Interaction between socioeconomic deprivation and likelihood of pre-emptive transplantation: Influence of competing risks and referral characteristics

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Running title

Socioeconomic factors influence pre-emptive transplantation

Key words

Socioeconomic deprivation

Pre-emptive kidney transplantation

End stage kidney disease

Competing risks survival analysis

Abbreviations

BP, Blood pressure

CKD, Chronic kidney disease

eGFR, Estimated glomerular filtration rate

ESKD, End stage kidney disease

PET, Pre-emptive kidney transplantation

RRT, Renal replacement therapy

SED, Socioeconomic deprivation

SIMD, Scottish Index of Multiple Deprivation

uPCR,Urinary Protein to creatinine ratio

Conflicts of interest

There are no conflicts of interest to declare

Abstract

Background

Socioeconomic deprivation (SED) influences likelihood of pre-emptive kidney transplantation (PET), but the mechanisms behind this are unclear. We explored the relationships between SED and patient characteristics at referral, which might explain this discrepancy.

Methods

A retrospective cohort study was performed. SED was measured by Scottish Index of Multiple Deprivation (SIMD). Logistic regression evaluated predictors of PET. A competing risks survival analysis evaluated the interaction between SED and progression to end stage kidney disease (ESKD) and death.

Results

Of 7,765 patients with follow-up of 5.69±6.52 years, 1,298 developed ESKD requiring RRT; 113 received PET, 64 of which were from live donors. Patients receiving PET were ‘less deprived’ with higher SIMD (5±7 vs 4±5; p=0.003). This appeared independent of overall comorbidity burden. SED was associated with a higher risk of death but not ESKD. Higher SIMD decile was associated with a higher likelihood of PET (OR 1.14, 95% CI 1.06, 1.23); the presence of diabetes and malignancy also reduced PET.

Conclusions

SED was associated with reduced likelihood of PET after adjustment for baseline comorbidity, and this was not explained by risk of death or faster progression to ESKD. Education and outreach into transplantation should be augmented in areas with higher deprivation.

Introduction

Socioeconomic factors have repeatedly been shown to influence management strategies in end stage kidney disease (ESKD) [1-3], however the mechanism behind these associations remains elusive.

Pre-emptive kidney transplantation (PET) whereby the patient receives a kidney transplant as first modality of renal replacement therapy (RRT), remains the optimal treatment of EKSD which improves patient and transplant outcomes by avoidance of a preceding period of dialysis and is recommended in all suitable patients by national guidance [4, 5]. Certain medical factors prove relative or absolute contraindications to transplantation, such as the presence of cardiovascular disease, peripheral vascular disease or a history of malignancy [6]. Timing of referral to nephrology services, and system factors within the transplant evaluation process, also influence the likelihood of a recipient being determined suitable for transplantation prior to the need for an alternative form of RRT [7]. Access to a live donor also increases the likelihood of PET, given that median waiting time on the deceased donor renal transplant list is greater than 3 years [8].

However, non-medical factors have been found to affect modality of RRT, creating inequity even within universal healthcare systems such as the United Kingdom. A recent prospective study demonstrated an association between various stigmata of socioeconomic deprivation (SED), such as level of education and car ownership, and live donor transplantation [3], which reflects findings in other healthcare scenarios such as in the United States [9] and Australia [10]. In contrast, a prospective multi-centre study of potential live donor assessment in the United Kingdom found no association between likelihood of successful donation and SED [11]. The mechanism by which SED leads to a discrepancy in RRT provision therefore remains elusive and may in part relate to recipient engagement and empowerment [12], as well as financial factors, such as transport to aspects of transplant evaluation or provision of income after live donor transplantation.

Nevertheless, the possibility that the discrepancy in RRT provision relates to differences in progression to ESKD has not been excluded. For example, patients of lower socioeconomic status may have greater mortality due to comorbid factors which remain important predictors of outcome despite the differences in cardiovascular disease in EKSD [13], and the competing risk of death may confound the interpretation

of RRT rates. Alternatively, patients with SED may be referred at a later stage of renal impairment, or may undergo faster progression to ESKD, both of which may hinder transplant evaluation and listing, or identification and assessment of potential live donors. There has been little longitudinal investigation into the association between SED and PET with regards to the factors associated with healthcare status and risk of progression to ESKD at the first assessment at the nephrology clinic.

