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Age Disparities in Access to First and Repeat Kidney Transplantation

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Background. Evidence suggests that older patients are less frequently placed on the waiting list for kidney transplantation (KT) than their younger counterparts. The trends and magnitude of this age disparity in access to first KT and repeat KT (re-KT) remain unclear. **Methods.** Using the US Renal Data System, we identified 2 496 743 adult transplant-naive dialysis patients and 110 338 adult recipients with graft failure between 1995 and 2018. We characterized the secular trends of age disparities and used Cox proportional hazard models to compare the chances of listing and receiving first KT versus re-KT by age (18–64 y versus ≥65 y). **Results.** Older transplant-naive dialysis patients were less likely to be listed (adjusted hazard ratio [aHR] = 0.18; 95% confidence interval [CI], 0.17-0.18) and receive first KT (aHR = 0.88; 95% CI, 0.87-0.89) compared with their younger counterparts. Additionally, older patients with graft failure had a lower chance of being listed (aHR = 0.40; 95% CI, 0.38-0.41) and receiving re-KT (aHR = 0.76; 95% CI, 0.72-0.81). The magnitude of the age disparity in being listed for first KT was greater than that for re-KT ($P_{interaction} < 0.001$), and there were no differences in the age disparities in receiving first KT or re-KT ($P_{interaction} = 0.13$). Between 1995 and 2018, the age disparity in listing for first KT reduced significantly ($P < 0.001$), but the age disparities in re-KT remained the same ($P = 0.16$). **Conclusions.** Age disparities exist in access to both first KT and re-KT; however, some of this disparity is attenuated among older adults with graft failure. As the proportion of older patients with graft failure rises, a better understanding of factors that preclude their candidacy and identification of appropriate older patients are needed.

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INTRODUCTION

Although the number of older (aged ≥65 y) adults receiving a kidney transplant (KT) has increased 3-fold in the past decade,[1-3] older patients are less frequently placed on the waiting list. This disparity is likely because of shorter life expectancy, higher rejection and medical complication rates,[4] and age-related comorbidities, including dementia[5] and frailty, which are associated with hospitalizations, higher immunosuppression intolerance, and post-KT mortality risk.[6-10] KT may be viewed as a more risky option in older candidates, despite the clear mortality benefit for those aged ≥65 y, which has been well documented since the 1990s.[1,2,11,12] However, the magnitude of and trends in age disparities in access to first KT are unclear.

After receiving KT, recipients live longer with a functioning graft, resulting in the survival of younger KT recipients into older adulthood. Therefore, graft failure is likely to increase among older KT recipients and more older patients will seek a repeat KT (re-KT). However, a second transplant may also have its own inherent risks for older patients. For example, lower-quality organs are preferentially given to older patients with a history of graft failure.[13,14] This could increase the risk of inferior outcomes, such as severe infections or rejection.[15] Therefore, transplant providers may have unique concerns regarding re-KTs of older patients, which may result in age disparities in access to re-KT.

Although prior work has reported disparities in access to KT by race and social determinants of health (income, insurance type, comorbidities, religiosity, and social support), less is known about age disparities in access to first KT and re-KT.[16,17] In clinical settings, older age has not been accepted as a contraindication for transplantation. The extent of these age disparities in access to first KT and re-KT and whether the magnitude of these disparities differs remain unclear.

Therefore, we sought to (1) quantify age disparities in listing and receiving first and re-KT, (2) test whether the age disparities differed for first and re-KT, and (3) characterize the trends in age disparities for first and re-KT.

MATERIALS AND METHODS

Data Source

We identified our population for this retrospective cohort study using the registry data from the US Renal Data System (USRDS).[18] The USRDS database includes information on donor, recipient, and transplant characteristics for all patients with kidney failure. Data on geographic distribution and socioeconomic status were ascertained by linking the patient's ZIP Code available on USRDS with the 2014 American Community Survey.[19,20] All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Study Population

In our study, the transplant-naive dialysis cohort consisted of adult patients with kidney failure between 1995 and 2018 who initiated dialysis within 90 d of diagnosis and had not received a previous KT. This cohort was used to evaluate the chance of being on the waiting list and receiving the first KT. The second cohort was the graft failure cohort, which consisted of all adult recipients with failed KTs between 1995 and 2018. Multiorgan transplant recipients and those failing first KT who neither resumed dialysis nor received re-KT within 90 d and those whose age was missing were excluded.

Exposure and Outcomes

For the transplant-naive dialysis cohort, patient age was ascertained at the date of the first dialysis service (cohort entry); for recipients in the graft failure cohort, patient age was ascertained at the time of graft failure (cohort entry). Age was treated as a time-fixed exposure and categorized as younger (18–64 y) and older (≥65 y). This older age cutoff arises from the fields of geriatrics/gerontology, is commonly used for clinical decision-making,[21-23] and is the most commonly used age cutoff for defining older adults in the field of transplantation.[1,24-26]

The outcomes of interest were listing for and receiving first KT in the transplant-naive dialysis cohort. In this cohort, all patients were followed from the date of first dialysis services to the date of being listed for first KT, censoring for death, receiving KT without being listed, or end of study (December 31, 2018). After being on the waiting list, they were followed from the date of listing until receiving first KT, censoring for death, waitlist removal, or end of study to estimate the chance of receiving first KT.

