

## Supplementary information

**Supplementary Table 1.** CPRD transplant medcodes for the kidney transplant cohort.

Medcode	Readcode	Readterm
2997	7B00.00	Transplantation of kidney
5504	7B00z00	Transplantation of kidney NOS
5911	ZV42000	[V]Kidney transplanted
11745	7B00100	Transplantation of kidney from live donor
17253	8L50.00	Renal transplant planned
18774	TB00111	Renal transplant with complication, w/o blame
24361	7B00200	Transplantation of kidney from cadaver
54990	TB00100	Kidney transplant with complication, w/o blame
55151	7B00000	Autotransplant of kidney
66705	7B00111	Allotransplantation of kidney from live donor
70874	7B00y00	Other specified transplantation of kidney
89924	7B00300	Allotransplantation of kidney from cadaver, heart-beating
96133	7B00400	Allotransplantation kidney from cadaver, heart non-beating
98364	7B00211	Allotransplantation of kidney from cadaver
105328	7B00212	Cadaveric renal transplant
105787	7B00600	Xenograft renal transplant

Abbreviations: CPRD, Clinical Practice Research Datalink; NOS, nitric oxide synthase; w/o, without

**Supplementary Table 2.** CPRD transplant medcodes for the liver transplant cohort.

Medcode	Readcode	Readterm
4405	7800	Transplantation of liver
9026	ZV42700	[V]Liver transplanted
27319	7800z00	Transplantation of liver NOS
31997	TB00200	Liver transplant with complication, w/o blame
32025	7800000	Orthotopic transplantation of liver
71422	7800100	Heterotopic transplantation of liver
89445	7800111	Auxillary liver transplant
99250	7800y00	Other specified transplantation of liver
100073	7800112	Piggy back liver transplant
105506	7800400	Orthotopic transplantation of whole liver
105758	8LH..00	Liver transplant planned

Abbreviations: CPRD, Clinical Practice Research Datalink; NOS, nitric oxide synthase; w/o, without

**Supplementary Table 3.** Summary of all inpatient HRGs used during last year before kidney graft failure.

HRG description	Count
Renal general disorders >69 years or with CC	11
Kidney or urinary tract infections <70 years w/o CC	10
Renal replacement associated procedures	9
Kidney intermediate endoscopic procedure <70 years w/o CC	9
Renal replacement therapy w/o CC	9
Kidney or urinary tract infections >69 years or with CC	8
Unspecified acute lower respiratory infection	8
Complications of procedures	7
Kidney intermediate endoscopic procedure >69 years or with CC	7
Chronic renal failure	6
Lobar, atypical or viral pneumonia, with intermediate CC	6
Inflammatory bowel disease >69 years or with CC	5
Intermediate percutaneous kidney or ureter procedures, ≥19 years, with intermediate CC	5
Non-interventional acquired cardiac conditions	5
Planned procedures not carried out	5
Septicemia	5
Unspecified acute lower respiratory infection with intermediate CC	5
Cardiac catheterization and angiography w/o complications	4
Exteriorisation of trachea with major CC	4
Large intestinal disorders >69 years or with CC	4
Lobar, atypical or viral pneumonia, with major CC	4
Renal general disorders <70 years w/o CC	4
Vascular access for renal replacement therapy	4
Acute renal failure >69 years or with CC	3
Kidney or urinary tract infections, with LOS ≥2 days, with major CC	3
Intestinal infectious disorders >69 years or with CC	3
Renal replacement therapy with CC	3
Lobar, atypical or viral pneumonia w/o CC	3
Minor infections (including immune disorders)	3
Malignant lymphoma, including Hodgkin's and non-Hodgkin's	3
Other respiratory diagnoses with intermediate CC	3
Stomach or duodenum disorders >69 years or with CC	3
Acute renal failure <70 years w/o CC	2
Admission for unexplained symptoms with intermediate CC	2
Arrhythmia or conduction disorders <70 years w/o CC	2
Arrhythmia or conduction disorders >69 years or with CC	2

HRG description	Count
Chest Pain <70 years w/o CC	2
Chronic kidney disease with LOS ≥2 days, with intermediate CC	2
Chronic kidney disease with LOS ≥2 days, w/o CC	2
Chronic liver disorders >69 years or with CC	2
Complications of procedures with major CC	2
Coronary artery bypass graft (first time) with percutaneous coronary intervention, pacing, EP or RFA	2
Fluid or electrolyte disorders <70 years w/o CC	2
Fluid or electrolyte disorders >69 years or with CC	2
Intermediate skin disorders category 1, with major CC	2
Intermediate skin disorders category 2, with major CC	2
Intermediate therapeutic general abdominal procedures, ≥19 years with major CC	2
Kidney major open procedure >49 years or with CC	2
Kidney or urinary tract infections, with LOS ≥2 days, with intermediate CC	2
Minor skin procedures - category 1 with CC	2
Miscellaneous vascular procedures with CC	2
Non-malignant large intestinal disorders, with LOS ≥2 days, with major CC	2
Other cardiac diagnoses	2
Red blood cell disorders <70 years w/o CC	2
Respiratory neoplasms with major CC	2
Septicemia with major CC	2
Small intestinal disorders (excluding IBD)	2
Therapeutic endovascular procedures	2
Therapeutic endovascular procedures with intermediate CC	2
Therapeutic pancreatic or biliary procedures	2
Abnormal findings w/o diagnosis	1
Actual or suspected myocardial infarction	1
Acute febrile illness with LOS ≤4 days, with major CC	1
Acute kidney injury w/o interventions, with intermediate CC	1
Acute kidney injury w/o interventions, with major CC	1
Acute myocardial infarction with CC	1
Admission for unexplained symptoms with major CC	1
Admission for unexplained symptoms	1
Anal disorders	1
Aplastic anemia with CC	1
Arrhythmia or conduction disorders, w/o CC	1
Bladder minor endoscopic procedure w/o CC	1
Bladder or urinary mechanical problems >69 years or with CC	1
Bronchiectasis	1