We therefore investigated the predictors of RRT modality in patients with incident ESKD, focusing on the effect of SED on pre-emptive kidney transplantation.

Materials & Methods

Study design and population

A retrospective single centre cohort study was performed, of a prospectively obtained database of adult patients with chronic kidney disease (estimated glomerular filtration rate (eGFR) below 60ml/min/1.73m^2). Patients were included whom attended general nephrology clinics in NHS Greater Glasgow and Clyde between 2006 – 2016, with follow up extended to 2017 (see supplementary online material). Individuals approaching the live kidney donor evaluation process were also included for a separate analysis, investigating the association between deprivation and successful live kidney donation. Data were obtained from the Strathclyde Electronic Renal Patient Record (SERPR, VitalPulse, UK) which includes description of primary renal diagnosis, demographics, comorbidity, dates of outpatient attendances, biometric measurements made at outpatient attendances, as well as biochemistry. Data regarding the date and modality of first RRT are also recorded. Measurements of serum creatinine and urinary protein to creatinine ratio (uPCR) were performed in standard accredited hospital biochemistry departments. Measurements were obtained at time of referral to the nephrology clinic and prior to the onset of RRT. eGFR was calculated from serum creatinine using the CKD-EPI formula [14] using the average of three sequential creatinine values from time of first clinic visit. Comorbidities were recognised if they were diagnosed prior to the onset of ESKD.

Socioeconomic deprivation

The Scottish Government provide online lookup files allowing use of patient postcode to generate an urban-rural classification[15] and divisions of socioeconomic deprivation, the Scottish Index of Multiple Deprivation (SIMD) [16]. The SIMD is a measure of relative deprivation, where postcodes are ranked on multiple domains including income, employment, education, health, access to services, crime and housing. An aggregate score is calculated, and each postcode ranked in order, to allow deciles to be calculated from the most (SIMD = 1) to least deprived (SIMD = 10). The SIMD has been used for the purposes of biomedical research in other studies previously and is felt to be a robust method of evaluating deprivation by geographical area [17-20]. For the purposes of a grouped survival analysis, the study population was numerically halved at the median SIMD by dichotomising into SIMD less than or equal to three, and SIMD greater than three.

Comorbidity

From the renal electronic patient record, we derived specific major comorbidities which may preclude or hinder progress towards transplantation, namely cardiovascular disease, malignancy and diabetes. Additionally we have derived a quantitative comorbidity score which is derived from a range of conditions, namely the Charlson comorbidity index [21], which has been validated in a series of populations [22, 23]. A survival analysis was performed to confirm an association between quartiles of comorbidity index and overall mortality. The Charlson comorbidity score itself was then entered into the logistic regression model in order to adjust for differences in baseline morbidity between socioeconomic groups.

Statistical analysis

Summary data are expressed as mean ± standard deviation, or median ± interquartile range where data are not normally distributed, whilst groups are compared using Student's t test or Wilcoxon's test. A competing risks survival analysis was conducted within the entire dataset to evaluate the progression to ESKD and death, with the first assessment at nephrology clinic representing the time of origin. A competing risks regression analysis was conducted with both the Fine and Grey's subdistribution hazards and cause specific hazards models. The variables associated with PET were evaluated in a logistic regression analysis, within the cohort of patients reaching ESKD. Regression analyses were carried out on datasets with missing data imputed by chained equations [24]. Five datasets were imputed from the original data, and an initial univariate regression analysis was carried out including variables which have previously been shown to associate with PET. All variables had less than 5% missing data apart from body mass index (BMI), which was therefore excluded from the imputation model. Stepwise variable selection was then carried out and this model applied to each imputed dataset in turn, before the model was pooled across the imputed datasets; the described results, including the McFadden's pseudo R^2, therefore represent the model pooled across the five imputed datasets. Statistical analysis is performed using R Studio version 1.1.383 running R version 3.4.2, with the mice, riskregression, ggplot2, forestplot, and cmprsk, and cr17 packages. Use of anonymised data from this database has been approved by the West of Scotland Ethics Committee via the NHS Greater Glasgow and Clyde 'Safe Haven' data for research group.

