2 (e-slides 52-54). Among adult LT recipients, 68.1% received both lungs, and 31.9% of recipients underwent single lung transplantation. The median recipient age in adult LT recipients was 58 years, 58% were male, 3.4% had a prior LT, 5.2% were supported on a ventilator at the time of transplant, 4.0% were supported on ECMO, and 5.2% of recipients received lungs from a DCD donor. The median donor age was 36 years, 95% of donors were <63 years old, 44.8% of donors had a history of drug use, 14.5% of donors had a history of smoking cigarettes, 22.2% had a history of hypertension, and 7.0% had diabetes (Table 2).

Among pediatric LT recipients, 97.5% received both lungs and 2.5% underwent single lung transplantation. Median recipient age in pediatric LT recipients was 14 years, 42.2% were male, 5.8% had a prior LT, 17.9% were supported on a ventilator at the time of LT, 5.4% were supported on ECMO, and 1.5% received lungs from a DCD donor. Median donor age was 14 years, 95% of donors were <50 years old, 16.6% of donors had a history of drug use, 4.2% of donors had a history of smoking cigarettes, 4.7% had a history of hypertension, and 1.9% had diabetes.

The distribution of blood types among adult and pediatric LT recipients was similar; 44% of recipients had blood type O, 40% of recipients had blood type A, 11% recipients had blood type B, and ~5% had blood type AB (e-Slide 55). For both adult and pediatric LT recipients, the use of pre-transplant ECMO has been much more frequent in North America compared to Europe and Parts of the World (e-slide 56).

Indication

Among adult LT recipients during 1992-2024, idiopathic pulmonary fibrosis (IPF, 27%) chronic obstructive pulmonary disease (COPD, 24%), and CF (10%) were the most frequent indications for transplant, whereas 35% of recipients had a diagnosis that was not reported under pre-defined categories (Figure 16, e-slide 57). The change in LT indications in adult LT recipients by year of transplant is shown in Figure 17 (e-slide 58). The percentage of LT recipients with a diagnosis of COPD has declined from 35% in 1990s to approximately 20% during the last decade, whereas those with a diagnosis of IPF have increased gradually to one-third of LT recipients. Notably, after a stable ~300 LT recipients/year with a diagnosis of CF

during 2010s, there has been a precipitous decline in number of patients with CF receiving LT since 2020 (e-slide 59). This decline is likely related to the advent and use of CFTR modulators.(21) In particular, the triple-combination CFTR modulators introduced in 2019 are effective in improving lung function in 90% of CF patients, often rapidly and in a sustained fashion. In a recent study of 65 adult LT candidates with CF who initiated CFTR modulators, 61 no longer met the criteria for transplant candidacy after one year of treatment.(22) The need for LT in CF now appears to be limited to a subset of patients with advanced CF with poor/inadequate response to CFTR modulators, or where CFTR modulators are not widely available.

The impact of CFTR modulators has been even more transformative in pediatric CF population since CF has been the most common indication for pediatric LT since 1990s. As with adult LT recipients, the number of children needing LT for CF has also declined steeply since 2020 (Figure 18, e-slides 59, 60).

Overall, 25% of adult LT recipients and 32% of pediatric LT recipients had a peak circulating panel reactive antibody (antibody to human leukocyte antigen) level >20% prior to transplant (e-slide 61). This is likely related to such patients having a prior history of thoracic surgery or ECMO support which increased their risk of developing these antibodies.

Additional Donor Characteristics

Head trauma is the most common cause of donor death among adult LT recipients, present in 39% of donors, followed by stroke in 35%, and anoxia in 21% (e-slide 62). The leading

causes of donor death in pediatric HT recipients include head trauma in 47%, stroke in 22%, and anoxia in 21% (e-slide 62).

In the ISHLT Registry 2025 cohort, the number of HCV seropositive donors in adult and pediatric LT recipients has been stable in Europe over the last 2 decades at 100-150 total LT recipients/year (e-slide 63). HCV seropositive donors have been increasingly used in adult LT candidates in North America since 2017. In recent years, approximately 200-250 adult LT recipients each year in North America had donors that were HCV seropositive (e-slide 63); pediatric LT recipients in North America have not received lungs from an HCV seropositive donor.

As described for adult HT recipients, the number of LT donors with history of drug use gradually increased in North America between 2005 and 2022, followed by a decline in 2023. The number of LT donors in Europe with a history of drug use has been consistently low (e-slide 64).

Post-Transplant 1-year Survival

Short-term survival has continued to improve over time in adult and pediatric LT recipients. In adult LT recipients, 1-year post-transplant survival was 75.8% during 1992-2000, which improved to 81.7% during 2001-2009, 86.8% during 2010-2017, and 88.4% during 2018-2023 (Figure 19, e-slide 65). Each incremental improvement in survival was statistically significant (p values <0.05 for all comparisons).

In pediatric LT recipients, the estimated 1-year post-transplant survival has increased over time. One-year survival was 74.8% during 1992-2000, increased to 82.9% during 2001-

2009, 85.6% during 2010-2017, and 86.8% during 2018-2023 (Figure 20, e-slide 66). This improvement, however, was statistically significant only when each subsequent era was compared to the time period between 1992 and 2000.

Multivariable Cox Models for 1-year Mortality

Adult LT recipients

The Cox model for adult LT recipients included 47623 transplants from 2005 and 2023. Statistically significant categorical risk factors associated with higher 1-year mortality in adult LT recipients included ECMO and ventilator support at the time of LT, single LT, donor use of drugs, and donor use of cigarettes (Figure 21, e-slide 68). Recent transplant eras (2012-2017, 2018-2023) were associated with lower risk of 1-year mortality. Continuous variables associated with higher 1-year mortality included older recipient age, lower recipient GFR, higher recipient bilirubin, older donor age, lower donor-recipient height ratio, and longer organ preservation time (Figure 22, e-slides 69-75).

Pediatric LT recipients

The Cox model for pediatric LT recipients included 1026 transplants from 2005 and 2023. None of the categorical risk factors analyzed were associated with 1-year mortality in pediatric LT recipients, however the direction of the observed associations suggests increased risk among recipients who were on ECMO or ventilator support. The lack of statistical significance of these two variables is likely related to the small sample size of this cohort.

(Figure 23, e-slide 77). Among continuous variables, a younger donor age was a significant risk factor for 1-year mortality (Figure 24, e-slide 79).

Conclusions

This annual report marks the official relaunch of the ISHLT TTX Registry after the pause in data submissions that occurred in 2018. Major trends highlighted in this report include a decline in adult HT recipients with ischemic cardiomyopathy during the last 3 decades, an increase in adult and pediatric HT recipients supported on MCS, and a sharp increase in short-term MCS utilization in adult HT recipients in North America. For both HT and LT recipients, the proportion of donors with a history of drug use and those who are seropositive for HCV have increased. Among adult and pediatric LT recipients, the most striking trend is a decline in the number of patients transplanted for CF due to advances in CF therapeutics.

This year's annual report marks the beginning of a new chapter in the ISHLT TTX Registry. This would not have been possible without the hard work and persistence of our existing partners. We want to officially thank and recognize the teams at our partner sites for their incredible efforts. There is significant momentum at the Registry presently with the recent signing of many additional DSAs and more data transfers anticipated next year. The richness and accuracy of our data depend on the active participation of our community, and we hope more partners will join soon. These important contributions will help shape our guidelines, enhance the quality of care for our patients, and contribute to transplant success and innovation worldwide.

