Transplant International

ORIGINAL ARTICLE

# Socio-economic disparity, access to care and patient-relevant outcomes after kidney allograft failure

Yun Hui Sheryl Wong[1], Germaine Wong[2,3,4], David W. Johnson[5,6,7], Stephen McDonald[8,9,10], Philip Clayton[8,9,10], Neil Boudville[1,11], Andrea K. Viecelli[5,6], Charmaine Lok[12,13], Helen Pilmore[14,15], Carmel Hawley[5,6,7], Matthew A. Roberts[16], Rachael Walker[17], Esther Ooi[11,18], Kevan R. Polkinghorne[19,20,21] & Wai H. Lim[1,11]

1 Department of Renal Medicine, Sir Charles Gairdner Hospital, Perth, WA, Australia
2 University of Sydney, Sydney, NSW, Australia
3 Centre for Kidney Research, The Children's Hospital at Westmead, Sydney, NSW, Australia
4 Department of Renal Medicine and National Pancreas Transplant Unit, Westmead Hospital, Sydney, NSW, Australia
5 Department of Nephrology, Princess Alexandra Hospital, Queensland, Australia
6 University of Queensland, Queensland, Qld, Australia
7 Translational Research Institute, Brisbane, Qld, Australia
8 South Australian Health and Medical Research Institute, ANZDATA Registry, Adelaide, SA, Australia
9 University of Adelaide, Adelaide, SA, Australia
10 Royal Adelaide Hospital, Adelaide, SA, Australia
11 Medical School, University of Western Australia, Perth, WA, Australia
12 Division of Nephrology, Department of Medicine, University Health Network-Toronto General Hospital, Toronto, ON, Canada
13 The University of Toronto, Toronto, ON, Canada
14 Department of Renal Medicine, Auckland City Hospital, Auckland, New Zealand
15 Department of Medicine, Auckland University, Auckland, New Zealand

## SUMMARY

Social disparity is a major impediment to optimal health outcomes after kidney transplantation. In this study, we aimed to define the association between socio-economic status (SES) disparities and patient-relevant outcomes after kidney allograft failure. Using data from the Australia and New Zealand Dialysis and Transplant registry, we included patients with failed first-kidney allografts in Australia between 2005 and 2017. The association between residential postcode-derived SES in quintiles (quintile 1-most disadvantaged areas, quintile 5-most advantaged areas) with uptake of home dialysis (peritoneal or home haemodialysis) within the first 12-months post-allograft failure, repeat transplantation and death on dialysis were examined using competing-risk analysis. Of 2175 patients who had experienced first allograft failure, 417(19%) and 505(23%) patients were of SES quintiles 1 and 5, respectively. Compared to patients of quintile 5, quintile 1 patients were less likely to receive repeat transplants (adjusted subdistributional hazard ratio [SHR] 0.70,95%CI 0.55–0.89) and were more likely to die on dialysis (1.37 [1.04–1.81]), but there was no association with the uptake of home dialysis (1.02 [0.77–1.35]). Low SES may have a negative effect on outcomes post-allograft failure and further research is required into how best to mitigate this. However, small-scale variation within SES cannot be accounted for in this study.

*Transplant International* 2021; 34: 2329–2340

**Key words**
home dialysis, kidney allograft failure, mortality, pre-emptive transplant, socio-economic status

Received: 17 November 2020; Revision requested: 16 June 2021; Accepted: 11 July 2021;
Published online: 14 September 2021


doi:10.1111/tri.14002

16 Eastern Health Clinical School, Monash University, Melbourne, Vic, Australia
17 Eastern Institute of Technology, Napier, New Zealand
18 School of Biomedical Sciences, University of Western Australia, Perth, WA, Australia
19 Department of Nephrology, Monash Medical Centre, Melbourne, Vic., Australia
20 Department of Medicine, Monash University, Melbourne, Vic., Australia
21 Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Vic., Australia

**Correspondence**
Yun Hui Sheryl Wong, Department of Renal Medicine, Sir Charles Gairdner Hospital, Perth, WA, Australia 6009. Tel.: +61-8-64572799; fax: +61864573942; e-mail: sherylwyh@gmail.com

## Introduction

Socio-economic disparity has historically been associated with lower levels of patient care and inferior outcomes in people with kidney failure on maintenance dialysis [1,2]. Registry data from the United States have shown that kidney transplant recipients of higher socio-economic status (SES) have a survival advantage compared to those of lower SES, with this effect preserved across ethnic groups [3]. The reasons for this survival disparity post-kidney transplantation remain unclear, but are likely to include differences in non-adherence status, employment status, language or cultural barriers and disparities in health literacy [4,5].

Short and intermediate kidney allograft survival has improved over the last two decades but longer-term allograft and patient survival has not substantially improved [6]. Related to patients with functioning kidney allografts, those returning to dialysis post-allograft failure face increased risk of mortality and experienced reduced quality of life [7]. Following allograft failure, access to optimal dialysis care including planned dialysis modalities is characteristically deficient [8]. Prior work has shown high rates of dialysis catheter use as the initial form of vascular access upon re-initiation of dialysis following allograft failure, a suboptimal form of access which contributes to the excess risk of mortality and morbidity post-allograft failure [9,10]. Pre-emptive transplantation is another management option that is associated with improved mortality after allograft failure [11]; however, research in the pre-transplant population has shown access for pre-emptive transplantation may be challenging for those of low SES [12].

The effect of low SES on outcomes post-allograft failure is unclear; however, low SES has been consistently shown to be associated with poorer clinical outcomes in patients with kidney failure worldwide [3]. Compared to kidney failure patients of high SES, those of low SES were more likely to experience delayed referral for kidney replacement therapy, less likely to initiate dialysis with established access, less likely to attain pre-emptive kidney transplantation and more likely to experience premature mortality post-initiation of dialysis [13–15]. In contrast, a study from the Australia and New Zealand Dialysis and Transplant (ANZDATA) registry showed that patients with kidney failure from higher SES were less likely to commence peritoneal dialysis (PD) compared to those from lower SES, although the uptake of home haemodialysis (HD) was similar [16], suggesting a complex interplay of patient and social factors that may contribute to the inconsistent associations between SES and outcome measures post-dialysis initiation. Patients re-initiating dialysis following kidney allograft failures often have better health literacy compared to transplant naïve patients [17], and therefore, the associations between SES and outcomes observed in the latter population may not be extrapolated to patients with prior allograft failure. The aims of this study were to examine the associations between SES and the uptake of home dialysis treatment at 12-months, likelihood of second kidney transplantation and risk of all-cause mortality following first allograft failure.

## Materials and methods

### Study population

Patients with a failed first deceased or live-donor kidney allografts in Australia between 1 January 2005 and 31 December 2017 reported to the ANZDATA registry were included in our study. Patients with no recorded residential postcode at time of allograft failure, no documented treatment type within 12 months of allograft failure or were recorded to have a return of first allograft function were excluded. The conduct of this study



Transplant International 2021; 34: 2329–2340

was approved by the University of Western Australia Human Research Ethics Committee, Perth, Australia.