Results

Baseline characteristics

Of an initial dataset of 7,765 patients with chronic kidney disease (CKD) and a median follow-up time of 5.69±6.52 years, 1,298 patients developed ESKD requiring RRT (see supplementary online material). Of those who received RRT, 113 received PET, 64 of which were obtained from live donors; 1006 received in hospital haemodialysis (HD), 13 home HD, and 166 peritoneal dialysis (PD). Of the live donors, 23 were received from a partner, 19 from a sibling, 10 from a parent, 3 were altruistic and 9 were from other donors. Distribution of SIMD is shown in supplementary online material.

Characteristics of those reaching ESKD and receiving PET

In comparison to those not requiring RRT, patients who developed ESKD had lower body mass index (BMI) (27.5±8.6 vs 28.6±7.6 kg/m^2; p<0.001), and were referred younger (56.4±26.2 vs 70.7±17.2 years; p<0.001), with lower eGFR (31.2±27.1 vs 37.5±22.3 ml/min/1.73m^2; p<0.001), higher blood pressure (BP) (150/82±34/18 vs 147/76±34/19 mmHg; p=0.004) and uPCR(156.3±310.3 vs 43.8±106.3 mg/mmol; p<0.001). There was no difference in SIMD decile (4±5 vs 4±5; p=0.60). There was lower prevalence of cardiovascular disease (21 vs 32%; p<0.001) and malignancy (11 vs 17%; p<0.001) in the group reaching ESKD, but no difference in the prevalence of diabetes (35 vs 37%; p=0.39) (table 1).

Patients who received a pre-emptive transplant had higher SIMD decile (5±7 vs 4±5; p=0.003), lower BMI (25.6±6.6 vs 27.7±8.7 kg/m^2; p=0.003), and were referred younger (36.5±19.5 vs 58.4±24.2 years; p<0.001), with higher eGFR (39.7±39.8 vs 30.6±26.2 ml/min/1.73m^2; p=0.001), lower blood pressure (BP) (138/82±32/17 vs 150/82±34/18 mmHg; p<0.001), and uPCR (93.2±184.8 vs 168.7±326.4 mg/mmol; p<0.001). There was a lower prevalence of cardiovascular disease (6 vs 22%; p<0.001), diabetes (15 vs 37%; p<0.001) and malignancy (3 vs 12%; p=0.004). Comorbidity score was lower in the group proceeding to PET compared to other RRT modalities (2 ± 1 vs 4 ± 3; p<0.001). The time between referral and ESKD was longer (8.7±12.1 vs 4.9±7.2 years; p<0.001) and RRT was commenced at a higher eGFR in the PET group (9.3±5.7 vs 7.04±3.8 ml/min/1.73m^2; p<0.001) (table 1).

Characteristics of patients from lower SIMD decile

Patients from SIMD≤3 had higher BMI (29.0±8.4 vs 28.1±7.3 kg/m^2; p<0.001), and were referred younger (68.7±19.0 vs 69.3±19.1 years; p=0.02), with higher uPCR

(57.0±192.2 vs 51.7±130.4 mg/mmol; p=0.003), albeit with no difference in referral eGFR (37.0±22.8 vs 36.3±23.1 ml/min/1.73m^2; p=0.18) or BP (148/77 ±34/19 vs 148/78±35/18 mmHg; p=0.69). There was a higher prevalence of cardiovascular disease (32 vs 28%; p<0.001), diabetes (38 vs 35%; p=0.001) and lower prevalence of malignancy (15 vs 17%; p=0.01). There was no difference in baseline comorbidity score between the two socioeconomic groups (6 ± 3 vs 5 ± 3; p=0.98) (table 2).

Patients with SIMD≤3 who progressed to ESKD had a higher utilisation of hospital HD (84 vs 72%; p<0.001), and lower prevalence of PD (9 vs 17%; p<0.001) and transplant (6 vs 10%; p=0.02) as first RRT method.

Association between socioeconomic status and survival

Cumulative incidence curves displaying the association between SED and progression to death and ESKD are shown in figure 1. Patients from SIMD≤3 had a greater likelihood of death (log rank p<0.001) but not ESKD (log rank p=0.33).

