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Outcomes for living kidney donors following donor nephrectomy in Aotearoa New Zealand: A 30-year retrospective cohort study

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Author contributions

LC contributed to design, data collection, and article writing. GI contributed to design, analysis and article writing. TG and BA contributed to data collection. CD, MS and PC contributed to design, analysis and editing. M.C. conceived the study concept, and contributed to design, data collection, analysis, article preparation and editing. All authors contributed to revising the manuscript, and approved the final version submitted for publication.

Data availability

Data for this study are not available for public review.

Abbreviations

ANZDATA, Australian and New Zealand Dialysis and Transplant Registry

CI, Confidence Interval

CVD, Cardiovascular Disease

KF, Kidney Failure

ICD-9-AM, International Classification of Diseases 9th revision, Australian Modification

ICD-10-AM, International Classification of Diseases 10th revision, Australian Modification

IQR, Interquartile Range

MoH, Ministry of Health

NHI, national health index

NMDS, National Minimum Dataset

NZ, New Zealand

NZBS, New Zealand Blood Service

Abstract

Background: Living donor kidney transplantation is the optimal treatment for people with kidney failure. Because living kidney donors do not derive health benefits from donation, contemporary and relevant information on post-donation outcomes need inform decision-making. Studies of donor outcomes are largely restricted to donations prior to 2010 in the USA and Europe. We studied donors over a 30-year period in Aotearoa New Zealand (NZ) to investigate short and long-term outcomes in a contemporary non-USA/non-European population.

Methods: This was a retrospective observational cohort study of all living kidney donors in NZ (1988-2018). The primary outcome was the incidence of kidney failure. Secondary outcomes were death, cardiovascular disease, and the incidence of complications within 90 days after nephrectomy. Donors were identified using multiple data sources: the NZ Blood Service, the Ministry of Health, hospital records, and the Australia and New Zealand Live Kidney Donor (ANZLKD) Registry. Outcomes were determined via data linkage with Australia and New Zealand Dialysis and Transplant Registry (ANZDATA) for kidney failure and with the NZ Ministry of Health using ICD coding for other outcomes. Follow-up was until 31st December 2019.

Results: 1339 people donated a kidney from 1988-2018. During 16,272 person-years of follow-up, 5 people developed kidney failure, an incidence of 3 per 10,000 person-years (95% CI 1.3-7.4). Patient survival was 99% (98.2-99.5) at 10 years; 30 people died during follow-up. The incidence of cardiovascular disease was 11.6 (95% CI 7.4-19.2) per 10,000 person-years. 292 donors (22%) experienced a complication following donor nephrectomy and 69 (5%) required intervention.

Conclusions: There is a low risk of kidney failure and other complications among living kidney donors in NZ. These findings represent important contemporary data that can support informed decision making.

Word count: /250

KEYWORDS: Living donor, kidney transplantation, kidney failure

INTRODUCTION

Kidney transplantation improves quality of life and survival at lower cost for patients with kidney failure (KF) compared with dialysis.[1-3] Globally, living donor kidney transplants constitute approximately 38% of transplant activity,[4] and help overcome the shortage of deceased organ donors. From a recipient perspective, receiving a living donor kidney transplant is associated with superior patient and graft survival compared with deceased donor kidneys, with 5 year patient survival exceeding 95%.[5] However, from a potential donor's perspective, kidney donation is a unique situation whereby a donor will undergo a medical procedure to assist another person, accepting the associated risks.

Potential living kidney donors are rigorously screened to ensure they do not have health conditions that might increase risks for recipients, such as through transmission of infection or malignancy.[6] They are assessed to minimise the risk of the early post-operative complications of surgery and anaesthesia [7] In addition, donors are carefully selected to ensure they are at low risk of developing chronic kidney disease post donation.

Historically, donors were not considered to be at an increased risk of adverse outcomes compared with healthy non-donors; studies reported similar or improved rates of mortality, KF and cardiovascular disease (CVD) comparable with the age-matched general population.[8-11] However, several more recent studies with matched healthy controls raised concerns that the risk of living kidney donation may have been underestimated. The risk may be underestimated given donors are heavily screened prior to proceeding with donation, and so an appropriate comparison is matched controls not the general population. Mjøen et al. (Norway)[12] and Muzaale et

al. (USA)[13] found increased risks of KF, death and CVD in donors compared to healthy controls. The relative risk of KF after 10-15 years was substantially increased in donors (5 to 10-fold) although the overall absolute risk of KF remained low. Nevertheless, both studies provide estimates of the absolute risks for KF associated with donation in their populations that may be broadly applicable to populations of potential donors elsewhere, including in Aotearoa New Zealand (NZ). Regarding other complications post donation, kidney donation is associated with occurrence of hypertension and proteinuria post nephrectomy.[14, 15]

The global health impacts of KF are increasingly recognised and there are significant geographical variations of burden of KF and the availability and accessibility of living kidney transplants across the world.[16] Many healthy adults are eager and willing to accept the risk of donor nephrectomy to help their loved ones who have KF. However, clinicians need to be able to provide donors with accurate data about their risks so they can make informed decisions. Population specific data will guide clinicians and improve efforts to address practices that can better inform and prepare future donors. Despite an increase in living donor kidney transplantation activity in NZ[5], there is no published data on outcomes for NZ living kidney donors. The risk of kidney failure are population specific and vary widely for different ethnic groups. Both the studies by Mjøen et al. (Norway)[12] and Muzaale et al. (USA)[13] reflect outcomes from a different population than for people living in NZ. We designed and conducted Live Donate NZ, an observational cohort study of living kidney donors in NZ, to investigate the long-term risks of KF, death, and CVD in this population. It will inform discussions between clinicians and potential donors in the future and provide long-term outcomes for people who are contemplating kidney donation.