HRG description	Count
Bronchiectasis with CC	1
Bronchopneumonia w/o CC	1
Catheter, ≥19 years	1
Chest Pain >69 years or with CC	1
Chronic kidney disease with LOS ≤1 day, not associated with renal dialysis	1
Chronic kidney disease with LOS ≥2 days, with major CC	1
Chronic obstructive pulmonary disease or bronchitis, w/o NIV, w/o intubation, with intermediate CC	1
Complex elderly with a cardiac primary diagnosis	1
Complications of procedures with intermediate CC	1
Deep vein thrombosis <70 years w/o CC	1
Deep vein thrombosis >69 years or with CC	1
Diabetes with hyperglycemic disorders, ≤69 years with intermediate CC	1
Disorders of the esophagus, with LOS ≥2 days, w/o major CC	1
Drainage of ascites	1
Electrophysiological and other percutaneous cardiac procedures >18 years	1
Examination, follow-up or special screening, with CC	1
Exteriorisation of trachea	1
Extracranial or upper limb arterial surgery	1
Extradural spine minor 2 with CC	1
Fluid and electrolyte disorders, ≤69 years with intermediate CC	1
Fluid and electrolyte disorders, ≥70 years with major CC	1
Foot procedures for diabetes or arterial disease, or procedures to amputation stumps	1
Gastrointestinal bleed <70 years w/o CC	1
Gastrointestinal bleed >69 years or with CC	1
General abdominal - diagnostic procedures	1
General abdominal disorders >69 years or with CC	1
General renal disorders with LOS ≥2 days, with intermediate CC	1
Hemorrhagic cerebrovascular disorders	1
Heart failure or shock >69 years or with CC	1
Heart failure or shock, with CC	1
Hypertension >69 years or with CC	1
Inborn errors of metabolism	1
Infections of bones or joints, with major CC	1
Inflammatory bowel disease - endoscopic or intermediate procedures <70 years w/o CC	1
Intermediate percutaneous kidney or ureter procedures, ≤18 years	1
Intermediate percutaneous kidney or ureter procedures, ≥19 years, with major CC	1
Intermediate percutaneous kidney or ureter procedures, ≥19 years, w/o CC	1

HRG description	Count
Intermediate skin disorders category 1, with intermediate CC	1
Intermediate skin disorders category 2, with intermediate CC	1
Intermediate therapeutic endoscopic retrograde cholangiopancreatography, with LOS ≤2 days	1
Intermediate therapeutic endoscopic retrograde cholangiopancreatography, with LOS ≥3 days, with intermediate CC	1
Intermediate therapeutic endoscopic retrograde cholangiopancreatography, with LOS ≥3 days, with major CC	1
Intracranial procedures except trauma - category 2	1
Kidney major endoscopic procedure	1
Large intestine - major procedures with CC	1
Lower limb arterial surgery with CC	1
Major ear procedures	1
Major head, neck and ear disorders, with major CC	1
Major mouth or throat procedures	1
Major mouth or throat procedures, ≥19 years with CC	1
Major multiple skin procedures with major CC	1
Major skin disorders category 2, with major CC	1
Major skin procedures >49 years or with CC	1
Major skin tumors	1
Major thoracic procedures with CC	1
Malignant disorder of the lymphatic/hematological systems with LOS >1 day	1
Malignant disorders of lymphatic or hematological systems, w/o CC	1
Malignant Liver or Pancreatic Disorders, with LOS ≤1 day	1
Minor cardiac procedures	1
Minor ear procedures	1
Minor infections with CC	1
Minor pain procedures	1
Minor procedures to the musculoskeletal system	1
Minor skin infections	1
Minor skin procedures - category 1 w/o CC	1
Minor skin procedures - category 2, with major CC	1
Minor thoracic procedures	1
Miscellaneous disorders of nervous system	1
Miscellaneous urinary tract findings with CC	1
Non-malignant breast disorders	1
Non-malignant pancreatic or biliary disorders, with major CCs	1
Non-surgical treatment of fibroids, menstrual disorders, or endometriosis	1
Non-transient stroke or cerebrovascular accident <70 years w/o CC	1
Other cardiothoracic or circulatory procedures >18 years	1

HRG description	Count
Other complex cardiac surgery with percutaneous coronary intervention, pacing, EP or RFA	1
Other endocrine disorders	1
Other non-viral infection with CC	1
Other non-viral infections	1
Other red blood cell disorders w/o CC	1
Other respiratory diagnoses >69 years or with CC	1
Other respiratory diagnoses with major CC	1
Other viral illness	1
Ovary, fallopian tube or pelvic disorders, w/o CC	1
Pancreatic disorders	1
Parathyroid procedures	1
Percutaneous coronary interventions with $\geq 3$ stents, rotablation, IVUS or pressure wire	1
Pleural effusion with intermediate CC	1
Poisoning, toxic, environmental and unspecified effects	1
Procedures on the lymphatic system with CC	1
Pulmonary embolism with CC	1
Pulmonary embolus with major CC	1
Pyrexia of unknown origin	1
Red blood cell disorders >69 years or with CC	1
Renal disease with renal failure	1
Respiratory failure w/o CC	1
Respiratory failure w/o intubation, with intermediate CC	1
Septicemia with intermediate CC	1
Small intestine - very major procedures	1
Soft tissue disorders >69 years or with CC	1
Sprains, strains, or minor open wounds >69 or with CC	1
Therapeutic endovascular procedures with major CC	1
Thrombocytopenia with CC	1
Urinary diversion w/o cystectomy	1
Urinary incontinence or other urinary problems, with major CC	1
Vascular access for renal replacement therapy, with CC	1
<b>Total</b>	<b>347</b>