The factors associated with the outcomes of death and ESKD are described in table 3. Covariables which were associated with an increased hazard of death were lower SIMD decile, cardiovascular disease, malignancy, diabetes, older age and higher uPCR at referral, and lower eGFR and BP at referral. The covariables which were significantly associated with an increased risk of ESKD were diabetes, higher systolic BP and uPCR at referral, and lower eGFR and age at referral; the presence of cardiovascular disease and malignancy were associated with a lower hazard of ESKD.

Factors influencing pre-emptive kidney transplantation

The covariables associated with a higher likelihood of receiving PET were analysed in a multiple logistic regression analysis (table 4). Higher SIMD decile was associated with a higher likelihood of PET; the presence of diabetes, malignancy, higher referral eGFR, age, and uPCR were associated with a lower likelihood of PET (McFadden's pseudo R^2 = 0.20; p<0.001) (figure 2).

In a survival analysis, quartile of comorbidity score was significantly associated with overall survival (see supplementary online material). The comorbidity score was then entered into the logistic regression model in place of the specific comorbidities used in the previous analysis. Higher SIMD remained associated with a higher likelihood of PET (McFadden's pseudo R^2 = 0.19; p<0.001) (figure 2).

Association between socioeconomic deprivation and live kidney donation

Given that SED was associated with reduced live kidney donation, we evaluated the relationship between deprivation and successful live kidney donation. Between 2009 and 2018, 1208 potential live donors (PLDs) were evaluated with age of 45.8 ± 21.4 years, follow-up 3.4 ± 8.5 months and SIMD of 4 ± 5. There was no association between deprivation and likelihood of successful donation (8 vs 11%; p=0.13), and neither was there a difference in the cumulative incidence of successful donation between groups (log rank p=0.27) (see supplementary online material).

Discussion

The UK National Institute for Clinical Excellence (NICE) guidelines suggest that PET is the optimal treatment modality for medically suitable patients [5], given that time on dialysis is one of the most significant modifiable factors relating to both transplant outcomes [4] and the development of cardiovascular disease [25]. Additionally, avoidance of dialysis prior to transplant prevents the need for vascular access procedures which may broaden longer term RRT options. Previous work has shown that access to both transplant and other home modalities of RRT is not equitable however, with socioeconomic [12] and ethnic [26, 27] factors affecting RRT choice in addition to medical factors.

The incidence of PET was lower in those from lower SIMD decile, and on multiple regression analysis, for each increment in SIMD decile, the incidence of patients receiving PET was increased by 14%. Data from other studies into the effect of SED on transplantation has been conflicting; in Australia, the rates of living but not deceased renal transplantation is reduced by SED [10], whilst in the United States patients from deprived backgrounds have lower rates of deceased donor, live donor, and pre-emptive transplantation [28]. Incidence of deceased donor transplantation is also altered by ethnicity in the United States, with the lowest rates in native American and black populations. In the United Kingdom, factors relating to SED [2] and dialysis centre [7] are associated with deceased and live kidney donation. Whilst ethnicity has not been found to be associated with wait listing in the United Kingdom [2], patients from ethnic minority groups are less likely to receive a live versus deceased donor transplant [3]. The reasons behind this are complex and involve several factors including unintentional bias amongst healthcare teams, differences in cultural acceptability of kidney donation, and variation in the distribution of morbidity in potential donors which may preclude donation. Using the granularity of the electronic renal database from which the data are derived, we investigated the mechanisms behind this association, with the hypothesis that deprivation may lead to later referral to nephrology services or a disparity in progression to ESKD.

Evaluation of baseline parameters at time of referral to the nephrology clinic demonstrated little difference between the two SIMD groups. Whilst proteinuria was greater in the more deprived group they differed by such a small degree that it would be deemed clinically insignificant; eGFR was no different between groups, and

patients from lower SIMD decile were in fact referred at a slightly younger age. The referral characteristics of the group from lower socioeconomic status did not therefore explain the gap in PET.

Evaluation of our entire cohort of patients with CKD allowed a competing risks survival analysis of the progression to ESKD, to determine if this accounted for the discrepancy in RRT provision between socioeconomic classes. In a competing risks analysis, patients are censored if a certain outcome develops prior to, and at the cost of, the outcome of interest; this is in contrast to a traditional (for example Kaplan-Meier) survival analysis which allows for only a single outcome. In our analysis, lower SIMD decile was associated with an increased hazard of death both in univariate and multivariate analysis. Despite this, the hazard of ESKD was no different from those in higher socioeconomic class, and even after adjustment for baseline characteristics in a multivariate analysis, there was no independent association between deprivation and a difference in progression to ESKD.