### Covariates of interest

Baseline patient characteristics included age at first allograft failure, race, sex, cause of kidney failure, body mass index (BMI) at time of allograft failure, presence of comorbid conditions (presence or absence of diabetes mellitus, cardiovascular disease, cerebrovascular accident, peripheral vascular disease at time of allograft failure) and smoking history. Data pertaining to donor type of first allograft and duration of first allograft function prior to failure were also extracted.

### Exposure factor

The primary exposure factor was SES derived from residential postcodes at the time of first allograft failure. Each patient's SES was classified into quintiles, based on the Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) classification by the Australian Bureau of Statistics (ABS), with quintile 5 representing the most advantaged areas and quintile 1 the most disadvantaged areas. The IRSAD index is a weighted combination of a number of Census population and housing measures of socio-economic position including income, educational level, employment and occupational status, home ownership and other indicators of relative advantage or disadvantage to classify residential postcodes into percentiles [18,19]. It is therefore a global summary of the economic and social conditions of people and households within an area, and the classification of the IRSAD raw values as quintiles allows for the generalisability and comparisons across regions in the different states and territories in Australia. In addition, residential geographical locations (major city, regional and remote), assigned by residential postcodes using the 2006 Australian Standard Geographical Classification, were also determined [18].

### Outcome measures

The primary outcome was the uptake of home dialysis treatment (either home HD or PD) within the first 12 months post-first allograft failure. Secondary outcomes included the likelihood of receiving a second kidney transplant or a pre-emptive (i.e. no dialysis prior to re-transplantation) kidney transplant post-first allograft failure and all-cause mortality on dialysis post-allograft failure.

### Statistical analysis

Data were expressed as number (percentages) for categorical variables, mean (standard deviation [SD]) for normally distributed continuous variables and median (interquartile range) for non-normally distributed continuous variables, with comparisons between groups undertaken using chi-square test, analysis of variance (ANOVA) and Kruskall-Wallis test, respectively, as appropriate. The association between SES (i.e. IRSAD in quintiles [as categories and as a continuous measure]), uptake of home dialysis treatments, second kidney transplantation and all-cause mortality on dialysis were examined using competing-risk analysis using the method described by Fine and Gray [20], with the estimates reported as adjusted subdistributional hazard ratio (SHR) and 95% confidence intervals (95%CI). For the uptake of home dialysis treatment in the first 12 months post-allograft failure, the competing events were re-transplantation or death occurring within the 12 months post-allograft failure. Death was the competing event for re-transplantation and re-transplantation was the competing event for all-cause mortality.

In a subgroup analysis restricted to patients who have received a second kidney transplant, the association between SES and likelihood of receiving a pre-emptive second kidney transplant was examined using adjusted logistic regression analysis. Age, race, sex, cause of kidney failure, BMI, smoking history, duration of first allograft, era and comorbid vascular conditions (coronary artery disease, peripheral vascular disease, cerebrovascular disease) at time of allograft failure were included in all multivariable-adjusted competing risk and logistic regression models because of the known (and previously established) biological relationships with outcomes. An additional competing-risk model was constructed for each outcome, excluding the variables that could be a consequence of SES including prevalent coronary artery disease, prevalent peripheral vascular disease, prevalent cerebrovascular disease, smoking history and body mass index (at time of allograft loss, Model 2).

Sensitivity analyses examining the associations between residential geographical locations and the outcomes of uptake of home dialysis treatments, second kidney transplantation and all-cause mortality on dialysis were undertaken in multivariable-adjusted models, with residential postcode-derived IRSAD quintiles excluded from all models. Statistical analyses were performed using the SPSS statistical software program (version 24: SPSS, North Sydney, Australia) and STATA

statistical software version 9.4, with p-values of less than 0.05 considered statistically significant.

## Results

Compared to the study cohort, there were lower proportions of Caucasian (81% vs. 71%, $P < 0.001$) and diabetic patients (25% vs. 19%, $P = 0.001$) in the excluded cohort without baseline residential postcode at the time of allograft loss (n = 559). However, the mean (SD) age (48.6 [15.4] vs. 46.5 [15.4] years, $P = 0.44$) and proportions of female patients (38% vs. 39%, $P = 0.75$), presence of coronary artery disease (17% vs. 15%, $P = 0.32$) and primary causes of kidney failure (GN: 48% vs. 52%, $P = 0.26$; diabetic nephropathy: 9% vs. 9%, $P = 1.0$) were similar between the study and excluded cohorts.

Table 1 shows the characteristics of the study population stratified according to IRSAD quintiles. The median (IQR) follow-up time for the study cohort was 2.3 (0.9–4.5) years. Of the 2175 patients who experienced first allograft failure during the study period, 417 (19.2%) patients were of the lowest quintile (most disadvantaged) and 505 (23.2%) were of the highest quintile (most advantaged) (Fig. 1). A greater proportion of patients in the lower quintiles had diabetes and vascular comorbid conditions at time of allograft failure compared to patients in the higher quintiles. A significant association was present for race ($P < 0.001$), which was demonstrated by the fact that a higher proportion of Indigenous patients were grouped into IRSAD quintile 1 (45%) as compared to IRSAD quintile 5 (0%); whereas for Caucasian patients, we observed a higher proportion grouped into quintile 5 (23%) as compared to the lowest quintile (18%).

### Association between SES and uptake of home dialysis treatment at 12 months

Six hundred and nine (28%) patients commenced home dialysis treatments within the first 12 months post-allograft failure, with 357 (16%) and 252 (12%) maintained on PD and home HD, respectively. There was no association between IRSAD quintiles (in categories) and uptake of home dialysis treatment in the adjusted competing-risk model (Table 2 and Fig. 2). In the model with IRSAD quintiles as a continuous measure, the adjusted SHR (95%CI) was 1.04 (0.95, 1.15). With the exclusion of variables that could be a consequence of SES (Model 2), there was no association between IRSAD quintiles and uptake of home dialysis treatment at 12 months, with estimates similar to the main model (Table 3).

### Association between SES and likelihood of second kidney transplantation

Seven hundred and fifty-four (35%) patients received a second kidney transplant in the follow-up period. Table 2 and Fig. 2 show the adjusted SHR (95%CI) of the association between IRSAD quintiles and likelihood of second kidney transplantation post-allograft failure. Compared to patients of IRSAD quintile 5, those in quintiles 1–3 were significantly less likely to receive a second kidney transplant. In the model with IRSAD quintiles as a continuous measure, the adjusted SHR (95%CI) was 1.11 (1.05, 1.17). The cumulative incidence curves of second kidney transplantation post-first allograft failure, stratified by the IRSAD quintiles, adjusted for the competing risk of death are shown in Fig. 3a. With the exclusion of variables that could be a consequence of SES (Model 2), patients in the lower quintiles were less likely to receive second kidney transplants compared to those in the highest quintile (Table 3).

