

# Transplantation Proceedings and Research

## Research Article

# Impact of COVID-19 Pandemic on Numbers and Characteristics of Liver Transplantations

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## Abstract

The purpose of the study is to provide a comprehensive overview of the liver donation and transplantation activity in Poland highlighting the impact of COVID-19 pandemic.

Reported data is based on the national transplant registries maintained by Polish Transplant Coordinating Centre Poltransplant: the national waiting list (indications) and transplantation registry (numbers of transplantations and results). This review compares the activity, characteristics of recipients and early (3-month) results of liver transplants from deceased and living donors during COVID-19 era (2020-2021) to the pre-pandemic periods (2018-2019 and 2012-2017, 2001-2011) and the long-term period (2001-2021).

In the COVID-19 era the number of hepatic transplants from deceased donors distinctly decreased (12%), but the number of transplanted livers to pediatric recipients that remained stable. The indications for the liver transplantation (LT) have

not changed significantly, except the incidence of liver cirrhosis as an indication for the primary LT in pediatric recipients and the incidence of primary non-function (PNF) as an indication for the reLT in adult recipients. In COVID-19 era the retransplantation status has also changed. The number of urgent cases decreased. Early liver transplant results have not changed.

This overview indicates that the COVID-19 pandemic affected liver transplant programs in Poland. The number of liver transplantations from deceased donors in adult and pediatric recipients decreased. The total number of liver transplantations to pediatric recipients was stable. Early liver transplantation results have not changed and the indications for liver transplantation remained largely the same as in previous years.

**Keywords:** liver transplantation, COVID-19, registries

## Introduction

Liver transplantation (LT) is a life-saving procedure for patients with acute and chronic liver failure. More than 200000 liver transplants were already performed worldwide. According to Global Report (<https://www.transplant-observatory.org/2021-global-report-5/> accessed on 30.12.2023), only in 2021, 34 694 liver grafts were transplanted in 68 countries. In Poland, between 1987 and 2024, 6614 liver transplants were performed: 6128 from deceased donors (DD), 486 from living donors (LD) and 80 livers were transplanted simultaneously with kidney, 7 with heart, 1 with lung and 1 with pancreas ([https://files.poltransplant.org.pl/Biuletyn\\_2024\\_www.pdf?utm\\_source=Poltransplant&utm\\_medium=biuletyn&utm\\_campaign=Biuletyn+Informacyjny+Poltransplantu+2024](https://files.poltransplant.org.pl/Biuletyn_2024_www.pdf?utm_source=Poltransplant&utm_medium=biuletyn&utm_campaign=Biuletyn+Informacyjny+Poltransplantu+2024) accessed on 22.12.2024). Simultaneous liver-kidney transplants have been performed in Poland for 24 years (since 2000), however the first simultaneous liver-pancreas transplantation was performed during the COVID-19 pandemic (in 2021). The paper provides a comprehensive overview of the impact of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and COVID-19 pandemic on adult and pediatric liver transplantation programs in Poland. According to the International Registry in Organ Donation and Transplantation (IRO-DaT, <https://www.irodat.org> accessed on 30.12.2023) in 2021 in Poland with the number of 273 liver transplants, which was the lowest in the last decade, the rate of liver transplantation from deceased donors was 7.4 pmp, that statistically ranked Poland on 28th place out of 62 countries (max. USA - 26.18 pmp, min. Dominican Republic - 0.1 pmp). The rate 0.52 pmp from living donors (n=20) ranked Poland on 30th out of 50 countries (max. South Korea - 22.42 pmp, min. Spain - 0.02 pmp). However, according to the national transplant registries, in the next year the number of hepatic transplants from deceased donors in Poland increased by 20%, so the rate of total liver transplants increased from 7.86 pmp in 2021 to 9.6 pmp in 2022. According to Global Report (<https://www.transplant-observatory.org/summary/> accessed on 30.12.2023), in 2022 the European rate was 14.22 pmp and global rate was 6.28 pmp. It is worth to emphasize, that in 2023 in Poland the total number of liver transplants increased to 523,

and further increased in 2024, reaching the highest historical level - 562 ([http://www.poltransplant.org.pl/statystyka\\_2024.html#gsc.tab=0](http://www.poltransplant.org.pl/statystyka_2024.html#gsc.tab=0) accessed on 22.12.2024).