We found no evidence therefore, that patients from lower socioeconomic class are referred at a later stage of CKD or progress to ESKD at a significantly quicker rate, and neither does the competing risk of death act as a confounder in the interpretation of the data. It is notable however that those receiving PET were referred at a higher eGFR and younger age; although there was no difference in stage of CKD in which patients were referred, earlier referral of patients with lower socioeconomic status may represent a mechanism by which the deficit of PET can be reduced.

In UK practice the recent landmark Access to Transplantation and Transplant Outcome Measures (ATTOM) study has dissected out many of the interactions between SED and live donor transplantation [3]. In addition to confirming many of the conclusions of previous registry studies, ATTOM explored the association between transplantation and the attributes comprising social status, such as literacy and car ownership. Indeed, lower educational attainment increased the time to be added to the transplant waiting list and to living donor transplant by 22% and 47%, respectively [29]. Car ownership may also directly affect transplantation prospects by limiting access to hospital-based assessment clinics, and by limiting attendance of potential live donors to low clearance clinics. Using SIMD, a postcode of residence-based tool, to assess SED has limitations, in that generalisations are made about individual patients and postcodes. It is possible that outliers exist within a postcode, with affluent

patients living in areas with high deprivation, and vice versa. This can introduce inaccuracy when using such methodology to evaluate individual outcomes. Nevertheless, there are advantages to its use in health records-based research, such as its ready availability, reproducibility, and links to other encounters with healthcare, which also allowed comparisons with a large group of controls who did not reach ESKD, or who received a different form of RRT.

It is widely accepted that deprivation is associated with an increased prevalence of cardiovascular disease, diabetes, and many other conditions [30], which is reflected in our data by the higher prevalence of cardiovascular disease and diabetes in this group of patients with CKD. Extended to the donor pool, given that potential live donors likely share socioeconomic factors with their recipients, these factors may limit the live donation in patients with SED thereby limiting the likelihood of PET. Certainly, live donation was less common in the cohort with SED, which partly explains the gap in pre-emptive transplantation. We also examined participants approaching our live donor evaluation process, and examined the association between successful donation and SED. We found no interaction between low SIMD and successful donation. This was reflected in a recent prospective analysis of potential live donor assessment found no interaction between deprivation and likelihood of successful donation [11], data which encourage researchers to look elsewhere for reasons behind the discrepancy in transplant provision.

Our study has several limitations which must be acknowledged. Firstly, the retrospective analysis of routinely collected data, albeit prospectively acquired, can introduce bias via incomplete recording of patient data, although conversely, the study design allows for a comprehensive evaluation of real world RRT practice. Given the difference in baseline comorbidity between socioeconomic groups, we performed a logistic regression analysis to adjust for this, to measure the specific effect size of differences in socioeconomic status. Although this is a conventional practice, it is possible that this did not fully account for differences in baseline comorbidity and residual confounding persists. Furthermore, the study pertains to a single transplant centre, and the findings may not be widely applicable. The electronic database from which data are derived does not record ethnicity, which has previously been shown to be a determinant of RRT choice and may confound the relationship between deprivation and RRT. The study cohort is fairly racially homogeneous however, with

only 5.3% of the West of Scotland population from non-white ethnic backgrounds [31]. Whilst on average there is greater SED in black and middle eastern populations, there is clearly a complex relationship between ethnicity and socioeconomic status which makes it difficult to fully define the independent relationship between ethnicity and transplantation [32]. Finally, whilst it could be argued that our analysis of those receiving pre-emptive transplant should include only those patients deemed eligible to undergo the procedure, by including all patients reaching ESKD we seek to reveal any bias in the process by which eligibility is determined. Our regression analysis, whereby baseline comorbidity is adjusted for, also seeks to account for this, and indeed there remains an independent association between SED and PET even after adjustment for comorbidities which may prove relative or absolute contraindications to transplantation.