Figure Legends

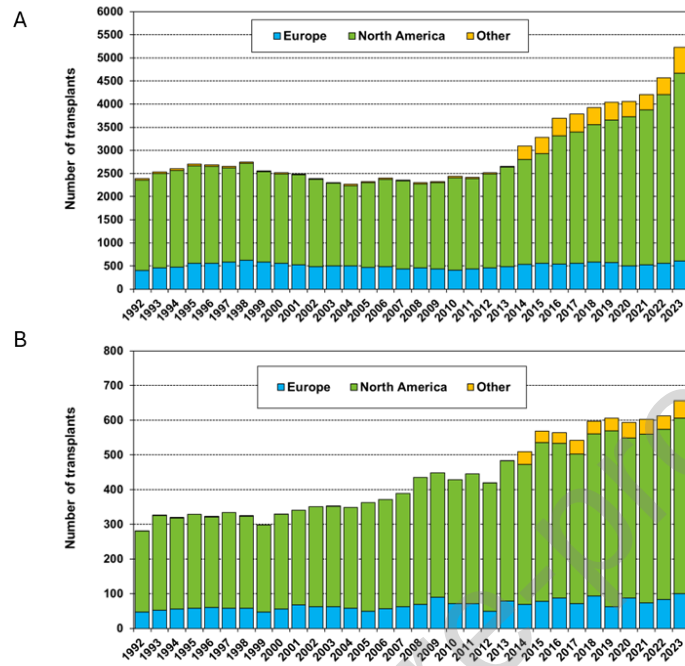


Figure 1: (A) Adult and (B) pediatric HT recipients between 1992 and 2023 in the ISHLT Registry, by year and location.

HT = heart transplant

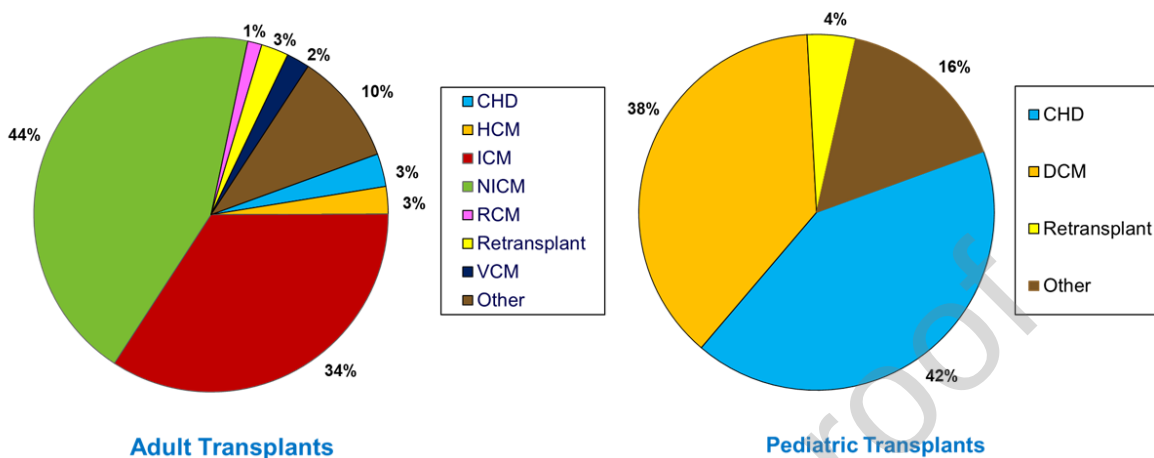


Figure 2: Cardiac diagnosis in adult and pediatric HT recipients between 1992 and 2024. CHD = heart transplant, congenital heart disease, HCM = hypertrophic cardiomyopathy, ICM = ischemic cardiomyopathy, NICM = non-ischemic cardiomyopathy, RCM = restrictive cardiomyopathy, VCM = valvular cardiomyopathy, DCM = dilated cardiomyopathy

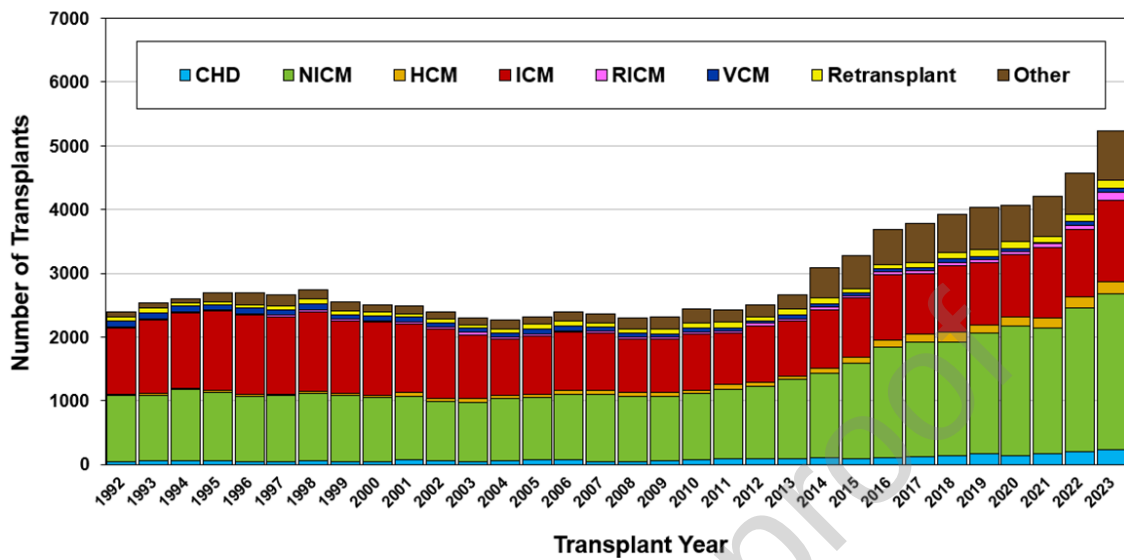


Figure 3: Cardiac diagnosis in adult HT recipients between 1992 and 2023, by year of transplant.

HT = heart transplant, CHD = congenital heart disease, NICM = non-ischemic cardiomyopathy, HCM = hypertrophic cardiomyopathy, ICM = ischemic cardiomyopathy, RCM = restrictive cardiomyopathy, VCM = valvular cardiomyopathy

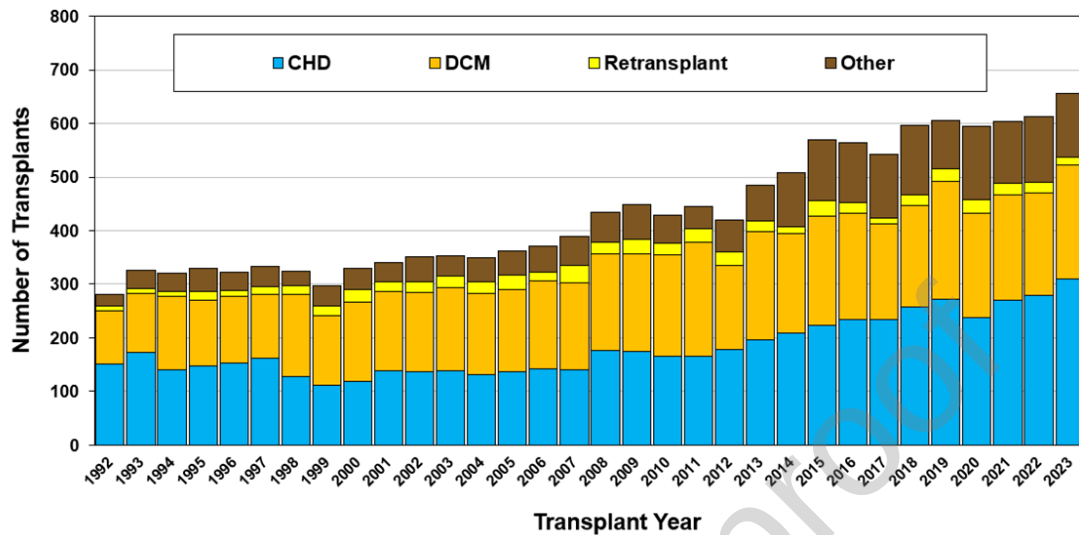


Figure 4: Cardiac diagnosis in pediatric HT recipients between 1992 and 2023, by year of transplant.

