

SUPPLEMENTARY CONTENT

Table S1. Classification of recipient cause of death.

Grouped category	Category	Causes of death
HCC specific	Recurring primary disease - malignant	Recurring primary disease - malignant
Other cancers	Other malignancy	Lymphoid malignant disease possible induced by immunosuppressive therapy Lymphoid malignant disease not induced by immunosuppressive therapy Malignant disease: lymphoproliferative disorders Nonlymphoid malignant disease possibly induced by immunosuppressive therapy Nonlymphoid malignant disease not induced by immunosuppressive therapy
Non–cancer specific	Respiratory failure	Elevated PVR/Pulmonary hypertension Pulmonary infection (protozoal) Pulmonary infection (bacterial) Pulmonary infection (viral) Pulmonary infection (fungal) Pulmonary embolus Respiratory failure
	Renal failure	Hyperkalemia Hypokalemia Renal failure
	Hepatic failure	Hepatitis B virus Other viral hepatitis Drug toxicity Cirrhosis – not viral Cystic liver disease Liver failure – cause unknown
	Gastrointestinal failure	Mesenteric infarction Peritonitis Pancreatitis Sclerosing peritoneal disease Perforation of peptic ulcer Perforation of colon
	Cardiac failure	Myocardial ischemia or infarction Hemorrhagic pericarditis Cardiac failure Fluid overload Cardiac tamponade

Sepsis	Septicemia ARDS Multi-system failure
Recurring benign disease	Recurrent primary disease – benign
Hemorrhage	Gastrointestinal hemorrhage Hemorrhage from graft site Hemorrhage from vascular access or dialysis circuit Hemorrhage from ruptured vascular aneurysm Hemorrhage from surgery Other hemorrhage
Graft failure	Uremia caused by graft failure Early graft dysfunction Donor organ failure
Infection	Infection – except for viral hepatitis Tuberculosis – lung Tuberculosis – elsewhere Generalized viral infection
CVA	Cerebrovascular accident
Other	Airway dehiscence Patient refused further treatment Suicide Therapy ceased for any other reason ESRF treatment withdrawn for medical reasons Bone marrow depression Cachexia Dementia Accident related to treatment Accident unrelated to treatment Other identified cause of death
Unknown	Cause of death uncertain/not determined Unknown Cause of death not requested

ARDS, acute respiratory distress syndrome; CVA, cerebrovascular accident; ESRF, end-stage renal failure; HCC, hepatocellular carcinoma; PVR, post void residual volume.

Table S2. Description of donor and recipient variables in the United Kingdom Liver Transplant Registry.

Variable	Notes
<i>Recipient factors</i>	
Age at transplant, years	
Sex	- Two levels: male, female
BMI, kg/m ²	- Recipient BMI was calculated using height and weight measured at registration - Implausible values of recipient height: <120 cm or >240 cm (3 values recoded as missing) - Implausible values of recipient weight: <30 kg or >180 kg (5 values recoded as missing)
Ethnicity	- Two levels: White, non-White
Previous abdominal surgery	- Two levels: no previous surgery, previous surgery
Ascites	- Two levels: no ascites, ascites
Renal support status	- Two levels: not required, required
Variceal bleed status	- Two levels: no variceal bleed, variceal bleed
Anti-HCV test result	- Two levels: negative, positive
Hospital in-patient status	- Two levels: out-patient, in-patient
Transplant year	
Encephalopathy	- Two levels: not encephalopathic, encephalopathic
INR	- Implausible values: >20 (1 value recoded as missing)
Serum bilirubin, µmol/L	
Serum creatinine, µmol/L	
Serum sodium, mmol/L	- Implausible values: <100 mmol/l (3 values recoded as missing)
Serum albumin, g/L	- Implausible values: <7 g/l or >60 g/l (10 values recoded as missing)
Serum potassium, mmol/L	- Implausible values: >8 mmol/l (18 values recoded as missing)
<i>Donor factors</i>	
Age at donation, years	
Sex	- Two levels: male, female
BMI, kg/m ²	- Implausible values: <10 kg/m ² or >100 kg/m ² (1 value recoded as missing)
Cause of death	- Three levels: trauma, CVA, other
Donor type	- Two levels: DBD, DCD
Graft type	- Two levels: whole, segment
CIT, hours	- Defined as the time between the start of cold perfusion in the donor to the start of flow through the organ in the recipient
Organ appearance	- Two levels: healthy, abnormal
<i>Variables excluded from the model</i>	
Donor-recipient blood group match	- Excluded due to sparse data (counts<10) - Three levels: identical, compatible, incompatible

