Non-retrieval and non-utilisation of deceased donor kidneys for transplantation: an Australian cohort study

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Abbreviations Page

Area under the curve, (AUC)

Australia and New Zealand Organ Donation Register, (ANZOD)

Body mass index, (BMI)

Confidence interval, (CI)

Donation after circulatory determination of death, (DCDD)

Donation after neurological determination of death, (DNDD)

Expanded criteria donor, (ECD)

Interquartile interval, (IQI)

Kidney donor profile index, (KDPI)

Odds ratio, (OR)

Standard criteria donor, (SCD)

Standard deviation, (SD)

Abstract

Background

An efficient organ donation program must maximise transplantation following initiation of organ recovery procedures.

Methods

We conducted a cohort study of deceased donors in Australia (2014-2021) using Australia and New Zealand Organ Donation Registry data to characterise kidney non-retrieval (post-incision) and non-utilisation (retrieved, not transplanted). Donor characteristics included kidney side (left/right), kidney-only procurement, kidney donor profile index (KDPI), cause of death, resuscitation, donation after circulatory/neurological determination of death (DCDD/DNDD) and donor criteria (standard SCD/extended ECD), year, age, sex, blood group, ethnicity, comorbidities, smoking, BMI, weight, remoteness, occupation, and socioeconomic disadvantage. System characteristics included jurisdiction of donor hospital, retrieval team, and recipient's hospital.

Results

Among 7,211 kidneys (3,683 donors) accepted for retrieval, 675 (9%) were non-retrieved and 430 (7%) were non-utilised. Crude non-retrieval rates doubled from 5% to 10% between 2014-2021 (p=0.01) while non-utilisation remained around 7% (p=0.1). After adjustment, non-retrieval was greater among donors with KDPI≥75 (OR 4.28, 95%CI: 2.08–8.81, p<0.001), diabetes (OR 1.74, 95%CI: 1.25–2.43, p=0.001), and in recent years (annual OR 1.08, 95%CI: 1.03–1.55, p=0.002), and lower for ECD DCDD (OR 0.46, 95%CI: 0.26-0.81, p=0.01). Non-utilisation was greater for SCD DCDD (OR 1.90, 95%CI: 1.28-2.82, p<0.001), blood group AB (OR 2.05, 95%CI: 1.16-3.64, p=0.03) and in recent years (annual OR 1.08,

95%CI: 1.02-1.15, p=0.01), and lower in Tasmania (OR 0.28, 95%CI: 0.08-0.97) and Queensland (OR 0.57, 95%CI: 0.36-0.92, p=0.03). Documented reasons for non-utilisation lacked transparency but included poor perfusion (17%).

Conclusion

Increasing utilisation of higher KDPI kidneys and enhancing perfusion could help maximise kidney transplantation.

Introduction

The scarcity of deceased donor kidneys combined with a growing number of people waiting for a kidney transplant has led to ongoing demand for donor kidneys that exceeds supply. From 2006 to 2019, 381 people died while waiting for a kidney transplant in Australia[1]. Although efforts to expand the donor pool have resulted in more donors accepted for transplantation, a significant number of deceased donor kidneys are not retrieved, or if retrieved, are subsequently not utilised for transplantation[2].

The organ retrieval process comprises three sequential stages: (i) identifying potential donors in intensive care units or emergency departments, (ii) evaluating potential donors' medical suitability and obtaining family consent, and (iii) the surgical retrieval of organs[3-5]. The decision to abandon kidney retrieval is made in the beginning of the third stage, whereas the decision to not utilise a kidney for transplantation may occur from the time of retrieval until the time of transplant surgery.

The definition of an actual deceased donor varies among countries[4]. In the UK, Canada, and USA, an actual deceased donor is an individual from whom at least one organ was retrieved for the purpose of transplantation[3, 6, 7]. In Australia, actual donors are individuals for whom the organ retrieval procedure commenced in the operating room (with surgical incision) for the purpose of transplantation (regardless of whether the organ was retrieved or transplanted)[8]. Despite these subtle definition variations, non-utilisation (sometimes referred to as organ discard) is internationally reported as organs retrieved from an actual donor but subsequently not utilised for transplantation. Organs accepted for retrieval but abandoned after surgical incision (non-retrieval), are rarely reported in published literature.

There is known variability in the non-utilisation rate for kidneys across countries[7, 9, 10]. This may stem from differences in donation and transplantation systems, including the criteria for donor eligibility and transplant centre acceptance[11-13]. For example, Australia's close integration of donation and transplantation services enhances communication such that donation will not proceed without an organ likely accepted for transplantation, thereby reducing non-utilisation rates[2]. However, kidney non-utilisation rates are increasing globally[14]. In Australia, the kidney non-utilisation rate has risen from 2.7% in 2005-2012 to 5-7% in 2018-2022[15, 16].

The acceptable threshold of non-retrieval and non-utilisation rates is unclear when balancing efficiency with limited resources. While maximising successful donations is important, we must also avoid expending resources that ultimitately results in non-utilisation. While every effort is made to ensure a safe and successful donation, there are instances where non-retrieval or non-utilisation of donor kidneys is unavoidable, such as discovery of unanticipated donor disease or anatomical anomalies[16, 17]. However, other reasons may be modifiable, such as organ trauma during surgical procedures, misadventure during transportation, or issues at destination, that present opportunities to increase utilisation of donor kidneys.

A recent study examined factors contributing to non-utilisation of donation after circulatory determination of death (DCDD) kidneys in Australia[18]. However, the study did not account for non-utilisation of single kidneys (i.e. where one kidney is utilised, and the other is not) nor did they describe non-retrieval rates[18]. Our aims were to describe non-retrieval and non-utilisation of kidneys from actual deceased donors, determine associated donor and system factors and describe the reasons for non-retrieval and non-utilisation.

Material and methods

Study population

We performed a cohort study of all actual deceased donors in Australia from 1 January 2014 to 31 December 2021. We explored non-retrieval and non-utilisation of kidneys from actual deceased donors, including kidneys deemed unsuitable for transplantation both before and after retrieval from the donor's body (Figure S1). We used a subset of Australian de-identified data from the Australia and New Zealand Organ Donation Register (ANZOD). ANZOD records administrative data on all organ donors in Australia and New Zealand, with data securely transferred from the electronic donor record by donor coordinators[19]. Ethical approval for this study was obtained from the University of Sydney Human Research Ethics Committee (Project No. 2021/916).