Abbreviations: CC, complication or comorbidity; EP, electrophysiology; HRG, Healthcare Resource Group; IBD, inflammatory bowel disease; IVUS, intravenous ultrasound; LOS, length of stay; NIV, non-invasive ventilation; RFA, radiofrequency ablation; w/o, without

**Supplementary Table 4.** Summary of all inpatient HRGs used during last year before liver graft failure.

HRG description	Count
Intermediate hepatobiliary interventional radiology procedures	7
Liver - major procedures >69 years or with CC	4
Non-malignant general abdominal disorders, with LOS $\geq 2$ days, with major CC	4
Admission for unexplained symptoms	3
Anal disorders	3
Biliary tract disorders <70 years w/o CC	3
Chronic liver disorders <70 years w/o CC	3
Complications of procedures	3
Drainage of ascites	3
General abdominal disorders >69 years or with CC	3
Inflammatory bowel disease >69 years or with CC	3
Malignant disorder of the lymphatic/hematological systems with LOS >1 day	3
Non-malignant liver disorders with major CCs	3
Non-surgical peripheral vascular disease with intermediate CC	3
Pathological fractures or malignancy of bone and connective tissue >69 years or with CC	3
Acute liver disorders	2
Acute renal failure <70 years w/o CC	2
Admission for unexplained symptoms with intermediate CC	2
Aplastic anemia w/o CC	2
Biliary tract disorders >69 years or with CC	2
Chronic liver disorders >69 years or with CC	2
Chronic renal failure	2
Epilepsy >69 years or with CC	2
Fluid or electrolyte disorders <70 years w/o CC	2
Gastrointestinal bleed >69 years or with CC	2
Intermediate skin disorders category 2, with intermediate CC	2
Intestinal infectious disorders, with LOS $\geq 2$ days, with major CC	2
Kidney or urinary tract infections >69 years or with CC	2
Large intestinal disorders >69 years or with CC	2
Lobar, atypical or viral pneumonia, with major CC	2
Major endoscopic or percutaneous, hepatobiliary or pancreatic procedures, with major CC	2
Malignant liver or pancreatic disorders, with LOS $\geq 2$ days	2
Non-interventional acquired cardiac conditions	2
Non-malignant general abdominal disorders, with LOS $\geq 2$ days, w/o major CC	2
Planned procedures not carried out	2
Renal replacement therapy with CC	2
Renal replacement therapy w/o CC	2

Respiratory neoplasms with intermediate CC	2
Respiratory neoplasms with major CC	2
Septicemia with major CC	2
Therapeutic endovascular procedures with intermediate CC	2
Unspecified acute lower respiratory infection with major CC	2
Actual or suspected myocardial infarction	1
Acute kidney injury w/o interventions, with intermediate CC	1
Aplastic anemia with CC	1
Arrhythmia or conduction disorders <70 years w/o CC	1
Arrhythmia or conduction disorders, w/o CC	1
Biliary tract neoplasms	1
Bladder intermediate endoscopic procedure w/o CC	1
Bronchopneumonia with major CC	1
Cardiac catheterization and angiography w/o complications	1
Catheter, ≥19 years	1
Chronic obstructive pulmonary disease or bronchitis with CC	1
Chronic obstructive pulmonary disease or bronchitis, with LOS ≤1 day, discharged home	1
Chronic obstructive pulmonary disease or bronchitis, w/o NIV, w/o intubation, with intermediate CC	1
Chronic obstructive pulmonary disease or bronchitis, w/o NIV, w/o intubation, with major CC	1
Complex elderly with a cardiac primary diagnosis	1
Complex elderly with a musculoskeletal system primary diagnosis	1
Complex elderly with a respiratory system primary diagnosis	1
Complex elderly with digestive system primary diagnosis	1
Complications of procedures with intermediate CC	1
Diagnostic procedures, esophagus and stomach	1
Electrophysiological and other percutaneous cardiac procedures >18 years	1
Examination, follow up and special screening	1
Fluid and electrolyte disorders, ≥70 years with intermediate CC	1
Fluid or electrolyte disorders >69 years or with CC	1
Foot procedures for diabetes or arterial disease, or procedures to amputation stumps	1
General abdominal - endoscopic or intermediate procedures <70 years w/o CC	1
General abdominal - very major or major procedures >69 years or with CC	1
Head injury >69 years or with CC	1
Heart failure or shock, w/o CC	1
Infectious or non-infectious gastroenteritis, with CC	1
Inflammatory bowel disease - endoscopic or intermediate procedures >69 years or with CC	1
Inhalation lung injury or foreign body, with major CC	1
Intermediate endoscopic or percutaneous, hepatobiliary or pancreatic procedures, with CC	1