HT = heart transplant, CHD = congenital heart disease, DCM = dilated cardiomyopathy

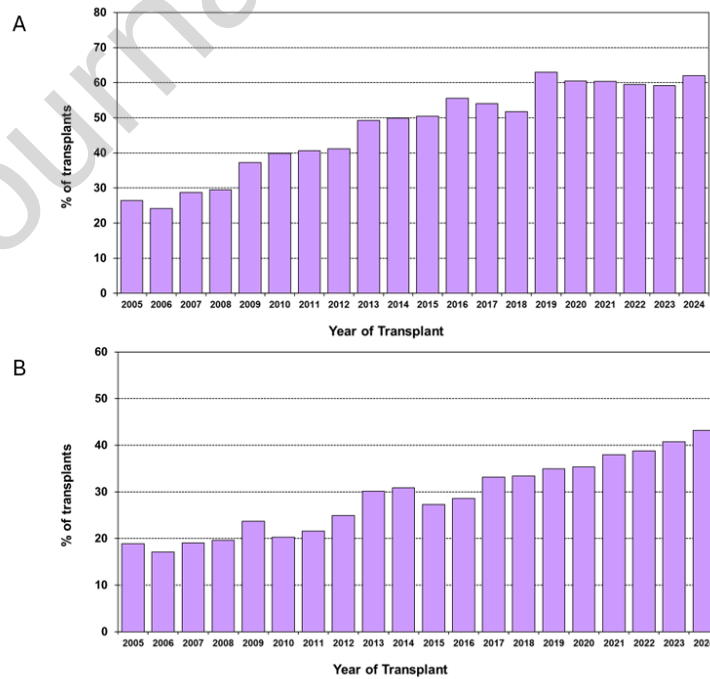


Figure 5: Percent of (A) adult and (B) pediatric HT recipients on MCS at transplant between 2005 and 2024, by year of transplant.

HT = heart transplant, MCS = mechanical circulatory support

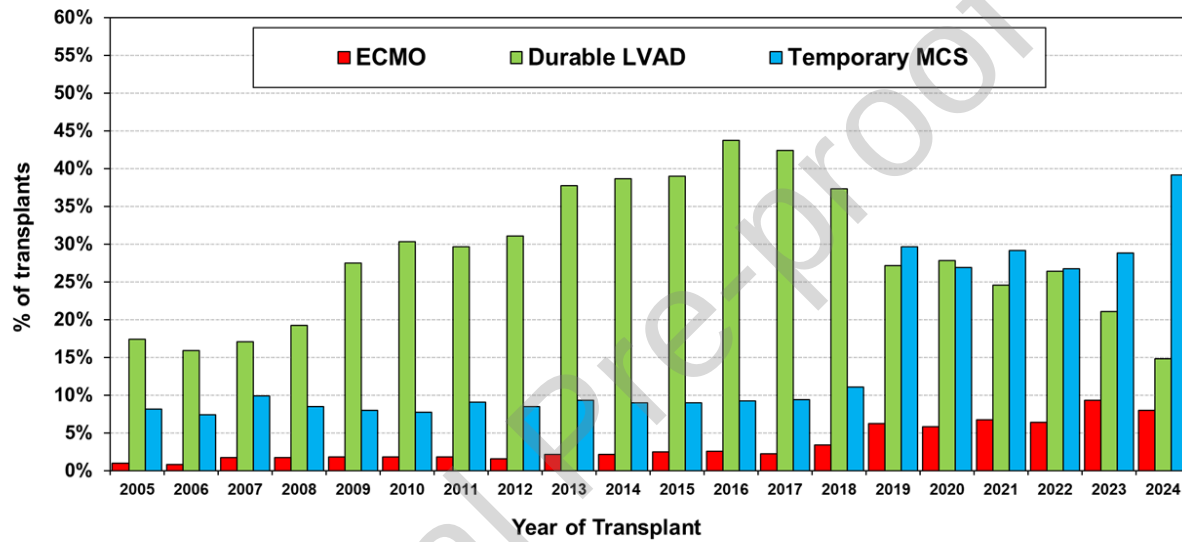


Figure 6: Percent of adult HT recipients on different types of MCS between 2005 and 2024, by year of transplant.

HT = heart transplant, ECMO = extracorporeal membrane oxygenation, LVAD = left ventricular assist device, MCS = mechanical circulatory support

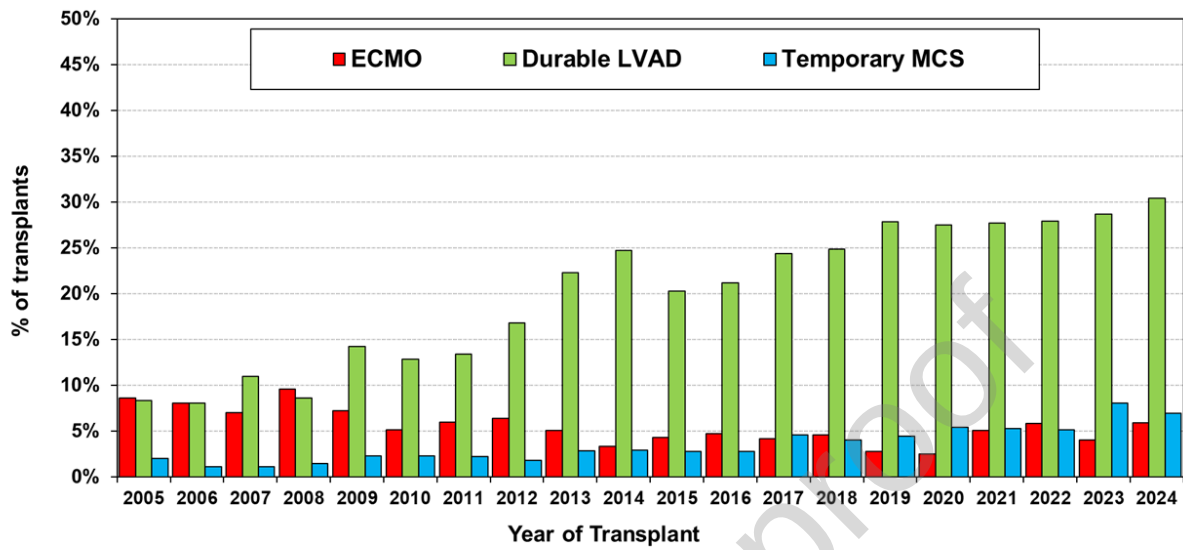


Figure 7: Percent of pediatric HT recipients on different types of MCS between 2005 and 2024, by year of transplant.