METHODS

Inclusion criteria

All living donor kidney transplantations performed in NZ Transplant Hospitals (Auckland, Christchurch, Waikato and Wellington Hospital) between 1988 and 2018 were included in this study. The follow up of the study completed in December 2019. People were excluded if they were not residents of Australia or NZ due to lack of follow-up data.

Living kidney donor identification

Living donors were identified by interrogation of multiple data sources. Since 2004, all living donors were recorded in the Australian and New Zealand Living Kidney Donor (ANZLKD) Registry. For transplants prior to 2004, or where data were not recorded in the living donor registry, details of recipients of living kidney transplants were recorded in the ANZDATA registry. To ensure all donors were identified, individual transplanting hospital records were additionally manually searched to identify the donors.

Data Linkage

All residents in NZ are assigned a National Health Index (NHI) number, a unique individual health system identifier that identifies and links them with national health records. We linked study data using the NZBS, the Ministry of Health (MoH), hospital records, and the Australia and New Zealand Dialysis and Transplant (ANZDATA) Registry for all living kidney donors from 1988-2018 who donated within New Zealand (figure 1). This was done using deterministic linkage for donations from

2004 onwards. For donors who donated prior to 2004, records of living donors were linked with records at NZBS and archives from the hospital tissue typing lab using the NHI for deterministic linkage where available and probabilistic linkage for those without the NHI based on name, date of birth and other identifiers. The NZ national collection of clinical information, mortality and cause of death were available after 1988 in the National Minimum Dataset (NMDS) and the National Mortality Collection from the New Zealand Ministry of Health (NZ MoH). The NMDS is a national collection of public and private hospital discharge information for inpatients and day patients, including clinical information. It provides statistical data, reports and analyses about all hospital inpatient and day patient health services nationally for the purpose of policy formation, performance monitoring, research, and review. Data collected from the donors' medical records include national health index (NHI) where applicable, age, sex, ethnicity, relationship to recipient, residency status and date of kidney transplant.

Statistical Analysis

Datasets were merged and analysed in Stata/IC 17.0 (Stata Corp, College Station, TX). All continuous variables were presented as means with standard deviations or medians with interquartile ranges depending on their distribution. Categorical variables were presented as proportions. Specific analyses based on the different outcomes are detailed below.

Outcomes:

Primary outcome: Kidney Failure

Kidney failure was defined as the commencement of dialysis treatment, or the receipt of a kidney transplant, whichever occurred first. The outcome of KF in living donors was obtained via data linkage of donor details with records held in the ANZDATA registry. The registry records cases of KF in Australia and NZ where a patient received treatment with long term maintenance dialysis, or received a kidney alone or multi-organ transplant that included a kidney to identify live donors who developed kidney failure without dialysis. The linked data was also reviewed for KF as a cause of death or if, during hospital admissions, there was a diagnosis or procedure ICD code that indicated acute or chronic KF (supplement table s1-4).[17]

Secondary outcome: Death

Causes of death were recorded using the International Classification of Diseases 9th and 10th revision, Australian Modification codes (ICD-9-AM, ICD-10-AM). Cause of death was categorised. Patient survival post donation was analysed using Kaplan-Meier Survival curves.

Secondary outcome: Cardiovascular Disease

CVD outcomes were defined using ICD-9-AM, ICD-10-AM codes during hospital admissions. Codes used to identify CVD events are listed in supplement table s4-8. Due to death being a competing risk for CVD, the cumulative incidence of competing events is graphically displayed.

Secondary outcome: Acute complications

All hospital admissions within 90 days of donation were obtained from the NMDS. Complications were defined using ICD-9-CMA and ICD-10-AM external cause code.

External cause ICD codes are used to classify the mechanism of an event or injury, which coders determine at the time of admission. We determined there was a complication if an admission had the external cause code group “Complications of medical and surgical care“. Admissions up until 31st December 1999 used ICD-9 coding and after 1stof January 2000 used ICD-10 coding. Complications were calculated on a per patient basis. The type of complications were determined using the diagnostic codes for that admission. Complications were then categorised based in 2 ways: 1) severity and 2) major and minor categories. Severity was determined using the adapted Clavien-Dindo Classification of surgical complications.[7, 18, 19] This grades the complication based on the level of treatment required, i.e. grade II transfusion, III radiological procedure or surgical intervention, IV organ failure. Any diagnoses within an admission were categorised into minor and major categories based on work from Lentine et. al.[7] These categories were assigned by 2 separate authors (GI, LH) with consensus by discussion. Adjudication from co-authors (MC, MS, PC) occurred if consensus was not reached. A patient could have multiple complications per admission.