Intermediate percutaneous kidney or ureter procedures, ≥19 years, with intermediate CC	1
Intermediate percutaneous kidney or ureter procedures, ≥19 years, w/o CC	1
Intermediate skin procedures category 2, with intermediate CC	1
Intermediate skin procedures category 2, with major CC	1
Intermediate therapeutic endoscopic retrograde cholangiopancreatography, with LOS ≤2 days	1
Intracranial procedures except trauma - category 4	1
Liver - complex procedures	1
Liver - major procedures <70 years w/o CC	1
Liver failure disorders with interventions	1
Lower respiratory tract disorders w/o acute bronchiolitis, with LOS ≥1 day, with CC	1
Major endoscopic or percutaneous, hepatobiliary or pancreatic procedures, w/o CC	1
Major gastrointestinal disorders with CC	1
Major mouth or throat procedures, ≥19 years with CC	1
Major open or laparoscopic, upper or lower genital tract procedures for malignancy	1
Malignancy of bone or connective tissue, with major CC	1
Miscellaneous vascular procedures with CC	1
Musculoskeletal signs and symptoms, with intermediate CC	1
Non OR admission for kidney or urinary tract neoplasms >69 years or with CC	1
Non-malignant breast disorders	1
Non-malignant pancreatic or biliary disorders, with catastrophic CCs	1
Other non-viral infection with CC	1
Other specified admissions and counselling	1
Pleural effusion with major CC	1
Poisoning, toxic, environmental and unspecified effects	1
Primary knee replacement	1
Red blood cell disorders >69 years or with CC	1
Renal replacement associated procedures	1
Respiratory failure w/o intubation, with major CC	1
Septicemia	1
Septicemia with intermediate CC	1
Single plasma exchange, leucopheresis or red cell exchange, with LOS ≤2 days, ≥19 years	1
Small intestine - major procedures >69 years or with CC	1
Spinal cord conditions with CC	1
Sprains, strains or minor open wounds, w/o CC	1
Therapeutic pancreatic or biliary procedures	1
Thoracic or lumbar spinal disorders >69 years or with CC	1
Unspecified acute lower respiratory infection	1
Valve disorders	1

Varicose vein procedures	1
<b>Total</b>	<b>177</b>

Abbreviations: CC, complication or comorbidity; HRG, Healthcare Resource Group; LOS, length of stay; NIV, non-invasive ventilation; w/o, without

**Supplementary Table 5.** Summary of all inpatient HRGs used 2–5 years before kidney graft failure.

	Count			
	Years before graft failure			
HRG description	Between 1 and 2 years	Between 2 and 3 years	Between 3 and 4 years	Between 4 and 5 years
Abdominal hernia procedures >69 years or with CC	0	0	0	1
Actual or suspected myocardial infarction	1	1	0	0
Acute myocardial infarction with CC	0	1	1	0
Acute myocardial infarction w/o CC	0	0	0	1
Acute renal failure >69 years or with CC	1	0	0	1
Admission for unexplained symptoms with intermediate CC	0	1	0	0
Amputations	0	0	1	0
Arm trauma diagnosis w/o procedure	1	0	0	0
Arrhythmia or conduction disorders <70 years w/o CC	0	0	2	0
Arrhythmia or conduction disorders >69 years or with CC	1	0	0	0
Arrhythmia or conduction disorders, with CC	1	0	0	0
Biliary tract disorders <70 years w/o CC	0	0	0	1

Bladder intermediate endoscopic procedure w/o CC	1	0	0	0
Bladder minor endoscopic procedure with CC	1	0	0	0
Bladder minor endoscopic procedure w/o CC	0	1	0	0
Bronchopneumonia with intermediate CC	1	0	0	0
Cardiac catheterization and angiography w/o complications	3	0	3	2
Cardiac pacemaker replacement/revision	0	1	0	0
Catheter, ≥19 years	1	1	1	1
Cerebral degenerations >69 years or with CC	2	0	0	0
Cervical spinal disorders >69 years or with CC	2	0	0	0
Chest pain <70 years w/o CC	0	2	0	0
Chest pain >69 years or with CC	0	0	1	0
Cholecystectomy >69 years or w CC	0	1	0	0
Chronic obstructive pulmonary disease or bronchitis, w/o NIV, w/o intubation, with major CC	1	0	0	0
Chronic renal failure	1	1	0	0
Closed pelvis or lower limb fractures >69 years or with	1	0	0	0

CC				
Closed upper limb fractures or dislocations <70 years w/o CC	1	0	0	0
Closed upper limb fractures or dislocations >69 years or with CC	0	1	0	0
Complex elderly with a nervous system primary diagnosis	1	0	0	0
Complex elderly with a respiratory system primary diagnosis	1	0	0	0
Complex major nose procedures	1	0	0	0
Complex major nose procedures with CC	0	1	0	0
Complications of procedures	3	0	0	1
Complications of procedures w/o CC	0	0	0	1
Cornea/sclera intermediate/high complexity	0	1	0	0
Deep vein thrombosis >69 years or with CC	1	0	0	0
Diabetes with hyperglycemic disorders, ≤69 years with intermediate CC	0	1	0	0
Diabetes with hypoglycemic disorders, ≥70 years	1	0	0	0

Diabetes with hypoglycemic emergency >69 years or with CC	1	0	0	0
Diabetes with lower limb complications	0	0	1	0
Diagnostic pancreatic or biliary procedures with CC	1	0	0	0
Diagnostic procedures, esophagus and stomach	2	0	0	0
Diagnostic radiology - arteries or lymphatics w/o CC	0	0	0	1
Disorders of the esophagus >69 years or with CC	0	1	0	0
Encephalopathy	0	1	0	0
Extradural spine major 2	0	1	0	0
Fluid or electrolyte disorders <70 years w/o CC	5	1	0	0
Fluid or electrolyte disorders >69 years or with CC	0	0	0	1
Foot procedures for diabetes or arterial disease, and procedures to amputation stumps	0	0	0	1
General abdominal disorders <70 years w/o CC	0	0	0	1
General abdominal disorders >69 years or with CC	1	1	0	0
General renal disorders with LOS $\geq$ 2 days, with	1	0	0	0