Ventilation status	- Excluded due to sparse data (counts<10) - Two levels: not ventilated, ventilated
UKELD score	- Excluded as it is calculated directly from other variables in the model, namely serum bilirubin, serum sodium and INR - A predictor of 1-year mortality in patients with liver disease who are registered for a transplant - Can take any value > 0 and a score ≥ 49 was required to meet the national listing criteria before the organ allocation policy changed in 2018
Lifestyle activity score	- Excluded as it was highly correlated with in-patient care, which was included in the models. - Five-level ordinal scale: able to carry out normal activity without restriction; only restricted in physically strenuous activity; can move freely – capable of self-care, unable to do any form of work, only capable of limited self-care, confined mostly to a bed or chair; completely reliant on nursing/medical care

BMI, body mass index; CIT, cold ischemia time; CVA, cerebrovascular accident; DBD, donation after brain death; DCD, donation after circulatory death; HCV, hepatitis C virus; INR, international normalized ratio; UKELD, United Kingdom Model for End-Stage Liver Disease.

Table S3. Classification of recipient liver disease.

Category	Diseases
Hepatocellular carcinoma	Hepatocellular carcinoma – noncirrhotic Hepatocellular carcinoma - cirrhotic
Cancer (not hepatocellular carcinoma)	Malignancy not classifiable Cholangiocarcinoma Hepatoblastoma Secondary hepatic malignancy Other mesenchymal tumors Other primary hepatic malignancy
Hepatitis C	Hepatitis C cirrhosis
Primary sclerosing cholangitis	Primary sclerosing cholangitis
Hepatitis B	Hepatitis B cirrhosis Acute hepatic failure - HBV
Primary biliary cirrhosis	Primary biliary cirrhosis
Alcoholic liver disease	Alcoholic liver disease
Autoimmune liver disease	Autoimmune chronic active liver disease
Metabolic liver disease	Alpha-1-antitrypsin deficiency Wilson’s disease Nonalcoholic fatty liver disease Other metabolic liver disease Primary oxalosis Hyperlipidemia Tyrosinemia Familial amyloidosis Familial cholestasis Hereditary haemochromatosis Glycogen storage disease Neonatal haemochromatosis Niemann-Pick type C Hypercholesterolemia Urea cycle disorder Crigler-Najjar syndrome Cholesterol ester storage disease Alper’s syndrome Mitochondrial disease
Acute liver disease	Acute hepatic failure – Budd-Chiari syndrome Acute hepatic failure – other virus Acute hepatic failure – serologically indeterminate FHF – viral FHF – drug induced

	FHF – toxin induced
	Acute hepatic failure – Wilson’s disease
	Acute hepatic failure – HAV
	Acute hepatic failure – paracetamol hepatotoxicity
	Acute hepatic failure – other drug toxicity
	Acute hepatic failure – other
	Trauma
Other	Chronic liver failure – unknown cause
	Budd-Chiari syndrome
	Cryptogenic cirrhosis
	Secondary biliary cirrhosis
	Biliary atresia
	Congenital hepatic fibrosis
	Congenital biliary disease
	Pediatric cholestatic liver disease
	Benign liver tumor
	Cystic fibrosis
	Graft vs host disease
	Neonatal hepatitis
	Polycystic liver disease
	Progressive familial intrahepatic cholestasis
	Acute rejection
	Chronic rejection
	Primary nonfunction
	Acute vascular occlusion – artery plus vein
	Nonthrombotic infarction
	Ductopenic rejection
	Recurrent disease
	Biliary complications
	Hepatic artery thrombosis
	Early graft dysfunction
	Acute vascular occlusion – venous
	Acute vascular occlusion – artery
	Alagilles syndrome
	Neonatal sclerosing cholangitis
	Other neonatal cholestasis
	Other
	Unknown
	Not reported

FHF, fulminant hepatic failure; HAV, hepatitis A virus; HBV, hepatitis B virus.