Sensitivity Analysis: Definition of complication

Two sensitivity analyses were conducted for the analysis of complications to ensure the robustness of estimates:

1) Any complications within 30 days
2) Any complications within initial admission for donor nephrectomy

Ethics

The study was approved by the Northern Health and Disability Ethics Committee (reference 15/NTA/47) and received funding from Auckland District Health Board Charitable Trust.

RESULTS

Records of transplants performed between 1988 and 2018 were complete, and all living donors were identified for transplants performed during that period. There were 1339 donors from 1988-2018, with an increase in donors over time. The demographics of the living donors are displayed in Table 1. Most donors were female (58%). The median age at donation was 44 years (IQR 35-52). Europeans (79%) was the predominant ethnicity group followed by Maori (10%), Asian (6%) and Pacific (3%). 62% of donors were genetically related to the transplant recipients.

Outcomes:

Kidney Failure

Five people developed KF treated with kidney replacement therapy during follow up (figure 2). No additional donors who were not receiving kidney replacement therapy had KF failure reported as a cause of death. The incidence rate of KF was 3 per 10,000 person-years (95% CI 1.3-7.4) with a follow-up time of 16,272 person-years. The death-censored native kidney survival was 100% at five years, 99.9% (95% CI 99.1-99.9%) at ten years, 99.3% (95% CI 97.6-99.8) at 20 years and 97.4 (95% CI 92.5-99.0) at 30 years. One donor was developed KF and commenced kidney replacement therapy after eight years post kidney donation due to glomerulonephritis. In contrast, the remaining four developed KF, all attributed to diabetic kidney disease, more than 15 years after kidney donation.

Death

There were 30 (0.08%) deaths of kidney donors recorded during the study follow-up period. The most common cause of death was malignancy 67% (n=20), followed by CVD 20% (n=6). The mean age at death was 63 years (SD 10.8). The Kaplan-Meier survival curve for death is shown in figure 3. The patient survival was 99.6% (95% CI 98.9-99.8%) at five years, 99.0% (95% CI 98.2-99.5%) at ten years, 95.7% (95% CI 93.4-97.2) at 20 years and 88.7% (95% CI 80.5-93.7) at 30 years.

Cardiovascular Disease

Nineteen people (1%) had an acute cardiovascular event during follow-up after donation. These were primarily due to ischaemic heart disease 68% (n=13), with the remaining due to cardiovascular death (n=6, 32%). 73.7% of donors who had a cardiovascular event were men (n=14). The median time from donation to admission with a cardiovascular event was 16.4 years (IQR 9.9-22.1). The cumulative incidence curves for cardiovascular events and the competing risk of non-cardiac death are displayed in figure 4. The follow-up time was 16,439 person-years, with an estimated incidence rate of 11.6 (95% CI 7.4-19.2) per 10,000 person years.

Complications

292 donors (22%) had reported a complication following donation. Of these, 69 (5%) had a complication requiring an intervention (Clavien-Dindo complication >1 : table 2) . The major types of complications are documented in table 3, with the most frequent being “other” complications followed by gastrointestinal and the minor categories are document in table s10. No living donors died in the first three months

after donation. 67 (5%) people were readmitted due to complications and one person was readmitted twice. For a donation admission, the median length of stay if there was a complication was five days (IQR 4-7, range 2-24) compared to a median stay of 4 days without (IQR 3-5, range 1-17) ($p<0.001$). The median length of stay for readmission was two days (IQR 1-3, range 0-40). The length of stay decreased over time, with the median length of stay being seven days (IQR 6-8) in 1988-1999 compared to 4 days (IQR 3-4) in 2010-2018.

Sensitivity analysis 1: Readmission within 30 days

When restricted to complications within 30 days of donation, there were 286 people with complications (22%) with 65 people with complications requiring an intervention (Clavien-Dindo complication > 1). These are documented in table s11.

Sensitivity analysis 2: Complications within donation admission

When restricted to complications only within the donation admission, 239 people (18%) had a complication. Of these 55 (4%) required an intervention (Clavien-Dindo complication > 1). Restriction to only donation admission excluded complications from the minor categories of haematuria, peritonitis and gastrointestinal haemorrhage.

Missingness:

There was limited missing data. 21 (1.6%) donors had no records of hospital admissions within -14 to +90 days of donation. All other data had no missingness.

DISCUSSION

This study explored multiple short and long-term patient important complications post-donation.