major CC				
Headache or migraine <70 years w/o CC	1	0	1	0
Headache or migraine >69 years or with CC	0	0	1	0
Heart failure or shock >69 years or with CC	0	2	0	0
Heart failure or shock, with CC	1	0	0	0
Hypertension <70 years w/o CC	0	1	0	0
Infections of bones or joints	1	0	0	0
Inflammatory bowel disease - endoscopic or intermediate procedures >69 years or with CC	0	1	0	0
Inflammatory bowel disease <70 years w/o CC	0	0	1	0
Inflammatory bowel disease >69 years or with CC	4	0	3	0
Inflammatory spine, joint or connective tissue disorders >69 years or with CC	0	0	1	0
Inguinal umbilical or femoral hernia repairs <70 years w/o CC	0	1	0	0
Inguinal umbilical or femoral hernia repairs >69 years or with CC	1	0	0	0
Intermediate head, neck and ear disorders, with	2	0	0	0

intermediate CC				
Intermediate maxillo-facial procedures, ≥19 years with CC	1	0	0	0
Intermediate medical head, neck or ear diagnoses with CC	1	0	0	0
Intermediate mouth or throat procedures	1	1	0	0
Intermediate oculoplastics procedures, ≥19 years	1	0	0	0
Intermediate percutaneous kidney or ureter procedures, ≥19 years, with intermediate CC	0	1	0	0
Intermediate percutaneous kidney or ureter procedures, ≥19 years, w/o CC	1	0	0	0
Intermediate skin disorders category 1, with intermediate CC	1	0	0	0
Intermediate skin disorders category 2, with major CC	1	0	0	0
Intermediate skin procedures category 2, with major CC	1	0	1	0
Intermediate urology interventional radiology procedures	1	0	0	0
Intestinal infectious disorders <70 years w/o CC	0	1	0	0



Intestinal infectious disorders >69 years or with CC	1	1	1	2
Intradural spine minor 1	0	1	0	0
Kidney intermediate endoscopic procedure <70 years w/o CC	1	2	0	0
Kidney intermediate endoscopic procedure >69 years or with CC	2	1	0	2
Kidney major endoscopic procedure	1	1	0	1
Kidney major open procedure >49 years or with CC	0	1	0	0
Kidney or urinary tract infections <70 years w/o CC	5	1	0	2
Kidney or urinary tract infections >69 years or with CC	6	4	1	1
Kidney or urinary tract infections, with LOS $\geq$ 2 days, with intermediate CC	0	1	0	0
Kidney or urinary tract infections, with LOS $\geq$ 2 days, with major CC	2	0	1	0
Kidney or urinary tract infections, with LOS $\geq$ 2 days, w/o CC	0	1	0	0
Large intestine - endoscopic or intermediate procedures	0	1	0	0
Large intestine - major	1	0	0	0

procedures w/o CC				
Large intestine - very major procedures	1	0	0	0
Lobar, atypical or viral pneumonia with CC	2	2	0	0
Lobar, atypical or viral pneumonia w/o CC	0	0	0	1
Lobar, atypical or viral pneumonia, with intermediate CC	0	1	1	0
Lobar, atypical or viral pneumonia, with major CC	1	0	0	0
Lower genital tract intermediate procedures	0	1	0	0
Lower limb arterial surgery with CC	0	1	0	0
Major congenital conditions	3	0	0	0
Major ear procedures	1	0	0	0
Major ear procedures, ≥19 years with CC	1	0	0	0
Major elbow and lower arm procedures for trauma, with CC	1	0	0	0
Major knee procedures for non-trauma, category 1, with CC	0	0	1	0
Major knee procedures for non-trauma, category 2, with CC	1	0	0	0
Major nose procedures	0	0	1	0
Major nose procedures, ≥19 years w/o CC	1	0	0	0

Major skin infections >69 years or with CC	2	0	1	2
Major vitreous retinal procedures	1	0	0	0
Minor breast surgery with CC	0	1	0	0
Minor dermatological conditions or benign tumors	1	0	0	0
Minor ear procedures	1	0	0	0
Minor foot procedures for non-trauma, category 2, ≥19 years, with CC	0	1	0	0
Minor hand procedures for non-trauma, category 1, with CC	0	1	0	0
Minor infections (including immune disorders)	0	1	0	2
Minor knee procedures for non-trauma, category 2, with CC	1	0	1	0
Minor medical head, neck or ear diagnoses <70 years w/o CC	0	2	0	0
Minor mouth or throat procedures, ≥19 years with CC	1	0	0	0
Minor procedures to the musculoskeletal system	0	1	0	0
Minor skin procedures - category 1 with CC	2	0	0	0
Minor skin procedures -	0	2	0	0

category 1 w/o CC				
Minor skin procedures - category 2 w/o CC	1	0	0	0
Minor skin procedures category 1	1	1	0	0
Minor spinal procedures	0	1	0	0
Miscellaneous urinary tract findings w/o CC	1	0	0	0
Miscellaneous vascular procedures	1	0	0	0
Multiple injury <70 years	2	0	0	0
Muscular disorders	0	0	1	0
Nervous system disorders	0	0	1	0
Non-inflammatory bone or joint disorders <70 years w/o CC	0	0	1	0
Non-interventional acquired cardiac conditions	0	1	0	0
Non-malignant general abdominal disorders, with LOS $\geq 2$ days, w/o major CC	1	0	0	0
Non-transient stroke or cerebrovascular accident >69 or more or with CC	0	1	0	0
Other cardiothoracic or circulatory procedures >18 years	0	0	0	1
Other gastrointestinal or metabolic disorders	1	0	2	0
Other red blood cell disorders w/o CC	1	0	0	1
Other respiratory diagnoses	1	0	0	0