Of 754 recipients who have received a second kidney transplant, 531 (70.4%) received kidneys from deceased donors. Fifty-six (7.4%) recipients received pre-emptive second transplants (54 of 56 were from live-donors). Patients in the lower IRSAD quintiles were less likely to receive a pre-emptive second kidney transplant compared to those in the highest quintile (quintile 1: adjusted OR 0.63 [0.25, 1.58]; quintile 2: 0.43 [0.16, 1.18]; quintile 3: 0.62 [0.27, 1.43]; quintile 4: 0.40 [0.17, 0.94]). Other covariates that were significantly associated with an increased likelihood of pre-emptive second kidney transplant were increasing duration of first allograft function (adjusted OR 1.10 [1.05, 1.14]) and recent era (2013–2017: adjusted OR 2.61 [1.13, 6.01]; 2005–2008: referent). In a sub-analysis limited only to patients who have received a second live-donor kidney transplant ($n = 223$), compared to the highest IRSAD category, the adjusted OR (95%CI) of patients in the lowest and middle IRSAD categories were 0.85 (0.29, 2.17) and 0.65 (0.29, 1.47), respectively.

### Association between SES and all-cause mortality on dialysis post-allograft failure

There were 560 (26%) deaths that had occurred in the follow-up period, censoring for kidney transplantation. In the competing-risk analysis (where kidney



Transplant International 2021; 34: 2329–2340

**Table 1.** Baseline characteristics of patients with failed first kidney allografts stratified by the Index of Relative Socio-economic Advantage and Disadvantage (IRSAD).

| | Quintiles of the index of relative advantage and disadvantage* | | | | | |
|---|---|---|---|---|---|---|
| | Quintile 1 n = 417 | Quintile 2 n = 336 | Quintile 3 n = 442 | Quintile 4 n = 475 | Quintile 5 n = 505 | p-values |
| Recipient (at allograft failure) | | | | | | |
| Age (years, median [IQR])* | 51 (38, 59) | 49 (38, 60) | 50 (37, 61) | 50 (41, 62) | 50 (38, 61) | 0.927 |
| Race (*n*, %) | | | | | | |
| Caucasian | 320 (76.7) | 285 (84.8) | 349 (79.0) | 392 (82.5) | 407 (80.6) | <0.001 |
| Indigenous | 46 (11.0) | 20 (6.0) | 20 (4.5) | 17 (3.6) | 0 (0.0) | |
| Others | 51 (12.3) | 31 (9.2) | 73 (16.5) | 66 (13.9) | 98 (19.4) | |
| Female gender (*n*, %) | 161 (38.6) | 117 (34.8) | 148 (33.5) | 186 (39.2) | 210 (41.6) | 0.080 |
| Cause of kidney failure (*n*, %) | | | | | | |
| GN | 204 (48.9) | 166 (49.4) | 195 (44.1) | 229 (48.2) | 259 (51.3) | 0.018 |
| Diabetes | 38 (9.1) | 28 (8.3) | 39 (8.8) | 46 (9.7) | 44 (8.7) | |
| Cystic | 29 (7.0) | 23 (6.8) | 27 (6.1) | 40 (8.4) | 44 (8.7) | |
| Vascular | 27 (6.5) | 14 (4.2) | 16 (3.6) | 12 (2.5) | 9 (1.8) | |
| Reflux | 54 (12.9) | 42 (12.5) | 60 (13.6) | 73 (15.4) | 60 (11.9) | |
| Others | 65 (15.6) | 63 (18.8) | 105 (23.8) | 75 (15.8) | 89 (17.6) | |
| BMI (kg/m$^2$, median [IQR]) * | 27.2 (23.7, 33.7) | 26.9 (23.1, 31.8) | 27.1 (23.4, 31.2) | 26.6 (23.1, 30.8) | 26.2 (22.6, 30.7) | 0.169 |
| Diabetes (n, %)* | 125 (30.0) | 86 (25.6) | 111 (25.1) | 126 (26.5) | 106 (21.0) | 0.039 |
| CAD (*N*, %)* | 74 (17.7) | 68 (20.2) | 81 (18.3) | 77 (16.2) | 68 (13.5) | 0.095 |
| CVA (*N*, %)* | 35 (8.4) | 18 (5.4) | 24 (5.4) | 27 (5.7) | 25 (5.0) | 0.211 |
| PVD (*n*, %)* | 47 (11.3) | 24 (7.1) | 38 (8.6) | 42 (8.8) | 44 (8.7) | 0.379 |
| Smoking history (n, %) | | | | | | |
| Non-smoker | 234 (56.1) | 193 (57.4) | 254 (57.5) | 256 (53.9) | 318 (63.0) | 0.020 |
| Former smoker | 108 (25.9) | 87 (25.9) | 111 (25.1) | 146 (30.7) | 127 (25.1) | |
| Current smoker | 64 (15.3) | 41 (12.2) | 61 (13.8) | 58 (12.2) | 38 (7.5) | |
| Unknown | 11 (2.7) | 15 (4.5) | 16 (3.6) | 15 (3.2) | 22 (4.4) | |
| Prior failed allograft | | | | | | |
| Era | | | | | | |
| 2005–2008 | 92 (22.1) | 71 (21.1) | 96 (21.7) | 92 (19.4) | 109 (21.6) | 0.600 |
| 2009–2012 | 134 (32.1) | 105 (31.3) | 160 (36.2) | 160 (33.7) | 152 (30.1) | |
| 2013–2017 | 191 (45.8) | 160 (47.6) | 186 (42.1) | 223 (46.9) | 244 (48.3) | |
| Duration first allograft (median [IQR]) | 8.6 (4.0, 14.5) | 9.4 (3.2, 14.8) | 9.1 (3.9, 14.6) | 9.4 (4.4, 15.7) | 9.4 (4.4, 14.9) | 0.597 |
| 12-months post-first allograft failure | | | | | | |
| PD | 75 (18.0) | 47 (14.0) | 76 (17.2) | 80 (16.8) | 79 (15.6) | 0.031 |
| Home HD | 39 (9.4) | 44 (13.1) | 50 (11.3) | 52 (10.9) | 67 (13.3) | |
| Satellite HD | 238 (57.1) | 185 (55.1) | 239 (54.1) | 251 (52.9) | 260 (51.5) | |
| Second transplant | 27 (6.5) | 24 (7.1) | 26 (5.9) | 45 (9.5) | 62 (12.3) | |
| Death | 38 (9.0) | 36 (10.7) | 51 (11.5) | 47 (9.9) | 37 (7.3) | |

Data expressed as number (proportion) or as median (interquartile range [IQR]).