In the graft failure cohort, the outcomes were listing for re-KT and receiving re-KT. Similarly, for listing for re-KT, all patients were followed up from the date of graft failure till the date of relisting, censoring for death, receiving re-KT without being listed, and end of study. For the outcome of receiving re-KT, patients who had been on the waiting list were followed up until receiving re-KT, censoring for death, waitlist removal, or end of study.

Age Disparities in Access to First KT and Re-KT

To investigate the age disparities in access to first KT in the transplant-naive dialysis cohort, we used Cox proportional hazard models to estimate the chances of listing and receiving first KT by age (18–64 y versus ≥65 y). The proportional hazard assumption was verified by visually inspecting the log–log plots. The hazard ratios (HRs) were adjusted for patient race, sex, hypertension, history of cancer, peripheral vascular disease, cardiovascular disease, heart failure, hepatitis B virus status, hepatitis C virus status, cytomegalovirus status, history of diabetes, alcohol dependence, tobacco use, functional impairment (binary variable defined as needing assistance with daily activities or unable to ambulate according to USRDS classification), era (1995–2000, 2001–2010, and 2011–2018), neighborhood characteristics, which included percentage of neighborhood population below poverty level, and percentage of population in an urban county. Blood type and sensitization were additionally adjusted for when modeling the chance of receiving first KT. To further explore at what age patients were no longer being listed or receiving first KT, we categorized older patients by age into subgroups (18–64 y versus 65–69 y, 70–74 y, ≥75 y) and used Cox

proportional hazard models adjusting for the same covariates mentioned above.

We further tested whether there were age disparities in receiving first KT among all patients with kidney failure, regardless of whether they were listed. To do this, we included all transplant-naive dialysis patients in the analysis, in contrast to the previous analysis in which patients were excluded who did not qualify to be on the waiting list or died before being listed. Therefore, in this sensitivity analysis, the time origin was the date of first dialysis service for the transplant-naive dialysis cohort and the date of graft failure for the graft failure cohort, censoring only for death and end of study.

We also separately investigated the age disparities in receiving live donor KT (LDKT) and deceased donor KT (DDKT). For a chance of receiving LDKT, the subpopulation consisted only of transplant-naive dialysis patients who received a first-time LDKT and those who were listed but never received KT. For DDKT, only patients receiving a first-time DDKT and those who were listed but never received KT were included. Patients were all followed up from the date of listing. Similar regressions using Cox proportional hazard models were performed.

We used a similar statistical approach for age disparities in access to re-KT in the graft failure cohort.

Difference in Age Disparities Between First and Re-KT

We tested whether the magnitude of age disparities differed between first KT and re-KT by appending the transplant-naive dialysis cohort with the graft failure cohort, and we sequentially introduced the interaction terms between age (18–64 y versus ≥65 y) and the sequence of KT (first KT versus re-KT) as a binary variable into the Cox proportional hazards models. A statistically significant ($P < 0.05$) coefficient of the interaction terms quantified the magnitude of age disparities that differed by whether the patient was receiving re-KT or first KT.

Trends in Age Disparities

We quantified the trends in age disparities by adding an interaction term between patient age and era (1995–2000, 2001–2010, and 2011–2018) in the model for the 4 outcomes (listing for first KT, receipt of first, listing for re-KT, and receipt of re-KT).

Sensitivity Analysis

We conducted 2 sensitivity analyses. We first treated age as a continuous variable and used cubic splines to identify the trend. We then treated death as a competing risk event in the graft failure cohort to study the differential risk of death before being listed for re-KT and death on the waiting list that may have contributed to the age disparities.

RESULTS

Characteristics of the Transplant-naive Dialysis Cohort and Graft Failure Cohort

The transplant-naive dialysis cohort consisted of 2 496 743 patients; 49.9% were older patients, were more likely to be female, were of White race, and had comorbidities including peripheral vascular disease, cardiovascular disease, heart failure, functional impairment, and a history of cancer but were less likely to have diabetes and tobacco use. In the graft failure cohort of 110 338 patients, 15.8% were older patients, were less likely to be female, were of White race, had comorbidities including diabetes, peripheral vascular disease, heart failure, and a history of cancer (Table 1). Among the 289 transplant centers that performed re-KT, 11 centers that transplanted patients with graft failure were older than their oldest first KT recipient. In the transplant-naive dialysis cohort, the median age at kidney failure between 2011 and 2018 (age 54 y) was much lower compared with the previous 2 eras of 1995–2000 (age 65 y and 2001–2010 (age 64 y). There was an increasing prevalence of diabetes and functional impairment but decreased prevalence of peripheral vascular disease and heart failure over time (**Table S1A, SDC,** http://links.lww.com/TP/C838). On the contrary, in the graft failure cohort, we observed a higher median age at graft failure between 2011 and 2018 (age 54 y) compared with the previous eras (**Table S1B, SDC,** http://links.lww.com/TP/C838).

