Barriers to Living Donor Kidney Transplantation in the United Kingdom: A National Observational Study

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Abstract

Background: Living donor kidney transplantation provides more timely access to transplantation and better clinical outcomes than deceased donor kidney transplantation. This study investigated disparities in the utilisation of living donor kidney transplantation in the UK.

Methods: 2055 adults undergoing kidney transplantation between November 2011 and March 2013 were prospectively recruited from all 23 UK transplant centres as part of the Access to Transplantation and Transplant Outcome Measures (ATTOM) study. Recipient variables independently associated with receipt of living donor versus deceased donor kidney transplantation were identified.

Results: Of 2055 patients, 807 (39.3%) received living donor kidney transplantation and 1248 (60.7%) received deceased donor kidney transplantation. Multivariable modelling demonstrated a significant reduction in the likelihood of living donor kidney transplantation for older age (odds ratio [OR] 0.11, 95% confidence interval [CI] 0.08-0.17, $p<0.0001$ for 65-75 years vs 18-34 years), Asian ethnicity (OR 0.55, 95% CI 0.39-0.77, $p=0.0006$ vs White), Black ethnicity (OR 0.64, 95% CI 0.42-0.99, $p=0.047$ vs White), divorced, separated or widowed (OR 0.63, 95% CI 0.46-0.88, $p=0.030$ vs married), no qualifications (OR 0.55, 95% CI 0.42-0.74, $p<0.0001$ vs higher education qualifications), no car-ownership (OR 0.51, 95% CI 0.37-0.72, $p=0.0001$), and no home-ownership (OR 0.65, 95% CI 0.85-0.79, $p=0.002$). The odds of living donor kidney transplantation varied significantly between countries in the UK.

Conclusions: Amongst patients undergoing kidney transplantation in the UK, there are significant age, ethnic, socioeconomic and geographic disparities in the utilisation of living donor kidney transplantation. Further work is needed to explore the potential for targeted interventions to improve equity in living donor transplantation.

Keywords: age, disparities, education, ethnicity, living donor kidney transplantation, socioeconomic deprivation.

Short summary: In this national observational study of 2055 kidney transplant recipients in the UK, we demonstrated that older, ethnic minority, less well educated and more socioeconomically deprived patients were significantly less likely to receive a kidney transplant from living donor versus a deceased donor.

Introduction

For patients with end-stage renal disease (ESRD), living donor kidney transplantation (LDKT) provides better clinical outcomes and more timely access to transplantation than deceased donor kidney transplantation (DDKT).[1-3] Current UK Renal Association guidelines recommend that LDKT be considered the treatment of choice for all patients suitable for kidney transplantation, whenever an appropriate living donor is available.[4] In contrast to the lengthy waiting time for DDKT, the LDKT procedure can be scheduled without delay, thereby minimising the time that patients are exposed to pre-transplant dialysis and its associated morbidity, or enabling avoidance of dialysis entirely (pre-emptive transplantation). Pre-emptive LDKT is considered by many to be the optimal treatment, providing superior graft and patient survival compared with kidney transplantation following a period of dialysis.[2, 4-6]

Despite these advantages, only a third of kidney transplants undertaken in the UK are from living donors.[7] Internationally, the UK falls behind many other countries in terms of LDKT activity.[8] A recent strategy set out by NHS Blood and Transplant (NHSBT) aims to increase LDKT activity in the UK from the current rate of 17 transplants per million population (pmp) to 26 transplants pmp by 2020.[9]

There are limited data on the factors that may prevent or enable patients to receive a LDKT in the UK. A better understanding of these factors will facilitate the identification of target patient groups and aid the development of appropriate interventions to improve LDKT rates. The principal aim of this study was to identify the recipient characteristics associated with achieving LDKT compared with DDKT, in a national sample of UK kidney transplant recipients. The study was conducted as part of the Access to Transplantation and Transplant Outcome Measures (ATTOM) research programme.

Subjects and Methods

Study population

ATTOM is a national prospective cohort study, investigating the factors that influence access, clinical and patient-reported outcomes and cost-effectiveness of renal transplantation in the UK. A full description of the ATTOM study methods and protocol has been reported previously.[10] As part of the ATTOM study, incident kidney transplant recipients were recruited at the time of transplantation from all 23 UK renal transplant centres. In each centre, recruitment took place over a 12-month period, between 1st November 2011 and 31st March 2013. Patients aged 18 – 75 years were eligible for inclusion. A total of 3002 patients received kidney-only transplants in the UK within the recruitment period; 134 were outwith the study age criteria and 775 declined to participate or were not able to be approached for recruitment. 38 of 2093 recruited patients were excluded from the analysis due to missing data for the main outcome variable (living or deceased donor). Thus, the final analysis cohort of 2055 patients represented 72% of eligible study participants (Figure 1). There were no significant differences in the age, gender or ethnicity distributions between study participants and the national registry adult kidney transplant recipient population (data not shown).[11]

Data collection

Extensive demographic, socioeconomic, clinical and comorbidity data were collected for each patient at the time of transplantation. Trained research nurses collected uniformly defined data items from patient interviews, case notes and local electronic patient information systems.