BMI, body mass index; CAD, coronary artery disease; CVA, cerebrovascular accident; GN, glomerulonephritis; HD, haemodialysis; PD, peritoneal dialysis; PVD, peripheral vascular disease.

*Characteristics at time of first allograft failure.

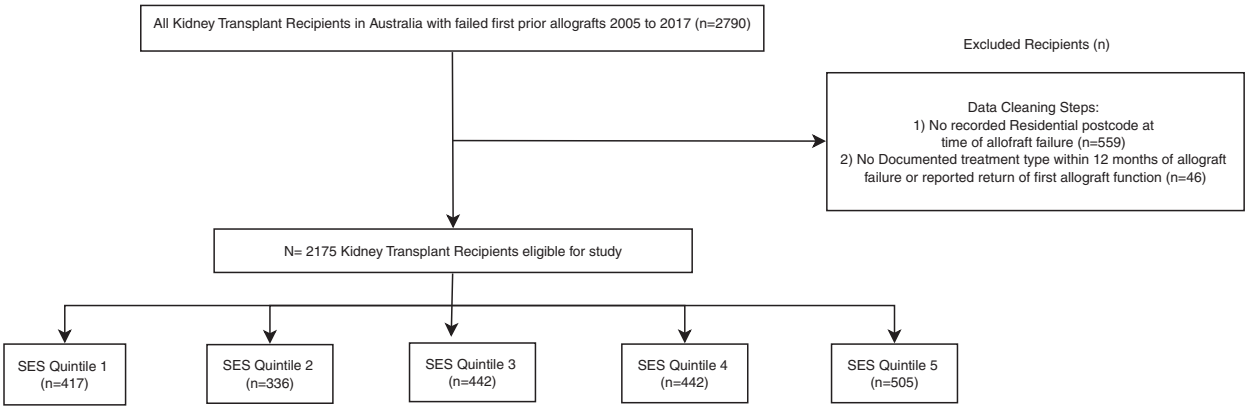


**Figure 1** Flow diagram of the study cohort of patients with prior failed first kidney allografts

transplantation was considered a competing event), patients in the lowest IRSAD quintiles were more likely to die on dialysis compared to those in the highest quintile (Table 2 and Fig. 2). In the model with IRSAD quintiles as a continuous measure, the adjusted SHR (95%CI) was 0.93 (0.88, 0.99). The cumulative incidence curves of all-cause mortality on dialysis post-first allograft failure, stratified by IRSAD quintiles, adjusted for the competing risk of second kidney transplantation are shown in Fig. 3b. With the exclusion of variables that could be a consequence of SES (Model 2), patients in the IRSAD quintiles 1 and 2 were more likely to die on dialysis compared to those in the highest quintile, with estimates similar to those of the main model (Table 3).

### Sensitivity analysis: association between geographical residential locations and outcomes

There were no associations between residential locations and all outcomes. For the uptake of home dialysis treatment at 12 months, compared to patients residing in major cities ($n$ = 1568), the adjusted HR (95%CI) for those in regional ($n$ = 554) and remote ($n$ = 53) locations were 1.24 (0.92, 1.67) and 1.66 (0.57, 4.81), respectively. For repeat transplantation, the adjusted HR (95%CI) for those in regional and remote locations were 0.98 (0.83, 1.17) and 0.80 (0.43, 1.49), respectively, compared to patients in major cities. For death on dialysis, compared to patients residing in major cities, the adjusted HR (95%CI) for those in regional and remote locations were 1.02 (0.83, 1.26) and 0.99 (0.63, 1.57), respectively.

## Discussion

In this longitudinal observational cohort of patients with a failed first kidney allograft, there was no association between SES and early uptake of home dialysis treatment post-allograft failure. However, patients of lowest SES may have been less likely to receive a second kidney transplant, including a pre-emptive kidney transplant, and may have been more likely to die on dialysis post-allograft failure compared to those of highest SES, independent of age, race and duration of first allograft survival.

The association between SES and uptake of home dialysis treatment for patients with kidney failure remains inadequately defined. In an ANZDATA registry study of 23,281 non-Indigenous patients starting dialysis between 2000 and 2011, patients from the most advantaged SES were up to 20% more likely to commence in-centre HD compared to patients from the most disadvantaged SES, but this association was reversed for the uptake of PD. There was no overall association between SES and uptake of home HD [16]. However, other cohort studies have challenged these observations [21,22], indicating that SES may be one of the many factors contributing to the decision-making process in the selection of dialysis modality type. In our study, there was no association between SES and early uptake of home dialysis treatment post-allograft failure, which may suggest that the decision for (re)-initiation of dialysis post-allograft failure may be influenced by other factors, such as the prior experience on dialysis and the nature and time-frame of the first allograft failure. However, these details are not sufficiently captured by the registry. Nevertheless, the comparisons of study findings of cohorts from different countries are often challenging as there are likely to be intrinsic dissimilarities in the provision and delivery of country and site-specific healthcare or dialysis services, the presence or absence of universal health care, differences in the definitions of SES, differential cost structure between


Transplant International 2021; 34: 2329–2340

**Table 2.** Association between the Index of Relative Socio-economic Advantage and Disadvantage, uptake of home dialysis treatment at 12 months, likelihood of second kidney transplants and death on dialysis following first allograft failure.