Statistical methods

We summarised occurrence of kidney non-retrieval and non-utilisation rates by donor and system characteristics using counts and proportions for categorical variables, and mean, standard deviation (SD), median, and interquartile interval (IQI) for continuous variables. Donor characteristics we considered included left and right kidney, kidneys from kidney-only donors, kidney donor profile index (KDPI), cause of death, cardiopulmonary resuscitation, donor type (extended criteria donor (ECD), standard criteria donor (SCD), donation after neurological determination of death (DNDD), and DCDD), calendar year of donation, age, sex, blood group, ethnicity, comorbidities (diabetes, hypertension and history of cancer), smoking status, body mass index (BMI), weight, remoteness of postcode (Accessibility/Remoteness Index of Australia), occupation and socioeconomic disadvantage decile (Socio-economic Index for Areas)[5, 20]. KDPI was calculated by using a formula that

included donor age, history of hypertension, diabetes, terminal creatinine, cause of death stroke, height, weight and DCDD[21].

ECD is defined as donors, aged ≥60 years, or ≥50 years with at least two of the following: cause of death stroke, history of hypertension or terminal creatinine ≥133µmol/L[20, 22].

Our analysis included single kidneys as well as dual-allocation and *en-bloc* kidneys, (where two kidneys from one donor are retrieved and transplanted together into one recipient), however we lacked data to differentiate between dual-allocation and *en-bloc* donations. Dual-allocation and *en-bloc* kidneys were considered as a single organ.

Differences in system characteristics between states and territories were accounted for by considering location of the donor's hospital, the retrieval team, and the recipient's hospital.

We reported kidney non-retrieval and non-utilisation rates overall, as well as stratified by donor and system characteristics. Non-retrieval rates were calculated as the number of non-retrieved kidneys divided by the number of kidneys from donors who were consented and deemed medically suitable for surgical retrieval (accepted for retrieval). Non-utilisation rates were calculated as the number of non-utilised kidneys divided by the number of kidneys retrieved. Confidence intervals were binomial for proportions. We used linear regression to calculate the non-retrieval and non-utilisation rate overtime and by KDPI.

We used logistic regression to identify donor and system characteristics associated with kidney non-retrieval and non-utilisation. We performed univariable analysis on all donor and system characteristics and included all variables with univariable $p<0.05$ in the initial multivariable model. We always included age, sex, BMI, donor type, diabetes, hypertension, and cancer history regardless of univariable p-value as these were considered clinically

relevant. We used backwards selection to remove variables from the multivariable model with $p>0.05$ and that were not effect modifiers (<10% change in all other odds ratios). We tested for changes in the effect of donor type, KDPI and state overtime by examining interactions with year and included those where $p<0.05$. We reported odds ratio (OR), 95% confidence interval (CI), and p-value from both univariable and multivariable models. We used robust estimation of variance to account for clustering of kidneys from the same donor. We categorised reasons for non-retrieval and non-utilisation based on National Disposition Codes and free-text descriptions.

Data were analysed using Stata 16.1.

Results

Study population

There was a total of 7,229 kidneys, including 7,087 single kidneys and 142 *en-bloc*/dual-allocation kidneys accepted for retrieval from 3,683 actual kidney donors in Australia between 1 January 2014 and 31 December 2021. We excluded 18 (<1%) single kidneys procured with the primary intent for research. The remaining 7,211 (99.8%) kidneys were included in our analysis.

Donor characteristics

The median age of kidney donors was 49 years. The majority were male (57%) of Australian & New Zealander ethnicity (77%), and with BMI categorised as normal/overweight (71%). Most donors had blood type O (47%, reflective of the Australian population), were classified as donor type SCD DNDD (49%), had hypertension (26%) and died of cerebral hypoxia/ischemia (37%)[23]. Furthermore, the majority lived in major cities (65%) and were from high and middle socio-economically advantaged postcodes (75%). All donor characteristics are summarised in Table 1.

Kidney non-retrieval and non-utilisation rates

Among 7,211 kidneys accepted for retrieval, 675 (9%) were not retrieved, including 59 from donors whose other kidney was retrieved (Figure 1). Of those kidneys retrieved for transplantation, 430 (7%) were not utilised.

The non-retrieval rate increased on average 0.7% every year (p=0.01) from 5% (95%CI: 3.7%-7.0%) in 2014 to 10% (95%CI: 8.3%-12.6%) in 2021. Amongst kidneys retrieved, the non-

utilisation rate was relatively more stable increasing on average only 0.4% per year (p=0.1) from 6% (95%CI: 4.3%-7.9%) in 2014 to 8% (95%CI: 6.0%-10.0%) in 2021.

There was some evidence that changes in the non-retrieval rate over time varied by KDPI p=0.03 (Figure 2). The average annual increase in the non-retrieval rate for KDPI≥75 was 1.8% (95%CI: 0.9%-2.8%), whereas for KDPI<75 it was 0.3% (95%CI: -0.7%-1.3%). However, the changes in the non-utilisation rate remained consistent across KDPI levels p=0.9.

Non-retrieval and non-utilisation rates by state and territory are presented in Table S1. The non-utilisation rates for kidneys travelling interstate and those travelling within state were no different (p=0.2, Figure 3).

Factors associated with non-retrieval and non-utilisation

Donor and system factors associated with non-retrieval and non-utilisation are presented in Figure 4, with all unadjusted and adjusted results presented in Tables S2-S3. Non-retrieval increased over time (annual OR 1.08, 95%CI: 1.03-1.15, p=0.002) and was more likely among donors with KDPI≥75 (versus KDPI<25, OR 4.28, 95%CI: 2.08-8.81, p<0.001). Donors with diabetes also had increased odds of non-retrieval (OR 1.74, 95%CI: 1.25-2.43, p=0.001). There was some evidence of an association between death category and non-retrieval (p=0.06); compared with intracranial haemorrhage, the highest risk of non-retrieval was among donors who died from cerebral infarct (OR 1.60, 95%CI: 1.02-2.51) followed by cerebral hypoxia/ischaemia (OR 1.52, 95%CI: 1.10-2.09). There was little evidence of an association between non-retrieval and blood group (p=0.16) and state/territory (p=0.19).

Conversely, non-retrieval was less likely in donors who were ECD DCDD (versus SCD DNDD, OR 0.46, 95%CI: 0.26-0.81, p=0.01). There was also some evidence that non-retrieval was

less likely in donors from the least socio-economically disadvantaged postcode (top 30% versus middle 40%, OR 0.73, 95%CI: 0.55-0.96, p=0.08).