Table S4. Recipient characteristics before LT (N = 9586).

Variable		Missing data, n (%)
Age at transplant, years		N/A
	Mean (SD)	52.2 (11.1)
	Median (range)	54 (17, 74)
Sex		111 (1.2)
	Male, n (%)	6144 (64.1)
	Female, n (%)	3331 (34.7)
Ethnicity		2 (<0.1)
	White, n (%)	8291 (86.5)
	Non-White, n (%)	1293 (13.5)
BMI at registration, kg/m ²		360 (3.8)
	Mean (SD)	26.7 (5.0)
	Median (range)	26.1 (11.6, 50.7)
Transplant year		N/A
	1997-2001, n (%)	2117 (22.1)
	2002-2006, n (%)	2114 (22.1)
	2007-2011, n (%)	2288 (23.9)
	2012-2016, n (%)	3067 (32.0)
Previous abdominal surgery		27 (0.3)
	No previous surgery, n (%)	8174 (85.3)
	Previous surgery, n (%)	1385 (14.4)
Ascites		33 (0.3)
	No ascites, n (%)	4360 (45.5)
	Ascites, n (%)	5193 (54.2)
Ventilation status		10 (0.1)
	Not ventilated, n (%)	9524 (99.4)
	Ventilated, n (%)	52 (0.5)
Renal support status		16 (0.2)
	Not required, n (%)	9112 (95.1)
	Required, n (%)	458 (4.8)
Variceal bleed status		76 (0.8)
	No variceal bleed, n (%)	6794 (70.9)
	Variceal bleed, n (%)	2716 (28.3)
Encephalopathy		89 (0.9)
	Not encephalopathic, n (%)	7049 (73.5)
	Encephalopathic, n (%)	2448 (25.5)
Lifestyle activity score		82 (0.9)
	Normal, n (%)	468 (4.9)
	Restricted, n (%)	2703 (28.2)
	Self-care, n (%)	4939 (51.5)
	Confined, n (%)	1150 (12.0)

	Reliant, n (%)	244 (2.5)	
Anti-HCV test result			656 (6.8)
	Negative, n (%)	7040 (73.4)	
	Positive, n (%)	1890 (19.7)	
In-patient status			7 (0.1)
	Out-patient, n (%)	8273 (86.3)	
	In-patient, n (%)	1306 (13.6)	
INR			210 (2.2)
	Mean (SD)	1.5 (0.9)	
	Median (range)	1.4 (0.7, 18.6)	
UKELD score			266 (2.8)
	Mean (SD)	55.0 (5.7)	
	Median (range)	55 (39, 86)	
Serum creatinine, $\mu\text{mol/L}$			23 (0.2)
	Mean (SD)	90.2 (42.7)	
	Median (range)	82 (16, 915)	
Serum bilirubin, $\mu\text{mol/L}$			48 (0.5)
	Mean (SD)	88.2 (121.5)	
	Median (range)	47 (2, 1151)	
Serum potassium, mmol/L			57 (0.6)
	Mean (SD)	4.2 (0.6)	
	Median (range)	4.2 (2.1, 7.6)	
Serum sodium, mmol/L			45 (0.5)
	Mean (SD)	136.5 (5.0)	
	Median (range)	137 (112, 160)	
Serum albumin, g/L			69 (0.7)
	Mean (SD)	31.1 (6.9)	
	Median (range)	31 (8, 56)	
HCC			N/A
	HCC, n (%)	1885 (19.7)	
	Non-HCC, n (%)	7701 (80.3)	

BMI, body mass index; HCC, hepatocellular carcinoma; HCV, hepatitis C virus; INR, international normalized ratio; UKELD, United Kingdom Model for End-Stage Liver Disease.

Table S5. Donor characteristics before LT (N = 9586).

