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Original Article

Deceased donor kidneys from higher distressed communities are significantly less likely to be utilized for transplantation

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ABSTRACT

The proportion of kidneys procured for transplantation but not utilized exceeds 20% in the United States. Factors associated with nonutilization are complex, and further understanding of novel causes are critically important. We used the national Scientific Registry of Transplant Recipients data (2010-2022) to evaluate associations of Distressed Community Index (DCI) of deceased donor residence and likelihood of kidney nonutilization (n = 209 413). Deceased donors from higher distressed communities were younger, had an increased history of hypertension and diabetes, were CDC high-risk, and had higher terminal creatinine and donation after brain death. Mechanisms and circumstances of death varied significantly by DCI. The proportion of kidney nonutilization was 19.9%, which increased by DCI quintile (Q1 = 18.1% to Q5 = 21.6%). The adjusted odds ratio of nonutilization from the highest quintile DCI communities was 1.22 (95% CI = 1.16-1.28; reference = lowest DCI), which persisted stratified by donor race. Donors from highly distressed communities were highly variable by the donor service area (range: 1%-51%; median = 21%). There was no increased risk for delayed graft function or death-censored graft loss by donor DCI but modest increased adjusted hazard for overall graft loss (high DCI = 1.05; 95% CI = 1.01-1.10; reference = lowest DCI). Results indicate that donor residential distress is associated with significantly higher rates of donor kidney nonutilization with notable regional variation and minimal impact on recipient outcomes.

1. Introduction

The proportion of deceased donor kidneys procured for the purpose of transplantation but ultimately not utilized exceeds 20% in the US and has risen in conjunction with recent changes in kidney allocation policies.[1-3] There are many known factors associated with organ nonutilization including donor demographic characteristics, comorbidities, logistical impediments, biopsy results, risk labeling, center practice, and allocation policy.[4-9] Although the specific proportion of nonutilized donor kidneys that would benefit potential candidates is not known, studies attempting to mitigate selection biases indicate that factors other than donor quality are significant contributors to nonutilization.[10-12] Comprehensive understanding of factors that predict potential donor nonutilization may facilitate development of more efficient allocation policies to expedite placement.[13,14] Cumulatively, research suggests that a significant proportion of nonutilized kidneys would provide a survival benefit to potential transplant candidates.[15] Recently, the National Academies of Medicine published a report highlighting challenges in the organ transplantation system, which emphasized the need to significantly reduce deceased donor kidney nonutilization as a key priority for improvement.[16]

Abbreviations: AHR, adjusted hazard ratio; AOR, adjusted odds ratio; CDC, Centers for Disease Control and Prevention; DCI, Distressed Community Index; DGF, delayed graft function; KDPI, kidney donor profile index; OPO, organ procurement organization; SRTR, Scientific Registry of Transplant Recipients.

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Given the significant implications of deceased donor nonutilization for donor families, potential kidney transplant recipients, and transplant providers, further understanding of novel mechanisms that may lead to donor kidney nonutilization is critically important. Although there are known risk factors for donor nonutilization associated with deceased donors in available research registries, there are likely additional characteristics of donors and processes of donor recovery and allocation that impact utilization. A potential novel source of variation in deceased donor kidney characteristics and processes of care is the community in which donors previously resided. There have been numerous studies in an array of health care contexts that illustrate the profound association of residential community with health outcomes in the general population and patients with end-stage kidney disease.[17-24] The mechanisms for these associations are varied but include higher prevalence of comorbidities, factors associated with low socioeconomic status, poorer access to health care, environmental risks, and behavioral risk factors, which may also characterize potential deceased donors. In addition, nonutilization of donor organs is associated with individual decision-making, which may be based on subjective factors affecting adjudication of potential donor offers.[11,25,26] These decisions may be influenced by the donor's residential location and circumstances of death. System-level variation in resources, market concentration, and donor management are the sources of variation in donor utilization and may have differential effect on distressed communities.[27-29] Importantly, disproportionate opportunities to donate on behalf of deceased donors may represent significant disparities and therefore are critically important to be understood more clearly.

In the current study, we aimed to evaluate whether the residence of deceased donors prior to donation is associated with donor kidney utilization and posttransplant outcomes. These associations may be due to the perceived or known risk factors among donors, causes of death and complications that are not routinely codified, subconscious biases regarding the viability of donor organs and/or logistical factors that are reflective of the communities of donors, or the hospitals that serve these communities. We sought to evaluate our aims using a national transplant database in the United States from 2010 to 2022.