Factors associated with non-utilisation differed from those associated with non-retrieval. Non-utilisation also increased over time (annual OR 1.08, 95%CI: 1.02-1.15, p=0.01), however was more likely for SCD DCDD (versus SCD DNDD, OR 1.90, 95%CI: 1.28-2.82, p<0.001) and blood group AB (versus A, OR 2.05, 95%CI: 1.16-3.64, p=0.03). Compared with New South Wales, non-utilisation was less likely among donors from Tasmania (OR 0.28, 95%CI: 0.08-0.97) and Queensland (OR 0.57, 95%CI: 0.36-0.92, p=0.03). There was some evidence that non-utilisation was more likely in donors from socio-economically disadvantaged postcodes (bottom 30% versus middle 40%, OR 1.47, 95%CI: 1.07-2.03, p=0.06), as well as those with non-neurological cause of death (versus intracranial haemorrhage, OR 2.02, 95%CI: 1.12-3.63, p=0.06). There was only weak evidence that non-utilisation differed by KDPI (p=0.14). No statistically significant interactions were identified. Based on the area under the curve (AUC) values, both models demonstrated 'fair' discriminatory ability (Supplementary Figure S2). This level of performance is consistent with what is typically observed in kidney outcome models[21, 24].

Reasons for kidney non-retrieval and non-utilisation

Twenty discrete reasons for kidney non-retrieval were recorded and grouped into main reasons (Figure 5, Table S4 and Table S5). The main reasons for non-retrieval were mostly attributed to donor characteristics. Primary concerns were related to unspecified donor diseases. For example, 'disease of organ' was the most common reason for non-retrieval (37%), however no further discrete information was available. Furthermore, in 76 (11%) cases no reason was recorded for kidney non-retrieval, and these were grouped in the risk-

other category. The most commonly cited system reason was ‘no suitable recipient’ (8%), and ‘declined in offer process’ (7%) with no additional details provided on the reasons behind these decisions.

Likewise, twenty-four discrete reasons for kidney non-utilisation were recorded and grouped into main reasons. The main reasons for non-utilisation were attributed to donor characteristics. There was an absence of recorded reasons in 69 cases (16%), which were categorised under the risk-other category. ‘Poor perfusion’ (17%) accounted for the second most commonly recorded reason. Notably, of the kidneys not-utilised due to poor perfusion, 74% were DCDD**.** The main system reasons included ‘no suitable recipient’ (10%), followed by ‘trauma to organ’ (7%).

Discussion

This is the first paper to examine the non-retrieval of deceased donor kidneys in Australia. We found, over the eight-year study period, the non-retrieval rate doubled and is increasing every year, while the non-utilisation rate remained relatively stable[15, 19]. In Australia, the non-utilisation rate is expected to be minimal but greater than zero, primarily because the definitive decision on transplant suitability is made immediately prior to transplant surgery[5]. Monitoring the non-retrieval rate is particularly important considering the significant logistical challenges, allocation of fixed resources, and associated costs involved in the preparation for organ donation surgery, and not least, mortality of potential recipients whilst on the waitlist. We found kidneys with KDPI≥75 were four times more likely not to be retrieved than those with KDPI<25. There was also some evidence that the non-retrieval rates were increasing annually for KDPI≥75 compared with KDPI<75. This may be attributable to increasing age and complexity of donors over time, with more significant donor multimorbidity. The primary purpose of KDPI is to predict deceased donor kidney transplant survival over time, which is not the context in which we have used it as an assessment of overall donor risk profile[25, 26]. Further investigation could determine if and under what circumstances these high KDPI kidneys could be effectively utilised.

Perhaps surprisingly, kidneys from ECD DCDD were more likely to be retrieved compared with SCD DNDD. This may be due to selection bias, where only the most favourable ECD DCDD proceed as actual donors, where others are foregone.

Donor type SCD DCDD was strongly associated with non-utilisation and poor perfusion emerged as one of the primary reasons for non-utilisation, predominately observed in DCDD kidneys. A recent Australian study identified warm ischemia as a predictive factor for non-

utilisation of DCDD kidneys[18]. After treatment withdrawal, and following circulatory arrest in DCDD, ischaemic injury to the kidneys occurs along with intravascular thrombosis contributing to inadequate perfusion[27]. While static cold storage is the most commonly used organ (or kidney) preservation method in Australia, current preliminary evidence supports the advantages of using normothermic ex-situ machine perfusion, however more research is needed [27-30]. Additionally, the use of hypothermic machine perfusion may facilitate more favourable logistics for both donor retrieval and transplant surgery. For example, this technique may allow more time for kidney allocation. The use of normothermic regional perfusion is gaining acceptance in DCDD kidney donation but has not been used to date in Australia. In 2018 an independent review of the organ donation, retrieval and transplantation system, initiated by the Australian Government, outlined interest in developing a national plan to enhance the use of perfusion systems[2].

We found variations in non-retrieval and non-utilisation rates by donor hospital state/territory, for example, Tasmania and Queensland had lower rates of non-utilisation compared with New South Wales. Unmeasured factors, such as location and logistics, may influence the decision to proceed to retrieval, contributing to jurisdictional differences. For instance, Tasmania relies on interstate retrieval services, which may impact the decision to proceed to organ retrieval for SCD DCDD, and ECD DNDD and DCDD. In such cases, the time-sensitive nature of organ viability may be compromised, potentially impacting the feasibility of retrieval. Similarly, Queensland is a large state, with many regional hospitals which logistically may impact the decision to proceed. The distance and time involved may affect whether the retrieval goes ahead, especially for more complex donor cases, given the critical time constraints involved. We also found non-retrieval and non-utilisation rates

changed over time even after adjusting for donor factors. This could also suggest differences and adjustments in system factors, such as transplant practices or policies overtime, or workforce changes. The impact of the COVID-19 pandemic beginning in 2020 in Australia led to suspension of kidney transplantation nationally from 24 March to mid-May 2020, and continuing logistic impediments even when re-started, due to lack of commercial flights and closure of state borders[31]. However, this was largely beyond our study period[32].

Similar geographic variations in non-utilisation are observed in the United States, where sources have recommended identifying hard-to-place kidneys early and expediting their distribution to centres most likely to accept them, thereby improving efficiency and reducing non-utilisation rates[28, 33, 34]. Of note, we excluded any effect of day of the week/weekend as an additional system-related factor from our analysis. Current evidence has shown no impact of weekends or public holidays on kidney non-utilisation rates or donation rates in Australia[35].