## Material and Methods

Comparative analysis of retrospective data regarding liver donation from deceased and living donors as well as liver transplantation to adult and pediatric recipients is based on the national transplant registries maintained by the Polish Transplant Coordinating Centre Poltransplant: the national waiting list (indications) and transplant register (numbers of liver retrieval and transplantation procedures and its results). Gathered data are presented in tables according to selected variables that are significant empirical indicators of the efficiency of transplant programs and provide essential information for national and international benchmarking.

This review compares the activity (average annual number of transplantations), characteristics of recipients (according to indications for transplantation) and early (3-month) results of liver transplants from deceased and living donors. The calculated and analyzed indicators are given as follows: during the pre-pandemic two-year period (2018-2019), in the COVID-19 pandemic two-year period (2020-2021) and in the long-term period (2001- 2021). However, in order to present the broader overview and possible trends, additional pre-pandemic periods: 2001-2011 and 2012-2017 are also provided.

## Results

### **General data on liver donation and transplantation in Poland**

#### **Liver donors and recipients**

The total number of liver transplants in Poland during the COVID-19 pandemic (2020-2021) was 588. It was a 12% decrease comparing to the activity (668 transplants) in the two years before the pandemic (2018-2019), but still more than in the long-term period (average 266 transplantations per year in years 2001-2021). The decrease in the number of transplants affected adult recipients (520 vs. 603 trans-

plants) and was due to the lower number of utilised deceased donors of this organ. However, the number of transplants in children, despite a 9% decrease of deceased donors rate, remained at similar level (68 vs. 65), which was due to the 12% increase in the activity of living donor liver transplantation (LDLT) program (48 vs. 43).

#### **Primary liver transplantation and liver retransplantation**

During pandemic, liver retransplantation (reLT) amounted 6% of all 588 LT procedures performed. This rate was the lowest comparing to the pre-pandemic period (8%) and long-term period 2001-2021 (7%) (Table 1).

In most cases (57) of the liver retransplantation in pediatric recipients (64 reLT in 21 years), liver grafts were retrieved from deceased donors. During pandemic there were one reLT performed in pediatric recipient, but the liver was harvested from a living donor.

Detailed data and indications for reLT in adult and pediatric recipients are presented in further sections of the paper.

#### **Early liver transplantation results**

The early (3-month survival rate of recipients with functioning transplants) results of liver transplantation according to the type of donors (deceased, living), the age of the recipients (adult, pediatric) and type of LT (primary or reLT) are presented in (Table 2). The best transplantation results were achieved in the following profiles:

- Primary transplants of liver fragments from living donors to pediatric recipients (the 3-month survival rate was 92%);
- Primary transplants of livers harvested from deceased donors transplanted to pediatric recipients (3-month survival rate was 90%);
- Primary transplantation of livers retrieved from deceased donors transplanted to adult recipients (3-month survival rate was 88%).

#### **Adult recipients**

##### **Numbers and characteristics of primary liver transplantation**

The indications for first-time elective liver transplantation in adult recipients did not change substantially during the pandemic period (Table 3). Cirrhosis of various etiologies was the most frequent indication (64%), as in the long-term period (66%). The changes in etiology of cirrhosis are presented in (Table 4). In the long-term period alcoholic liver disease (ALD) and hepatitis C virus have been most common etiologies of the liver cirrhosis (26% and 22%, respectively). Nevertheless, during the pandemic the rate of alcoholic liver cirrhosis has increased (42%).

In all analyzed periods: the pre-pandemic, the pandemic and the long-term period 2001 - 2021, 15% of all indications for first-time liver transplantation in adult recipients were hepatocellular carcinoma (HCC) (Table 5). In the COVID-19 era, however, for the first time since 2001, an increase in the

number of primary transplants for HCC developed in non-cirrhotic livers and a decrease in the number of transplants due to HCC located in the cirrhotic liver were observed. Other than HCC, primary or secondary liver cancers, both in the pandemic period and the long-term period, accounted for 9% of the performed transplants in the group of cancer indications and 2% of all indications.

During the pandemic period an acute liver failure of various etiologies was a less frequent (3%) indication for primary liver transplantation in adult recipients comparing to pre-pandemic period (5%) and the long-term period (4%) (Table 6).