Ethnicity was coded as White, Black, Asian or Other (including patients of Chinese and mixed origin). Level of highest educational attainment was coded as no qualifications,

qualifications at secondary education level or equivalent (e.g. General Certificate of Secondary Education [GCSE], General Certificate of Education Advanced level [A-level], [National Vocational Qualification] NVQ 1-3) or qualifications at higher education level or equivalent (e.g. bachelor's degree, higher degree, NVQ 4-5). Employment status was coded as employed (including full-time, part-time or self-employed), unemployed, long term sick/disabled, retired or other (including those looking after the family home, those not in work for some other reason and students). Primary renal diagnosis was classified by ERA-EDTA codes[12]. Donor details and recipient calculated reaction frequency (cRF), were obtained from linkage to UK Transplant Registry data. The cRF is a measure of recipient human leukocyte antigen (HLA) sensitisation, calculated as the percentage of 10,000 recent donors to which the recipient has pre-formed HLA antibodies. A comorbidity score was calculated for each patient using a modified Charlson comorbidity index for patients with ESRD.[13] The index consists of weighted scores assigned to 14 comorbid conditions (myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic pulmonary disease, rheumatological disease, peptic ulcer disease, diabetes without complications, diabetes with complications, leukaemia, lymphoma, moderate-severe liver disease and metastatic disease). Our dataset did not include two of the conditions (rheumatological disease and peptic ulcer disease). Scores were therefore calculated from the remaining 12 variables.

Statistical methods

Baseline characteristics of LDKT and DDKT recipients and donors were compared by chi-squared tests for categorical data and Wilcoxon tests for non-parametric continuous data. Recipient variables associated with receiving LDKT versus DDKT were analysed using logistic regression. Variables leading to a change in log likelihood at $p<0.15$ on univariable

analysis were entered into the multivariable model. The importance of each variable in the multivariable model was tested by examining the difference in log-likelihood between the model with and without the variable. If the difference was not significant ($p>0.05$) the variable was removed. Each time a variable was removed, the effect of removing each of the remaining variables was retested until the most parsimonious model was achieved. Potential interactions between variables were tested, none were significant. Less than 7% of values were missing for any variable. For modelling purposes, missing values were imputed using the fully conditional specification logistic regression method. Ten imputed datasets were modelled separately, then combined to produce final parameter estimates. Sensitivity analysis using case-wise deletion of missing values did not change conclusions.

Complex links between socioeconomic deprivation and ethnicity with respect to access to and outcomes from renal replacement therapy (RRT) have previously been reported.[14, 15] To avoid any confounding and/or interaction from ethnicity, a subgroup analysis was undertaken in White patients only, using the same multivariable modelling methods as described above.

A second subgroup analysis examined the recipient variables associated with receiving a transplant pre-emptively versus after the initiation of dialysis in the LDKT cohort. Multivariable modelling methods were the same as described above.

All data were analysed using SAS®9.4 (SAS Institute Inc, Cary, USA).

Results

Type of transplant received

Of 2055 kidney transplant recipients, 1248 (60.7%) received DDKT (583 donors after brain-death and 665 donors after circulatory-death) and 807 (39.3%) received LDKT. A significantly higher proportion of LDKT recipients received pre-emptive transplants compared with DDKT recipients (35.5% vs 12.0%, $p<0.0001$).

Recipient characteristics

There were considerable differences in the characteristics of LDKT versus DDKT recipients (Table 1). LDKT recipients were significantly younger than DDKT recipients (median age 46 vs 53 years), a higher proportion were of White ethnicity (87.1% vs 79.5%) and married or living with a partner (65.1% vs 60.5%). LDKT recipients were more likely to have obtained qualifications at secondary education level (53.0% vs 47.9%) and at higher education level (27.3% vs 18.3%). Compared with DDKT recipients, LDKT recipients had higher rates of employment (43.7% vs 31.3%), car-ownership (91.0% vs 80.2%) and home-ownership (66.1% vs 62.0%), suggesting they were a less socioeconomically deprived population. The cause of renal failure was less likely to be diabetes, hypertension or renal vascular disease in the LDKT group. LDKT recipients had a significantly lower prevalence of comorbidity compared with DDKT recipients. The proportion of kidney transplants that were LDKTs was significantly higher in Northern Ireland (NI) at 68.5%, compared with 39.0% in England, 36.6% in Wales and 31.2% in Scotland in this study.

Donor characteristics

Characteristics of the donors are shown in Table 2 and Table 3. Living donors were significantly younger and more likely to be female than deceased donors. A higher proportion of deceased donors were of White ethnicity compared with living donors. 354 (43.9%) living donors were not genetically related to the recipient. Parent, child, other blood relative and spouse living donors were more likely to be female. Pooled/altruistic living donors had the highest proportion of White donors.

Factors associated with probability of living donor transplantation amongst kidney transplant recipients

Associations between recipient variables and the likelihood of LDKT versus DDKT were characterised using univariable and multivariable logistic regression (Table 4, Figure 2). The multivariable model demonstrated that with each sequential increase in age group, there was a marked reduction in the probability of LDKT versus DDKT, such that patients aged 65-75 years were around 90% less likely to undergo LDKT compared with patients aged 18-34 years (odds ratio [OR] 0.11, 95% confidence interval [CI] 0.08-0.17, p<0.0001). Compared with White patients, Asian patients (OR 0.55, 95% CI 0.39-0.77, p=0.0006) and Black patients (OR 0.64, 95% CI 0.42-0.99, p=0.047) were less likely to undergo LDKT than DDKT. Patients who were divorced, separated or widowed had a lower probability of LDKT compared with patients who were married or living with a partner (OR 0.63, 95% CI 0.46-0.88, p=0.03). Having no formal qualifications (OR 0.55, 95% CI 0.42-0.74, p<0.0001) and having only secondary education qualifications (OR 0.76, 95% CI 0.59-0.97, p=0.01) reduced the odds of LDKT compared with patients with higher education qualifications. Not owning a car (OR 0.51, 95% CI 0.37-0.72, p<0.0001) and not owning a home (OR 0.65, 95% CI 0.49-0.85, p=0.002) decreased the odds of LDKT versus DDKT. With adjustment for recipient variables, the odds of LDKT versus DDKT were over 3-fold higher for patients in NI (OR

3.25, 95% CI 1.89-5.57, p<0.0001) compared with patients in England. Further analysis showed the odds of LDKT in NI were also higher compared with Wales (OR 3.77, 95% CI 1.88-7.56, p=0.0002) and Scotland (OR 4.53, 95% CI 2.42-8.48, p<0.0001), but there were no significant differences between patients in England, Wales and Scotland.