HT = heart transplant, ECMO = extracorporeal membrane oxygenation, LVAD = left ventricular assist device, MCS = mechanical circulatory support

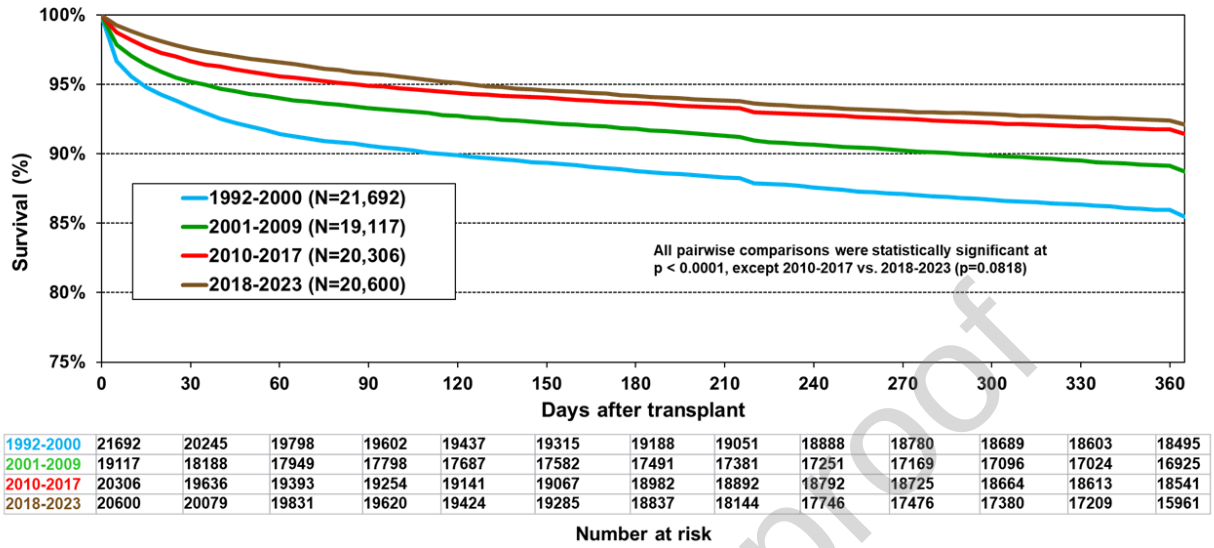


Figure 8: Post-transplant 1-year survival in adult HT recipients between 1992 and 2023, by era of transplant.

HT = heart transplant

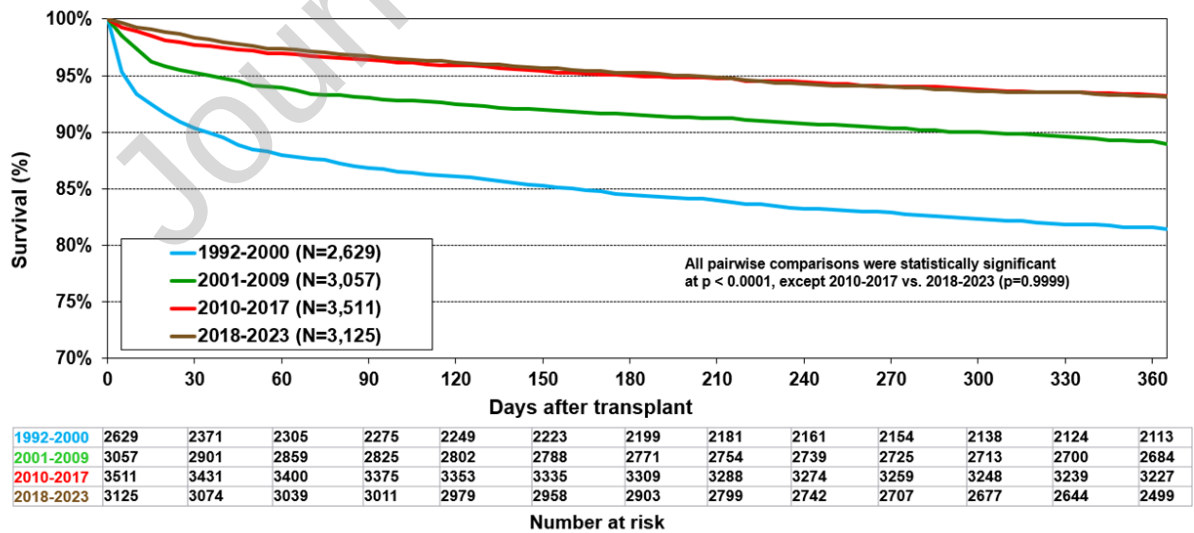


Figure 9: Post-transplant 1-year survival in pediatric HT recipients between 1992 and 2023, by era of transplant.

HT = heart transplant

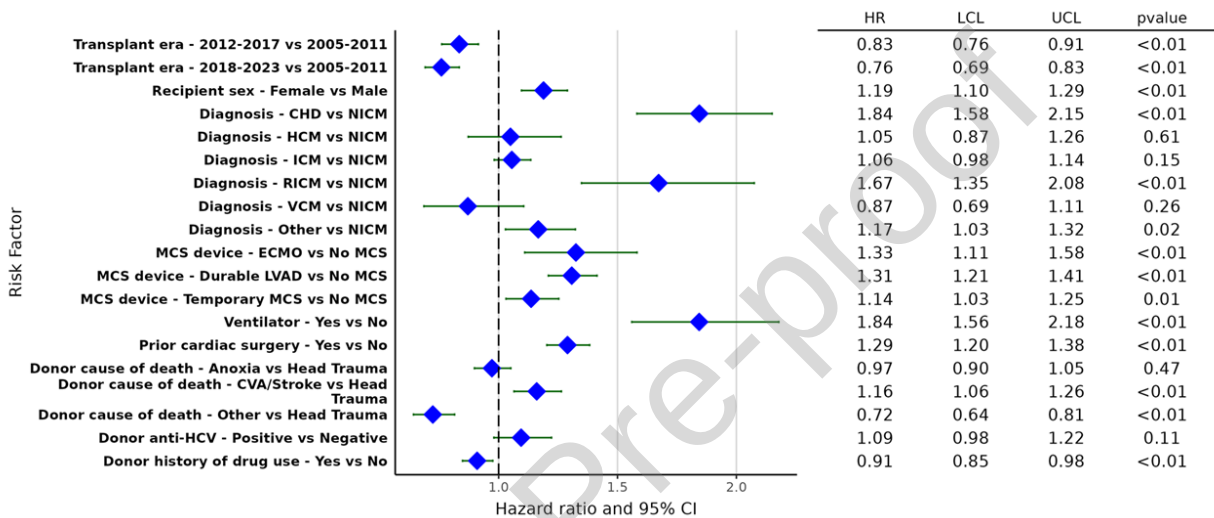


Figure 10: Categorical risk factors for post-transplant 1-year mortality in adult HT recipients between 2005 and 2023.

HT = heart transplant, CHD = congenital heart disease, NICM = non-ischemic cardiomyopathy, HCM = hypertrophic cardiomyopathy, RICM = restrictive cardiomyopathy, ECMO = extracorporeal membrane oxygenation, LVAD = left ventricular assist device, MCS = mechanical circulatory support, CVA = cerebrovascular accident

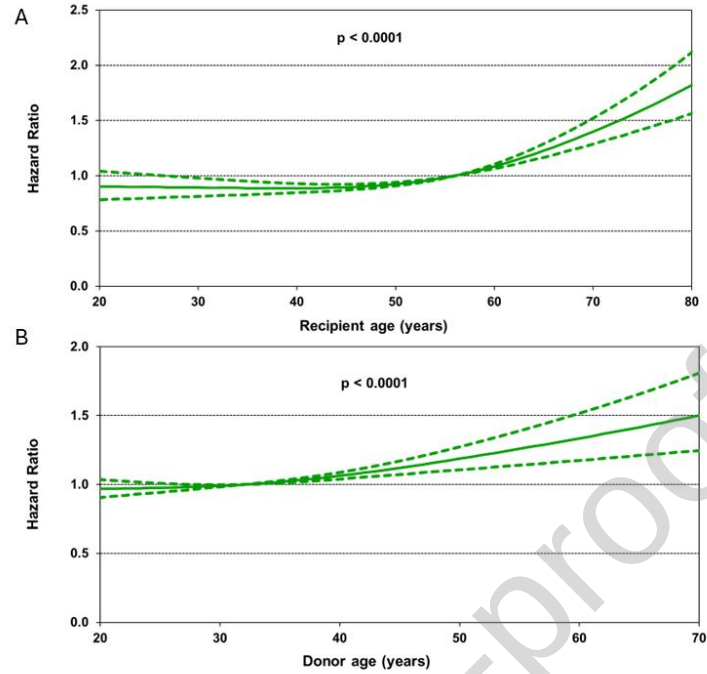


Figure 11: Adjusted association of (A) recipient age and (B) donor age with 1-year post-transplant mortality in adult HT recipients between 2005 and 2023.