Four years after kidney failure in the transplant-naive dialysis cohort, 3.9% of the older patients were on the waiting list for first KT, 3.8% received first KT, and 60.4% died at the end of the fourth year (Figure 1A) compared with the 17.1%, 18.4%, and 34.4% for younger patients (Figure 1B). Similarly, among older patients with graft failure, 6.8% were on the waiting list for re-KT, 12.5% received re-KT, and 62.1% died 4 y after graft failure (Figure 2A) in contrast to younger patients among whom the corresponding estimates were 20.3%, 29.5%, and 28.2% (Figure 2B). In light of an increasing number of patients with graft failure, the proportion of older patients with graft failure increased from 5.3% in 1995 to 26.8% in 2018 (Figure 3).

Age Disparities in the Access to First and Re-KT

In the transplant-naive dialysis cohort, older patients had an 82% lower chance of listing for first KT (adjusted HR [aHR] = 0.18; 95% confidence interval [CI], 0.17-0.18) and 12% lower chance of receiving first KT after being on the waiting list (aHR = 0.88; 95% CI, 0.87-0.89) compared with younger patients (Table 2). Notably, the age disparity for all transplant-naive dialysis patients receiving first KT was much greater (aHR = 0.64; 95% CI, 0.63-0.65) than that observed among listed patients only (Table 2). When older age was categorized into subgroups, we found that, starting from age 75, patients were rarely listed for first KT (aHR = 0.03; 95% CI, 0.03-0.03), an age subgroup that, however, accounted for 25% of the total transplant-naive dialysis cohort. Specifically, only 0.84% of the patients aged ≥75 y were listed by the end of the study (Table 3). Additionally, older transplant-naive dialysis patients had a 49% lower chance of receiving LDKTs (aHR = 0.51; 95% CI, 0.50-0.53) and 5% lower chance of receiving DDKTs (aHR = 0.95; 95% CI, 0.94-0.97; Table 4).

In the graft failure cohort, older patients had a 60% lower chance of listing for re-KT (aHR = 0.40; 95% CI, 0.38-0.41) and a 24% lower chance of receiving re-KT after being on the waiting list (aHR = 0.76; 95% CI, 0.72-0.81) compared with younger patients (Table 2). Similarly, a greater age disparity for receiving re-KT (aHR = 0.55; 95% CI, 0.51-0.61) was observed among all graft-failed

TABLE 1.

Characteristics of the transplant-naive dialysis cohort and the graft failure cohort by age (1995–2018)

	Transplant-naive dialysis cohort		Graft failure cohort	
Characteristics	**18–64 y (n = 1 249 908)**	**≥65 y (n = 12 468 35)**	**18–64 y (n = 92 947)**	**≥65 y (n = 17 391)**
Era (%)				
1995–2000	19.7	19.5	20.6	8.1
2001–2010	41.7	42.2	43.7	35.6
2011–2018	38.6	38.3	35.7	56.3
Female (%)	42.1	46.0	41.3	38.5
Race (%)				
Non-Hispanic White	42.8	63.4	51.8	56.8
Non-Hispanic Black	34.5	20.8	30.9	26.1
Hispanic	16.7	10.8	12.3	11.0
Other	6.0	5.0	5.1	6.1
Body mass index (kg/m^2)	28.1 (23.7–34.1)	26.2 (22.7–30.8)	25.8 (22.3–30.4)	27.4 (24.3–31.1)
History of cancer (%)	4.0	10.1	2.2	4.8
Peripheral vascular disease (%)	10.3	16.9	4.8	7.5
Cardiovascular disease (%)	7.3	11.8	3.0	4.7
Heart failure (%)	24.9	40.9	11.7	18.9
Hypertension (%)	87.5	86.8	90.4	91.6
Diabetes (%)	48.3	44.3	25.8	31.5
Functional impairment (%)	8.1	14.6	1.7	1.8
Alcohol dependence (%)	2.5	0.8	0.7	0.7
Tobacco use (%)	8.7	3.9	5.8	4.5
Neighborhood percent living in urban areas, median (IQR)	94.2 (73.0–98.9)	93.5 (70.5–98.9)	93.5 (72.6–98.8)	94.4 (74.7–98.9)
Neighborhood percent below poverty level, median (IQR)	18.5 (11.6–26.9)	15.6 (9.5–23.2)	15.5 (9.4–23.3)	15.1 (9.2–22.8)

Continuous variables are shown in median (IQR), including body mass index, neighborhood percent living in urban areas, and neighborhood percent below poverty level.
IQR, interquartile range.

patients compared with patients on the waiting list already (Table 2). Furthermore, older graft failure patients had a 65% decreased chance of receiving LDKTs (aHR = 0.35; 95% CI, 0.31-0.40) and a 13% decreased chance of receiving DDKTs (aHR = 0.87; 95% CI, 0.82-0.93; Table 4).