Our study's strengths involve analysing nationwide data covering all kidney donors in Australia. However, data granularity posed limitations. We could only access up to three donor comorbidities and identifiable facility details were restricted. Organ extended or prolonged cold ischaemic time, was only available as a reason for non-retrieval and non-utilisation and not collected as a continuous time variable. Ischaemic time can directly contribute to the decision to not retrieve or utilise a kidney, especially if the likelihood of successful transplantation decreases as time passes. One study found that for every additional hour of total ischaemic time (from donor renal artery interruption until clamp release in the recipient), there was a 2% increase in the overall risk of graft loss for the recipient[36]. Essential information about logistics (e.g. transportation type and duration), and

time and location of the decision to not-utilise (e.g., during donor surgery, transport, or recipient surgery) were unavailable. Understanding the timing of the decision is particularly important to help inform future research and policy decisions. For example, there is often an attempt to pre-allocate ECD kidneys to transplant centres before retrieval to reduce ischaemic time[37]. If pre-allocation is attempted and no transplant centre agrees to accept the kidneys, they may not be retrieved.

The data collection for reasons of non-retrieval and non-utilisation lacked detail and frustrated our attempts to understand clinical events. Also, the collection and recording of reasons have also varied overtime. A US study encountered similar data-related challenges, with "no recipients located" frequently listed as a reason, restricting insight[11]. Understanding the reasons why kidneys are not retrieved or utilised can help guide system solutions such as enhancing surgical, perfusion, storage, and transport processes. Notably, the Australian Organs and Tissue Authority has listed enhanced data collection and reporting as a strategy in their 2023-24 strategic plan[38].

Conclusion

In Australia, annual non-retrieval rates of deceased donor kidneys are increasing and have doubled in eight years, reaching 10%, while non-utilisation rates remained stable around 7%. Non-retrieval is four times more likely for kidneys with KDPI≥75 compared to KDPI<25. This highlights the potential for targeted efforts to maximise utilisation of kidneys with KDPI≥75 where possible. Poor perfusion particularly for DCDD, emerged as a primary reason for non-utilisation. Extended ischaemic times was also listed as a reason for non-retrieval and non-utilisation and both findings support the implementation of machine perfusion

technology. Improved data collection metrics must be applied to gain further insights to optimise kidney utilisation through improved systems and processes.

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Disclosure Statement

The authors declare no conflicts of interest.

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Figure legends

Figure 1 Study population for analysis. All actual deceased donor kidneys accepted for retrieval in Australia between the years 2014 to 2021.

Figure 2 Kidney non-retrieval and non-utilisation rates (unadjusted) over calendar year and by kidney donor profile index (KDPI) from 1 January 2014 to 31 December 2021. Australian COVID-19 pandemic period highlighted in purple. Confidence intervals depicted as grey bands for the overall line. Absolute total number of kidneys by KDPI across each year is provided at the base of figure.

Figure 3 Sankey plot of kidney utilisation and non-utilisation by retrieving team states and territories New South Wales (NSW), Victoria (VIC), Queensland (QLD), South Australia (SA), Western Australia (WA) and Northern Territory (NT) and corresponding destination states and territories.

Figure 4 Multivariable model of donor and system characteristics associated with kidney non-retrieval and non-utilisation. Odds ratios are shown for each covariate and 95% confidence intervals. P-values are provided in Table S3.

Figure 5: Main reasons for kidney non-retrieval and non-utilisation by donor and system characteristics. The full list of discrete reasons mapped to main reasons provided in Table S4.

List of Supporting Information

Table S1: Kidney non-retrieval and non-utilisation rates by donor hospital states and territories and retrieving team state between years 2014 to 2021.

Table S2: Univariable analysis of kidney non-retrieval and non-utilisation by donor and system characteristics. All covariates with p-values <0.05 and effect modifiers >10% were included in the multivariable model.

Table S3: Multivariable analysis of kidney non-retrieval and non-utilisation by donor and system characteristics. P-values are provided for each covariate.

Table S4: List of discrete reasons mapped to main reasons for kidney non-retrieval by donor and system characteristics. Numbers unable to be provided due to small count.

Table S5: List of discrete reasons mapped to main reasons for kidney non-utilisation by donor and system characteristics. Numbers unable to be provided due to small count.

Figure S1: Flowchart depicting Australia's deceased organ donor process.

Figure S2: Performance of multivariate logistic regression models for kidney non-retrieval and non-utilisation

Tables

Table 1 Australian actual deceased donor kidneys not retrieved, not utilised and utilised by donor and system characteristics from years 2014 to 2021.

Characteristics, n (column %)	Not retrieved		Retrieved, not utilised		Utilised		Total	
Total kidneys (row %)	675	(9)	430	(7)	6,106	(85)	7,211	(100)
Single kidneys	675	(100)	417	(97)	5,977	(98)	7,069	(98)
Left kidney	*331*	*(49)*	*200*	*(48)*	*3,004*	*(50)*	*3,535*	*(49)*
Right kidney	*344*	*(51)*	*217*	*(52)*	*2,973*	*(50)*	*3,534[a]*	*(49)*
En bloc/Dual kidney (counted as one kidney)	0	(0)	13	(3)	129	(2)	142	(2)
Kidneys from kidney-only donors								
DNDD	108	(63)	51	(27)	942	(63)	1,101	(59)
DCDD	63	(37)	137	(73)	560	(37)	760	(41)
Kidney donor profile index (KDPI)								
Best (≤24%)	90	(13)	42	(10)	1,381	(23)	1,513	(21)
Best to Average (25%-49%)	118	(17)	72	(17)	1,604	(26)	1,794	(25)
Average to Poor (50%-74%)	145	(21)	120	(28)	1,643	(27)	1,908	(26)
Poorest (≥75%)	322	(48)	196	(46)	1,478	(24)	1,996	(28)
Cause of death								
Cerebral Infarct	54	(8)	23	(5)	343	(6)	420	(6)
Cerebral Hypoxia / Ischaemia	259	(38)	139	(32)	2,285	(37)	2,683	(37)
Intracranial Haemorrhage	242	(36)	172	(40)	2,197	(36)	2,611	(36)
Traumatic Brain Injury	99	(15)	53	(12)	1,021	(17)	1,173	(16)
Other Neurological Condition	*	*	*	*	>100	*	>100	*
Non-Neurological Condition	*	*	*	*	>100	*	>100	*
Cardiopulmonary resuscitation								
Yes	288	(43)	190	(44)	2,989	(49)	3,467	(48)