HT = heart transplant

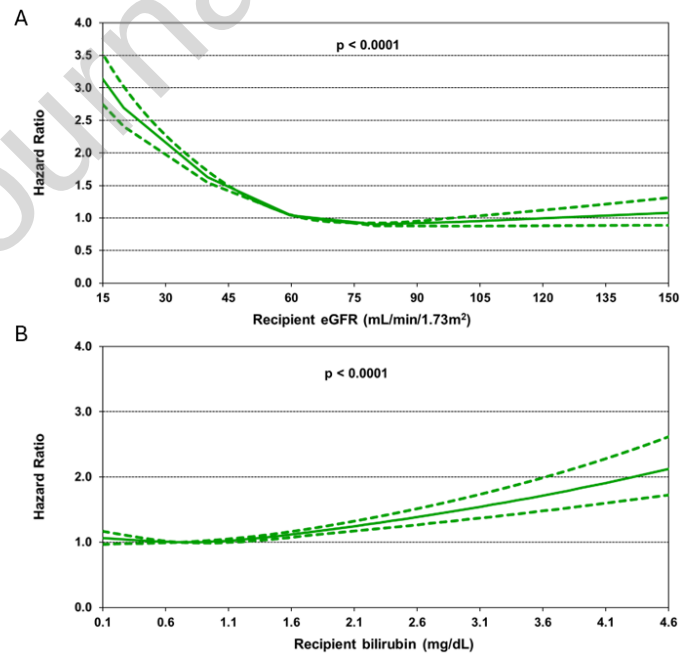


Figure 12: Adjusted association of (A) recipient eGFR and (B) bilirubin with 1-year post-transplant mortality in adult HT recipients between 2005 and 2023.

eGFR = estimated glomerular filtration rate, HT = heart transplant

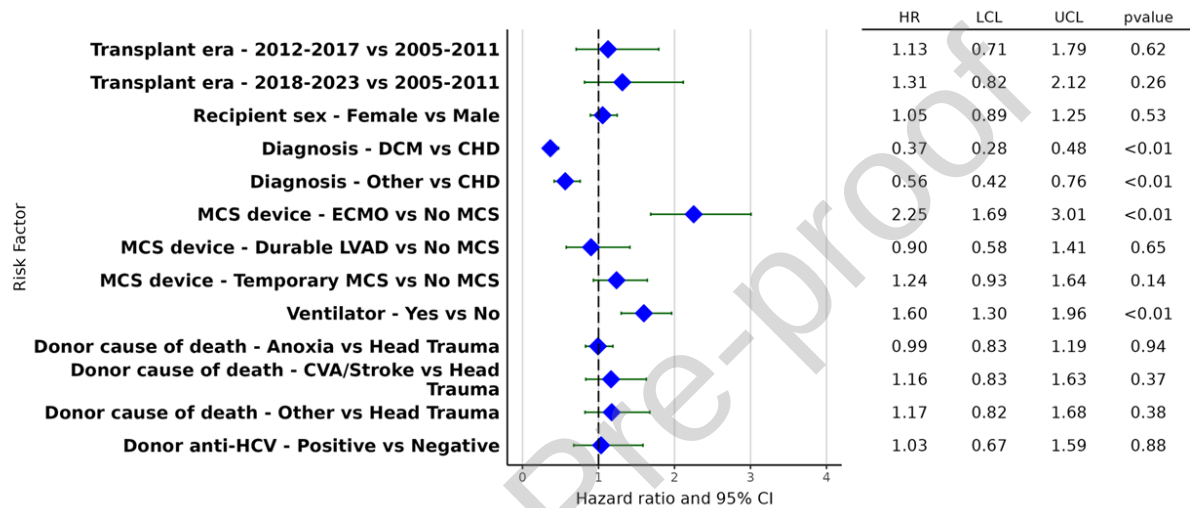


Figure 13: Categorical risk factors for post-transplant 1-year mortality in pediatric HT recipients between 2005 and 2023.

HT = heart transplant, CHD = congenital heart disease, DCM = dilated cardiomyopathy, ECMO = extracorporeal membrane oxygenation, MCS = mechanical circulatory support

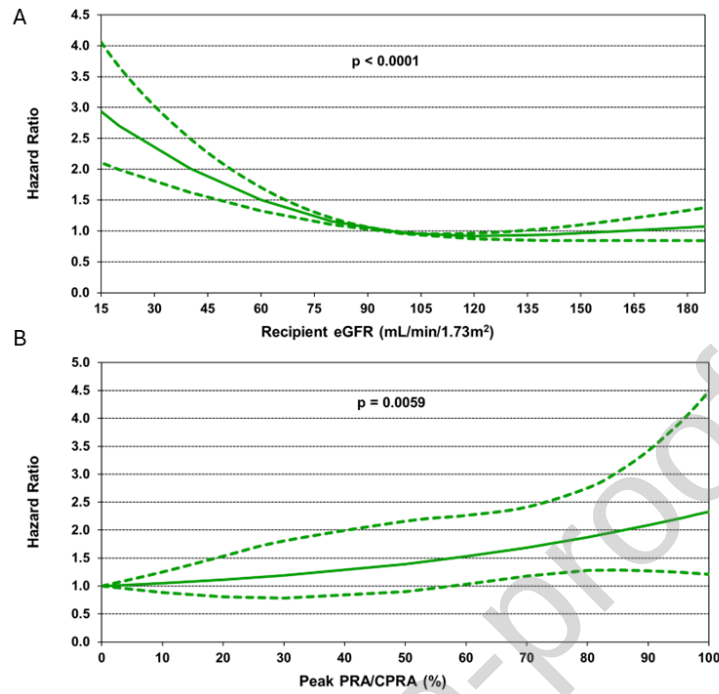


Figure 14: Adjusted association of (A) recipient eGFR and (B) peak PRA with 1-year post-transplant mortality in pediatric HT recipients between 2005 and 2023.

eGFR = estimated glomerular filtration rate, PRA = panel reactive antibody, CPRA = calculated panel reactive antibody, HT = heart transplant

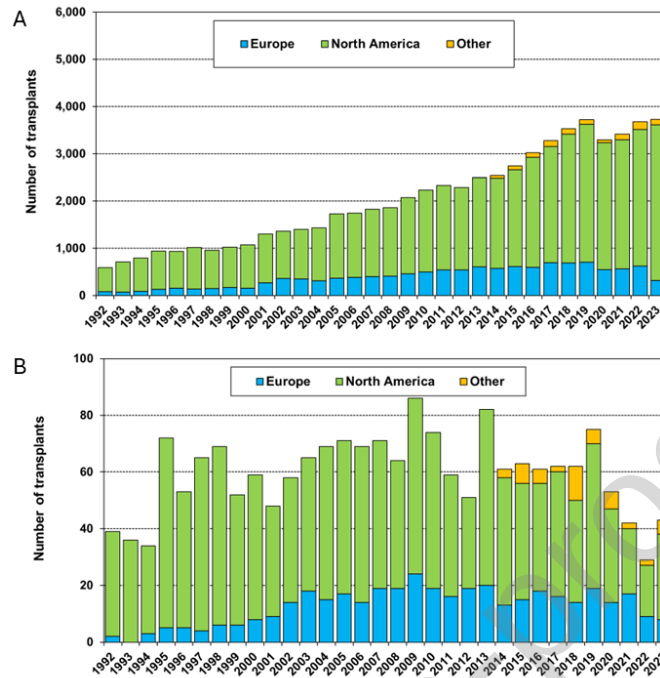


Figure 15: (A) Adult and (B) pediatric LT recipients between 1992 and 2023 reported in ISHLT