The predominant indications were paracetamol or other drugs overdose and unrecognised causes (31%) as well as liver injuries (19%).

##### **Numbers and characteristics of liver re-transplantation**

In pandemic period most (57%) of the reLT procedures were performed in patients awaiting elective liver transplantation. The number of liver retransplantations in urgent cases was lower (43%) comparing to pre-pandemic and the long-term periods (59%).

The most common indications for retransplantation during the pandemic period in adult recipients were vascular complications (43%) and recurrence of non-cancerous primary liver disease (23%) (Table 7). The proportion of these indications for retransplantation was most likely similar in the long-term period 2001-2021, but there is a level of uncertainty, due to the unreported data in the 2001-2017 period. The incidence of primary non-function (PNF) as an indication for the reLT in adult recipients was found as a significant difference ( $p=0.03$ ).

#### **Pediatric recipients**

##### **Numbers and characteristics of primary liver transplantation**

The most common indications for elective treatment with primary liver transplantation (whole organ or part of it in the case of living donors) in pediatric recipients during the pandemic period were congenital biliary atresia (51% of all transplants), cirrhosis (13%), primary (non-HCC) liver tumors (10%) and metabolic diseases (9%) (Table 8). These rates over the past 20 years of liver transplantation in children were respectively: atresia - 41%, cirrhosis - 10%, primary (other than HCC) liver tumors - 7% (mainly hepatoblastoma) and metabolic diseases - 11% (most commonly Wilson's disease, alpha-1 – antitrypsin deficiency, cystic fibrosis) (Table 9).

Donor type	Recipient	2001 – 2011			2012 – 2017			2018 – 2019			2020 – 2021			2001-2021		
		LT+reLT	reLT	%	LT+reLT	reLT	%	LT+reLT	reLT	%	LT+reLT	reLT	%	LT+reLT	reLT	%
Deceased donor	Adults	1829	85	5	1857	143	8	603	49	8	520	35	7	4809	312	6
	Pediatric	238	41	17	86	13	15	22	3	14	20	0	0	366	57	16
Living donor	Pediatric	188	2	1	136	3	2	43	1	2	48	1	2	415	7	2
<b>Total</b>		<b>2255</b>	<b>128</b>	<b>6</b>	<b>2079</b>	<b>159</b>	<b>8</b>	<b>668</b>	<b>53</b>	<b>8</b>	<b>588</b>	<b>36</b>	<b>6</b>	<b>5590</b>	<b>376</b>	<b>7</b>

Table 1: Liver retransplantation in adult and pediatric recipients

	2001 – 2011		2012 – 2017		2018 – 2019		2020 – 2021		2001-2021	
	Recipients with functioning liver graft/all LT	%	Recipients with functioning liver graft/all LT	%	Recipients with functioning liver graft/all LT	%	Recipients with functioning liver graft/all LT	%	Recipients with functioning liver graft/all LT	%
Deceased donors										
All recipients/all LT	1749/2167	81	1714/1943	88	539/625	86	491/540	91	4493/5175	87
Adult recipients/all LT	1545/1929	80	1636/1857	88	519/603	86	471/520	91	4171/4808	87
Adult recipients/ primary LT	1488/1844	81	1536/1714	90	486/554	88	444/485	92	3954/4497	88
Adult recipients/ reLT	57/85	67	100/143	70	33/49	67	27/35	77	217/312	70
Pediatric recipients/all LT	204/238	86	78/86	91	20/22	91	20/20	100	322/366	88
Pediatric recipients/primary LT	174/197	88	66/73	90	17/19	89	20/20	100	277/309	90
Pediatric recipients/reLT	30/41	73	12/13	92	3/3	100	–	–	45/57	79
All recipients/primary LT	1662/2041	81	1602/1787	90	503/ 573	88	464/505	92	4231/4806	88
All recipients, reLT	87/126	69	112/156	72	36/52	69	27/35	77	262/369	71
Living donors										
Pediatric recipients/all LT	169/188	90	129/136	95	39/43	91	42/48	88	379/415	91
Pediatric recipients/primary LT	168/186	90	126/133	95	39/42	93	42/47	89	375/408	92
Pediatric recipients/ reLT	1/2	50	3/3	100	0/1	–	0/1	–	4/7	57