<70 years w/o CC				
other respiratory diagnoses with intermediate CC	0	0	2	0
Other viral illness	1	0	0	0
Other viral illness with CC	1	0	0	0
Pacemaker implant except for AMI, heart failure or shock	0	0	0	1
Pancreas - very major procedures	0	1	0	0
Percutaneous coronary intervention	0	0	0	1
Percutaneous coronary intervention, 0 to 2 stents	1	0	0	0
Phacoemulsification cataract extraction and insertion of lens	0	0	1	0
Planned procedures not carried out	2	2	1	0
Pleural effusion with CC	1	0	0	0
Poisoning, toxic, environmental and unspecified effects	1	0	0	0
Prostate transurethral resection procedure >69 years or with CC	1	0	0	0
Pulmonary edema	1	0	0	0
Red blood cell disorders <70 years w/o CC	0	3	1	0
Red blood cell disorders >69 years or with CC	1	2	1	0
Removal of fixation device	0	1	0	0

>69 years or with CC				
Renal disease	0	1	0	2
Renal disease with renal failure	0	1	0	0
Renal general disorders <70 years w/o CC	1	0	1	0
Renal general disorders >69 years or with CC	3	1	1	0
Renal replacement associated procedures	0	1	0	0
Scrotum testis or vas deferens open procedures >69 years or with CC	1	0	0	0
Septicemia	1	0	0	0
Septicemia with intermediate CC	0	0	0	2
Sleep disordered breathing	1	0	0	0
Soft tissue disorders >69 years or with CC	0	1	0	0
Soft tissue or other bone procedures - category 1 >69 years or with CC	0	1	0	0
Soft tissue or other bone procedures - category 2 <70 years w/o CC	1	0	0	0
Sprains, strains or minor open wounds, w/o CC	0	1	0	0
Sprains, strains, or minor open wounds <70 years w/o CC	1	0	0	0
Sprains, strains, or minor open wounds >69 years or	0	0	2	0

with CC				
Stomach or duodenum - major procedures <70 years or w/o CC	0	0	1	0
Stomach or duodenum disorders <70 years w/o CC	0	1	1	0
Stomach or duodenum disorders >69 years or with CC	2	2	0	0
Stomach or duodenum very major procedures	1	0	0	0
Syncope or collapse <70 years w/o CC	1	1	0	0
Syncope or collapse >69 years or with CC	0	1	0	0
Syncope or collapse, w/o CC	1	1	0	0
Therapeutic endovascular procedures with intermediate CC	1	0	0	0
Therapeutic pancreatic or biliary procedures	2	0	0	0
Tonsillectomy, ≥19 years with CC	1	0	0	0
Transient ischemic attack <70 years w/o CC	1	1	0	0
Unspecified acute lower respiratory infection	3	0	1	1
Unspecified acute lower respiratory infection with intermediate CC	1	0	0	0
Unspecified acute lower	0	0	1	0

respiratory infection with major CC				
Upper genital tract major procedures	0	0	1	0
Ureter major endoscopic procedure	0	1	0	0
Ureteric or bladder disorders	1	0	0	0
Urinary tract findings >69 years or with CC	1	2	0	0
Vascular access for renal replacement therapy	3	1	0	0
<b>Total</b>	<b>146</b>	<b>87</b>	<b>46</b>	<b>35</b>

Abbreviations: AMI, acute myocardial infarction; CC, complication or comorbidity; HRG, Healthcare Resource Group; LOS, length of stay; NIV, non-invasive ventilation; w/o, without



**Supplementary Table 6.** Summary of all inpatient HRGs used 2–5 years before liver graft failure.

	Count			
	Years before graft failure			
HRG description	Between 1 and 2 years	Between 2 and 3 years	Between 3 and 4 years	Between 4 and 5 years
Abdominal hernia procedures >69 or with CC	0	1	1	1
Abnormal findings w/o diagnosis	0	0	0	1
Abnormal findings w/o diagnosis, with CC	0	0	1	0
Abnormal findings w/o diagnosis, w/o CC	1	0	0	0
Actual or suspected myocardial infarction	1	0	0	0
Acute liver disorders	1	0	0	0
Acute myocardial infarction w/o CC	1	1	0	0
Admission for unexplained symptoms with major CC	0	1	0	0
Admission for unexplained symptoms	1	1	0	0
Amputations	0	0	0	1
Antenatal admissions not related to delivery event	2	0	0	0
Aortic or abdominal surgery, with CC	1	0	0	0
Arrhythmia or conduction disorders <70 w/o CC	0	0	0	3
Biliary tract disorders <70 w/o CC	0	1	0	0
Biliary tract disorders >69 or	1	1	0	0

with CC				
Bladder intermediate endoscopic procedure w/o CC	1	0	0	0
Bladder major endoscopic procedure	0	0	0	1
Bladder minor endoscopic procedure w/o CC	0	0	1	0
Cardiac catheterization and angiography w/o complications	1	0	2	0
Chest pain <70 w/o CC	0	0	1	0
Chest pain >69 or with CC	1	0	1	0
Chronic liver disorders <70 w/o CC	1	1	0	0
Chronic obstructive pulmonary disease or bronchitis with CC	0	1	0	0
Chronic obstructive pulmonary disease or bronchitis, w/o NIV, w/o intubation, with intermediate CC	2	0	0	0
Closed upper limb fractures or dislocations <70 w/o CC	1	0	0	0
Closed upper limb fractures or dislocations >69 or with CC	0	1	0	0
Complex elderly with a cardiac primary diagnosis	1	0	0	0
Complex elderly with a hematology, infectious	1	0	0	0