Variable		Missing data, n (%)
Age at donation, years		N/A
	Mean (SD)	46.9 (15.7)
	Median (range)	48 (5, 86)
Sex		N/A
	Male, n (%)	5127 (53.5)
	Female, n (%)	4459 (46.5)
BMI, kg/m ²		329 (3.4)
	Mean (SD)	25.9 (4.8)
	Median (range)	25.2 (10.5, 67.6)
Donor type		N/A
	DBD, n (%)	8248 (86.0)
	DCD, n (%)	1338 (14.0)
Donor vs recipient blood group match		1 (<0.1)
	Identical, n (%)	9311 (97.1)
	Compatible, n (%)	256 (2.7)
	Incompatible, n (%)	18 (0.2)
Graft type		N/A
	Whole, n (%)	8894 (92.8)
	Segment, n (%)	692 (7.2)
Organ appearance		1016 (10.6)
	Healthy, n (%)	6646 (69.3)
	Abnormal, n (%)	1924 (20.1)
CIT, hours		541 (5.6)
	Mean (SD)	9.6 (3.0)
	Median (range)	9.4 (0, 23)
Cause of death		35 (0.4)
	Trauma, n (%)	1246 (13.0)
	CVA, n (%)	6284 (65.6)
	Other, n (%)	2021 (21.1)

BMI, body mass index; CIT, cold ischemia time; CVA, cerebrovascular accident; DBD, donation after brain death; DCD, donation after circulatory death.

Table S6. Estimated HRs for the confounding variables from the adjusted flexible parametric model (N = 6724).

Variable		HR (95% CI)	P
Recipient factors			
Age at transplant, 10 years ^a		1.29 (1.22, 1.37)	<0.001
Age at transplant, 10 years, squared ^a		1.06 (1.03, 1.09)	<0.001
Sex	Male	1.0	-
	Female	0.92 (0.82, 1.02)	0.108
Ethnicity	White	1.0	-
	Non-White	0.99 (0.85, 1.14)	0.863
BMI at registration, ^a kg/m ²		0.98 (0.97, 1.00)	0.006
BMI at registration, kg/m ² , squared ^a		1.002 (1.001, 1.003)	<0.001
Transplant year		0.96 (0.95, 0.97)	<0.001
Previous abdominal surgery	No previous surgery	1.0	-
	Previous surgery	1.09 (0.97, 1.23)	0.161
Ascites	No ascites	1.0	-
	Ascites	1.08 (0.97, 1.19)	0.158
Renal support status	Not required	1.0	-
	Required	1.02 (0.82, 1.27)	0.872
Variceal bleed status	No variceal bleed	1.0	-
	Variceal bleed	1.02 (0.92, 1.13)	0.716
Encephalopathy	Not encephalopathic	1.0	-
	Encephalopathic	1.04 (0.93, 1.17)	0.461
Anti-HCV test result	Negative	1.0	-
	Positive	1.33 (1.19, 1.50)	<0.001
In-patient status	Out-patient	1.0	-
	In-patient	1.31 (1.14, 1.50)	<0.001
INR ^a		1.00 (0.95, 1.05)	0.849
Log (serum creatinine, µmol/l) ^a		1.28 (1.10, 1.49)	0.001
Log (serum bilirubin, µmol/l) ^a		0.93 (0.88, 0.98)	0.004
Serum potassium, 10 mmol/l ^a		1.30 (0.54, 3.16)	0.558
Serum sodium, 10 mmol/l ^a		0.91 (0.82, 1.01)	0.076
Serum albumin, 5 g/l ^a		0.97 (0.93, 1.01)	0.121
Donor factors			

Age at donation, 10 years ^a		1.06 (1.03, 1.10)	0.001
Sex	Male	1.0	-
	Female	0.94 (0.85, 1.03)	0.193
BMI, ^a per kg/m ²		1.01 (1.00, 1.02)	0.122
Donor type	DBD	1.0	-
	DCD	1.20 (1.00, 1.45)	0.051
Graft type	Whole	1.0	-
	Segment	1.12 (0.91, 1.38)	0.302
Organ appearance	Healthy	1.0	-
	Abnormal	1.15 (1.03, 1.29)	0.015
CIT, hours ^a		1.02 (1.00, 1.03)	0.043
Cause of death	CVA	1.0	-
	Trauma	1.06 (0.92, 1.21)	0.495
	Other	0.96 (0.84, 1.09)	

^aCentered around median values.