Factors associated with probability of living donor transplantation amongst White ethnicity kidney transplant recipients

The same analysis was undertaken in a subgroup of White patients only (n=1692), and confirmed that the effects of socioeconomic factors on the likelihood of LDKT versus DDKT were independent of ethnicity (Table 5).

Factors associated with probability of pre-emptive transplantation amongst living donor kidney transplant recipients

A further subgroup analysis in the LDKT group examined factors associated with achieving pre-emptive transplantation versus transplantation after the initiation of dialysis (Table 6). Patients with missing data for pre-transplant treatment modality (n=3) and patients with a previous transplant (n=117) were excluded, leaving a final cohort of 687 LDKT recipients. Multivariable analysis demonstrated a significantly decreased likelihood of pre-emptive LDKT for Asian patients (OR 0.45, 95% CI 0.23-0.86, p=0.016), unemployed patients (OR 0.44, 95% CI 0.21-0.92, p=0.029), patients unable to work due to long term sickness/disability (OR 0.44, 95% CI 0.28-0.68, p=0.0002), retired patients (OR 0.47, 95% CI 0.29-0.75, p=0.002), not owning a car (OR 0.41, 95% CI 0.19-0.86, p=0.018) and not owning a home (OR 0.65, 95% CI 0.44-0.96, p=0.029).

Discussion

Amongst patients undergoing kidney transplantation in the UK, there are significant age, ethnic, socioeconomic and geographic disparities in the utilisation of living donor versus deceased donor kidney transplantation. Older age, Black and Asian ethnicity, being divorced, separated or widowed, lower educational attainment and measures of greater socioeconomic deprivation (non car and home ownership) were significantly and independently associated with a reduced likelihood of LDKT versus DDKT. For the period of the study, geographic differences were also noted, with patients in NI having a greater probability of LDKT versus DDKT compared with patients in the rest of the UK. Furthermore, the study demonstrated that amongst those who do undergo LDKT, ethnic and socioeconomic disparities persist in determining whether LDKT is received pre-emptively. Asian ethnicity, unemployment and greater socioeconomic deprivation were associated with a lower likelihood of pre-emptive LDKT versus LDKT after the initiation of dialysis.

A major strength of the present study is that we recruited all patients prospectively and collected accurate, reliable and comprehensive data. A large proportion (72%) of the national adult kidney transplant population were included in the study. Nevertheless, as it was not possible to recruit the entire kidney transplant population, it must be recognised that the study is limited by a risk of selection bias. Reassuringly, the age, gender and ethnicity of study participants were not significantly different to the national adult kidney transplant population.[11] Furthermore, the study cohort included patients from all 23 UK renal transplant centres as well as nationally comparable proportions of LDKT, DDKT and pre-emptive recipients, thereby reducing the potential for bias. However, differences in other unmeasured characteristics between study participants and non-participants cannot be ruled out. Another limitation of the study, is that we were unable to account for the fact that some

patients may not have had a medically suitable living donor. This could be a potential explanation for the observed lower utilisation of LDKT for certain patient groups. It is known that ethnic minorities have a higher prevalence of hypertension and diabetes with associated ESRD, thus precluding kidney donation.[16, 17] Similarly, greater socioeconomic deprivation is linked to poorer health,[18] potentially limiting the pool of living donors available to more deprived patients. Furthermore, due to the observational nature of the study, the results can only describe associations, and as such causality of the observed relationships cannot be inferred.

In recent years, a great deal of attention has been directed towards disparities in access to DDKT in the UK. Individuals who are older, more socially deprived, from ethnic minority backgrounds or treated in certain transplant centres are less likely to be listed for and subsequently receive DDKT.[19-23] Despite LDKT providing optimal clinical outcomes for patients with ESRD, there have been limited data on whether patients experience disparities in utilising this treatment. Udayaraj et al. reported a lower probability of LDKT for patients with greater socioeconomic deprivation and patients from Black and South Asian backgrounds in the UK.[24] However, this study analysed the rates of LDKT amongst patients starting RRT, therefore a major confounding factor is the poorer health amongst more socioeconomically deprived and ethnic minority populations, leading to a higher proportion of patients being medically unsuitable for transplantation. The present study adds new knowledge about the factors associated with receiving LDKT as opposed to DDKT, amongst a cohort of patients deemed suitable to undergo transplantation. This is a select population of patients who have already successfully navigated the process of transplant referral, evaluation and listing. Therefore, it is concerning that the striking disparities observed appear to occur over and above the well-recognised inequities that patients face before even reaching this

stage. These findings are not confined to the UK. Our results are consistent with those of a US study by Gore et al. which reported lower odds of LDKT relative to DDKT for patients who were older, from ethnic minority groups, with lower socioeconomic status and lower levels of education.[25] Roodnat et al. showed the same factors reduced the likelihood of LDKT versus DDKT in the Netherlands.[26] It is interesting that similar results have been demonstrated both within publicly funded as well as private healthcare systems, suggesting factors other than financial disadvantage play an important role.