Disease, poisoning, or non-specific primary diagnosis				
Complex major head, neck and ear disorders, with intermediate CC	1	1	0	0
Complex major head, neck and ear disorders, with major CC	2	0	0	0
Complex major nose procedures with CC	1	0	0	0
Complications of procedures	2	3	0	0
Diabetes and other hyperglycemic disorder <70 w/o CC	1	0	0	0
Diagnostic procedures, esophagus and stomach	2	1	0	0
Disorder of balance etiology unknown with CC	0	1	0	0
Epilepsy <70 w/o CC	0	1	0	0
Epilepsy >69 or with CC	3	4	0	0
Fluid or electrolyte disorders <70 w/o CC	1	1	1	1
Fluid or electrolyte disorders >69 or with CC	1	0	1	0
Foot procedures for diabetes or arterial disease, or procedures to amputation stumps	0	0	1	0
Gastrointestinal bleed, with LOS $\geq$ 2 days, with major CC	1	1	0	0
General abdominal - diagnostic procedures	0	1	0	0

General abdominal disorders >69 or with CC	0	1	0	0
Heart failure or shock >69 or with CC	0	2	0	0
Infectious or non-infectious gastroenteritis, with CC	1	0	0	0
Inflammatory bowel disease >69 or with CC	1	1	2	0
Inflammatory spine, joint or connective tissue disorders >69 or with CC	0	0	1	0
Inguinal umbilical or femoral hernia repairs >69 or with CC	0	1	0	0
Intermediate endoscopic or percutaneous, hepatobiliary or pancreatic procedures, w/o CC	1	0	0	0
Intermediate hip procedures for trauma, with major CC	1	0	0	0
Intermediate mouth or throat procedures, 19 years and over with intermediate CC	1	0	0	0
Intermediate skin disorders category 2, with major CC	0	1	0	0
Intermediate therapeutic endoscopic retrograde cholangiopancreatography, with LOS $\leq$ 2 days	1	0	0	0
Intermediate therapeutic general abdominal procedures, 19 years and	2	0	0	0

over with major CC				
Intermediate thoracic procedures w/o CC	0	1	0	0
Intermediate thoracic procedures w/o CC	0	1	0	0
Intestinal infectious disorders <70 w/o CC	1	0	0	0
Intestinal infectious disorders >69 or with CC	1	0	0	0
Kidney or urinary tract infections >69 or with CC	2	2	0	0
Kidney or urinary tract infections, with LOS $\geq$ 2 days, with major CC	0	0	1	0
Large intestinal disorders >69 or with CC	0	1	0	0
Liver - major procedures <70 w/o CC	5	2	0	1
Liver - major procedures >69 or with CC	0	2	0	1
Liver - very major procedures	1	0	2	0
Lobar, atypical or viral pneumonia, with intermediate CC	1	0	0	1
Lobar, atypical or viral pneumonia, with major CC	0	1	0	0
Lower respiratory tract disorders w/o acute bronchiolitis	1	0	0	0
Major endoscopic or percutaneous, hepatobiliary	1	0	0	0

or pancreatic procedures, with intermediate CC				
Major head, neck and ear disorders, with intermediate CC	0	1	0	0
Major reconstructive surgery	0	1	0	0
Minor dermatological conditions or benign tumors	1	0	0	0
Minor head, neck and ear disorders, with CC	0	1	0	0
Minor nose procedures, 19 years and over with CC	1	0	0	0
Minor pain procedures	0	1	0	0
Non-interventional acquired cardiac conditions	0	1	1	0
Non-malignant breast disorders	1	0	0	0
Other non-viral infection with CC	1	0	0	0
Other respiratory diagnoses <70 w/o CC	1	0	0	0
Other specified admissions and counselling	1	0	0	0
Other viral illness	1	1	0	1
Phakoemulsification cataract extraction and insertion of lens	0	0	1	0
Planned procedures not carried out	0	1	0	0
Pleural effusion with intermediate CC	0	1	0	0

Poisoning, toxic, environmental and unspecified effects	0	0	1	1
Removal of fixation device >69 or with CC	0	1	0	0
Septicemia with intermediate CC	1	1	0	0
Single plasma exchange, leucophoresis or red cell exchange, with LOS ≤2 days, 19 years and over	2	0	0	0
Sleeping disorders affecting breathing	1	0	0	0
Small intestine - very major procedures	1	0	0	0
Stomach or duodenum disorders <70 w/o CC	0	0	1	0
Stomach or duodenum disorders >69 or with CC	0	0	0	1
Syncope or collapse >69 or with CC	0	1	0	0
Therapeutic pancreatic or biliary procedures	1	0	0	0
Thyroid procedures with CC	1	0	0	0
Unspecified acute lower respiratory infection	0	0	0	1
Unspecified acute lower respiratory infection with intermediate CC	0	0	1	0
Urinary incontinence or other urinary problems, with intermediate CC	1	0	0	0

Valve disorders	1	0	0	0
Vascular access for renal replacement therapy, with CC	0	2	0	0
<b>Total</b>	<b>70</b>	<b>52</b>	<b>21</b>	<b>15</b>

Abbreviations: CC, complication or comorbidity; HRG, Healthcare Resource Group; LOS, length of stay; w/o, without