Characteristics, n (column %)	Not retrieved		Retrieved, not utilised		Utilised		Total	
Not reported	*0*	*(0)*	*0*	*(0)*	***	*(0)*	***	*(0)*
Donor criteria and pathway								
Standard Criteria	390	(58)	246	(57)	4,403	(72)	5,039	(70)
DNDD	255	(38)	124	(29)	3,176	(52)	3,555	(49)
DCDD	135	(20)	122	(28)	1,227	(20)	1,484	(21)
Extended Criteria	285	(42)	184	(43)	1,703	(28)	2,172	(30)
DNDD	228	(34)	106	(25)	1,240	(20)	1,574	(22)
DCDD	57	(8)	78	(18)	463	(7)	598	(8)
Calendar year								
2014 – 2017	286	(42)	172	(40)	2,992	(49)	3,450	(48)
2018 – 2021	389	(58)	258	(60)	3,114	(51)	3,761	(52)
Age, median (IQI)	54	(39-65)	55	(45-64)	48	(33-59)	49	(34-60)
<1-5	*	*	*	*	>50	*	>50	*
6-18	*	*	*	*	>300	*	>300	*
19-29	58	(9)	42	(10)	822	(13)	922	(13)
30-49	181	(27)	105	(24)	2,063	(34)	2,349	(33)
50-59	156	(23)	112	(26)	1,368	(22)	1,636	(23)
≥60	251	(37)	164	(38)	1,435	(24)	1,850	(26)
Female	290	(43)	170	(40)	2,619	(59)	3,079	(43)
Blood group								
O	352	(52)	205	(48)	2,828	(46)	3,382	(47)
A	227	(34)	143	(33)	2,417	(40)	2,787	(39)
B	73	(11)	61	(14)	674	(11)	808	(11)
AB	23	(3)	21	(5)	187	(3)	231	(3)
Ethnicity[b]								
Aboriginal and/or Torres Strait Islander	*	*	*	*	>100	*	>200	*

Characteristics, n (column %)	Not retrieved		Retrieved, not utilised		Utilised		Total	
Māori or Pacific Islander	*	*	*	*	59	(1)	76	(1)
Australian or New Zealander	485	(72)	315	(73)	4,717	(77)	5,517	(77)
European[c]	72	(11)	46	(11)	540	(9)	658	(9)
African or Middle Eastern[d]	*	*	*	*	>100	*	>100	*
Asian[e]	63	(9)	42	(10)	425	(7)	530	(7)
People of the Americas	*	*	*	*	>50	*	>50	*
Comorbidities								
Diabetes	118	(17)	63	(15)	420	(7)	601	(8)
Hypertension	259	(38)	163	(38)	1,433	(23)	1,855	(26)
History of cancer	79	(12)	55	(13)	421	(7)	555	(8)
Smoking status								
Current	264	(39)	160	(37)	2,629	(43)	3,053	(42)
Former	165	(24)	116	(27)	1,294	(21)	1,575	(22)
Never	246	(36)	154	(36)	2,183	(36)	2,583	(36)
Body mass index (kg/m^2)								
Underweight (≤18.4)	*	*	*	*	>150	*	>150	*
Normal (18.5-24.9)	249	(37)	117	(27)	2,148	(35)	2,514	(35)
Overweight (25.0-29.9)	232	(34)	153	(36)	2,197	(36)	2,582	(36)
Obese (≥30)	171	(25)	148	(34)	1,576	(26)	1,895	(26)
Not categorised (young age)	*	*	*	*	>20	*	>20	*
Weight (kg), mean (SD)	79	(21)	84	(23)	80	(21)	80	(21)
Residential remoteness								
Major City	443	(66)	304	(71)	3,942	(65)	4,689	(65)
Inner Regional	171	(25)	84	(20)	1,408	(23)	1,663	(23)
Outer Regional	51	(8)	30	(7)	575	(9)	656	(9)
Remote Australia	*	*	*	*	>50	*	>100	*
Overseas	*	*	*	*	>50	*	>50	*

Characteristics, n (column %)	Not retrieved		Retrieved, not utilised		Utilised		Total	
Occupation								
Managers	23	(3)	13	(3)	211	(3)	247	(3)
Professionals	86	(13)	52	(12)	964	(16)	1,102	(15)
Technicians And Trade Workers	68	(10)	47	(11)	796	(13)	911	(13)
Community And Personal Server Workers	28	(4)	24	(6)	367	(6)	419	(6)
Clerical And Administrative Workers	39	(6)	16	(4)	321	(5)	376	(5)
Sales Workers	20	(3)	19	(4)	223	(4)	262	(4)
Machinery Operators And Drivers	18	(3)	15	(3)	211	(3)	244	(3)
Labourers	52	(8)	41	(10)	517	(8)	610	(8)
Unemployed	81	(12)	39	(9)	600	(10)	720	(10)
Other[f]	260	(39)	164	(38)	1,896	(31)	2,320	(32)
Socioeconomic deprivation								
Least disadvantage (decile 1 - 3)	179	(27)	149	(35)	2,014	(33)	2,342	(33)
Middle disadvantage (decile 4 - 7)	321	(48)	157	(37)	2,623	(43)	3,101	(43)
Most disadvantage (decile 8 - 10)	175	(26)	124	(29)	1,469	(24)	1,768	(25)
Donor hospital states or territory								
New South Wales	157	(23)	122	(28)	1,597	(26)	1876	(26)
Victoria	190	(28)	162	(38)	1,793	(29)	2145	(30)
Queensland	141	(21)	42	(10)	1,204	(20)	1387	(19)
South Australia	88	(13)	35	(8)	509	(8)	632	(9)
Western Australia	58	(9)	50	(12)	598	(10)	706	(10)
Northern Territory	*	*	*	*	>50	*	>50	*
Australian Capital Territory	20	(3)	11	(3)	177	(3)	208	(3)
Tasmania	*	*	*	*	>150	*	>150	*
Retrieval team states[g]								
New South Wales	0	(0)	137	(32)	1,811	(30)	1,948	(30)
Victoria	*	*	>150	*	>1,500	*	>2,000	*