Kidney failure

In this analysis, 5 out of 1339 donors developed KF in the follow period and the incidence rate of KF was 3 per 10,000 person-years (95% CI 1.3-7.4). Although these risks of KF after kidney donation do not exceed KF rates in the general population[10, 20, 21] two studies comparing donors with donation-attributable risk found that donation is associated with a small but significant risk of KF. However, the absolute increase in KF attributable to donation was minimal .[11,12] Mjøen et al. showed that the overall incidence of KF among donors was 302 cases per million with a median follow-up of 15 years.[11] Muzaale et al. reported the cumulative incidence of KF at 15 years was 30.8 per 10,000 donors compared with 3.9 per 10,000 in matched donors (risk attributable to donation of 26.9 per 10,000).[12] Our findings reaffirm that low risk of KF post donation is consistent with previous reports of KF in donors.[11,12] In our study, only one donor developed KF due to glomerulonephritis after eight years post kidney donation and the remaining four donors developed later KF with diabetic kidney disease as the most common cause of KF after 15 years post kidney donation. Our findings confirm the findings of an earlier study that showed early KF in donors within 10 years post kidney donation was predominantly attributed to glomerulonephritis. In contrast, later KF in donors was due to diabetic kidney disease and hypertension.[22] Diabetic kidney disease and hypertension were unlikely to be the cause of KF in donors in the early period post kidney donations as these conditions were absolute or relative contraindications for

living kidney donation.[23, 24] This highlights that as a community we need to be vigilant in screening and managing diabetes in the donor population.

Death

While early studies reported that the living donor population experienced fewer deaths when compared to matched general population, there was no data on relative survival. [9-12, 25-27] More recent studies with alternative method have reported the observed and expected survival.[28, 29] The Swedish study had 459 donors from 1964 until the end of 1994 and reported observed survival of 85% in the donor group after 20 years of follow-up, whereas the expected survival rate was 66%[28]. The study was from an earlier era and better survival among donors may be due to more selective criteria for donation. In a Japanese study, the observed survival in living donors were 98.2%, and the expected survival was 97% at five years donation.[29] Our study demonstrates that living kidney donors in NZ have a low mortality risk on long term follow up.

CVD

There is plausibility for an excess of cardiovascular risk or mortality after kidney donation. Most studies have a short follow-up after donation, with few cases of ischaemic heart disease (IHD), resulting in a lack of statistical power.[9, 27, 30] The aforementioned studies all suffer from few events, relatively short follow-up and uncertainty whether the control group was considered an appropriate comparison (low CVD risk). Another study[31] found significantly higher risk CVD compared to healthy controls. In the latter study, after a mean observation time of 11.3 years (SD 8.1) for donors and 16.4 years (SD 5.7) for controls, 3.5 % (n=35) of donors were

diagnosed with IHD versus 1.7% (n-267) of the controls. The adjusted odds ratio for CVD was 1.64 (95% CI 1.1-2.4, p=0.01) in donors compared with controls. However, diagnoses of CVD were based on self-reports among the controls which may result in underreporting and recall bias.[31] Mjøen et al. found increased CVD and mortality in living donors compared to healthy donors and attributed the difference in the findings compared to prior studies due to the longer follow-up in their study.[11] Our study reported 1.4% (n=19) donors suffer CVD requiring admission post donation and an incidence rate of 11.6 (95%CI 7.4-19.2) per 10,000 person years which remains low and reassuring for donors. This, however, needs to be interpreted that our data will only capture those with CVD requiring hospitalisation so any less severe CVD managed in the community may be missed.

Secondary complications

The perioperative mortality rate of living donor nephrectomy ranges from 0.02% and 0.04% and morbidity varies from 8% to 18%.[7, 32, 33] The variation in the complication rates is likely due to differences in the definition of perioperative complications and ascertainment methodology. The higher incidence of overall complications in our study likely reflects differing definitions of the outcome measure. Our study broadens the definition to encompass specific complications, including cardiac, respiratory, gastrointestinal, bleeding, and infection and includes any complication within 90 days rather than the initial hospital admission. The longer length of hospital stay in the earlier era between 1988-1999 compared to later period in 2010-2018 maybe due to the difference in surgical technique for living donor nephrectomy or changes in post-operative models of care. Open donor nephrectomy was implemented in an earlier era and laparoscopic nephrectomy was introduced in June 2000. Since then, the

laparoscopic approach has become the standard surgical approach for donor nephrectomy in New Zealand. The laparoscopic technique benefits from a shorter hospital stay.[34, 35] Admission to intensive care is not collected within the MOH dataset, which is one of the inclusion criteria for Grade IV for Clavien-Dindo, so this could not be included within the categories of complications and may underestimate complication severity. This highlights some of the difficulties in using administrative datasets for complications. The external codes are assigned by coders using clinical information at the time event. This increase in granular information presumably can allow the coders to discriminate whether a complication is attributable to donation or not. The limitation of using the coding approach is that coders may not recognise some complications at the time, and therefore, underreporting of potentially more minor complications.

Examining comprehensive longitudinal outcomes into a contemporary era is imperative to provide donors with short- and long-term risks of donation, particularly given the change in who we accept as donors[25]. Effective risk communication is essential for shared decision-making, the gold standard for health care decisions.[36] Being able to provide donors with accurate information risks, benefits and consequences of donation are part of the informed consent process from the decision-making framework set out within the KDIGO Clinical Practice Guideline on the Evaluation and Care of Living kidney Donors Guidelines.[6] Ideally, these risks would be individualised, include the degree of uncertainty[37] and presented as absolute values[38]. Grams et al [39] have developed an internet-based risk prediction calculator which can calculate the risk of KF pre-donation at 15 years and over the donors life time.[40] Unfortunately, the usefulness of this tool for decision making is

hampered by the lack of risk post-donation. The difficulty in creating a risk score post-donation based on individual donor characteristics is hampered by the need for both long-term follow-up and a large number of donors, due to fortunately low numbers of donors who have KF.