| | Home dialysis at 12 months | Second transplant | Death on dialysis |
|---|---|---|---|
| IRSAD quintiles | | | |
| Quintile 1 | 1.02 (0.77, 1.35) | 0.70 (0.55, 0.89)* | 1.37 (1.04, 1.81)* |
| Quintile 2 | 1.03 (0.78, 1.38) | 0.69 (0.54, 0.88)* | 1.40 (1.04, 1.89)* |
| Quintile 3 | 0.99 (0.76, 1.27) | 0.72 (0.58, 0.90)* | 1.31 (0.99, 1.73) |
| Quintile 4 | 1.08 (0.83, 1.40) | 0.87 (0.70, 1.08) | 1.28 (0.98, 1.67) |
| Quintile 5 | 1.00 | 1.00 | 1.00 |
| Age at allograft failure | 0.99 (0.98, 0.99)* | 0.97 (0.96, 0.98)* | 1.06 (1.05, 1.07)* |
| Race | | | |
| Caucasian | 1.00 | 1.00 | 1.00 |
| Indigenous | 0.73 (0.42, 1.27) | 0.33 (0.18, 0.60)* | 1.99 (1.47, 2.71)* |
| Others | 1.04 (0.80, 1.35) | 0.78 (0.63, 0.97)* | 0.80 (0.64, 1.01) |
| Male gender | 0.97 (0.81, 1.16) | 1.12 (0.96, 1.31) | 0.82 (0.68, 1.00)* |
| Cause of kidney failure | | | |
| GN | 1.00 | 1.00 | 1.00 |
| Diabetes | 0.79 (0.48, 1.27) | 0.54 (0.28, 1.04) | 1.38 (1.02, 1.86)* |
| Cystic | 0.93 (0.64, 1.35) | 0.71 (0.49, 1.03) | 1.26 (0.93, 1.69) |
| Vascular | 0.86 (0.51, 1.47) | 0.58 (0.31, 1.11) | 1.27 (0.80, 1.99) |
| Reflux | 1.00 (0.78, 1.28) | 0.93 (0.76, 1.15) | 1.40 (1.03, 1.90)* |
| Others | 0.93 (0.72, 1.19) | 0.82 (0.67, 1.00)* | 1.35 (1.04, 1.76)* |
| Diabetes | 0.95 (0.72, 1.24) | 0.49 (0.37, 0.66)* | 1.36 (1.08, 1.72)* |
| CAD | 0.75 (0.55, 1.00) | 0.79 (0.59, 1.05) | 1.35 (1.10, 1.67)* |
| CVA | 1.01 (0.67, 1.53) | 0.64 (0.41, 1.00) | 1.39 (1.05, 1.85)* |
| PVD | 0.58 (0.37, 0.91)* | 0.52 (0.31, 0.86)* | 2.10 (1.65, 2.68)* |
| Era | | | |
| 2005–2008 | 1.00 | 1.00 | 1.00 |
| 2009–2012 | 0.86 (0.69, 1.09) | 0.90 (0.75, 1.08) | 0.94 (0.76, 1.14) |
| 2013–2017 | 0.97 (0.77, 1.22) | 1.25 (1.03, 1.52)* | 0.80 (0.64, 1.01) |
| Duration first allograft (per year) | 1.00 (0.99, 1.01) | 1.03 (1.02, 1.04)* | 0.99 (0.98, 1.00) |

Data presented as adjusted subdistributional hazard ratios and 95% confidence intervals from competing-risk models (*denotes $P < 0.05$). All models were adjusted for age, race, sex, cause of kidney failure, body mass index, smoking history, duration of first allograft, era and comorbid vascular conditions (coronary artery disease, peripheral vascular disease, cerebrovascular disease) at time of allograft failure.

BMI, body mass index; CAD, coronary artery disease; CVA, cerebrovascular accident; ESKD, end-stage kidney disease; GN, glomerulonephritis; IRSAD, Index of Relative Socio-economic Advantage and Disadvantage; PVD, peripheral vascular disease.

private versus public funding models, and systematic differences and individual preferences in the management of patients with kidney failure, all of which are likely to influence the decision for specific uptake of dialysis modality post-allograft failure.

The important roles of SES in determining kidney transplant access has been shown in several population cohort studies. In an analysis of Organ Procurement and Transplantation Network/United Network for Organ Sharing (OPTN/UNOS) data of 203,267 kidney transplant candidates and 114,547 kidney transplant recipients from the United States (1999–2009), patients of higher SES had increased access to kidney transplantation, particularly live-donor kidney transplantation and were also less likely to be delisted or die on the waiting list compared to patients of lower SES. However, it is important to note that these findings may not be applicable to countries with universal healthcare systems. In a study of 21,190 adult non-Indigenous patients who commenced chronic kidney replacement therapy in Australia between 2000 and 2010, which does have a universal healthcare system, patients from the most advantaged SES quartile were 30% more likely to receive a live-donor kidney transplant compared to the most disadvantaged quartile. However, there was no association between SES and access to deceased donor kidney transplantation [23]. A study of 768 children in Australia showed that geographical remoteness but not

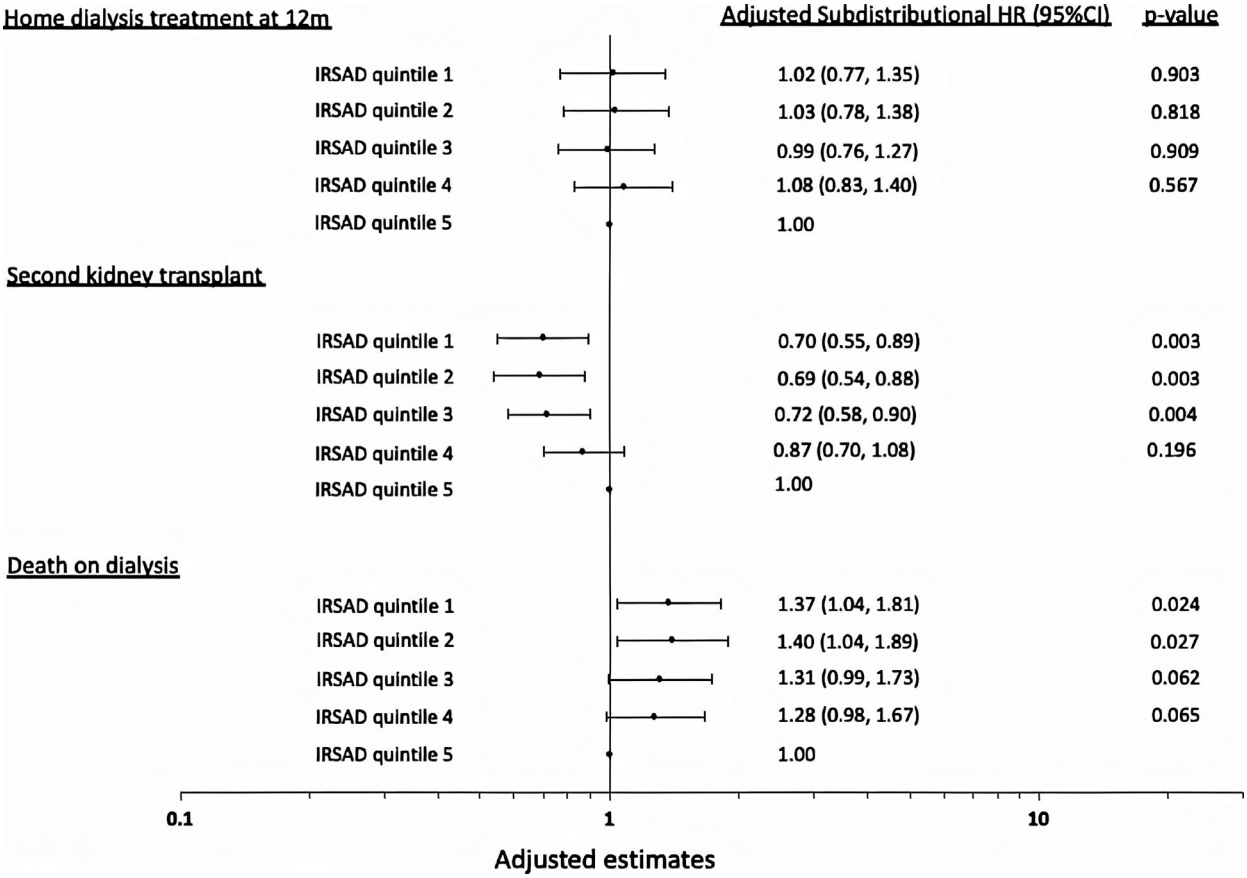


**Figure 2** Forest plots showing the adjusted subdistributional hazard ratio (SHR) with 95% confidence intervals (95%CI) of the associations between socio-economic status (SES; expressed as quintiles or as three categories of the Index of Relative Socio-economic Advantage and Disadvantage [IRSAD]), and uptake of home dialysis within 12 months post-first allograft failure, second kidney transplant and all-cause mortality on dialysis