In conclusion, there is a discrepancy in the provision of pre-emptive and live donor transplantation in patients with socioeconomic deprivation. This is not accounted for by differences in the clinical characteristics at time of referral to nephrology services, the rate at which progression to ESKD occurs, and neither is the gap explained by the competing risk of death. With each increment in SIMD decile, there is a 14% increased likelihood of undergoing pre-emptive renal transplantation. Further research into the barriers of pre-emptive transplantation in patients from deprived backgrounds is required. Imaginative initiatives which improve access to, and knowledge of, renal transplantation should be a focus of the transplant community moving into the future.

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Tables

Table 1

	Total n = 7765	No ESKD n = 6467	Other RRT n = 1185	PET n = 113	p value
SIMD	4 ± 5	4 ± 5	4 ± 5	5 ± 7	0.003
BMI (kg/m^2)	28.5 ± 7.8	28.6 ± 7.6	27.7 ± 8.7	25.6 ± 6.6	0.003
Referral creatinine (µmol/L)	163.3 ± 79.0	159.3 ± 70.3	199.0 ± 128.4	178.0 ± 157.7	<0.001
Referral age (years)	68.9 ± 19.1	70.7 ± 17.2	58.4 ± 24.2	36.5 ± 19.5	<0.001
Referral eGFR (ml/min/1.73m^2)	36.7 ± 23.0	37.5 ± 22.3	30.6 ± 26.2	39.7 ± 39.8	0.001
Referral BP (mmHg)	148/77 ± 34/19	147/76 ± 34/19	150/82 ± 34/18	138/82 ± 32/17	<0.001
Referral uPCR (mg/mmol)	54.5 ± 140.4	43.8 ± 106.3	168.7 ± 326.4	93.2 ± 184.8	<0.001
eGFR at RRT (ml/min/1.73m^2)	na	na	7.04 ± 3.8	9.3 ± 5.7	<0.001
Time to RRT (years)	na	na	4.9 ± 7.2	8.7 ± 12.1	<0.001
Cardiovascular disease (%)	30	32	23	6	<0.001
Diabetes (%)	36	37	37	15	<0.001
Malignancy (%)	14	17	12	3	0.004

Charlson comorbidity index	5 ± 3	6 ± 3	4 ± 3	2 ± 1	<0.001

Table 1 Baseline characteristics. P values refer to a comparison of patients receiving pre-emptive transplantation versus those receiving other modalities of renal replacement therapy. ESKD = End stage kidney disease, RRT = Renal replacement therapy, PET = Pre-emptive transplant, SIMD = Scottish Index of Multiple Deprivation, BMI = Body mass index, eGFR = Estimated glomerular filtration rate, uPCR = Urinary protein to creatinine ratio.

Table 2

	SIMD>3 n = 4170	SIMD≤3 n = 3454	p value
SIMD	7 ± 4	2 ± 1	<0.001
BMI (kg/m^2)	28.1 ± 7.3	29.0 ± 8.4	<0.001
Referral creatinine (µmol/L)	164.0 ± 79.7	162.7 ± 77.0	0.24
Referral age (years)	69.3 ± 19.1	68.7 ± 19.0	0.02
Referral eGFR (ml/min/1.73m^2)	36.3 ± 23.1	37.0 ± 22.8	0.18
Referral BP (mmHg)	148/78 ± 35/18	148/77 ± 34/19	0.69
Referral uPCR (mg/mmol)	51.7 ± 130.4	57.0 ± 192.2	0.003
Cardiovascular disease (%)	28	32	<0.001
Diabetes (%)	35	38	0.001
Malignancy (%)	17	15	0.01
Charlson comorbidity index	5 ± 3	6 ± 3	0.98
Hospital HD (%)	72	84	<0.001
Home HD (%)	1	0.7	0.38
Peritoneal dialysis (%)	17	9	<0.001
Transplant (%)	10	6	0.02
Live (%)	7	3	0.004

Table 2 Baseline parameters of patients with SIMD decile less than or equal to three in comparison to the remainder of the cohort. The proportional uptake of each RRT modality refers to those patients reaching ESKD. BMI = Body mass index, eGFR = Estimated glomerular filtration rate, BP = Blood pressure, uPCR = Urinary protein to creatinine ratio, HD = Haemodialysis, SIMD = Scottish Index of Multiple Deprivation.