Strengths

This a comprehensive longitudinal study of all living donors in NZ spanning 30 years. Long-term follow-up of healthy living kidney donors can be difficult to maintain as they may default from regular follow-up leading to incomplete post donation information. We are able to use data linkage to national registries and ANZDATA to ascertain KF, CVD, death and reduce lost to follow-up in our study population. There is complete capture of all cases of treated KF and all death data. Other studies have restricted to donation admission, which may miss essential complications that cause readmission to hospital.

There are also limitations to the study. There are limited data on living donors' characteristics at the time of donation. This analysis doesn't include a comparison control group of non-donors, so a relative risk cannot be calculated. Over the years, the living donor criteria have expanded to include acceptance of genetically unrelated living donors (including non-directed donors), development of exchange programs (established in 2011) and use of expanded-criteria living donors, particularly elderly donors. There needs to be caution with the extrapolation of risk from previous eras of donors to the current potentially more marginal donors. The uncertainty of risk as donor criteria expand will need further prospective monitoring of complications to quantify the future risks better. This means the rates of KF and

complications may not be as generalisable to the current cohort of donors. The major limitation of this study is the use of coded administrative datasets, particularly to determine post-operative complications. These were derived from administrative coding at the time of admission rather than clinical judgment. This analysis only included complications that led to a hospital admission which may have excluded less severe complications. The outcome of CVD was derived from hospital admissions or procedures. Thus, if someone was diagnosed with CVD in primary care this would not be captured, potentially missing less severe CVD. These limitations must be acknowledged when interpreting the rates of postoperative complications and the outcome of CVD.

This study demonstrated a low risk of several short- and long-term outcomes for donors post-living kidney donation. There is a low risk of long-term patient important complications of KF, CVD, and death over a 30-year follow-up period. Perioperative complications are common in keeping with previous literature; however, severe complications are rare. Being able to inform donors about these risks may help with consent and decision-making about kidney donation. Further research presenting the absolute risk for donors post donation should be the aspiration for the living donor community.

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Tables:

Factor	Value (n=1339)
Age at donation, median (IQR)	44.7 (35.7, 52.5)
Donor sex	
Female	777 (58.0%)
Male	562 (42.0%)
Ethnicity	
European	1060 (79.2%)
Māori	139 (10.4%)
Pacific	47 (3.5%)
Asian	80 (6.0%)
Other	13 (1.0%)
Related Donor	834 (62.3%)
Year of Donation	
1988-1997	189 (14.1%)
1998-2007	431 (32.2%)
2008-2018	719 (53.7%)

Table 1: Live Kidney donor demographics

Clavien Dindo Complication Grade	Number	Percent
1	223	76.4%
2	7	2.4%
3	61	20.9%
4	1	0.3%

Table 2: Acute Complications based on severity

Complication	Number (% of total complications) n=292
Bleeding	38 (13.0%)
Cardiac	54 (18.5%)
Fluid imbalance	43 (14.7%)
Gastrointestinal	126 (43.2%)
Genitourinary	41 (14.0%)
Hernia	1 (0.3%)
Infection	65 (22.3%)
Injury	33 (11.3%)
Kidney Impairment	12 (4.1%)
Other Complication	181 (62.0%)
Respiratory	66 (22.6%)
Thrombosis	1 (0.3%)
Vascular	10 (3.4%)
Wound	25 (8.6%)

*Table 3: Complications categorised into Major categories *Note: there can be multiple diagnoses per patients*

Figures Legends

Figure 1: Process of data linkage

Figure 2: Cumulative Hazard of Kidney Failure after live kidney donation.

Figure 3: Kaplan- Meier of Patient survival after live kidney donation.

Figure 4: Cumulative incidence curves for the competing risks of cardiovascular events and non-cardiac death over time after live kidney donation