2. Methods

This study used data from the Scientific Registry of Transplant Recipients (SRTR). The SRTR data system includes data of all donors, waitlisted candidates, and transplant recipients in the United States, which were submitted by the members of the Organ Procurement and Transplantation Network. The Health Resources & Services Administration, US Department of Health and Human Services, provides oversight of the activities of the Organ Procurement and Transplantation Network and SRTR contractors. The data reported here have been supplied by the Hennepin Health care Research Institute as the contractor for the SRTR. The interpretation and reporting of these data are the responsibility of the authors and in no way should be seen as an official policy of or interpretation by the SRTR or the US Government.

The initial study population included all deceased donors in the SRTR from January 1, 2010, to February 28, 2022. We excluded donors that did not have a zip code, or zip codes were listed as out of range for residential addresses. We also only included donor kidneys that were transplanted or procured for the purpose of transplantation, excluding donor organs that were used for research or were not authorized. We also excluded donors who did not have a zip code listed in the Distressed Community Index (DCI). The DCI was developed by the Economic Innovation Group and comprised zip code–level estimates reflecting educational attainment, poverty, employment, housing vacancy rate, household income, and change in establishments.[30] Prior research has demonstrated that DCI is associated with surgical patient outcomes, and the association of DCI was similar to other census-based indices reflecting the socioeconomic status and other social determinants of health.[17] For the current study, we used the DCI index for 2017 and merged the data with the deceased donor residential zip code.

In addition to donor variables in the SRTR files, we calculated the kidney donor risk index and transformed it to the kidney donor profile index (KDPI) using the 2020 mapping conversion. For data that were missing, we converted values to a missing level to retain observations in statistical models. We compared the characteristics of donor kidneys and transplant recipients deriving from quintiles of DCI and donor nonutilization based on χ^2tests. We developed multivariable generalized estimating equations for the binary outcome of donor organ nonutilization with risk adjustment incorporating the year of donation, individual components of KDPI, and the DCI. Due to the dependence of donor organs deriving from the same donor, we incorporated donor ID as a repeated measure in the models. We presented the association of donor nonutilization and DCI based on the AORs to be consistent with the majority of research examining the risk factors for organ nonutilization. However, as odds ratios can be inflated estimates of relative risk when the incidence of the outcome is relatively high, we also presented the association of DCI with organ nonutilization using a log-binomial model to estimate the risk ratio. To evaluate the association between the residential distressed index and outcomes, we categorized DCI into quintiles (based on pre-existing 20% levels), which characterize the national distribution of community distress in the general population. In addition, we examined the association of DCI with donor kidney nonutilization considering DCI as a continuous variable, and used a spline with 5 knots at predefined percentiles (5%, 25%, 50%, 75%, and 95%). In addition, we utilized stratified models to estimate the adjusted proportion of nonutilization by donor race accounting for race/ethnicity and the sex of deceased donors. Finally, we generated multivariable generalized estimating equations for donor kidney nonutilization stratified by the level of KDPI.

For deceased donor kidneys that were transplanted, we also evaluated recipient outcomes based on DCI as a primary exposure variable. We used generalized estimating equations for the outcome of delayed graft function (DGF), defined as any dialysis treatment within 7 days of transplant. These models included donors as repeated measures to account for the dependence of observations by donors. We used multivariable Cox models to evaluate the time to overall graft survival, defined as the composite endpoint of graft loss and death, death-censored graft survival, and patient death. These models included a robust sandwich estimator to account for repeated measures by donors. Models were censored at the end of patient follow up and administratively censored on February 28, 2022. The study was approved by the Institutional Review Board at the University of Colorado. All statistical analyses were conducted in SAS (version 9.4). We also produced a zip code tabulation area-level map in ArcGIS Pro v2.4 to visualize donors residing in zip code areas classified as the most distressed (highest DCI quintile).

3. Results

The study cohort included deceased donors with at least one donor kidney procured for the purpose of kidney transplantation that was either transplanted or not utilized between January 1, 2010, and February 28, 2022. Donors that did not have residential zip codes (n = 269) or had zip codes that did not match a zip code within the DCI (n = 6935) were excluded. There were an additional 5859 donor kidneys in which one of the 2 donor kidneys was not coded as recovered for transplant and not utilized or transplanted. The final study cohort comprised 209 413 kidneys derived from 107 636 donors. The distribution of donor characteristics by donor residential distress community index quintile is displayed in Table 1. Overall, donors that were younger, Black, after brain death, high terminal creatinine, and a history of hypertension and diabetes, prior Centers for Disease Control and Prevention (CDC) guidelines for donors at a high risk for disease transmission and positive hepatitis C status were more likely to be in higher distress communities.