Table 2: Early (3-month) results of liver transplantation (LT) according to the type of donors (deceased, living), the age of the recipients (adult, pediatric) and type of transplantation (primary or retransplantation)

Indication	2001 – 2011	2012 – 2017	2018 – 2019	2020 – 2021	2001 – 2021
	n (%)				
Cirrhosis	984 (56)	841 (49)	276 (50)	251 (52)	2352 (52)
Cholestatic liver diseases	275 (16)	233 (14)	94 (17)	72 (15)	674 (15)
HCC in cirrhotic liver	79 (5)	329 (19)	66 (12)	50 (10)	524 (12)
Metabolic liver diseases	93 (5)	49 (3)	27 (5)	28 (6)	197 (4)
Acute liver failure	82 (5)	61 (4)	25 (5)	16 (3)	184 (4)
HCC* in non-cirrhotic liver	37 (2)	40 (2)	16 (3)	26 (5)	119 (3)
Viral cirrhosis and ALD**	34 (2)	51 (3)	9 (2)	11 (2)	105 (2)
Other or unidentified liver diseases	60 (3)	27 (2)	2 (0.4)	3 (1)	92 (2)
Budd–Chiari Syndrome	38 (2)	26 (2)	7 (1)	7 (1)	78 (2)
Benign liver tumors	20 (1)	15 (1)	14 (3)	7 (1)	56 (1)
Primary liver tumors (HCC excluded)	13 (1)	16 (1)	7 (1)	3 (1)	39 (1)
Parasitic liver diseases	15 (1)	15 (1)	3 (1)	5 (1)	38 (1)
Secondary liver tumors	10 (1)	6 (0)	4 (1)	4 (1)	24 (1)
Congenital biliary diseases	4 (0)	5 (0)	4 (1)	2 (0.4)	15 (0.3)
<b>Total</b>	<b>1744</b>	<b>1714</b>	<b>554</b>	<b>485</b>	<b>4497</b>

**Table 3:** Indications for primary liver transplantation in adult recipients

Indication	2001 – 2011	2012 – 2017	2018 – 2019	2020 – 2021	2001 – 2021	
	n (%)	% of liver transplants				
ALD	258 (24)	267 (22)	131 (37)	130 (42)	786 (26)	17
HCV*	351 (32)	226 (19)	36 (10)	31 (10)	644 (22)	14
HCC in cirrhotic liver	79 (7)	329 (27)	66 (19)	50 (16)	524 (18)	12
AIH**	129 (12)	127 (10)	46 (13)	34 (11)	346 (12)	8
HBV***	118 (11)	81 (7)	24 (7)	22 (7)	245 (8)	5
Other or unidentified	87 (8)	65 (5)	34 (10)	26 (8)	212 (7)	5
HCV/HBV	41 (4)	75 (6)	5 (1)	8 (3)	129 (4)	3
Viral liver cirrhosis and ALD	34 (3)	51 (4)	9 (3)	11 (4)	105 (4)	2
<b>Total</b>	<b>1097</b>	<b>1221</b>	<b>351</b>	<b>312</b>	<b>2981</b>	<b>66</b>

\*HCV - cirrhosis caused by hepatitis C virus

\*\*AIH - Autoimmune hepatitis

\*\*\*HBV - cirrhosis of the liver caused by the hepatitis B virus

**Table 4:** Etiology of cirrhosis – the most common indication for elective, primary liver transplantations

Indication	2001 – 2011	2012 – 2017	2018 – 2019	2020 – 2021	2001 – 2021	
	n (%)	% of LT				
HCC in cirrhotic liver	79 (57)	329 (86)	66 (71)	50 (60)	524 (74)	12%

HCC in non-cirrhotic liver	37 (27)	40 (10)	16 (17)	26 (31)	119 (17)	3%
Primary liver tumors (excluding HCC)	13 (9)	16 (4)	7 (8)	3 (4)	39 (6)	1%
Secondary liver tumors	10 (7)	6 (2)	4 (4)	4 (5)	24 (3)	1%
<b>Total</b>	<b>139</b>	<b>391</b>	<b>93</b>	<b>83</b>	<b>706</b>	<b>17%</b>