The well-recognised markers of socioeconomic deprivation (car ownership and home ownership) were strongly associated with a reduced likelihood of LDKT versus DDKT in this study. A subgroup analysis of White patients only confirmed that the effects of socioeconomic deprivation were independent of ethnicity. Lower rates of LDKT in socioeconomically deprived patients have also been reported in Australia[27] and the US[28, 29]. The reasons behind this finding are unclear. It is known that living donor-recipient pairs usually come from the same socioeconomic group.[30] In the UK, kidney transplantation including medication and after-care are provided free of charge. However, it is possible that other costs such as transportation, childcare and lost income from time off work could play a role in deterring potential living donors or deterring those in need of a kidney from approaching potential donors.[31] A financial reimbursement policy for expenses incurred by living donors does exist in the UK, but it is not implemented consistently by transplant centres. A recent qualitative study of DDKT recipients found that many were unaware of the living donor reimbursement policy.[32] Despite this, socioeconomically deprived patients did not perceive financial concerns to be a major barrier to LDKT, and described passivity and disempowerment in treatment decisions, short-term focus and lack of social support as more significant obstacles to LDKT.[32]

It is well recognised that ethnic minority patients wait longer for a DDKT in the UK, due to the mismatch between the HLA types of minority patients and those of the predominantly White donor pool.[33] One might therefore expect a higher uptake of LDKT in ethnic minority patients. Our study found the opposite, with patients from Black and Asian backgrounds having lower odds of LDKT than DDKT, compared with White patients. Similar disparities have been reported in the US[15, 34] and Canada.[35] These disparities have worsened over time, and are likely contributing to differences in outcomes between White and non-White patients.[36] The reasons for these disparities are not well understood, possible explanations cited include cultural and religious beliefs,[37, 38] reluctance to engage with the medical system,[39, 40] institutional prejudice,[41, 42] language barriers[43] and concern over a higher risk for living donors from minority ethnic backgrounds.[44-46]

We have demonstrated that a patient's level of educational attainment is independently associated with their likelihood of LDKT versus DDKT. Educational attainment is related to health literacy, which has been shown to be an important factor for both potential kidney transplant recipients as well as potential living donors in successfully navigating the living donation and transplantation process.[47, 48] Higher academic achievement may be linked to a better ability to understand the benefits of LDKT or to take part in informed and shared decision-making.

The finding that patients who were married or living with a partner had better access to LDKT is likely to be related to the opportunity for spousal donation. Spouses represented a considerable proportion (23.3%) of living donors in this study, and the majority were female (61.7%). Being married or living with a partner may also confer other benefits such as having a better social support network or access to more unrelated or child donors.

Older age was associated with dramatically reduced odds of LDKT versus DDKT. Previous research has demonstrated that older age is associated with a lower probability of attempted

donor recruitment.[49] Older patients have reported an unwillingness to put younger donors at risk, particularly their children.[50] In our study 18.2% of the living donors were parents whereas only 9.3% were children.

Despite adjustment for demographic and socioeconomic factors, we found striking geographic differences in LDKT activity, with patients in NI experiencing higher odds of LDKT versus DDKT compared with patients in England, Wales and Scotland. Our results reflect the actual number of LDKTs pmp which were around twice as high in NI (31.1) compared with the rest of the UK (England 15.9, Wales 16.6, Scotland 10.9) at the time of the study.[51] Around this time, an initiative was instigated in NI to promote LDKT and pre-emptive transplant as the treatment of choice. The key measures included education to promote a change of mind-set amongst nephrologists (particularly non-transplant nephrologists) as well as the entire transplant team, together with improved infrastructure and more streamlined services to enable timely work-up and transplantation (e.g. one-stop living donor assessment clinic). Effective leadership, persistence and gaining the support of commissioners and management were critical in achieving these changes (personal communication, A. Courtney, 17/01/2017). Our results and the national figures indicate that such a strategy can be very successful in increasing LDKT utilisation. The higher LDKT rate in NI led to a lower DDKT rate (NI 15.0, England 24.9, Wales 33.0, Scotland 26.7)[51] and there are now very few long-waiting patients on the waiting list in NI.[52] Moreover, the number of LDKTs in NI has continued to increase (40 pmp in 2016, one of the highest in the world), demonstrating that the changes have led to a sustained improvement rather than a temporary peak in activity. This is encouraging when exploring potential avenues to improve LDKT across the UK as a whole.

Our study showed for the first time in the UK that socioeconomic deprivation, unemployment and Asian ethnicity were independently associated with a lower likelihood of pre-emptive

LDKT. These findings are consistent with studies from the US and Australia.[5, 25, 27] The disparity experienced by socioeconomically deprived individuals is likely to be related to an increased likelihood of late referral to specialist renal services in the UK,[53] however this does not explain the disparity for patients of Asian ethnicity.