**Table 3.** Association between the Index of Relative Socio-economic Advantage and Disadvantage, uptake of home dialysis treatment at 12 months, likelihood of second kidney transplants and death on dialysis following first allograft failure, excluding variables that may be a consequence of socio-economic status.

| | Home dialysis at 12 months | Second transplant | Death on dialysis |
|---|---|---|---|
| IRSAD quintiles | | | |
| Quintile 1 | 0.76 (0.49, 1.16) | 0.70 (0.56, 0.88)* | 1.32 (1.01, 1.72)* |
| Quintile 2 | 1.03 (0.69, 1.56) | 0.69 (0.54, 0.87)* | 1.33 (1.00, 1.78)* |
| Quintile 3 | 0.97 (0.66, 1.42) | 0.73 (0.59, 0.91)* | 1.20 (0.91, 1.58) |
| Quintile 4 | 0.92 (0.63, 1.35) | 0.88 (0.72, 1.09) | 1.16 (0.90, 1.50) |
| Quintile 5 | 1.00 | 1.00 | 1.00 |
| IRSAD quintiles (continuous) | 1.04 (0.95, 1.14) | 1.10 (1.05, 1.16)* | 0.93 (0.88, 0.99)* |

Data presented as adjusted subdistributional hazard ratios and 95% confidence intervals from competing-risk models (*denotes $P < 0.05$). All models were adjusted for age, race, sex, cause of kidney failure, duration of first allograft and era at time of allograft failure. The variables excluded from these models included prevalent coronary artery disease, prevalent peripheral vascular disease, prevalent cerebrovascular disease, smoking history and body mass index at time of allograft loss.

IRSAD, Index of Relative Socio-economic Advantage and Disadvantage.

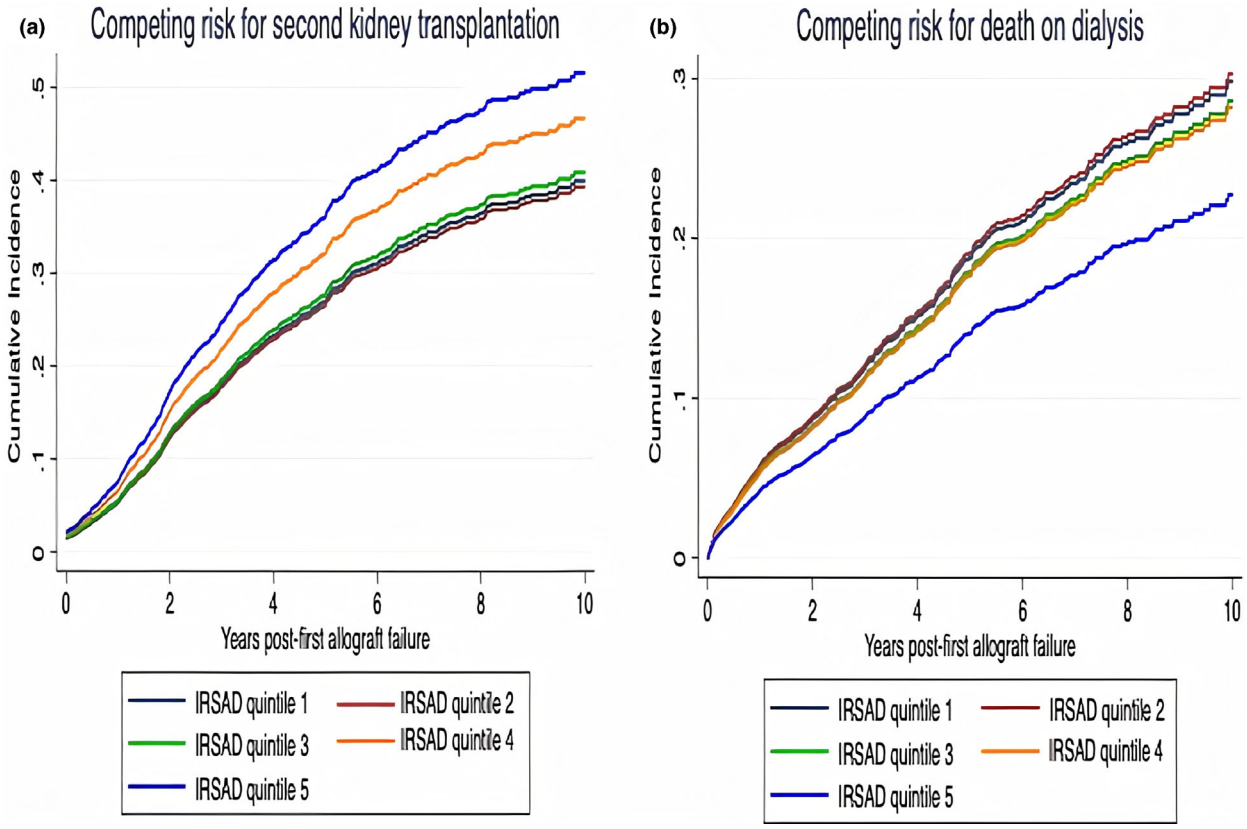


**Figure 3** Adjusted cumulative incidence of second kidney transplantation (a) and all-cause mortality on dialysis (b), stratified by socio-economic status of the Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) in quintiles; adjusted for the competing risk of mortality and second kidney transplantation, respectively

SES was associated with a 35% reduced probability of pre-emptive kidney transplantation [24]. Other studies have shown similar associations, with studies suggesting SES may in part explain the disparity of transplantation access according to race and presence of comorbidities [25,26]. In our study, lower SES was associated with reduced likelihood of repeat transplantation, including pre-emptive transplantation, potentially reflecting differences in factors affecting transplant access between children and adults. For example, children in remote areas may face more difficulties compared to adults in attending multiple clinics at transplant centres necessary for pre-transplant workups, whereas for adults, SES may play a significant role in access to live-donor kidney transplants through more robust family and social networks. Nevertheless, there may be discernible intrinsic differences in the understanding, barriers (including medical and surgical suitability) and commitments of patients being considered for first compared to repeat transplantation, and the greater risk of allo-sensitization following allograft failure may substantially reduce re-transplantation potential. In addition, the finding that Indigenous patients were less likely than Caucasian patients to access kidney transplantation is well described [27]; and the increased likelihood of repeat kidney transplantation in the more recent era is likely to reflect the increased organ donation rate in Australia over the last decade [28].