Table 1
Characteristics of deceased donors by Distressed Community Index

Donor characteristic	Level (n)	Donor-Distressed Community Index					P value
		Q1 (%)	Q2 (%)	Q3 (%)	Q4 (%)	Q5 (%)	
Age, y	<18 (9993)	20.3	17.1	18.9	20.6	23.1	<.001
	18-39 (41 445)	20.3	17.9	19.1	20.9	21.9	
	40-59 (43 041)	20.8	18.3	18.8	20.5	21.6	
	>60 (13 157)	23.7	18.8	19.1	19.7	18.7	
Sex	Female (42 624)	21.3	17.9	19.0	20.4	21.4	.001
	Male (65 012)	20.6	18.3	18.9	20.6	21.6	
Race/Ethnicity	Asian (2698)	37.3	20.4	18.9	14.5	8.9	<.001
	Black (16 190)	10.2	11.3	14.9	21.5	42.2	
	Hispanic (14 565)	12.7	14.0	19.7	26.1	27.6	
	White (72 864)	24.4	20.4	19.7	19.4	16.2	
	Other (1319)	16.2	17.9	19.0	22.7	24.1	
Blood type	A (39 910)	21.7	19.0	19.3	20.3	19.8	<.001
	B (12 710)	21.2	17.4	18.4	19.6	23.5	
	AB (3739)	23.3	17.9	18.3	19.4	21.0	
	O (51 277)	20.1	17.7	18.8	21.1	22.4	
Donor type	DBD (85 082)	19.9	17.6	18.9	21.0	22.6	<.001
	DCD (22 554)	24.6	19.9	19.1	18.8	17.6	
Donor cause of death as stroke	No (77 378)	20.8	18.3	18.8	20.5	21.6	<.001
	Yes (30 258)	21.2	17.6	19.2	20.7	21.4	
High creatinine (>1.5 mg/dL)	No (82 382)	21.4	18.4	19.1	20.4	20.7	<.001
	Yes (25 254)	19.3	17.2	18.3	20.9	24.2	
History of hypertension	No (72 777)	21.7	18.4	19.0	20.3	20.7	<.001
	Yes (34 859)	19.2	17.5	18.9	21.0	23.4	
History of diabetes	No (96 461)	21.3	18.3	18.8	20.4	21.2	<.001
	Yes (11 175)	17.4	16.7	19.9	21.8	24.1	
Met CDC guidelines for high risk	No (86 072)	21.6	18.3	19.0	20.2	20.9	<.001
	Yes (21 536)	18.1	17.4	18.6	22.0	23.9	
Hepatitis C status[a]	No (10 0441)	21.4	18.2	18.9	20.4	21.2	<.001
	Yes (7195)	14.6	16.9	19.4	22.8	26.2	
Kidney donor profile index	%[b]	52%	52%	53%	54%	57%	<.001
Total (n = 107 636)		20.9	18.1	18.9	20.5	21.5	

DBD, donors after brain death; DCD, donors after cardiac death.
[a] Missing data: CDC high-risk donors (n = 28) and hepatitis C (n = 299)
[b] Using 2017 KDRI/KDPI scaling factor

The distribution of donors was relatively consistent with the quintiles in the national population with all the distribution within 2% (18%-22%) within each quintile. Table 2 displays the distribution of circumstances and mechanisms of death by the distress community index quintile. Donors with homicide as a circumstance of death were almost 4-fold more likely to be in the highest distress communities, and death due to a gunshot wound was almost twice as likely to reside in the highest distress communities.

The overall proportion of donor kidney nonutilization during the study period was 19.9%. Nonutilized donor kidneys were more common among donors that were older, female, Black and Asian, type-AB blood, after cardiac death, high terminal creatinine levels (>1.5 mg/dL), died owing to stroke, had a history of hypertension or diabetes, meet prior CDC high-risk guidelines, had positive hepatitis C status, and increasing distress index (Table 3). The unadjusted odds ratios for donor kidney nonutilization increased from 1.12 (95% confidence interval [CI]: 1.07-1.16) in quintile 2 of DCI (reference = Q1) to 1.21 (95% CI: 1.16-1.26; Supplementary Table). The estimates of the association of DCI with donor kidney nonutilization based on risk ratios were similar but slightly attenuated. These associations persisted in the multivariable generalized estimating equations displayed in Table 2. As indicated, relative to donor kidneys from the lowest distress index quintile, kidneys from donors in the highest distress quintile residential communities had an adjusted odds ratio (AOR) for nonutilization of 1.22 (95% CI = 1.16-1.28). The association of donor residential index as a continuous variable with the AOR for nonutilization is displayed in Figure 1. As displayed, the AOR for nonutilization increased in a nonlinear trajectory, including an AOR for nonutilization exceeding 30% at the highest DCI relative to the lowest level. Figure 2 displays the age- and sex-adjusted proportion of nonutilization stratified by race across the distress index level. Overall, kidneys from Black donors were less likely to be utilized than white or Hispanic donor kidneys adjusted for age and sex, but the adjusted proportion of nonutilization by donor residential distressed community increased within each race strata. The association of higher nonutilization rate by donor-distressed community was consistent across eras (2010-2013, 2014-2017, and 2018-2022), even though the overall nonutilization rates increased.