LDKT, and in particular pre-emptive LDKT provides optimal clinical outcomes for patients with ESRD, yet its uptake is variable within the UK. This study has identified specific patient groups with a lower likelihood of undergoing LDKT relative to DDKT. We have demonstrated that demographic, socioeconomic and geographic factors are more strongly associated with the type of transplant received, than clinical factors including comorbidity, primary renal diagnosis, HLA sensitisation or previous transplantation. Moreover, a remarkable finding is that even amongst LDKT recipients, disparities persist in receiving pre-emptive transplantation. This demonstrates the strength of social factors in influencing access to healthcare, and may reflect similar inequities across a wide range of healthcare services. The demonstrated disparities may reflect both barriers in certain patient groups as well as important positive factors in others. Furthermore, these influencing factors are likely to apply to both potential recipients and donors. If particular groups experience avoidable barriers to receiving or donating a LDKT, there is a responsibility to provide tailored resources to remove these barriers. Improving access to LDKT will not only benefit individual patients; but will also have favourable effects for the wider ESRD population by effectively increasing the overall pool of available organs. However, both donor and recipient welfare and autonomy undoubtedly remain the primary focus. Some patients may prefer not to pursue LDKT due to concerns about risks to their potential donors, just as some potential donors may be unwilling to donate.[50, 54]

Identifying disadvantaged patient groups is essential to directing further research into potentially modifiable factors and appropriate interventions. Several studies in the US have explored targeted interventions including culturally sensitive education programs,[55, 56] home-based education[57, 58] and patient advocates[59] with promising results for reducing disparities in LDKT. Similar programs in the UK may provide more equitable opportunity for disadvantaged patients to explore the option of living donor kidney transplantation.

Contributors

All authors contributed to the study design. DW conducted the literature review and data analysis. MLR and RJJ provided statistical input for the data analysis. DW and GCO drafted the manuscript. All authors interpreted the data, provided intellectual content, revised the drafts and approved the final version. DW and GCO are guarantors for the paper.

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Conflict of interest statement

None declared. The results presented in this paper have not been published previously in whole or part, except in abstract form.

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Ethics approval

East of England Research Ethics Committee (reference number 11/EE/0120).

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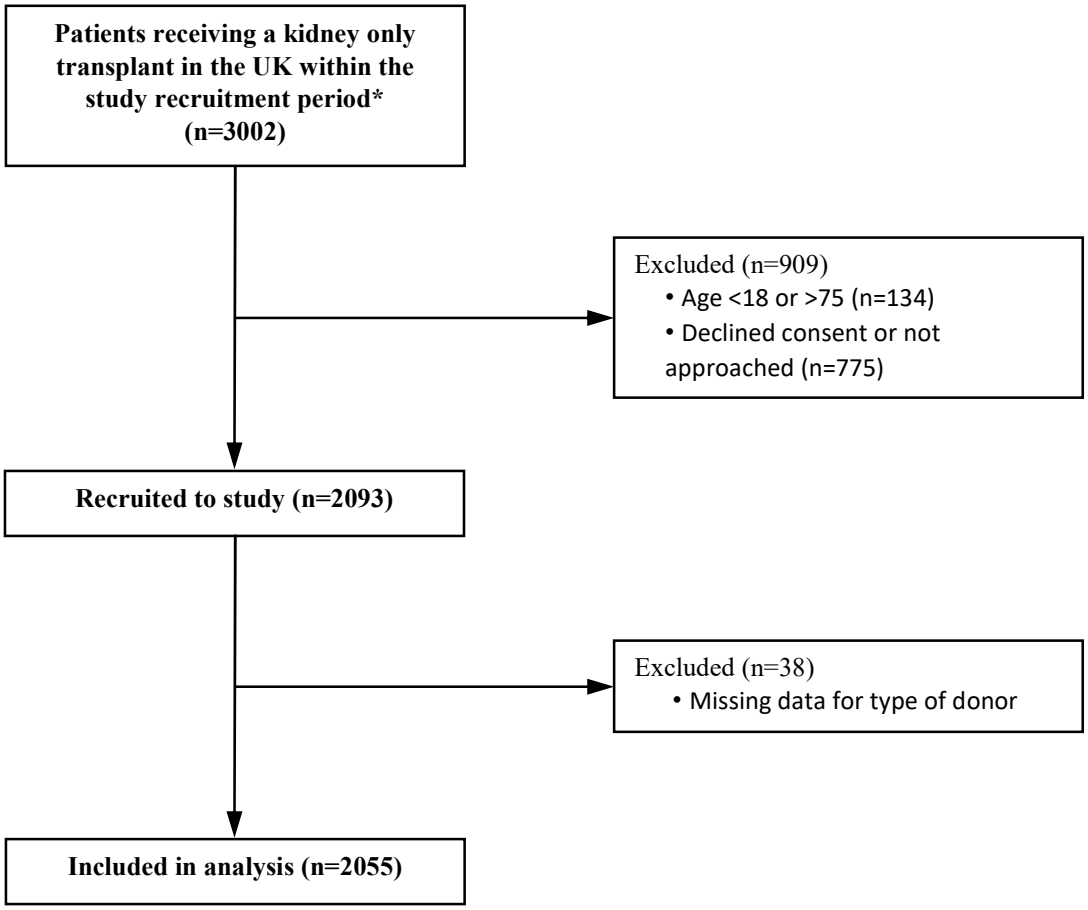
Tables and Figures

Figure 1. Study population



*Recruitment took place over a 12-month period in each centre, between 1st November 2011 and 31st March 2013