Registry, by year and location

LT = lung transplant

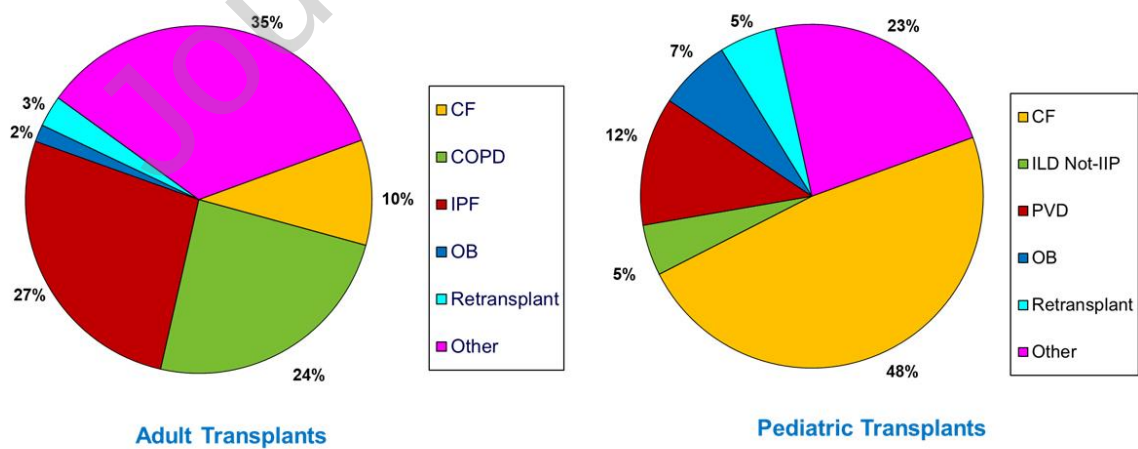


Figure 16: Underlying pulmonary diagnosis in adult and pediatric LT recipients between 1992 and 2024.

LT = lung transplant, CF= cystic fibrosis, COPD = chronic obstructive pulmonary disease, IPF = idiopathic pulmonary fibrosis, OB = obliterative bronchiolitis, ILD, not IIP = interstitial lung disease, not idiopathic interstitial pneumonia, PVD = pulmonary vascular disease

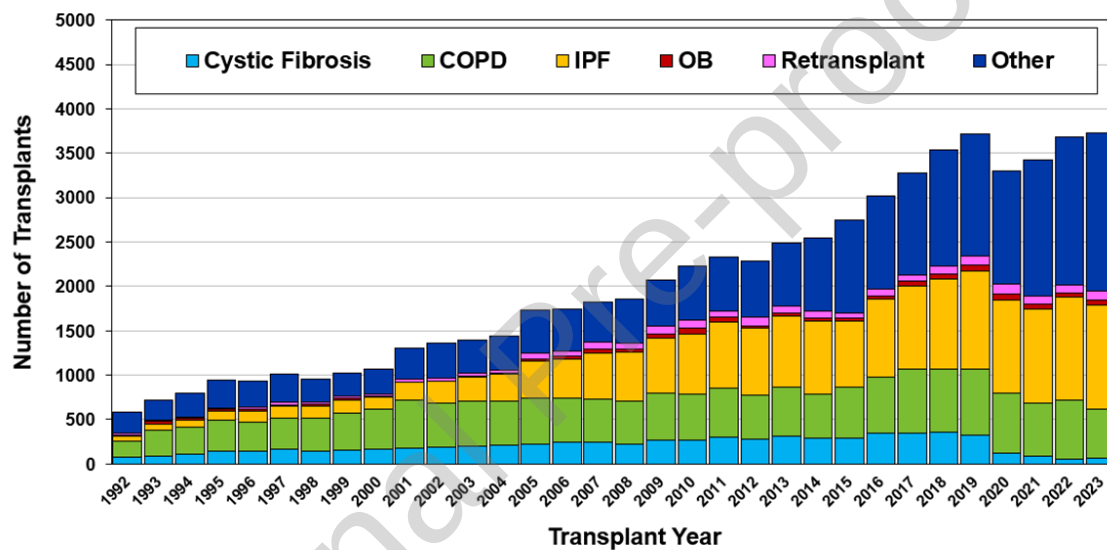


Figure 17: Pulmonary diagnosis in adult LT recipients between 1992 and 2023, by year of transplant

LT = lung transplant, COPD = chronic obstructive pulmonary disease, IPF = idiopathic pulmonary fibrosis, OB = obliterative bronchiolitis

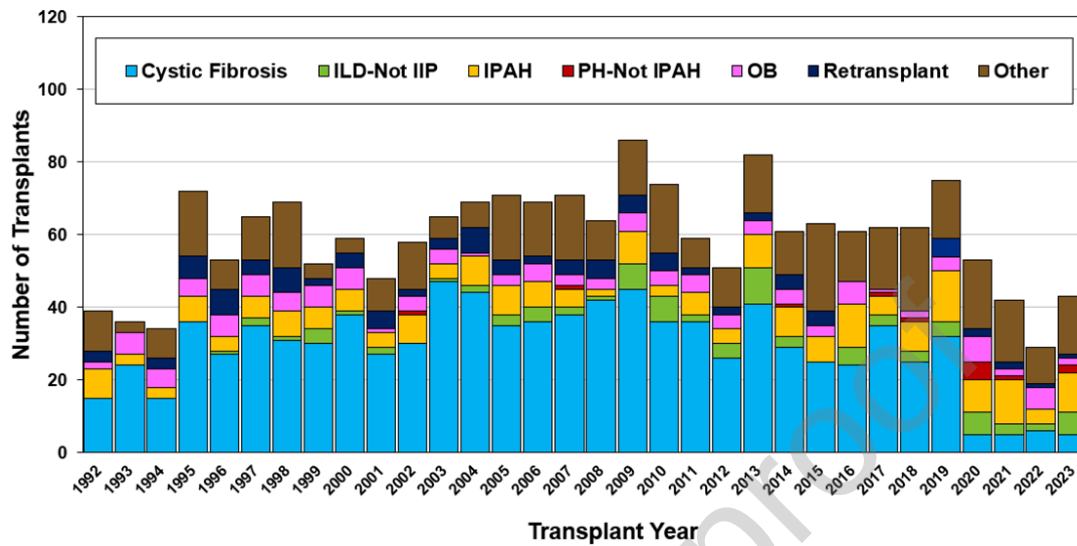


Figure 18: Pulmonary diagnosis in pediatric LT recipients between 1992 and 2023, by year of transplant.

LT = lung transplant, ILD, not IIP = interstitial lung disease, not idiopathic interstitial pneumonia, IPAH = idiopathic pulmonary artery hypertension, PH-not IPAH = pulmonary hypertension, not idiopathic pulmonary artery hypertension, OB = obliterative bronchiolitis

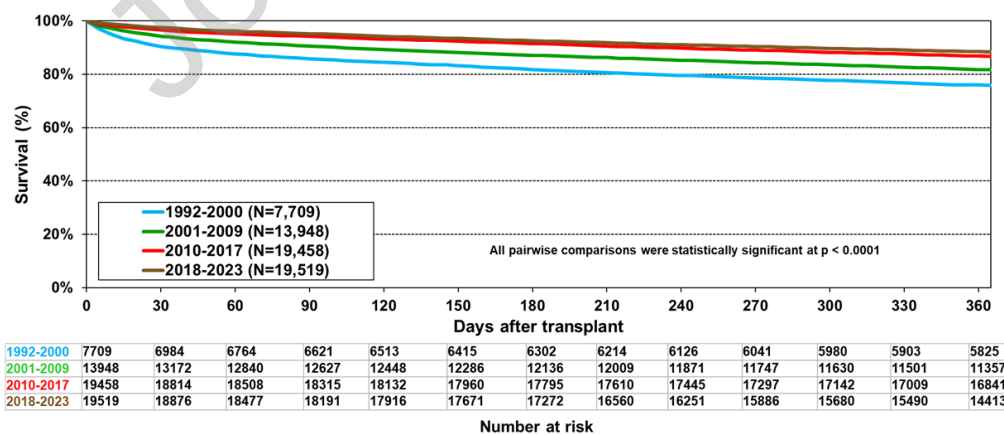


Figure 19: Post-transplant 1-year survival in adult LT recipients between 1992 and 2023, by era of transplant.