Table 3

Event	Predictor	Increment	CSH		SHR	
			HR	95% CI	HR	95% CI
ESKD	Female		1.00	0.89, 1.12	1.01	0.90, 1.14
	SIMD	1	0.99	0.97, 1.01	1.00	0.98, 1.02
	Cardiovascular disease		0.79	0.68, 0.90	0.85	0.73, 0.98
	Malignancy		0.76	0.64, 0.90	0.84	0.70, 0.99
	Diabetes		1.35	1.20, 1.52	1.18	1.05, 1.34
	Referral age (years)	10	0.72	0.69, 0.75	0.58	0.56, 0.60
	Referral eGFR (ml/min/1.73m^2)	10	0.69	0.66, 0.71	0.75	0.72, 0.78
	Referral systolic BP (mmHg)	10	1.03	1.02, 1.04	1.03	1.02, 1.04
	Referral uPCR (mg/mmol)	100	1.03	1.02, 1.03	1.04	1.02, 1.05
Death	Female		0.95	0.89, 1.03	0.97	0.90, 1.04
	SIMD	1	0.97	0.95, 0.98	0.97	0.96, 0.98
	Cardiovascular disease		1.22	1.13, 1.31	1.33	1.24, 1.43
	Malignancy		1.19	1.09, 1.30	1.25	1.14, 1.37

Diabetes		1.37	1.27, 1.47	1.45	1.07, 1.24
Referral age (years)	10	2.23	2.14, 2.23	1.82	1.75, 1.89
Referral eGFR (ml/min/1.73m^2)	10	0.90	0.87, 0.92	0.99	0.96, 1.01
Referral systolic BP (mmHg)	10	0.98	0.97, 0.99	0.98	0.96, 0.99
Referral uPCR (mg/mmol)	100	1.02	1.01, 1.02	1.01	1.00, 1.02

Table 3 Regression analysis of the covariables associated with progression to death or end stage kidney disease, by the cause specific hazards model, and Fine and Gray's subdistribution hazards model. SIMD = Scottish Index of Multiple Deprivation, eGFR = Estimated glomerular filtration rate, BP = Blood pressure, uPCR = Urinary protein to creatinine ratio, CSH = Cause specific hazard, SHR = Subdistribution hazard ratio, ESKD = End stage kidney disease, HR = Hazard ratio.

Table 4

Variable	Increment	OR	95% CI	p value
SIMD	1	1.14	1.06, 1.23	<0.001
Diabetes		0.56	0.31, 0.99	0.05
Malignancy		0.28	0.08, 0.94	0.04
Cardiovascular disease		0.54	0.24, 1.24	0.16
Referral eGFR (ml/min/1.73m^2)	10	0.88	0.82, 0.95	0.001
Referral age (years)	10	0.57	0.49, 0.67	<0.001
Referral systolic BP (mmHg)	10	0.95	0.87, 1.04	0.36
Referral uPCR (mg/mmol)	100	0.84	0.75, 0.95	0.004
SIMD	1	1.14	1.06, 1.23	<0.01
Charlson comorbidity index	1	0.82	0.70, 0.97	0.02
Referral eGFR (ml/min/1.73m2)	10	0.87	0.81, 0.94	<0.001
Referral age (years)	10	0.59	0.49, 0.71	<0.001
Referral systolic BP (mmHg)	10	0.96	0.87, 1.05	0.36
Referral uPCR (mg/mmol)	100	0.84	0.75, 0.95	0.004

Table 4 Multiple logistic regression analysis of the covariable influencing pre-emptive kidney transplantation. SIMD = Scottish Index of Multiple Deprivation, eGFR = Estimated glomerular filtration rate, BP = Blood pressure, uPCR = Urinary protein to creatinine

Legend to figures

Figure 1

Cumulative incidence curves demonstrating association between socioeconomic status and progression to end stage kidney disease or death. Produced with the cr17 R package. ESKD = End stage kidney disease, SIMD = Scottish Index of Multiple Deprivation.

Figure 2

Forest plot of factors influencing likelihood of pre-emptive kidney transplant with specific comorbidities (A) and comorbidity index (B). SIMD = Scottish Index of Multiple Deprivation, eGFR = Estimated glomerular filtration rate, BP = blood pressure, uPCR = Urinary protein creatinine ratio, OR = Odds ratio, CI = Confidence interval.