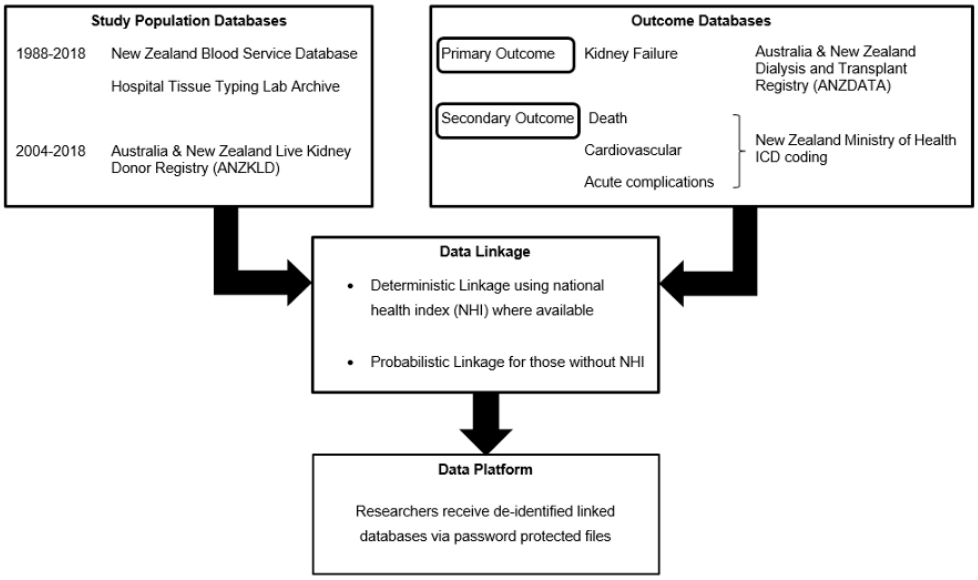

Figure 1: Process of data linkage

159x98mm (144 x 144 DPI)

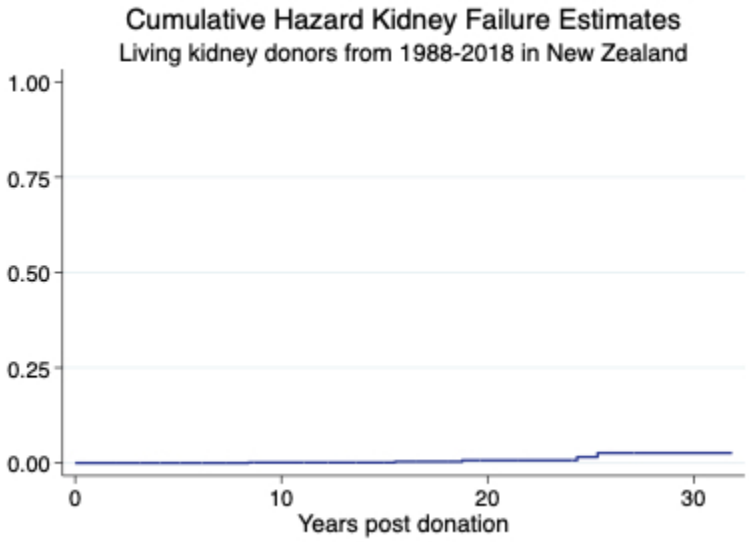

Figure 2: Cumulative Hazard of Kidney Failure after live kidney donation.

139x101mm (72 x 72 DPI)

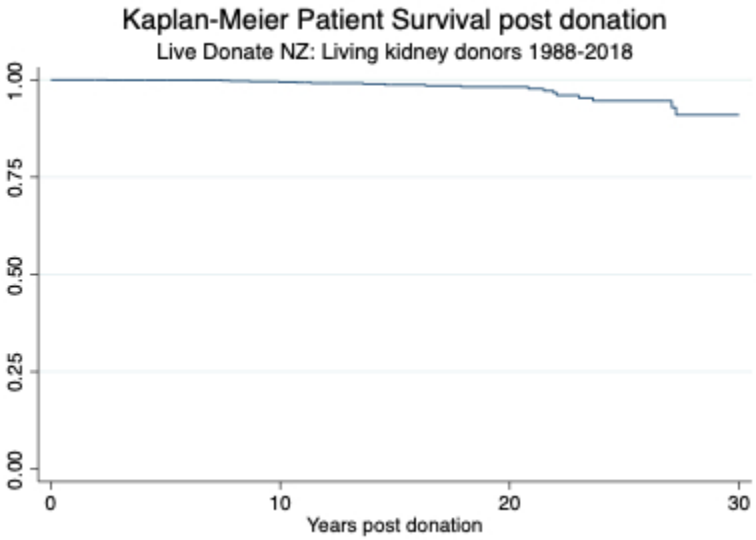

Figure 3: Kaplan- Meier of Patient survival after live kidney donation.

139x101mm (72 x 72 DPI)

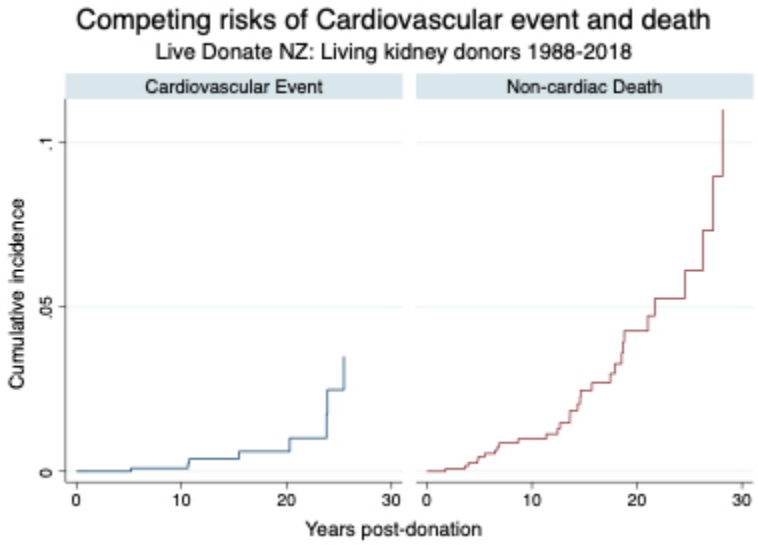

Figure 4: Cumulative incidence curves for the competing risks of cardiovascular events and non-cardiac death over time after live kidney donation