Difference in Age Disparities Between First and Re-KT

The age disparity in being listed for first KT (aHR = 0.18, 95% CI, 0.17-0.18) was significantly different from the age disparity in being listed for re-KT (aHR = 0.38; 95% CI, 0.37-0.39; $P_{interaction} < 0.001$). There was no significant difference in age disparities of receiving first KT (aHR = 0.87; 95% CI, 0.85-0.88) or re-KT (aHR = 0.91; 95% CI, 0.86-0.96; $P_{interaction} = 0.13$).

Trends in Age Disparities

Between 1995 and 2018, there were significant improvements in the age disparities in listing for first KT (1995–2000: aHR = 0.09, 95% CI, 0.09-0.10; 2001–2010: aHR = 0.17, 95% CI, 0.16-0.17; 2011–2018: aHR = 0.24, 95% CI, 0.24-0.25; $P_{interaction} < 0.001$). The age disparity in receiving first KT improved between 1995 and 2010 but declined during 2011–2018 (1995–2000: aHR = 0.78, 95% CI, 0.75-0.81; 2001–2010: aHR = 0.92, 95% CI, 0.90-0.94; 2011–2018: aHR = 0.86, 95% CI, 0.85-0.88; $P_{interaction} < 0.001$). No significant trends in the age disparities were observed in the graft failure cohort (listing for re-KT: $P_{interaction} = 0.16$; receiving re-KT: $P_{interaction} = 0.07$; **Table S2, SDC,** http://links.lww.com/TP/C838).

Sensitivity Analysis

In the continuous form of age with restricted cubic splines, around 60 to 65 y of age we observed a greater reduction in slopes for HRs in listing for first KT, listing for re-KT, and receiving re-KT (**Figure S1, SDC,** http://links.lww.com/TP/C838). After applying the competing risk framework, the inference on age disparities in access to re-KT remained the same (listing for re-KT: aHR = 0.31; 95% CI, 0.29-0.32; receiving re-KT: aHR = 0.61; 95% CI, 0.56-0.65).

DISCUSSION

Among the 2 496 743 transplant-naive dialysis patients in this national registry study, we found that older patients were 82% less likely than younger patients to be listed for and 12% less likely to receive first KT between 1995 and 2018. However, there was a steady reduction in age disparities in being listed for first KT over time. The age disparities in access to KT were greater in the transplant-naive dialysis population receiving LDKTs than that observed in receiving DDKTs (LDKT versus DDKT: aHR = 0.51; 95% CI, 0.50-0.53 versus aHR = 0.95; 95% CI, 0.94-0.97). We identified a 60% lower chance of listing for re-KT and a 24% lower chance of receiving re-KT among older patients in the graft failure cohort. There was a statistically significant higher age disparity in being listed for first KT than re-KT ($P_{interaction} < 0.001$). There was, however, no difference in age disparities between receiving first and re-KT ($P_{interaction} = 0.13$). Thus, although older patients continue to have lower access to first KT and re-KT, some of the age disparity is attenuated for re-KT.