Characteristics, n (column %)	Not retrieved		Retrieved, not utilised		Utilised		Total	
Queensland	0	(0)	42	(10)	1,199	(20)	1,241	(19)
South Australia	*	*	>20	*	>500	*	>500	*
Western Australia	0	(0)	49	(11)	591	(10)	640	(10)
Northern Territory	0	(0)	*	*	>20	*	>20	*
New Zealand (outside Australia)	*0*	*(0)*	*0*	*(0)*	*	*	*	*
Destination facility states[h]								
New South Wales	0	(0)	18	(18)	1,860	(30)	1,878	(30)
Victoria	0	(0)	45	(45)	1,969	(32)	2,014	(32)
Queensland	0	(0)	15	(15)	1,153	(19)	1,168	(19)
Sout Australia	0	(0)	*	*	>500	*	>500	*
Western Australia	0	(0)	*	*	>500	*	>500	*

[a]Difference in total single kidneys: seven donors had no R) kidneys recorded in the data, but seven L) kidneys were retrieved and utilised; six donors had no L) kidneys recorded in the data, but five R) kidneys were retrieved and utilised and one single R) kidney was retrieved and not utilised.

[b]Categorised based on the Australian Standard Classification of Cultural and Ethnic Groups 2019.

[c]Noth-West European (e.g. British, Irish), Western European (e.g. Austrian, Flemish, French, German), Northern European (e.g. Danish, Finnish, Icelandic, Norwegian, Swedish), South and Eastern European (e.g. Italian, Maltese, Portuguese, Spanish, Greek, Romanian, Polish, Russian).

[d]Includes North African, Sub-Suharan African and Middle Eastern.

[e]North-East Asian (e.g. Chinese, Japanese, Korean, Taiwanese, & Mongolian), South-East Asian (e.g. Burmese, Cambodian, Filipino, Indonesian, Lao, Malay, Singaporean, Thailander, Timorese, & Vietnamese), Southern Asian (e.g. Indian, Nepalese, Sri Lankan, & Pakistani), and Central Asian (e.g., Armenian, Afgan, Hazara).

[f]Includes Student, Child/Baby, Pensioner, Housewife/Husband, Retired.

[g]Victoria provides kidney retrieval services to Tasmania. New South Wales provides kidney retrieval services to the Australian Capital Territory. Northern Territory has its own local kidney retrieval service.

[h]No kidney transplant services in Tasmania, Australian Capital Territory or Northern Territory. Victoria provides kidney transplant services for Tasmania (in Victoria). New South Wales provides kidney transplant services for the Australian Capital Territory (in New South Wales). South Australia provides kidney transplant services for the Northern Territory (in South Australia).

*Small numbers prohibit precise reporting due to privacy protection

Figures

Figure 1 Study population for analysis. All actual deceased donor kidneys accepted for retrieval in Australia between the years 2014 to 2021.