139x101mm (72 x 72 DPI)

Supplement

Table of Contents

Clinical code	Clinical code description
403	Hypertensive renal disease
585	Chronic renal failure and impairment
586	Renal failure, unspecified

Table s1: ICD-9 diagnosis codes for kidney failure

ICD 10 Clinical code	Clinical code description
I12	Hypertensive chronic kidney disease
N18	Chronic kidney disease
N17	Acute kidney failure
N170	Acute kidney failure with tubular necrosis
N179	Acute kidney failure, unspecified

Table s2: ICD-10 diagnosis codes for kidney failure

Clinical code	Clinical code description
3995	Haemodialysis
5498	Peritoneal dialysis

Table s3: ICD-9 procedure codes for kidney failure

ICD 10 clinical code	Clinical code description
Z49	Encounter for care involving renal dialysis
Z490	Preparatory care for renal dialysis
Z491	Encounter for fitting and adjustment of extracorporeal dialysis catheter
Z492	Encounter for fitting and adjustment of peritoneal dialysis catheter
Z992	Dependence on renal dialysis

Table s4: ICD-10 procedure codes for kidney failure

Clinical code	Clinical code description
403	Hypertensive renal disease
404	Hypertensive heart and renal disease
410	Acute myocardial infarction
411	Other acute and subacute forms of ischaemic heart disease
413	Angina pectoris
4275	Cardiac arrest

Table s5: ICD-9 diagnosis codes for cardiovascular disease

Clinical code	Clinical code description
I12	Hypertensive chronic kidney disease
I20	Angina pectoris
I21	ST elevation (STEMI) and non-ST elevation (NSTEMI) myocardial infarction
I22	Subsequent ST elevation (STEMI) and non-ST elevation (NSTEMI) myocardial infarction
I23	Certain current complications following ST elevation (STEMI) and non-ST elevation (NSTEMI) myocardial infarction (within the 28 day period)
I24	Other acute ischemic heart diseases
I25	Chronic ischemic heart disease
I46	Cardiac arrest

Table s6: ICD-10 diagnosis codes for cardiovascular disease

Clinical code	Clinical code description
360	Removal of coronary artery obstruction
361	Bypass anastomosis for heart revascularisation
362	Heart revascularisation by arterial implant
363	Other heart revascularisation
369	Other operations on vessels of heart

Table s7: ICD-9 procedure codes for cardiovascular disease

Clinical code	Clinical code description
Z951	Presence of aortocoronary bypass graft
Z955	Presence of coronary angioplasty implant and graft
Z958	Presence of other cardiac and vascular implants and grafts
Z959	Presence of cardiac and vascular implant and graft, unspecified
Z9861	Coronary angioplasty status

Table s8: ICD-10 procedure codes for cardiovascular disease

	Complication Definition		
Factor	**Initial Analysis: Complication within 90 days**	**Complication within 30 days**	**Complication within donation admission**
N	292	286	239
Bleeding	38 (13.0%)	37 (12.9%)	27 (11.3%)
Cardiac	54 (18.5%)	53 (18.5%)	43 (18.0%)
Fluid imbalance	43 (14.7%)	41 (14.3%)	32 (13.4%)
Gastrointestinal	126 (43.2%)	124 (43.4%)	86 (36.0%)
Genitourinary	36 (12.3%)	36 (12.6%)	30 (12.6%)
Hernia	1 (0.3%)	1 (0.3%)	1 (0.4%)
Infection	65 (22.3%)	60 (21.0%)	41 (17.2%)
Injury	33 (11.3%)	32 (11.2%)	30 (12.6%)
Kidney Impairment	12 (4.1%)	12 (4.2%)	10 (4.2%)
Other Complication	71 (24.3%)	70 (24.5%)	53 (22.2%)
Respiratory	68 (23.3%)	66 (23.1%)	61 (25.5%)
Thrombosis	2 (0.7%)	2 (0.7%)	2 (0.8%)
Vascular	11 (3.8%)	11 (3.8%)	10 (4.2%)
Wound	28 (9.6%)	22 (7.7%)	8 (3.3%)

Table s9: Primary and Sensitivity analysis Complications categorised into major categories