Table 1. Kidney transplant recipient characteristics by type of donor

	Living donor transplant recipients n=807	Deceased donor transplant recipients n=1248	p-value**
Demographic variables			
Median age (years)	46 (34 - 56)	53 (44 - 63)	<0.0001
Age group			<0.0001
18 – 34	229 (28.4)	128 (10.3)	
35 – 49	261 (32.3)	359 (28.8)	
50 – 64	249 (30.9)	526 (42.2)	
65 – 75	68 (8.4)	235 (18.8)	
Gender			0.191
Male	493 (61.1)	798 (63.9)	
Female	314 (38.9)	450 (36.1)	
Ethnicity *			0.0002
White	703 (87.1)	989 (79.5)	
Asian	61 (7.6)	138 (11.1)	
Black	35 (4.3)	94 (7.6)	
Other	8 (1.0)	23 (1.9)	
Socioeconomic variables			
Civil status *			<0.0001
Married / Living with partner	494 (65.1)	697 (60.5)	
Divorced / Separated / Widowed	66 (8.7)	201 (17.5)	
Single	199 (26.2)	254 (22.1)	
Qualifications *			<0.0001
Higher education	207 (27.3)	210 (18.3)	
Secondary education	402 (53.0)	551 (47.9)	
No qualifications	150 (19.8)	390 (33.9)	
Employment status *			<0.0001
Employed	332 (43.7)	361 (31.3)	
Unemployed	59 (7.8)	92 (8.0)	
Long term sick / disability	182 (24.0)	343 (29.7)	
Retired	112 (14.7)	287 (24.9)	
Other	75 (9.9)	71 (6.2)	
Car ownership *	691 (91.0)	928 (80.2)	<0.0001
Home ownership *	501 (66.1)	716 (62.0)	0.068
Clinical variables			
Primary renal diagnosis *			<0.0001
Diabetic nephropathy	48 (6.0)	132 (10.6)	
Glomerulonephritis	229 (28.5)	311 (24.9)	
Polycystic kidney disease	113 (14.1)	209 (16.8)	
Pyelonephritis	127 (15.8)	133 (10.7)	
Hypertensive nephropathy	37 (4.6)	86 (6.9)	
Renal vascular disease	10 (1.2)	27 (2.2)	
Other	156 (19.4)	193 (15.5)	
Uncertain	84 (10.5)	156 (12.5)	
Charlson Comorbidity Score *			<0.0001
0	625 (77.7)	851 (68.4)	
1	91 (11.3)	168 (13.5)	
2	59 (7.3)	136 (10.9)	
≥3	29 (3.6)	90 (7.2)	
Previous transplant	117 (14.5)	157 (12.6)	0.212
Highly sensitised (cRF>85%) *	96 (11.9)	119 (9.5)	0.086

Pre-transplant treatment modality *			<0.0001
Haemodialysis	351 (43.7)	718 (57.6)	
Haemodiafiltration	14 (1.7)	39 (3.1)	
Continuous ambulatory peritoneal dialysis	73 (9.1)	204 (16.4)	
Automated peritoneal dialysis	67 (8.3)	130 (10.4)	
Failing transplant	14 (1.7)	6 (0.5)	
Pre-emptive	285 (35.5)	150 (12.0)	
Geographic variables			
Country			<0.0001
England	670 (83.0)	1049 (84.1)	
Wales	34 (4.2)	59 (4.7)	
Northern Ireland	50 (6.2)	23 (1.8)	
Scotland	53 (6.6)	117 (9.4)	

cRF; calculated reaction frequency
Data are median (IQR) or number (%)
* Data are missing for some participants and excluded from percentage calculations. Numbers of missing data are shown in supplementary table S1.
** Wilcoxon test for age. All others chi-squared test.

Table 2. Donor characteristics

	Living donor n=807	**Deceased donor n=1248**	**p-value****
Median age (years)	48 (39 - 57)	54 (42 - 64)	<0.0001
Age group *			<0.0001
<18	0 (0.0)	28 (2.2)	
18 – 34	141 (17.5)	156 (12.5)	
35 – 49	295 (36.6)	296 (23.7)	
50 – 64	307 (38.1)	497 (39.8)	
65 – 75	61 (7.6)	236 (18.9)	
>75	2 (0.3)	35 (2.8)	
Gender *			0.002
Male	376 (46.7)	671 (53.8)	
Female	429 (53.3)	577 (46.2)	
Ethnicity *			<0.0001
White	716 (88.8)	1169 (95.0)	
Asian	50 (6.2)	22 (1.8)	
Black	28 (3.5)	22 (1.8)	
Other	12 (1.5)	17 (1.4)	

Data are median (IQR) or number (%)
* Data are missing for some participants and excluded from percentage calculations. Numbers of missing data are shown in supplementary table S1.
** Wilcoxon test for age. All others chi-squared test.

Table 3. Living donor characteristics by donor-recipient relationship

	Living donors (n=807)						
	Parent n=147 (18.2%)	**Child n=75 (9.3%)**	**Sibling n=196 (24.3%)**	**Other blood relative n=35 (4.3%)**	**Spouse/ partner n=188 (23.3%)**	**Pooled/ altruistic n=93 (11.5%)**	**Other non-related n=73 (9.1%)**
Age group *							
18 – 34	0 (0.0)	51 (68.0)	49 (25.0)	5 (14.7)	10 (5.3)	12 (12.9)	14 (19.2)
35 – 49	33 (22.5)	24 (32.0)	94 (48.0)	14 (41.2)	69 (36.7)	29 (31.2)	32 (43.8)
50 – 64	94 (64.0)	0 (0.0)	44 (22.5)	15 (44.1)	94 (50.0)	38 (40.9)	22 (30.1)
65 – 75	20 (13.6)	0 (0.0)	9 (4.6)	0 (0.0)	15 (8.0)	12 (12.9)	5 (6.9)
>75	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (2.2)	0 (0.0)
Gender *							
Male	62 (42.2)	34 (45.3)	99 (50.5)	16 (47.1)	72 (38.3)	50 (53.8)	43 (59.7)
Female	85 (57.8)	41 (54.7)	97 (49.5)	18 (53.0)	116 (61.7)	43 (46.2)	29 (40.3)
Ethnicity *							
White	132 (89.8)	64 (85.3)	169 (86.2)	30 (88.2)	170 (90.4)	86 (92.5)	65 (89.0)
Asian	9 (6.1)	5 (6.7)	15 (7.7)	2 (5.9)	11 (5.9)	2 (2.2)	6 (8.2)
Black	2 (1.4)	5 (6.7)	10 (5.1)	2 (5.9)	4 (2.1)	4 (4.3)	1 (1.4)
Other	4 (2.7)	1 (1.3)	2 (1.0)	0 (0.0)	3 (1.6)	1 (1.1)	1 (1.4)

Data are number (%)
* Data are missing for some participants and excluded from percentage calculations. Numbers of missing data are shown in supplementary table S1.