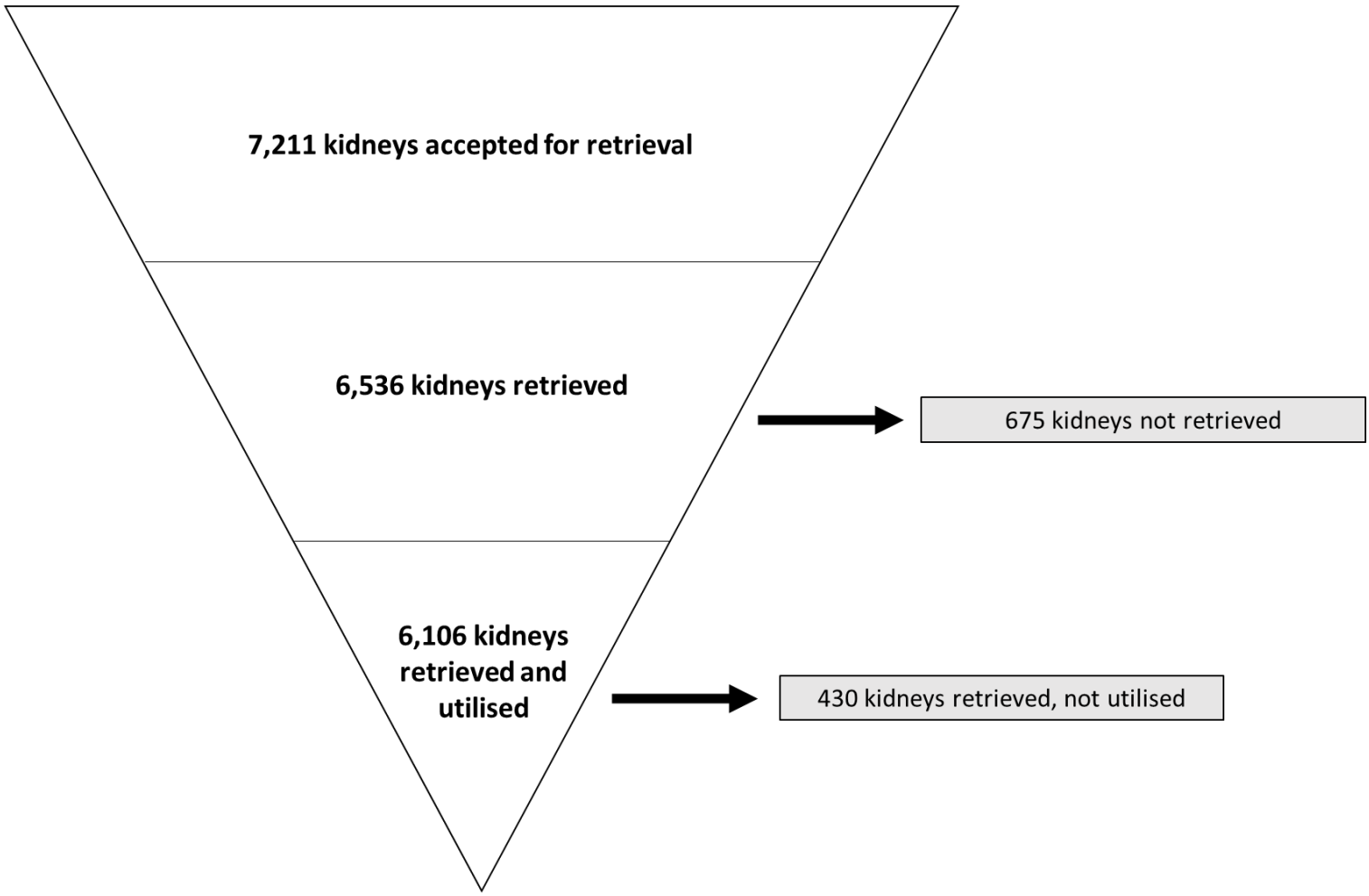
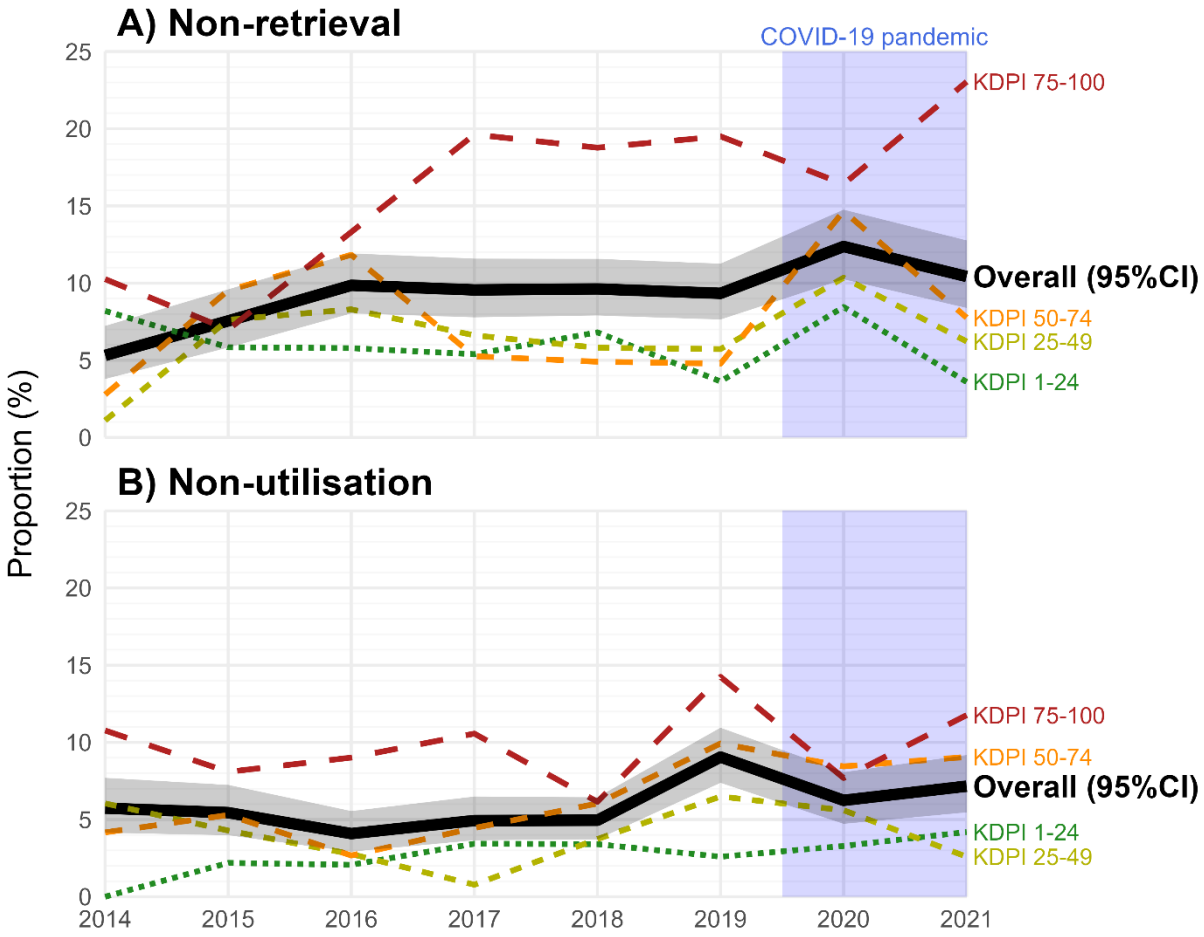
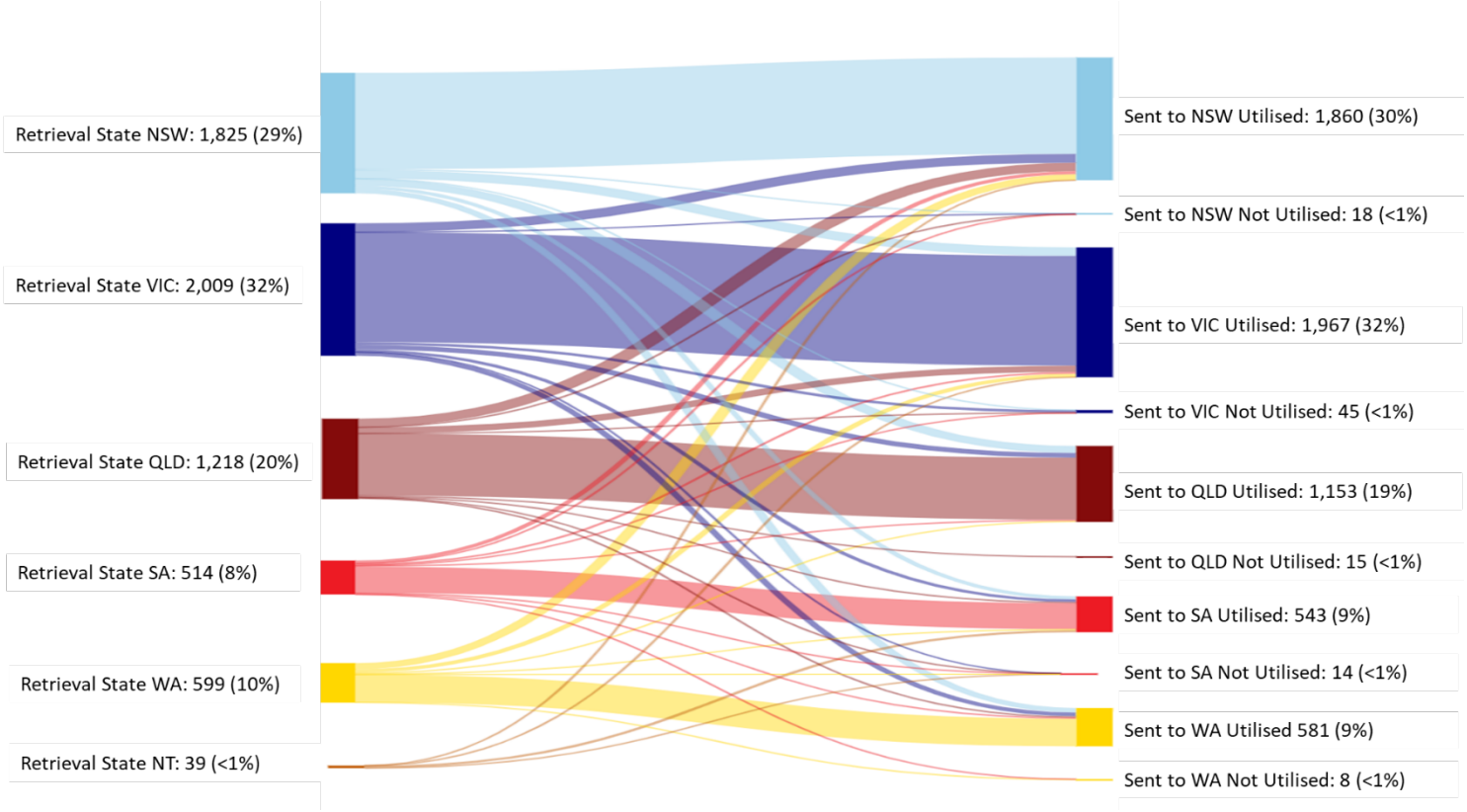