BMI, body mass index; CI, confidence interval; CIT, cold ischemia time; CVA, cerebrovascular accident; DBD, donation after brain death; DCD, donation after circulatory death; HCV, hepatitis C virus; HR, hazard ratio; INR, international normalized ratio.

Table S7. Estimated HRs from the multivariable Cox proportional hazards model of survival after transplantation (N = 6724).

Variable		HR (95% CI)	P	P from Schoenfeld test
<i>Recipient factors</i>				
HCC	Non-HCC	1.0	-	-
	HCC	1.27 (1.11, 1.45)	<0.001	0.044
Age of recipient, 10 years ^a		1.29 (1.23, 1.37)	<0.001	<0.001
Age of recipient, 10 years, squared ^a		1.06 (1.03, 1.09)	<0.001	0.008
Sex	Male	1.0	-	-
	Female	0.91 (0.82, 1.02)	0.097	0.580
Ethnicity	White	1.0	-	-
	Non-white	0.99 (0.85, 1.14)	0.879	0.106
BMI at registration, ^a kg/m ²		0.98 (0.97, 1.00)	0.005	0.522
BMI at registration, kg/m ² , squared ^a		1.002 (1.001, 1.004)	<0.001	0.896
Transplant year		0.96 (0.95, 0.97)	<0.001	0.024
Previous abdominal surgery	No previous surgery	1.0	-	-
	Previous surgery	1.09 (0.96, 1.23)	0.175	0.228
Ascites	No ascites	1.0	-	-
	Ascites	1.07 (0.97, 1.19)	0.177	0.995
Renal support status	Not required	1.0	-	-
	Required	1.02 (0.82, 1.28)	0.838	0.575
Variceal bleed status	No variceal bleed	1.0	-	-
	Variceal bleed	1.02 (0.92, 1.12)	0.731	0.326
Encephalopathy	Not encephalopathic	1.0	-	-
	Encephalopathic	1.04 (0.93, 1.17)	0.481	0.682
Anti-HCV test result	Negative	1.0	-	-
	Positive	1.34 (1.19, 1.50)	<0.001	0.092
In-patient status	Out-patient	1.0	-	-
	In-patient	1.31 (1.14, 1.50)	<0.001	0.185
INR ^a		1.00 (0.95, 1.05)	0.852	0.814
Log (serum creatinine, μmol/l) ^a		1.29 (1.11, 1.50)	0.001	0.429
Log (serum bilirubin, μmol/l) ^a		0.93 (0.88, 0.98)	0.004	<0.001
Serum potassium, 10 mmol/l ^a		1.29 (0.53, 3.11)	0.578	0.335
Serum sodium, 10 mmol/l ^a		0.91 (0.82, 1.01)	0.069	0.182
Serum albumin, 5 g/l ^a		0.97 (0.93, 1.01)	0.122	0.379

<i>Donor factors</i>				
Age at donation, years ^a		1.06 (1.03, 1.10)	0.001	0.809
Sex	Male	1.0	-	-
	Female	0.94 (0.85, 1.04)	0.221	0.347
BMI, ^a per kg/m ²		1.01 (1.00, 1.02)	0.122	0.178
Donor type	DBD	1.0	-	-
	DCD	1.19 (0.99, 1.44)	0.065	0.576
Graft type	Whole	1.0	-	-
	Segment	1.12 (0.91, 1.39)	0.282	0.947
Organ appearance	Healthy	1.0	-	-
	Abnormal	1.15 (1.03, 1.29)	0.013	0.147
CIT, hours ^a		1.02 (1.00, 1.04)	0.040	
Cause of death	CVA	1.0	-	-
	Trauma	1.06 (0.92, 1.21)		0.736
	Other	0.96 (0.84, 1.08)	0.482	0.595

^aCentered around median values.

BMI, body mass index; CI, confidence interval; CIT, cold ischemia time; CVA, cerebrovascular accident; DBD, donation after brain death; DCD, donation after circulatory death; HCC, hepatocellular carcinoma; HCV, hepatitis C virus; HR, hazard ratio; INR, international normalized ratio.