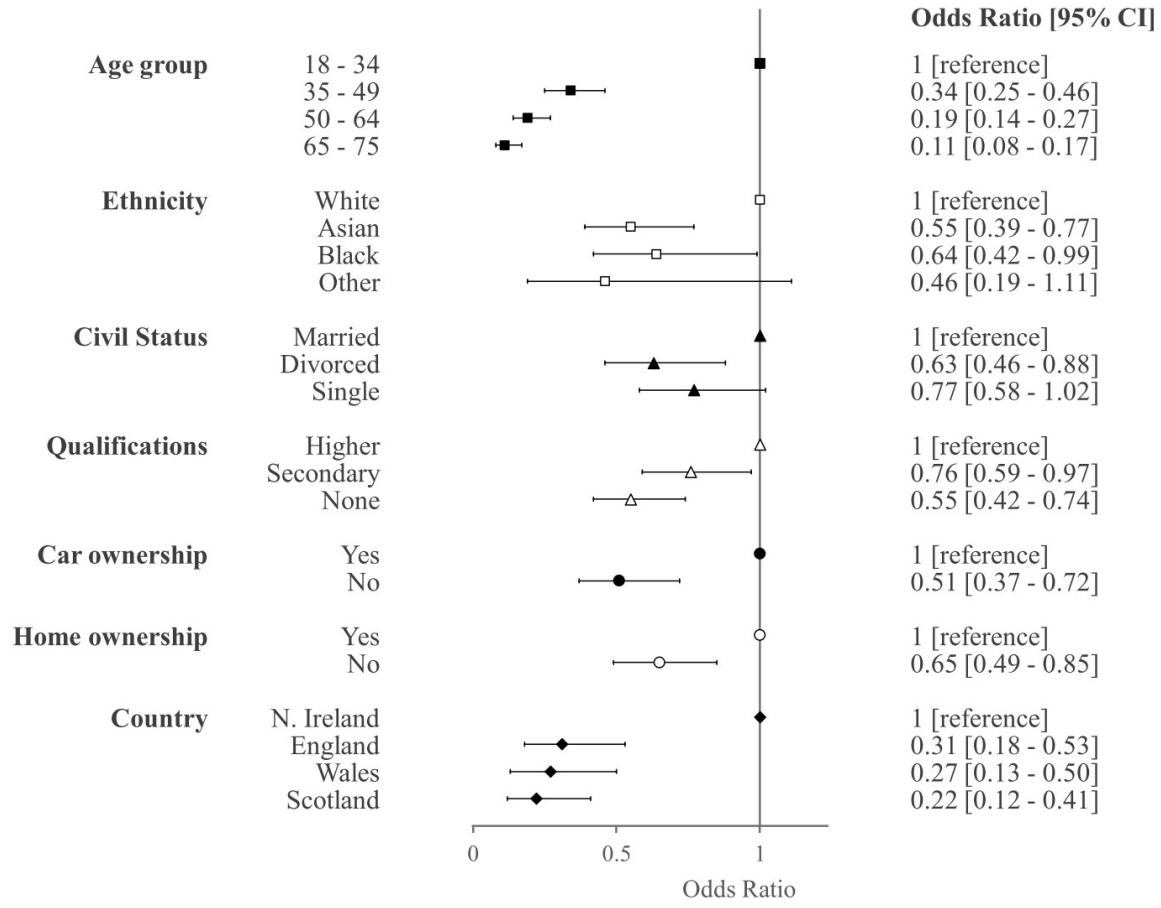
Table 4. Univariable and multivariable logistic regression analysis of factors associated with living donor kidney transplantation versus deceased donor kidney transplantation