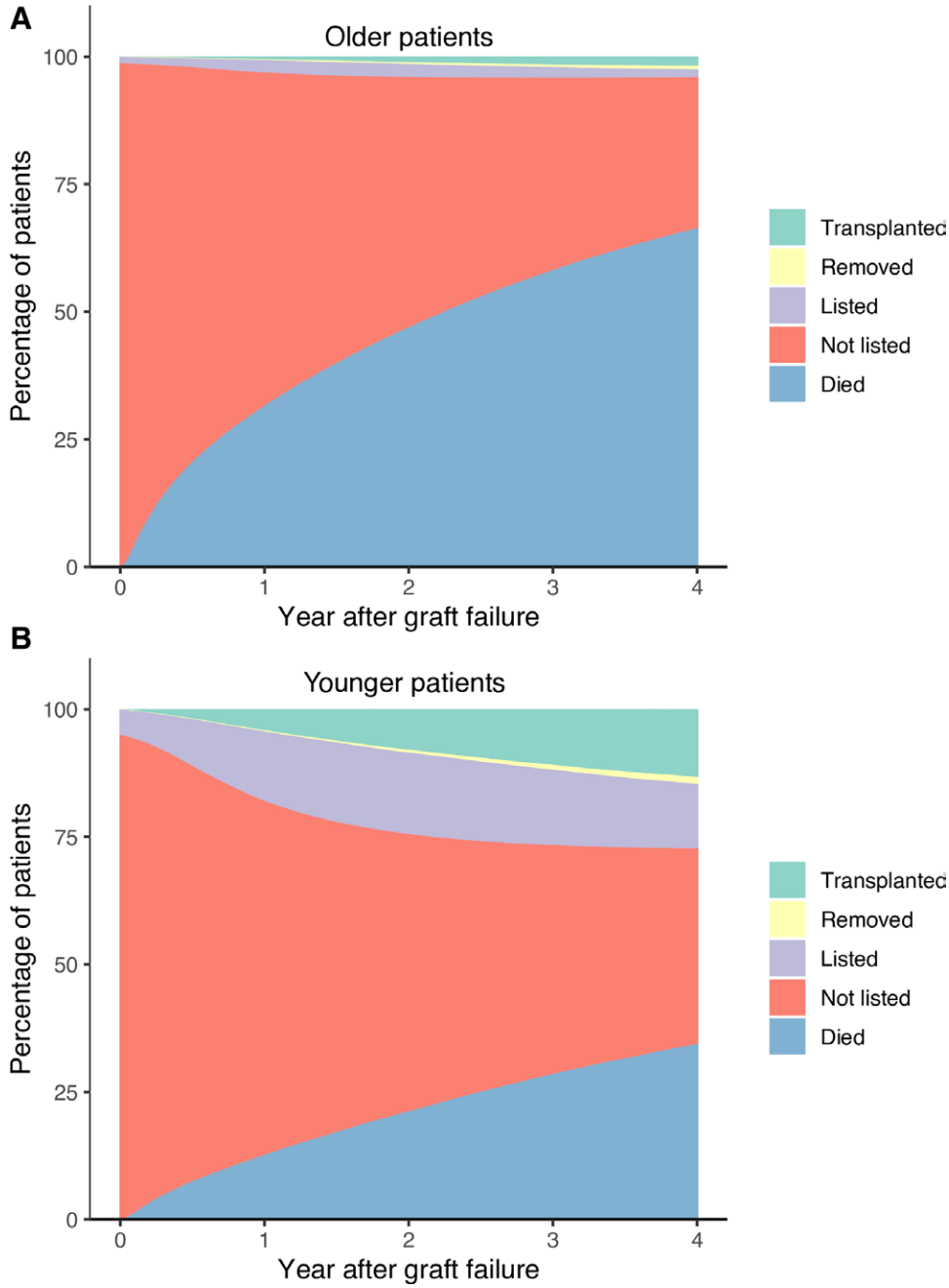

FIGURE 1. The 4-y sequelae of events following (A) kidney failure among older patients (aged ≥65 y) and (B) kidney failure among younger patients (aged between 18 and 64 y). This cohort included patients who were diagnosed with kidney failure between 1995 and 2018.

Our central finding that age disparities exist at first KT is consistent with several other studies.[12,27,28] Although older age alone is not a contraindication to KTs,[29] transplant centers may have variable selection criteria for older patients, mostly based on long-term prognosis and comorbidities, particularly cardiovascular diseases.[18,30] However, 1 study conducted on a large cohort of potentially excellent, older candidates with high predicted 3-y survival found that only 23% were listed and 8% were transplanted.[12] This may be because of age discrimination or an overestimation of a patient's frailty status and level of cognitive impairment, which are recognized as risk factors for poor outcomes and impact access to KT.[6] Some clinicians may perceive their patient as being frail and unable to undergo KT because of older age. However, perceived frailty is an inadequate proxy for measured frailty among patients undergoing hemodialysis.[31] Studies also showed that patients who experienced cognitive impairment have a 25% lower chance of listing and a longer time to listing.[32-34] However, it is also worth noting that patients and providers found it unethical to solely use cognitive or frailty status for listing decision.[35,36] Current guidelines allow individual transplant centers to weigh patient and clinical characteristics, which may amplify age-related bias and other sex and race-related biases.

Furthermore, there were also profound age disparities in re-KT. One study debating whether older patients should