	Complication Definition		
Factor	**Initial Analysis: Complication within 90 days (n=292)**	**Complication within 30 days (n=286)**	**Complication within donation admission (n=239)**
N			
Bleeding			
Anaemia	9 (3.1%)	9 (3.1%)	7 (2.9%)
Bleeding other	8 (2.7%)	7 (2.4%)	6 (2.5%)
Haematoma	23 (7.9%)	23 (8.0%)	19 (7.9%)
Haematuria	2 (0.7%)	2 (0.7%)	
Cardiac			
Cardiac dysrhythmias	7 (2.4%)	7 (2.4%)	6 (2.5%)
Hypertension	10 (3.4%)	9 (3.1%)	8 (3.3%)
Hypotension	35 (12.0%)	35 (12.2%)	29 (12.1%)
Pulmonary Oedema	10 (3.4%)	10 (3.5%)	8 (3.3%)
Syncope and pre-syncope	3 (1.0%)	3 (1.0%)	2 (0.8%)
Fluid imbalance			
Electrolyte disturbance	10 (3.4%)	9 (3.1%)	7 (2.9%)
Fluid overload	2 (0.7%)	2 (0.7%)	2 (0.8%)
Oedema	1 (0.3%)	1 (0.3%)	1 (0.4%)
Volume depletion	33 (11.3%)	33 (11.5%)	24 (10.0%)
Gastrointestinal			
Adhesion	10 (3.4%)	10 (3.5%)	6 (2.5%)
Constipation	42 (14.4%)	41 (14.3%)	28 (11.7%)
Gastritis	3 (1.0%)	3 (1.0%)	1 (0.4%)
Gastro-oesophageal reflux	4 (1.4%)	4 (1.4%)	3 (1.3%)
Gastrointestinal haemorrhage	3 (1.0%)	3 (1.0%)	
Gastrointestinal other	33 (11.3%)	32 (11.2%)	15 (6.3%)
Ileus	35 (12.0%)	35 (12.2%)	30 (12.6%)
Nausea and vomiting	41 (14.0%)	41 (14.3%)	26 (10.9%)
Peritonitis	2 (0.7%)	2 (0.7%)	
Genitourinary			
Paraphimosis	1 (0.3%)	1 (0.3%)	1 (0.4%)
Urinary retention	23 (7.9%)	23 (8.0%)	18 (7.5%)

Urinary tract other	12 (4.1%)	12 (4.2%)	11 (4.6%)
Hernia			
Hernia repair	1 (0.3%)	1 (0.3%)	1 (0.4%)
Infection			
Fever	7 (2.4%)	6 (2.1%)	5 (2.1%)
Gastroenteritis	2 (0.7%)	2 (0.7%)	2 (0.8%)
Other infection	38 (13.0%)	34 (11.9%)	20 (8.4%)
Respiratory infections	10 (3.4%)	10 (3.5%)	7 (2.9%)
Urinary Tract Infections	12 (4.1%)	10 (3.5%)	8 (3.3%)
Wound infection	26 (8.9%)	24 (8.4%)	14 (5.9%)
Injury			
Injury to other structures	32 (11.0%)	32 (11.2%)	30 (12.6%)
Injury to urinary tract	2 (0.7%)	1 (0.3%)	1 (0.4%)
Kidney Impairment			
Kidney Impairment	11 (3.8%)	11 (3.8%)	10 (4.2%)
Other Complication			
Other	71 (24.3%)	70 (24.5%)	53 (22.2%)
Respiratory			
Atelectasis	23 (7.9%)	23 (8.0%)	20 (8.4%)
Pleural Effusion	4 (1.4%)	4 (1.4%)	4 (1.7%)
Pneumothorax/Haemothorax	13 (4.5%)	13 (4.5%)	12 (5.0%)
Respiratory other	45 (15.4%)	44 (15.4%)	41 (17.2%)
Pneumonia	11 (3.8%)	10 (3.5%)	8 (3.3%)
Thrombosis			
Thrombosis	2 (0.7%)	2 (0.7%)	2 (0.8%)
Vascular			
Vascular injury	9 (3.1%)	9 (3.1%)	9 (3.8%)
Vascular Other	3 (1.0%)	3 (1.0%)	2 (0.8%)
Wound			
Cellulitis	2 (0.7%)	2 (0.7%)	1 (0.4%)
Disruption of wound	4 (1.4%)	4 (1.4%)	1 (0.4%)
Wound Pain	18 (6.2%)	13 (4.5%)	3 (1.3%)
Wound Other	5 (1.7%)	4 (1.4%)	3 (1.3%)

Table s10: Primary and Sensitivity analysis of complications categorised into minor categories.

Factor	**Initial Analysis Complication within 90 days (n=69)**	**Complication within 30 days (n=65)**	**Complication within donation admission (n=50)**
N			
Bleeding	18 (26%)	17 (26%)	13 (26%)
Cardiac	21 (30%)	20 (31%)	13 (26%)
Fluid imbalance	14 (20%)	12 (18%)	8 (16%)
Gastrointestinal	31 (45%)	30 (46%)	18 (36%)
Genitourinary	12 (17%)	12 (18%)	10 (20%)
Hernia	1 (1%)	1 (2%)	1 (2%)
Infection	16 (23%)	12 (18%)	7 (14%)
Injury	15 (22%)	14 (22%)	12 (24%)
Kidney Impairment	5 (7%)	5 (8%)	5 (10%)
Other Complication	25 (36%)	25 (38%)	17 (34%)
Respiratory	14 (20%)	12 (18%)	9 (18%)
Thrombosis	1 (1%)	1 (2%)	1 (2%)
Vascular	4 (6%)	4 (6%)	4 (8%)
Wound	14 (20%)	10 (15%)	2 (4%)

Table s11: Primary and Sensitivity analysis of complications reviewing major categories of complications requiring intervention (with a Clavien-Dindo score >1)