Figure 2 Kidney non-retrieval and non-utilisation rates (unadjusted) over calendar year and by kidney donor profile index (KDPI) from 1 January 2014 to 31 December 2021. Australian COVID-19 pandemic period highlighted in purple. Confidence intervals depicted as grey bands for the overall line. Absolute total number of kidneys by KDPI across each year is provided at the base of figure.



	2014	2015	2016	2017	2018	2019	2020	2021
Total kidneys, N	**715**	**808**	**954**	**973**	**1050**	**1050**	**865**	**796**
KDPI 1-24	122	137	242	204	235	193	213	167
KDPI 25-49	182	210	217	257	241	262	232	193
KDPI 50-74	216	189	262	247	265	272	225	232
KDPI 75-100	195	272	233	265	309	323	195	204

Figure 3 Sankey plot of kidney utilisation and non-utilisation by retrieving team states and territories New South Wales (NSW), Victoria (VIC), Queensland (QLD), South Australia (SA), Western Australia (WA) and Northern Territory (NT) and corresponding destination states and territories. Victoria provides kidney retrieval services to Tasmania. New South Wales provides kidney retrieval services to the Australian Capital Territory.



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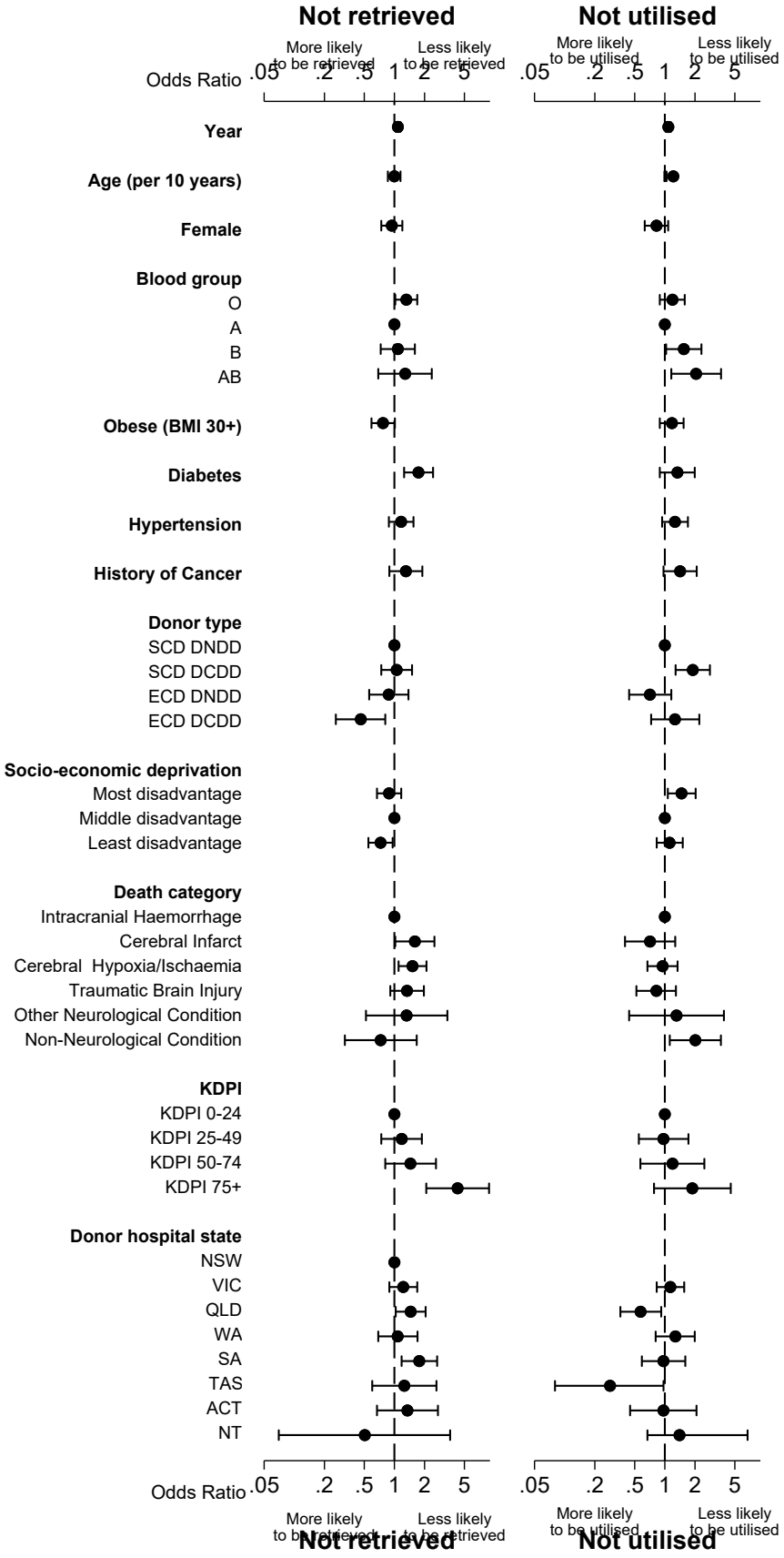

Figure 5 Main reasons for kidney non-retrieval and non-utilisation by donor and system characteristics. The full list of discrete reasons mapped to main reasons provided in Table S4.