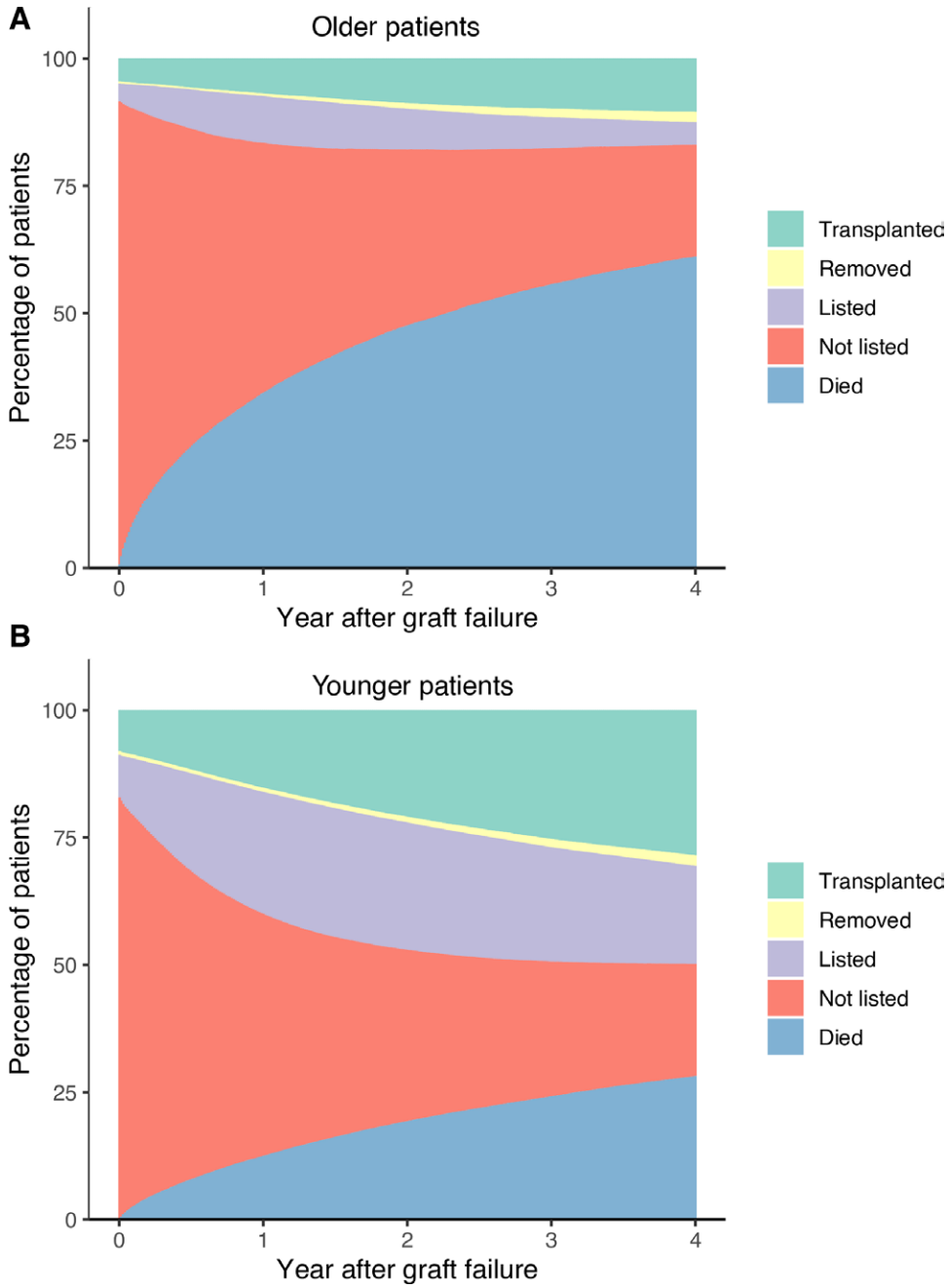

FIGURE 2. The 4-y sequelae of events following (A) graft failure among older patients (aged ≥65 y) and (B) graft failure among younger patients (aged between 18 and 64 y). The cohort included patients who had previously received kidney only transplantation and then experienced graft failure between 1995 and 2018.

be offered re-KT found that older re-KT recipients had outcomes that were comparable with age-matched first KT recipients;[37] hence, age alone should not be a contraindication for re-KT. Because of historical reasons, re-KT was perceived to be associated with a poor prognosis. However, the past 2 decades have shown increasing benefits of re-KT among older adults, including decreased mortality and post-KT outcomes that are comparable with those who receive their first KT at an older age.[24] Therefore, re-KT provides the best chance for long-term survival and quality of life in patients with graft failure compared with maintenance dialysis therapy.[38-40] However, this reflects an important issue. If re-KT is deemed beneficial to older patients in both survival and quality of life, then clinicians may focus their efforts not only on recognition of the disparities that limit access to KT but also standardization of recommendation and candidacy that identifies appropriate older patients for re-KT.

Recent registry analysis of all incident dialysis patients from 1995–2014 found that those with a history of graft failure were 1.5 times more likely to be listed for re-KT than transplant-naive dialysis patients for first KT.[41] Our study built off these findings and reported a reduction in age disparities when listing for re-KT than for first KT. The advantage in accessing re-KT may be explained by the fact that patients with graft failure, who have first-hand experience of the benefits of transplantation, have an established ongoing relationship with a transplant center