The association between SES and mortality in incident kidney failure patients has been consistently shown, with similar relationships observed for patients maintained on different dialysis modality and across countries with dissimilar healthcare systems [29–33]. In a study from Australia, incident dialysis patients from the most disadvantaged SES quartile were 10% more likely to die on dialysis compared to patients from the most advantaged SES quartile, with the magnitude of the disparity greatest for younger patients [13]. In a recent meta-analysis of 14 cohort studies comprising 798,303 HD and 20,167 PD patients, lower SES was associated with an increased risk of mortality on dialysis, although the magnitude of the effect varied with the nature of the SES indicator [14]. In contrast, the association between SES and mortality following (re)-

initiation of dialysis post-allograft failure remains uncertain. In a systematic review of 40 population cohort studies comprising of almost 250,000 patients who had commenced dialysis post-allograft failure, the authors were unable to identify any patient, social or environmental-related factors that influenced prognosis on dialysis post-allograft failure, but SES was not assessed in the large majority of these studies and there was substantial heterogeneity and risk of bias in this meta-analysis [34]. These findings suggest that factors relating to mortality risk may be dissimilar between incident dialysis patients with and without prior allograft failure but may also highlight the lack of substantive evidence to dispel the conflicting associations. In our study, there was an inverse relationship between SES and risk of mortality on dialysis, such that patients of lower SES were 40% more likely to die on dialysis compared to those of the highest SES, accounting for the competing event of re-transplantation. In addition, the findings that increasing age, Indigenous patients and the presence of diabetes and other vascular comorbidities at the time of allograft loss were associated with an increased risk of mortality on dialysis were not unexpected as these characteristics have been consistently shown to be associated with survival on dialysis and after kidney transplantation [35,36].

The associations between geographical residential locations and uptake of specific dialysis modalities, repeat transplantation and death on dialysis post-allograft failure remain poorly defined [34], and there are likely discernible intrinsic differences in the barriers, patient and treatment-related factors (e.g. greater risk of allo-sensitization following allograft failure, differential comorbidities between patients with and without prior allograft failures, prior experience with dialysis modality pre-allograft failure) prior to and following allograft failures. Consequently, the study findings reporting on the association between geographical locations and these outcomes in incident dialysis patients cannot be readily extrapolated to patients with prior allograft failure. In this study, there were no associations between geographical residential locations and any outcomes. Given that less than 3% of the study cohort resided in remote residential areas, there is likely considerable uncertainty in the estimates to provide an accurate assessment of the true difference between geographical locations and clinical outcomes.

Our study has several notable limitations. Selection bias remained likely because of probable systematic differences in the management of kidney failure in patients of differing SES between treatment sites and clinicians. Even though there were multiple confounding factors adjusted for in the analyses, there may have been other unmeasured and residual confounders, such as the severity of comorbid conditions, adherence to medical treatment, accessibility to healthcare resources and differences in transplant suitability and access, which were not collected by the ANZDATA registry. Our study used the SEIFA index developed by the Australian Bureau of statistics to classify postcode data using multiple variables to determine IRSAD quintiles and geographical residential locations. An important limitation to our study was that individual SES status varied across a particular postcode, although multiple previous studies have used a similar method for determining SES [16,23]. In addition, prior studies have consistently shown an independent association between postcode-derived SES and mortality (in the general population and in patients with kidney failure) [13,37,38], dialysis-related complications [39,40] and access to kidney transplantation [23,41], emphasizing the prognostic significance of postcode-derived SES in Australia. In addition, the presence of missing residential postcode data may have influenced the accuracy of the estimates of the association between postcode-derived SES and clinical outcomes.

Our study findings showed that higher SES was associated with increased likelihood of repeat transplantation and a lower risk of all-cause mortality on dialysis following first kidney allograft failure, but there was no association with the early uptake of home dialysis treatment. These findings will need to be examined in larger cohorts and across different countries with dissimilar healthcare systems. In particular, further in-depth characterization of the social and economic vulnerabilities contributing to the inequalities of treatment access and health outcomes, for example with individual level socio-economic data, is warranted. Despite not finding an association between SES and early uptake of home dialysis, our secondary analysis suggested a possible signal for SES being associated with important outcomes such as mortality and pre-emptive transplantation. Further research into this area may help to inform strategies and interventions aimed at resolving these disparities.

## Authorship

WL and YW participated in the design of the study. WL participated in the data analysis; all authors participated in the interpretation of the data and writing of the paper.



Transplant International 2021; 34: 2329–2340

## Funding

None.

## Conflict of interest

None declared.

## Acknowledgements

The authors would like to gratefully acknowledge the substantial contributions of the entire Australian and New Zealand nephrology community (physicians, surgeons, database managers, nurses, renal operators and patients) that provide information to, and maintain, the ANZDATA database. The data reported here have been supplied by ANZDATA registry. The interpretation and reporting of these data are the responsibility of the authors and in no way should be seen as official policy or interpretation of ANZDATA. Wai H Lim is supported by a Clinical Research Fellowship from the Raine Foundation, University of Western Australia and Health Department of Western Australia. David Johnson is supported by a National Health and Medical Research Council Practitioner Fellowship. Germaine Wong is supported by a National Health and Medical Research Council Career Development Fellowship. Andrea Viecelli is supported by a Jacquot Research Establishment Fellowship. Esther Ooi is supported by a Heart Foundation Future Leader Fellowship (Award ID: 102538).

## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

**Figure S1**. The distribution of the raw Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) values of the study cohort.