**Table 5:** Tumor as an indication for liver transplantation in adult recipients

Indication	2001 – 2011	2012 – 2017	2018 – 2019	2020 – 2021	2001 – 2021
	n (%)				
Other or unidentified	28 (34)	18 (30)	9 (36)	5 (31)	60 (33)
Mushroom (toadstool) poisoning	23 (28)	13 (21)	1 (4)	1 (6)	38 (21)
Paracetamol or other drugs overdose	9 (11)	14 (23)	4 (16)	5 (31)	32 (18)
HBV	3 (4)	7 (11)	3 (12)	1 (6)	14 (8)
AIH	1 (1)	4 (7)	4 (16)	1 (6)	10 (5)
Liver injury	3 (4)	3 (5)	1 (4)	3 (19)	10 (5)
Wilson's disease	8 (10)	1 (2)	1 (4)	–	10 (5)
HCV	4 (5)	–	2 (8)	–	6 (3)
Budd – Chiari syndrome (BCS)	1 (1)	1 (2)	–	–	2 (1)
HAV*	1 (1)	–	–	–	1 (1)
PSC**	1 (1)	–	–	–	1 (1)
Acute liver failure (total)	82	61	25	16	184

\*HAV - liver cirrhosis caused by hepatitis A virus infection

\*\*PSC – Primary sclerosing cholangitis

**Table 6:** Primary liver transplantation in acute liver failure in adult recipients

Indication	2001 – 2011	2012 – 2017	2018 – 2019	2020 – 2021	2001 – 2021
	n (%)				
No information available; Cause unidentified	85 (100)	124 (87)	5 (10)	1 (3)	215 (69)
Vascular complications	–	–	19 (39)	15 (43)	34 (11)
Relapse of the primary liver disease (neoplasms excluded)	–	8 (5)	6 (12)	8 (23)	22 (7)
Biliary complications	–	10 (7)	5 (10)	2 (6)	17 (5)
Primary nonfunction (PNF)	–	–	1 (2)	5 (14)*	6 (2)
Septic complications	–	1 (<1)	1 (2)	2 (6)	4 (1)
Chronic graft rejection	–	–	2 (4)	1 (3)	3 (10)
Cancer relapse	–	–	–	1 (3)	1 (<1)
<b>Total</b>	<b>85</b>	<b>143</b>	<b>49</b>	<b>35</b>	<b>312</b>

\* Significant difference, p=0.03

**Table 7:** Indications for liver retransplantation in adult recipients

Indication	2001 – 2011	2012 – 2017	2018 – 2019	2020 – 2021	2001 – 2021
	n (%)				
Biliary atresia	140 (37)	83 (40)	36 (59)	34 (51)	293 (41)
Other or unidentified	83 (22)	13 (6)	1 (2)	1 (1)	98 (14)
Metabolic diseases	37 (10)	35 (17)	4 (7)	6 (9)	82 (11)
Cirrhosis	46 (12)	18 (9)	2 (3)	9 (13)*	75 (10)
Acute liver failure	27 (7)	16 (8)	5 (8)	4 (6)	52 (7)
Primary liver tumor (excluding HCC)	16 (4)	21 (10)	8 (13)	7 (10)	52 (7)
Cholestatic diseases	15 (4)	10 (5)	4 (7)	4 (6)	33 (5)
HCC in non-cirrhotic liver	9 (2)	6 (3)	0 (0)	2 (3)	17 (2)
Benign liver tumors	8 (2)	1 (0)	1 (2)	0 (0)	10 (1)
Budd– Chiari syndrome (BCS)	2 (1)	2 (1)	0 (0)	0 (0)	4 (1)
<b>Total</b>	<b>383</b>	<b>206</b>	<b>61</b>	<b>67</b>	<b>717</b>