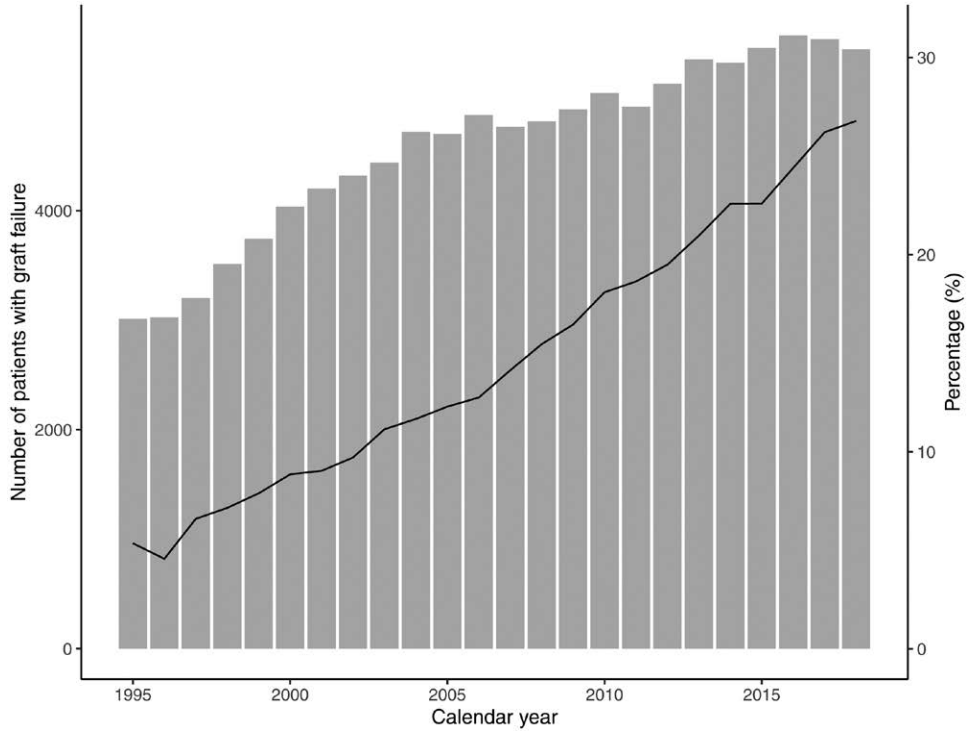

FIGURE 3. From 1995 to 2018, the absolute number of patients who had previously received kidney only transplantation and then experienced graft failure each calendar year (bars), and the proportion of patients ≥65 y (lines).

TABLE 2.

Chances of listing for first KT and receiving first KT among older patients compared with younger patients in the transplant-naive dialysis cohort (N = 2 496 743), and chances of listing for re-KT and receiving re-KT among older patients compared with younger patients in the graft failure cohort (N = 110 338) between 1995 and 2018

	Transplant-naive dialysis cohort		Graft failure cohort	
Age, y	**Unadjusted HR (95% CI)**	**aHR (95% CI)**	**Unadjusted HR (95% CI)**	**aHR (95% CI)**
Listing for KT[a]				
18–64	Reference	Reference	Reference	Reference
≥65	0.17 (0.17-0.18)	0.18 (0.17-0.18)	0.39 (0.37-0.40)	0.40 (0.38-0.41)
Receiving KT[b]				
18–64	Reference	Reference	Reference	Reference
≥65	0.88 (0.87-0.89)	0.88 (0.87-0.89)	0.90 (0.85-0.96)	0.76 (0.72-0.81)
Receiving KT[c]				
18–64	Reference	Reference	Reference	Reference
≥65	0.17 (0.16-0.17)	0.64 (0.63-0.65)	0.43 (0.41-0.46)	0.55 (0.51-0.61)

[a]Models adjusted for race, sex, cancer, infections (HBV, HCV, and CMV), peripheral vascular disease, cardiovascular disease, heart failure, hypertension, diabetes, functional impairment, alcohol dependence, tobacco use, percentage of neighborhood population below poverty level and percentage of population in an urban county, and era of kidney failure.
[b]Models built on listed patients only and adjusted for race, sex, blood type, panel-reactive antibodies, history of cancer, infections (HBV, HCV, and CMV), peripheral vascular disease, cardiovascular disease, heart failure, hypertension, diabetes, functional impairment, alcohol dependence, tobacco use, percentage of neighborhood population below poverty level, percentage of population in an urban county, and era at listing.
[c]Models built on all transplant-naive dialysis patients including those listed, unlisted, and died before being listed. Adjusted for race, sex, blood type, panel-reactive antibodies, history of cancer, infections (HBV, HCV, and CMV), peripheral vascular disease, cardiovascular disease, heart failure, hypertension, diabetes, functional impairment, alcohol dependence, tobacco use, percentage of neighborhood population below poverty level, percentage of population in an urban county, and era at listing.
aHR, adjusted HR; CI, confidence interval; CMV, cytomegalovirus; HBV, hepatitis B virus; HCV, hepatitis C virus; HR, hazard ratio; KT, kidney transplant; re-KT, repeat KT.

and are familiar with navigating the system for accessing transplantation.[41,42] However, despite the apparent advantage of listing in graft failure patients over first KT patients, the study also pointed out that <15% of patients in either group ultimately received a (re-)KT, leaving the majority of them on dialysis with higher mortality risk.[41] It is in line with our finding that within 4 y after graft failure, 28% of younger patients died because of not having received a timely re-KT. This is even more concerning in older patients as the mortality within 4 y reached 62%, suggesting the need for better strategies to improve older patient survival who returned to dialysis and an allocation system that advances in line with clinicians' identification of older candidates.

To our knowledge, this study is the first to use a large, nationally representative sample of transplant recipients to evaluate the age disparities in access to first and re-KT over time. It also further explored the age disparities in first- and

TABLE 3.