**Supplementary Table 7.** Use of other drug therapies for kidney transplants during years 2–5 before graft failure.

	Number of patients (%)			
	Years before grafts failure			
BNF chapter <sup>a</sup>	Between 1 and 2 years	Between 2 and 3 years	Between 3 and 4 years	Between 4 and 5 years
Alpha-adrenoceptor blocking drugs/alpha-blockers (in urinary retention)	78 (37.5)	53 (33.3)	30 (27.8)	24 (29.3)
Angiotensin-converting enzyme inhibitors	80 (38.5)	50 (31.4)	32 (29.6)	21 (25.6)
Angiotensin-II receptor antagonists	55 (26.4)	42 (26.4)	29 (26.9)	20 (24.4)
Antiplatelet drugs	98 (47.1)	69 (43.4)	50 (46.3)	38 (46.3)
Beta-adrenoceptor blocking drugs	59 (28.4)	46 (28.9)	27 (25.0)	21 (25.6)
Beta-adrenoceptor blocking drugs/prophylaxis of migraine	0	0	0	10 (12.2)
Bisphosphonates and other drugs affecting bone metabolism	34 (16.3)	21 (13.2)	16 (14.8)	12 (14.6)
Broad-spectrum penicillin antibiotics	78 (37.5)	51 (32.1)	35 (32.4)	26 (31.7)
Calcium-channel blockers	98 (47.1)	69 (43.4)	42 (38.9)	31 (37.8)
Cephalosporins	39 (18.8)	22 (13.8)	16 (14.8)	14 (17.1)
H <sub>2</sub> -receptor antagonists	33 (15.9)	23 (14.5)	16 (14.8)	12 (14.6)
Long-term control of gout	42 (20.2)	28 (17.6)	16 (14.8)	10 (12.2)
Loop diuretics	82 (39.4)	51 (32.1)	39 (36.1)	29 (35.4)
Non-opioid and compound analgesics	47 (22.6)	42 (26.4)	19 (17.6)	11 (13.4)
Non-opioid and compound	47 (22.6)	35 (22.0)	23 (21.3)	15 (18.3)

analgesics/opioid analgesics				
Oral anticoagulants	0	0	0	10 (12.2)
Oral bicarbonate	34 (16.3)	22 (13.8)	0	0
Oral iron	32 (15.4)	0	0	0
Proton pump inhibitors	89 (42.8)	63 (39.6)	40 (37.0)	30 (36.6)
Quinolones	0	0	16 (14.8)	14 (17.1)
Statins	126 (60.6)	81 (50.9)	63 (58.3)	44 (53.7)
Sulphonamides and trimethoprim	0	0	19 (17.6)	0
Unknown	0	23 (14.5)	0	0
Vaccines and antisera - influenza vaccines	35 (16.8)	29 (18.2)	18 (16.7)	15 (18.3)
Vitamin D	75 (36.1)	48 (30.2)	36 (33.3)	25 (30.5)

BNF, British National Formulary

<sup>a</sup>Drug therapies are defined by BNF chapter.

**Supplementary Table 8.** Use of other drug therapies for liver transplants during years 2–5 before graft failure.

	Number of patients (%)			
	Years before graft failure			
BNF chapter <sup>a</sup>	Between 1 and 2 years	Between 2 and 3 years	Between 3 and 4 years	Between 4 and 5 years
Alpha-adrenoceptor blocking drugs/alpha-blockers (in urinary retention)	0	7 (16.7)	5 (16.1)	0
Angiotensin-converting enzyme inhibitors	9 (14.5)	7 (16.7)	5 (16.1)	4 (16.7)
Angiotensin-II receptor antagonists	9 (14.5)	0	0	0
Antimotility drugs/cough suppressants/opioid analgesics	0	6 (14.3)	4 (12.9)	0
Antiplatelet drugs	23 (37.1)	11 (26.2)	10 (32.3)	8 (33.3)
Beta-adrenoceptor blocking drugs	0	5 (11.9)	3 (12.5)	0
Bisphosphonates and other drugs affecting bone metabolism	14 (22.6)	12 (28.6)	8 (25.8)	7 (29.2)
Broad-spectrum penicillins	32 (51.6)	16 (38.1)	12 (38.7)	7 (29.2)
Calcium supplements	0	0	4 (12.9)	0
Calcium-channel blockers	24 (38.7)	11 (26.2)	6 (19.4)	5 (20.8)

Cephalosporins	0	5 (11.9)	0	0
Detection strips, blood for glucose - biosensor strips	15 (24.2)	6 (14.30)	0	0
Drugs affecting biliary composition and flow	13 (21.0)	9 (21.4)	6 (19.4)	6 (25.0)
Drugs used in megaloblastic anemias	0	0	4 (12.9)	3 (12.5)
H <sub>2</sub> -receptor antagonists	0	0	0	3 (12.5)
Hypnotics	0	0	4 (12.9)	3 (12.5)
Lancet sterile single use	9 (14.5)	6 (14.3)	0	0
Loop diuretics	11 (17.7)	0	5 (16.1)	0
Needle for pre-filled and reusable pen injector	9 (14.5)	0	0	3 (12.5)
Non-opioid and compound analgesics	23 (37.1)	18 (42.9)	11 (35.5)	5 (20.8)
Non-opioid and compound analgesics/opioid analgesics	9 (14.5)	0	5 (16.1)	0
Opioid analgesics	12 (19.4)	9 (21.4)	6 (19.4)	3 (12.5)
Oral iron	0	0	5 (16.1)	5 (20.8)

Osmotic laxatives	10 (16.1)	0	0	0
Penicillinase-resistant penicillins	12 (19.4)	6 (14.3)	0	0
Proton pump inhibitors	32 (51.6)	20 (47.6)	12 (38.7)	9 (37.5)
Sedating antihistamines	0	0	0	4 (16.7)
Selective beta 2 agonists	11 (17.7)	0	0	0
Selective serotonin re-uptake inhibitors	0	7 (16.7)	0	0
Statins	21 (33.9)	14 (33.3)	7 (22.6)	3 (12.5)
Thyroid hormones	0	6 (14.3)	0	0
Topical corticosteroids	0	0	6 (19.4)	4 (16.7)
Unknown	0	0	0	4 (16.7)
Vitamin D	22 (35.5)	14 (33.3)	10 (32.3)	8 (33.3)

BNF, British National Formulary

<sup>a</sup>Drug therapies are defined by BNF chapter.