\* Significant difference,  $p=0.04$

**Table 8:** Indications for the primary liver transplantation in pediatric recipients (from deceased and living donors)

Indication	2001-2011	2012-2017	2018-2019	2020-2021	2001-2021		
	n	n	n	n	n	% of all LT *	% of LT due to metabolic diseases **
Cystic Fibrosis (CF)	8	6	1	1	16	2%	20%
Wilson's disease	10	5	1	–	16	2%	20%
Alpha – 1 Antitrypsine Deficiency (AATD)	7	5	1	2	15	2%	18%
Oxalosis	5	1	–	–	6	1%	7%
Maple Syrup Urine Disease (MSD)	–	4	–	–	4	1%	5%
Hyperammonemia	1	3	–	–	4	1%	5%
Ornithine Transcarbamylase Deficiency (OTCD)	–	2	–	1	3	<1%	4%
Argininosuccinic Aciduria (AS)	–	2	–	–	2	<1%	2%
Graft –Versus– Host Disease (GvHD)	1	–	–	1	2	<1%	2%
Hemolytic Uremic Syndrome (HUS)	–	2	–	–	2	<1%	2%
Nonalcoholic Steatohepatitis (NASH)	1	1	–	–	2	<1%	2%
Tyrosinemia	–	1	–	1	2	<1%	2%
Byler's disease (Progressive familial intrahepatic cholestasis - PFIC)	1	–	–	–	1	<1%	1%

Carbamoyl -Phosphate Synthetase 1 Deficiency (CPS1D)	–	1	–	–	1	<1%	1%
Glikogenosis	1	–	–	–	1	<1%	1%
Hemochromatosis	1	–	–	–	1	<1%	1%
Long– Chain 3 Hydroxyacyl-Coenzyme A Dehydrogenase Deficiency (LCHAD)	1	–	–	–	1	<1%	1%
Glycosylation disorders	–	1	–	–	1	<1%	1%
Berdon's syndrome (Megacystis microcolon intestinal hypoperistalsis syndrome – MMIH)	–	1	–	–	1	<1%	1%
Tricho–hepato–enteric syndrome (THE)	–	–	1	–	1	<1%	1%
<b>Total</b>	<b>37</b>	<b>35</b>	<b>4</b>	<b>6</b>	<b>82</b>	<b>11%</b>	<b>100%</b>

\* all LT in pediatric recipients - 717

\*\* LT due to metabolic diseases in pediatric recipients - 82

**Table 9:** Metabolic diseases as indications for liver transplantation in pediatric recipients

Indication	2001 – 2011	2012 – 2017	2018 – 2019	2020 – 2021	2001 – 2021
	n (%)				
Other or unidentified	7 (26)	14 (88)	3 (60)	3 (75)	27 (52)
Mushroom (toadstool) poisoning	10 (37)	2 (13)	–	1 (25)	13 (25)
Paracetamol overdose (other drugs)	4 (15)	–	–	–	4 (8)
HBV	3 (11)	–	–	–	3 (6)
TALDO syndrome	–	–	2 (40)	–	2 (4)
Wilson's disease	1 (4)	–	–	–	1 (2)
HAV	1 (4)	–	–	–	1 (2)
Fibrosis	1 (4)	–	–	–	1 (2)
<b>Total acute liver failure</b>	<b>27</b>	<b>16</b>	<b>5</b>	<b>4</b>	<b>52</b>

**Table 10:** Primary liver transplantation in acute organ failure in pediatric recipients

The rate of primary transplants for acute organ failure during the pandemic period for pediatric recipients was 6%, and did not differ markedly from that calculated for the long-term period 2001-2021 (7%). The most common indications were a toadstool poisoning (25%) and unidentified causes (75%) (Table 10).

#### **Numbers and characteristics of liver re-transplantation**

Only one retransplant (in the urgent recipient) was performed in pediatric recipient during the pandemic period (2020-2021), and four (two in urgent recipients) in years 2018-2019. During the long-term period 2001-2021, a total of 64 retransplants (average 3.2 per year) were performed in

this population of recipients, accounting for 8% of all transplants. As the information on the indications for retransplantation in children in the long-term 2001-2021 period is mostly unreported, thus statistical study in this area is not feasible.

## **Discussion**

On March 4, 2020, the first case of SARS-CoV-2 coronavirus infection ("patient zero") was confirmed in Poland. At the end of May 2020, three months of the pandemic, the total number of confirmed cases of COVID-19 infection was 23 786, three months later (end of August) there were 67 372 patients, and after one year (March 4, 2021) the quantity reached 1 750

659 cases. Since the beginning of the pandemic, there have been restrictions on the provision of health services, other than those related to COVID-19, caused directly by the impact of the virus itself (infected medical personnel, patients' fear of moving and undergoing medical procedures in treatment facilities), but primarily due to secondary measures to treat the infected and curb the pandemic (conversion of hospitals into hospitals dedicated to treating COVID-19 patients, limiting elective procedures, committing forces and resources to fight the pandemic, the exodus of personnel to newly established temporary hospitals). All of these phenomena also affected transplant medicine, and the strength of their impact the transplant professionals observed on a daily basis.