Access to first KT among older transplant-naive dialysis patient subgroups and access to re-KT among older graft-failed patient subgroups from 1995 to 2018

	Transplant-naive dialysis cohort		Graft failure cohort	
Age, y	Unadjusted HR (95% CI)	aHR (95% CI)	Unadjusted HR (95% CI)	aHR (95% CI)
Listing for KT[a]				
18–64	Reference	Reference	Reference	Reference
65–69	0.41 (0.40-0.41)	0.43 (0.43-0.44)	0.52 (0.50-0.54)	0.54 (0.51-0.56)
70–74	0.17 (0.17-0.18)	0.18 (0.17-0.18)	0.28 (0.26-0.30)	0.29 (0.27-0.31)
≥75	0.03 (0.03-0.03)	0.03 (0.03-0.03)	0.16 (0.14-0.18)	0.15 (0.13-0.17)
Receiving KT[b]				
18–64	Reference	Reference	Reference	Reference
65–69	0.86 (0.85-0.88)	0.88 (0.87-0.90)	0.91 (0.85-0.97)	0.79 (0.74-0.84)
70–74	0.91 (0.89-0.94)	0.89 (0.87-0.91)	0.91 (0.81-1.03)	0.71 (0.63-0.80)
≥75	0.88 (0.84-0.93)	0.82 (0.79-0.86)	0.80 (0.63-1.01)	0.61 (0.48-0.78)

[a]The adjusted models accounted for race, sex, cancer, infections (HBV, HCV, and CMV), peripheral vascular disease, cardiovascular disease, heart failure, hypertension, diabetes, functional impairment, alcohol dependence, tobacco use, percentage of neighborhood population below poverty level and percentage of population in an urban county, and era of kidney failure.
[b]The adjusted models accounted for race, sex, blood type, panel-reactive antibodies, history of cancer, infections (HBV, HCV, and CMV), peripheral vascular disease, cardiovascular disease, heart failure, hypertension, diabetes, functional impairment, alcohol dependence, tobacco use, percentage of neighborhood population below poverty level and percentage of population in an urban county, and era at listing.
aHR, adjusted HR; CI, confidence interval; CMV, cytomegalovirus; HBV, hepatitis B virus; HCV, hepatitis C virus; HR, hazard ratio; KT, kidney transplant; re-KT, repeat KT.

TABLE 4.

Chance of receiving first deceased and LDKT among transplant-naive dialysis patients and chance of receiving deceased and live donor re-KT among graft failure patients (1995–2018)

	Transplant-naive dialysis cohort		Graft failure cohort	
Age, y	Unadjusted HR (95% CI)	aHR (95% CI)	Unadjusted HR (95% CI)	aHR (95% CI)
DDKT	(N = 368 351)		(N = 43 540)	
18–64	Reference	Reference	Reference	Reference
≥65	0.92 (0.91-0.93)	0.95 (0.94-0.97)	1.01 (0.96-1.08)	0.87 (0.82-0.93)
LDKT	(N = 245 158)		(N = 29 826)	
18–64	Reference	Reference	Reference	Reference
≥65	0.56 (0.54-0.57)	0.51 (0.50-0.53)	0.44 (0.39-0.50)	0.35 (0.31-0.40)

The graft failure cohort consisted of adult (≥18 y of age) patients who experienced graft failure between 1995 and 2018 after first kidney only transplantation. The transplant-naive dialysis cohort were adult patients on dialysis during the same time period. The adjusted models accounted for race, sex, blood type, panel-reactive antibodies, history of cancer, infections (HBV, HCV, and CMV), peripheral vascular disease, cardiovascular disease, heart failure, hypertension, diabetes, functional impairment, alcohol dependence, tobacco use, percentage of neighborhood population below poverty level and percentage of population in an urban county, and era at listing.
aHR, adjusted HR; CI, confidence interval; CMV, cytomegalovirus; DDKT, deceased donor kidney transplant; HBV, hepatitis B virus; HCV, hepatitis C virus; HR, hazard ratio; LDKT, live donor KT; re-KT, repeat KT.

re-KT. Ample studies have documented other disparities in access to KT but only a few isolated the independent effect of age inequality.[16,43,44] Although there is evidence indicating a lower likelihood of listing and receiving first KT for older patients, literature that also incorporated patients with graft failure and explored the age disparities of re-KT is very limited.

We acknowledge that this study has limitations. There is a potential for unmeasured confounding. Older patients are at risk for significantly higher comorbidities and poor health conditions than younger patients, which could affect mortality and contribute to higher proportions of death while being listed for re-KT. The population of preemptive KT recipients was excluded in this study because of the unavailability of the pretransplant data that otherwise would allow us to create an appropriate control group comparable with the transplant-naive dialysis population. Possible effects of clustering by listing center or transplant center could exist. However, because patients who were not listed or transplanted naturally lacked this information, we were unable to account for center-level variation.

In conclusion, significant age disparities exist in access to first and re-KT. However, a lower magnitude of age disparity was observed in patients with graft failure being listed for re-KT, a population that is familiar with transplant procedures and has already received KT, than transplant-naive dialysis patients. Transplant centers should be aware of these age disparities and help identify appropriate older patients who would benefit from first KT and re-KT, regardless of their age.

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