## REFERENCES

1. Johns TS, Estrella MM, Crews DC, *et al.* Neighborhood socioeconomic status, race, and mortality in young adult dialysis patients. *J Am Soc Nephrol* 2014; **25**: 2649.
2. Kimmel PL, Fwu CW, Eggers PW. Segregation, income disparities, and survival in hemodialysis patients. *J Am Soc Nephrol* 2013; **24**: 293.
3. Goldfarb-Rumyantzev AS, Koford JK, Baird BC, *et al.* Role of Socioeconomic Status in Kidney Transplant Outcome. *Clin J Am Soc Nephrol* 2006; **1**: 313.
4. Chapman JR. Compliance: the patient, the doctor, and the medication? *Transplantation* 2004; **77**: 782.
5. Petersen E, Baird BC, Barenbaum LL, *et al.* The impact of employment status on recipient and renal allograft survival. *Clin Transplant* 2008; **22**: 428.
6. Coemans M, Susal C, Dohler B, *et al.* Analyses of the short- and long-term graft survival after kidney transplantation in Europe between 1986 and 2015. *Kidney Int* 2018; **94**: 964.
7. Ojo A, Wolfe RA, Agodoa LY, *et al.* Prognosis after primary renal transplant failure and the beneficial effects of repeat transplantation: multivariate analyses from the United States Renal Data System. *Transplantation* 1998; **66**: 1651.
8. Chan MR, Oza-Gajera B, Chapla K, *et al.* Initial vascular access type in patients with a failed renal transplant. *Clin J Am Soc Nephrol* 2014; **9**: 1225.
9. Johnston O, Zalunardo N, Rose C, Gill JS. Prevention of sepsis during the transition to dialysis may improve the survival of transplant failure patients. *J Am Soc Nephrol* 2007; **18**: 1331.
10. Perl J, Hasan O, Bargman JM, *et al.* Impact of dialysis modality on survival after kidney transplant failure. *Clin J Am Soc Nephrol* 2011; **6**: 582.
11. Girerd S, Girerd N, Duarte K, *et al.* Preemptive second kidney transplantation is associated with better graft survival compared with non-preemptive second transplantation: a multicenter French 2000–2014 cohort study. *Transplant Int* 2018; **31**: 408.
12. Jay CL, Dean PG, Helmick RA, Stegall MD. Reassessing preemptive kidney transplantation in the United States: Are we making progress? *Transplantation* 2016; **100**: 1120.
13. Krishnasamy R, Gray NA. Low socioeconomic status adversely effects dialysis survival in Australia. *Nephrology* 2018; **23**: 453.
14. Tao S, Zeng X, Liu J, Fu P. Socioeconomic status and mortality among dialysis patients: a systematic review and meta-analysis. *Int Urol Nephrol* 2019; **51**: 509.
15. Axelrod DA, Dzebisashvili N, Schnitzler MA, *et al.* The interplay of socioeconomic status, distance to center, and interdonor service area travel on kidney transplant access and outcomes. *Clin J Am Soc Nephrol* 2010; **5**: 2276.
16. Grace BS, Clayton PA, Gray NA, McDonald SP. Socioeconomic differences in the uptake of home dialysis. *Clin J Am Soc Nephrol* 2014; **9**: 929.
17. Taylor DM, Fraser SDS, Bradley JA, *et al.* A systematic review of the prevalence and associations of limited health literacy in CKD. *Clin J Am Soc Nephrol* 2017; **12**: 1070.
18. Australia Bureau of Statistics. Technical Paper Socio-Economic Indexes for areas (SEIFA). 2016.
19. Australia Bureau of Statistics. Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia, 2016.
20. Fine JP, Gray RJ. A proportional hazards model for the subdistribution of a competing risk. *J Am Stat Assoc* 1999; **94**: 496.
21. Shen JI, Chen L, Vangala S, *et al.* Socioeconomic factors and racial and ethnic differences in the initiation of home dialysis. *Kidney Med* 2020; **2**: 105.
22. Prakash S, Perzynski AT, Austin PC, *et al.* Neighborhood socioeconomic status and barriers to peritoneal dialysis: a mixed methods study. *Clin J Am Soc Nephrol* 2013; **8**: 1741.

23. Grace BS, Clayton PA, Cass A, McDonald SP. Transplantation rates for living- but not deceased-donor kidneys vary with socioeconomic status in Australia. *Kidney Int* 2013; **83**: 138.
24. Francis A, Didsbury M, Lim WH, *et al*. The impact of socioeconomic status and geographic remoteness on access to pre-emptive kidney transplantation and transplant outcomes among children. *Pediatric nephrology (Berlin, Germany)* 2016; **31**: 1011.
25. Gaylin DS, Held PJ, Port FK, *et al*. The impact of comorbid and sociodemographic factors on access to renal transplantation. *JAMA* 1993; **269**: 603.
26. Patzer RE, Perryman JP, Schrager JD, *et al*. The role of race and poverty on steps to kidney transplantation in the Southeastern United States. *Am J Transplant* 2012; **12**: 358.
27. Khanal N, Lawton PD, Cass A, McDonald SP. Disparity of access to kidney transplantation by Indigenous and non-Indigenous Australians. *Med J Aust* 2018; **209**: 261.
28. Australia and New Zealand Organ Donation Registry. 2020 Annual Report, Section 5: Deceased Donor Kidney Donation. Adelaide, Australia, 2020.
29. Moist LM, Bragg-Gresham JL, Pisoni RL, *et al*. Travel time to dialysis as a predictor of health-related quality of life, adherence, and mortality: the Dialysis Outcomes and Practice Patterns Study (DOPPS). *Am J Kidney Dis* 2008; **51**: 641.
30. Lim WH, Boudville N, McDonald SP, Gorham G, Johnson DW, Jose M. Remote indigenous peritoneal dialysis patients have higher risk of peritonitis, technique failure, all-cause and peritonitis-related mortality. *Nephrol Dial Transplant* 2011; **26**: 3366.
31. Rucker D, Hemmelgarn BR, Lin M, *et al*. Quality of care and mortality are worse in chronic kidney disease patients living in remote areas. *Kidney Int* 2011; **79**: 210.
32. Xu R, Han QF, Zhu TY, *et al*. Impact of individual and environmental socioeconomic status on peritoneal dialysis outcomes: a retrospective multicenter cohort study. *PLoS One* 2012; **7**: e50766.
33. Ward FL, O'Kelly P, Donohue F, *et al*. The influence of socioeconomic status on patient survival on chronic dialysis. *Hemodial Int* 2015; **19**: 601.
34. Kabani R, Quinn RR, Palmer S, *et al*. Risk of death following kidney allograft failure: a systematic review and meta-analysis of cohort studies. *Nephrol Dialysis Transplant* 2014; **29**: 1778.
35. Lim WH, Wong G, Pilmore HL, McDonald SP, Chadban SJ. Long-term outcomes of kidney transplantation in people with type 2 diabetes: a population cohort study. *The Lancet Diab Endocrinol* 2017; **5**: 26.
36. Cherukuri A, Bhandari S. Analysis of risk factors for mortality of incident patients commencing dialysis in East Yorkshire, UK. *QJM* 2010; **103**: 41.
37. Turrell G, Mathers C. Socioeconomic inequalities in all-cause and specific-cause mortality in Australia: 1985–1987 and 1995–1997. *Int J Epidemiol* 2001; **30**: 231.
38. Draper G, Turrell G, Oldenburg B. *Health Inequalities in Australia: Mortality*. Canberra: Queensland University of Technology and the Australian Institute of Health and Welfare, 2004.
39. Tang W, Grace B, McDonald SP, *et al*. Socio-economic status and peritonitis in Australian non-indigenous peritoneal dialysis patients. *Perit Dial Int* 2015; **35**: 450.
40. Chan S, Cho Y, Koh YH, *et al*. Association of socio-economic position with technique failure and mortality in Australian non-indigenous peritoneal dialysis patients. *Perit Dial Int* 2017; **37**: 397.
41. Sypek MP, Clayton PA, Lim W, *et al*. Access to waitlisting for deceased donor kidney transplantation in Australia. *Nephrology* 2019; **24**: 758.