LT = lung transplant

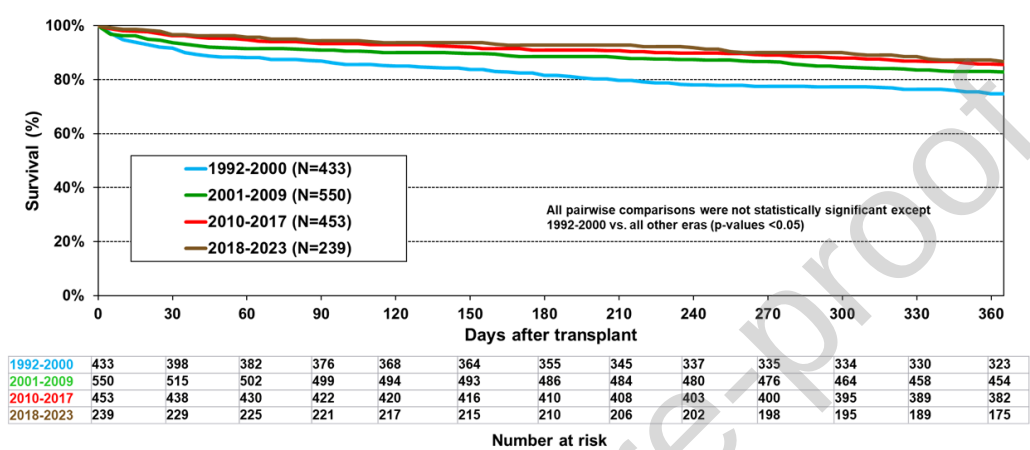


Figure 20: Post-transplant 1-year survival in pediatric LT recipients between 1992 and 2023, by era of transplant.

LT = lung transplant

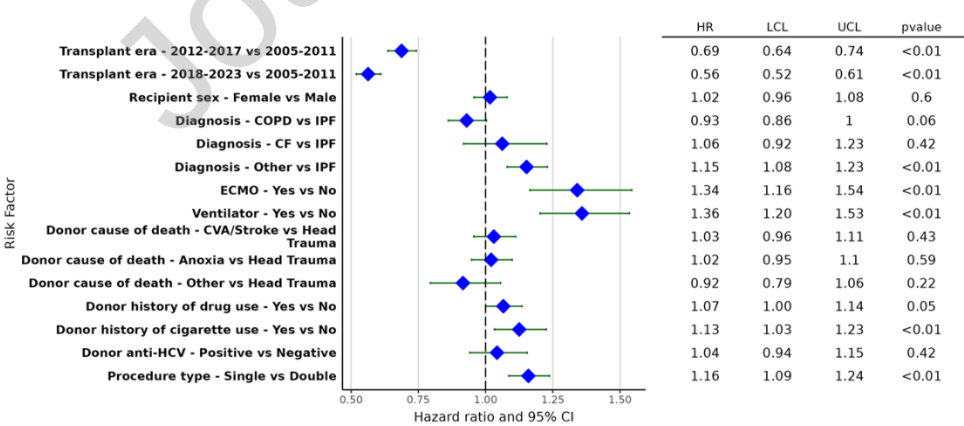


Figure 21: Categorical risk factors for 1-year post-transplant mortality in adult LT recipients between 2005 and 2023.

LT = lung transplant, IPF = idiopathic pulmonary fibrosis, ECMO = extracorporeal membrane oxygenation

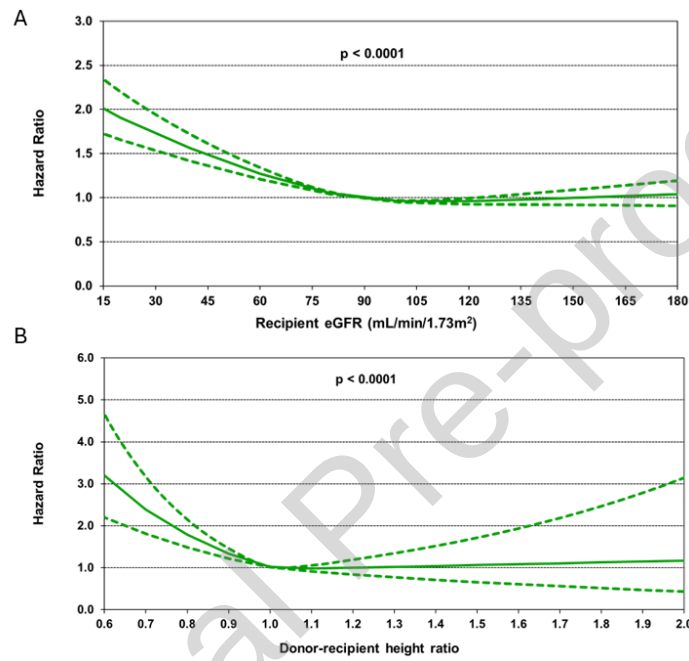


Figure 22: Adjusted association of (A) recipient eGFR and (B) donor-recipient height ratio with 1-year post-transplant mortality in adult LT recipients between 2005 and 2023.

eGFR = estimated glomerular filtration rate, LT = lung transplant

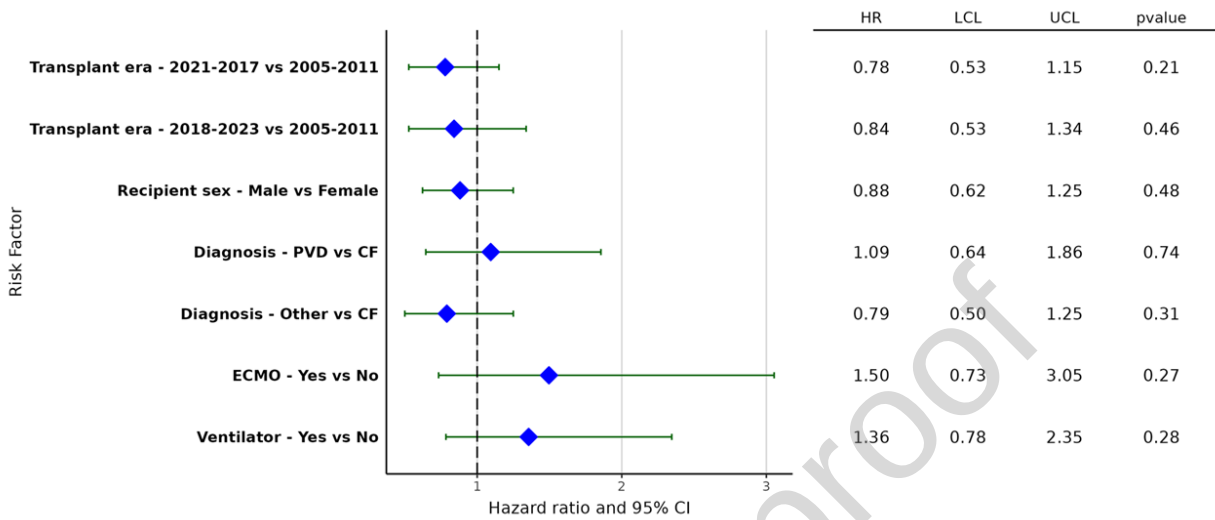


Figure 23: Categorical risk factors for post-transplant 1-year mortality in pediatric LT recipients between 2005 and 2023.