A worldwide decrease in transplantation, including LT, was reported during COVID-19 pandemic, particularly in 2020 [1-4]. A decrease was also reported for pediatric LT [5] and living donor LT [6]. The extent of this effect differed from country to country, with some recovering quickly [7].

In Poland during the pandemic era many centers active in organ donation and transplant programs have decreased or even temporarily suspended their activity, becoming a COVID-19 designated hospitals. In Poland, since the pandemic era, the trans-plant programs have been led according to SARS-CoV-2 related recommendations developed by the national medical consultants and national authorities and institutions, as the Ministry of Health and the Polish Transplant Coordinating Centre Poltransplant. The latest update of the recommendations was published December 6, 2023 ([https://poltransplant.pl/Download/covid/2023\\_12\\_06\\_Stanowisko\\_Poltransplantu\\_ws\\_COVID-19.pdf](https://poltransplant.pl/Download/covid/2023_12_06_Stanowisko_Poltransplantu_ws_COVID-19.pdf)).

Due to the decrease of the donation and transplantation rates, numerous patients with organ failures awaiting for transplants became collateral victims of the pandemic. Only in 2021, 34 patients in Poland died while waiting for liver transplants on the national waiting list. According to the national transplant registries, at the end of November 2024, in Poland there were 195 patients still awaiting for liver transplantation (including 1 for simultaneous liver and lung and 4 for simultaneous liver and kidney transplantation), therefore there are complex measures that must to be undertaken to increase availability to this method of treatment. Interestingly, no decrease in the total number of LTs in pediatric recipients was observed in Poland. The decrease of LTs from deceased donors was compensated by the increase of LTs from living donors.

The indications for LT remained largely the same in 2020-2021 as in previous years. This is similar to the results in France reported by Legeai et al [3].

Alcohol-related liver disease (ALD) is one of the most prevalent types of liver disease worldwide [8]. It is also a major indication for liver transplantation worldwide [9]. Alcoholic liver cirrhosis represents the second most frequent indication for liver trans-plantation worldwide, accounting for about 30% of all primary transplants in Europe and about 25% in the

USA [8]. Interestingly, some studies reported an increase in harmful alcohol use and ALD in years 2020-2021 [10-13]. An increase in the incidence of ALD before and during the pandemic was observed in the United States [14]. In Poland, ALD is a predominant indication for LT with frequency increasing over the years, including the 2020-2021 period.

No significant differences were observed in the indications for liver transplantation in adult recipients during the pandemic period compared to the previous two years. Even those visible in Table 8 (paracetamol and other drugs overdose (31%) and liver injury (19%) in acute liver failure) are not statistically significant ( $p=0.25$  and  $p=0.11$ , respectively). The only two statistical significant differences between pandemic (2020-2021) and pre-pandemic period (2018-2019) were the increased incidence of liver cirrhosis as an indication for the primary LT in pediatric recipients ( $p=0.04$ ) and increased incidence of primary non-function (PNF) as an indication for the reLT in adult recipients ( $p=0.03$ ).

Moreover, it is worth noting that over the years the number of unidentified diseases as indication for reLT in adult recipients has been decreasing over the years, probably due to improved data reporting to transplant registries.

After the decrease in LTs in years 2020-2021, an increase was observed in Poland, with 334 LTs performed in 2022, 523 in 2023 and 562 in 2024 (at the end of November 2024). This is in line with a post-pandemic increase in transplantation activity observed in other countries.

## Conclusions

In the era of COVID-19 in Poland:

1. The number of transplanted livers from deceased donors distinctly decreased;
2. The number of transplanted livers to pediatric recipients was stable;
3. The number of retransplantations in urgent cases decreased;
4. Early liver transplant results have not changed;
5. The indications for LT remained largely the same in 2020-2021 as in previous years Except of the incidence of liver cirrhosis as an indication for the primary LT in pediatric recipients and the incidence of primary non-function (PNF) as an indication for the reLT in adult recipients no significant differences were observed.

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