	Univariable		Multivariable	
Demographic variables	**Odds Ratio [95% CI]**	**p-value**	**Odds Ratio [95% CI]**	**p-value**
Age group				
18 – 34	1 [reference]		1 [reference]	
35 – 49	0.41 [0.31-0.53]	<0.0001	0.34 [0.25-0.46]	<0.0001
50 – 64	0.27 [0.20-0.34]	<0.0001	0.19 [0.14-0.27]	<0.0001
65 – 75	0.16 [0.11-0.23]	<0.0001	0.11 [0.08-0.17]	<0.0001
Gender				
Male	1 [reference]			
Female	1.13 [0.94-1.36]	0.192		
Ethnicity				
White	1 [reference]		1 [reference]	
Asian	0.62 [0.45-0.85]	0.003	0.55 [0.39-0.77]	0.0006
Black	0.52 [0.35-0.78]	0.001	0.64 [0.42-0.99]	0.047
Other	0.49 [0.22-1.10]	0.081	0.46 [0.19-1.11]	0.084
Socioeconomic variables				
Civil status				
Married / Living with partner	1 [reference]		1 [reference]	
Divorced / Separated / Widowed	0.46 [0.34-0.63]	<0.0001	0.63 [0.46-0.88]	0.030
Single	1.10 [0.88-1.36]	0.406	0.77 [0.58-1.02]	0.067
Qualifications				
Higher education	1 [reference]		1 [reference]	
Secondary education	0.73 [0.58-0.92]	0.009	0.76 [0.59-0.97]	0.010
No qualifications	0.39 [0.30-0.51]	<0.0001	0.55 [0.42-0.74]	<0.0001
Employment status				
Employed	1 [reference]			
Unemployed	0.71 [0.50-1.02]	0.064		
Long term sick / disability	0.58 [0.46-0.73]	<0.0001		
Retired	0.42 [0.33-0.55]	<0.0001		
Other	1.12 [0.79-1.58]	0.542		
Car ownership				
Yes	1 [reference]		1 [reference]	
No	0.41 [0.31-0.55]	<0.0001	0.51 [0.37-0.72]	0.0001
Home ownership				
Yes	1 [reference]		1 [reference]	
No	0.82 [0.68-1.00]	0.053	0.65 [0.49-0.85]	0.002
Clinical variables				
Primary renal diagnosis				
Diabetic nephropathy	1 [reference]			
Glomerulonephritis	2.03 [1.40-2.94]	0.0002		
Polycystic kidney disease	1.48 [0.99-2.22]	0.054		
Pyelonephritis	2.62 [1.74-3.95]	<0.0001		
Hypertensive nephropathy	1.19 [0.72-1.98]	0.498		
Renal vascular disease	1.02 [0.46-2.26]	0.968		
Other	2.22 [1.50-3.29]	<0.0001		
Uncertain	1.48 [0.97-2.27]	0.068		
Charlson Comorbidity Score				
0	1 [reference]			
1	0.74 [0.56-0.97]	0.031		

2	0.59 [0.43-0.82]	0.002		
≥3	0.45 [0.30-0.70]	0.0003		
Previous transplant				
No	1 [reference]			
Yes	1.18 [0.91-1.53]	0.212		
Highly sensitised (cRF>85%)				
No	1 [reference]			
Yes	1.28 [0.97-1.71]	0.087		
Geographic variables				
Country				
England	1 [reference]		1 [reference]	
Wales	0.90 [0.59-1.39]	0.642	0.86 [0.54-1.38]	0.539
Northern Ireland	3.40 [2.06-5.63]	<0.0001	3.25 [1.89-5.57]	<0.0001
Scotland	0.71 [0.51-1.00]	0.047	0.72 [0.50-1.03]	0.073

cRF; calculated reaction frequency, CI; confidence interval.

Figure 2. Multivariable logistic regression analysis of factors associated with living donor kidney transplantation versus deceased donor kidney transplantation



CI; confidence interval, N. Ireland; Northern Ireland

Table 5. Multivariable logistic regression analysis of factors associated with living donor kidney transplantation versus deceased donor kidney transplantation amongst White patients only

Recipient variables	Odds Ratio [95%CI]	p-value
Age group		
18 – 34	1 [reference]	
35 – 49	0.31 [0.22-0.44]	<0.0001
50 – 64	0.17 [0.12-0.25]	<0.0001
65 – 75	0.11 [0.07-0.17]	<0.0001
Civil status		
Married / Living with partner	1 [reference]	
Divorced / Separated / Widowed	0.60 [0.42-0.86]	0.006
Single	0.70 [0.51-0.96]	0.028
Qualifications		
Higher education	1 [reference]	
Secondary education	0.73 [0.55-0.96]	0.027
No qualifications	0.53 [0.38-0.74]	0.0001
Car ownership		
Yes	1 [reference]	
No	0.50 [0.35-0.73]	0.0003
Home ownership		
Yes	1 [reference]	
No	0.68 [0.50-0.91]	0.01
Country		
England	1 [reference]	
Wales	0.91 [0.56-1.47]	0.693
Northern Ireland	3.43 [1.98-5.95]	<0.0001
Scotland	0.71 [0.49-1.04]	0.076

CI; confidence interval.

Table 6. Multivariable logistic regression analysis of factors associated with pre-emptive living donor kidney transplantation

Recipient variables	Odds Ratio [95% CI]	p-value
Ethnicity		
White	1 [reference]	
Asian	0.45 [0.23-0.86]	0.016
Black	1.19 [0.53-2.65]	0.672
Other	1.17 [0.17-7.79]	0.874
Employment status		
Employed	1 [reference]	
Unemployed	0.44 [0.21-0.92]	0.029
Long term sick / disability	0.44 [0.28-0.68]	0.0002
Retired	0.47 [0.29-0.75]	0.002
Other	1.41 [0.80-2.50]	0.240
Car ownership		
Yes	1 [reference]	
No	0.41 [0.19-0.86]	0.018
Home ownership		
Yes	1 [reference]	
No	0.65 [0.44-0.96]	0.029

CI; confidence interval.

Supplementary Material

Table S1. Missing data

Kidney transplant recipient missing data

	Living donor transplant recipients n=807	**Deceased donor transplant recipients n=1248**
Demographic variables		
Age	0	0
Gender	0	0
Ethnicity	0	4
Socioeconomic variables		
Civil status	48	96
Qualifications	48	97
Employment status	47	94
Car ownership	48	91
Home ownership	49	93
Clinical variables		
Primary renal diagnosis	3	1
Charlson Comorbidity Score	3	3
Previous transplant	0	0
Calculated reaction frequency	1	0
Pre-transplant treatment modality	3	1
Geographic variables		
Country	0	0

Donor missing data

	Living donor n=807	**Deceased donor n=1248**
Age	1	0
Gender	2	0
Ethnicity	1	18
Donor-recipient relationship	0	0