LT = lung transplant, PVD = pulmonary vascular disease, CF = cystic fibrosis, ECMO = extracorporeal membrane oxygenation

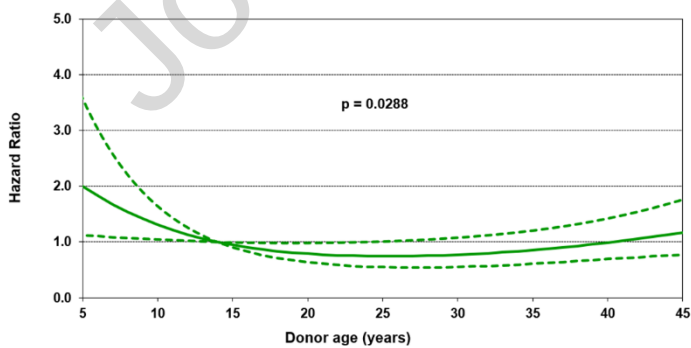


Figure 24: Adjusted association of donor age with 1-year post-transplant mortality in pediatric LT recipients between 2005 and 2023.

LT = lung transplant

Table Legends

Table 1: Select baseline characteristics of adult and pediatric heart transplant recipients between 1992 and 2004 (e-slides 11, 12, 13). ECMO = extra corporeal membrane oxygenation, DCD = donation after circulatory death, BMI = body mass index, eGFR = estimated glomerular filtration rate, PVR = pulmonary vascular resistance, HCV = hepatitis C virus, NAT = nucleic acid test, LV = left ventricle

Table 2: Select baseline characteristics of adult and pediatric lung transplant recipients performed between 1992 and 2004 (e-slides 52, 53, 54). DCD = donation after circulatory death, BMI = body mass index, ECMO = extra corporeal membrane oxygenation, eGFR = estimated glomerular filtration rate, PVR = pulmonary vascular resistance, HCV = hepatitis C virus, NAT = nucleic acid test, LV = left ventricle

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Table 1. Select baseline characteristics for adult and pediatric heart transplants performed between 1992 and 2024

	Adult Heart (N = 98176)	Pediatric Heart (N = 14357)
Transplant Variables		
Geographic location		
Europe	17.0%	15.2%
North America	78.2%	81.6%
Other	4.8%	3.2%
Transplant era		
1992-2000	23.8%	20.0%
2001-2009	21.5%	23.7%
2010-2017	24.3%	27.6%
2018-2024	30.3%	28.7%

	Adult Heart (N = 98176)	Pediatric Heart (N = 14357)
DCD transplant	2.4%	0.4%
Multiorgan transplant	4.5%	0.7%
Total organ preservation time (hours)	3.2 (1.5 - 5.1)	3.6 (1.7 - 5.6)
Recipient Variables		
Age at transplant (years)	55.0 (26.0 - 68.0)	6.0 (0.1 - 17.0)
Male sex	75.3%	55.6%
BMI (kg/m ²)	26.2 (19.4 - 35.0)	16.6 (12.4 - 27.8)
Previous transplant	2.8%	4.9%
Prior cardiac surgery (non-transplant)	44.2%	N/A
Pre-transplant ventilator	3.2%	16.5%
Total bilirubin (mg/dl)	0.7 (0.2 - 2.6)	0.6 (0.2 - 3.9)
eGFR (mL/min/1.73 m ²) ¹	60.3 (30.1 - 102.1)	88.9 (32.9 - 173.5)
Pulmonary vascular resistance (Woods unit)	2.1 (0.6 - 5.4)	2.6 (0.6 - 13.1)
Donor Variables		
Age (years)	32.0 (16.0 - 54.0)	8.0 (0.0 - 34.0)
Male sex	70.3%	58.4%
History of diabetes	3.1%	1.0%
History of hypertension	13.7%	1.6%
History of drug use	54.3%	15.1%
Anti-HCV positive	8.7%	5.0%
HCV NAT positive	4.9%	0.0%
Left ventricular ejection fraction (%)	60.0 (50.0 - 75.0)	65.0 (50.0 - 77.0)
Donor-recipient PHM difference (%) ²	0.9 (-22.6 - 37.7)	N/A
Donor-recipient weight ratio	N/A	1.3 (0.8 - 2.5)

Abbreviations: DCD, donation after circulatory death; ECMO, extracorporeal membrane oxygenation; BMI, body mass index; eGFR, estimated glomerular filtration rate; PHM, predicted heart match

Summary statistics included transplants with non-missing data

Categorical variables are expressed as percentages

Continuous factors are expressed as median (5th – 95th percentiles)

¹ GFR was estimated using the CKD-EPI formula for adults and modified Schwartz formula for pediatrics

² PHM difference was calculated as [(donor heart mass – recipient heart mass)/recipient heart mass]*100

Table 2. Select baseline characteristics for adult and pediatric lung transplants performed between 1992 and 2024

	Adult Lung (N = 67861)	Pediatric Lung (N = 1925)
Transplant Variables		
Geographic location		
Europe	18.8%	21.2%
North America	79.5%	76.0%
Other	1.7%	2.8%
Transplant era		
1992-2000	11.9%	24.9%
2001-2009	21.7%	31.2%
2010-2017	30.8%	26.6%
2018-2024	35.6%	17.2%
Donation after circulatory death	5.2%	1.5%
Multiorgan transplant	2.6%	4.6%
Procedure type		
Double	68.1%	97.5%
Single	31.9%	2.5%
Total organ preservation time (hours)	5.3 (2.7 - 10.5)	5.4 (1.8 - 7.9)
Recipient Variables		
Age at transplant (years)	58.0 (26.0 - 70.0)	14.0 (0.6 - 17.0)
Male sex	58.0%	42.2%
BMI (kg/m ²)	24.9 (17.5 - 32.4)	16.9 (13.1 - 24.2)
Previous transplant	3.4%	5.8%
Pre-transplant ECMO	4.0%	5.4%
Pre-transplant ventilator	5.2%	17.9%
Pre-transplant intravenous inotropes	0.1%	4.9%
Total bilirubin (mg/dl)	0.5 (0.2 - 1.3)	0.4 (0.1 - 2.1)
eGFR (mL/min/1.73 m ²) ¹	86.5 (52.5 - 140.6)	124.7 (56.8 - 227.2)

	Adult Lung (N = 67861)	Pediatric Lung (N = 1925)
Transplant Variables		
Pulmonary vascular resistance (Woods units)	2.7 (1.0 - 8.7)	4.8 (1.7 - 32.4)
FVC% predicted	48.0 (25.0 - 85.0)	41.0 (18.0 - 86.0)
FeV1 (%)	34.0 (14.0 - 80.0)	26.0 (13.0 - 81.0)
Donor Variables		
Age (years)	36.0 (16.0 - 62.0)	14.0 (0.0 - 49.0)
Male sex	58.7%	49.4%
Male donor to female recipient	15.7%	26.7%
History of diabetes	7.0%	1.9%
History of hypertension	22.2%	4.7%
History of drug use	44.8%	16.6%
History of cigarette use	14.5%	4.2%
Anti-HCV positive	8.7%	6.5%
HCV NAT positive	2.8%	0.0%
PO2 (mm/Hg)	420.0 (63.3 - 571.0)	434.0 (81.4 - 575.0)
pO2/FiO2 ratio	438.0 (168.8 - 584.5)	451.0 (201.0 - 586.0)
Left ventricular ejection fraction (%)	60.0 (34.0 - 73.0)	60.0 (35.0 - 77.0)
Donor-recipient height ratio	1.0 (0.9 - 1.1)	1.0 (0.9 - 1.2)

Abbreviations: ECMO, extracorporeal membrane oxygenation; BMI, body mass index; eGFR, estimated glomerular filtration rate

Summary statistics included transplants with non-missing data

Categorical variables are expressed as percentages

Continuous factors are expressed as median (5th – 95th percentiles)

¹eGFR was estimated using the CKD-EPI formula for adults and modified Schwartz formula for pediatrics