The association of the donor residential distress index with the characteristics of donor management is depicted in Figure 3. Kidneys from higher distress communities were less likely to have been placed on a perfusion pump, but the proportion of biopsies performed among donor kidneys was relatively similar by DCI. The proportion of donors with glomerulosclerosis of >20% increased by distress level from 8.8% in the lowest distress quintile to 11.0% in the highest distress quintile ($P < .001$). Donor kidneys were increasingly likely to be shared outside of the local region by increasing the distress index, and among donor kidneys transplanted, a longer cold ischemia time was more likely from the highest distress index donors (P values < .001). The proportion of donors residing in the highest quintile index of distress was highly variable by donor service area and designated organ procurement organization (OPO). Figure 4 displays the distribution of donors from the highest quintile distress index ranging from 1.3% to 50.8%, with a median proportion of 21.4%. There was a positive correlation ($r = 0.37$, $P = .004$) between the proportion of highly distressed donors and donor nonutilization by individual organ procurement donor service area (Fig. 5).

The adjusted probability of donor nonutilization stratified by the KDPI is depicted in Figure 6. There was a statistically significant interaction between the KDPI and DCI ($P < .001$) for donor kidney nonutilization. As depicted, there was an increase in nonutilization by DCI in each KDPI strata; however, the association with the adjusted odds of nonutilization was greater in the highest KDPI groups (KDPI > 85%) relative to the lower KDPI groups. Figure 7 depicts 45 019 donors residing in the highest DCI quintile zip code tabulation areas (n = 3656). As displayed, higher distressed communities with donors were prevalent across the United States but particularly prominent in the southeast and certain urban areas.

The characteristics of recipients of transplanted donor kidneys by donor DCI are displayed in Table 4. There were statistically significant differences in recipient demographic and clinical characteristics and donor DCI; however, numerical differences were modest. There was no statistically significant increased risk of DGF and donor DCI and a statistically significantly lower risk of DGF among donors from the highest distress index relative to donors from the lowest distress index quintile. There was a statistically significant increase in the adjusted hazard ratio

Table 2
Circumstances and mechanisms of death of donors by Distressed Community Index

Recipient characteristic	Level (n)	Donor residential Distressed Community Index					
		Q1 (%)	Q2 (%)	Q3 (%)	Q4 (%)	Q5 (%)	*P* value
Circumstances of death	Natural causes (45 536)	21.2	18.0	19.1	20.2	21.6	<.001
	Motor vehicle accident (15 469)	20.4	19.0	19.9	20.8	19.9	
	Suicide (10 681)	22.6	19.2	19.6	19.9	18.8	
	Homicide (5090)	10.8	11.7	15.7	23.6	38.2	
	Other (30 860)	21.8	18.5	18.5	20.7	20.4	
Mechanisms of death	Intracranial hemorrhage/stroke (30 969)	21.2	17.6	19.1	20.6	21.4	<.001
	Blunt injury (21 809)	21.0	19.0	19.2	20.8	20.1	
	Cardiovascular (18 261)	21.0	18.4	18.6	20.2	21.8	
	Drug intoxication (12 262)	22.1	19.1	18.7	20.0	20.2	
	Gunshot wound (9511)	15.5	15.6	17.6	21.9	29.4	
	Asphyxiation (5921)	23.5	18.1	19.9	20.4	18.1	
	Others (16 668)	21.7	18.6	19.5	19.8	20.5	

(AHR) for overall graft loss (AHR = 1.05; 95% CI = 1.01-1.10) and death (AHR = 1.06; 95% CI: 1.01-1.12) associated with donors from the highest distress index relative to the lowest residential distress index. However, there was no statistically significant association of highest donor distress with death-censored graft loss (AHR = 1.04; 0.97-1.10). There was a mild association between the donor distress quintile and recipient DCI quintile. Recipients in the lowest distressed communities received donors from lowest distress communities (23.8% of transplants vs. 18.9% from highest distressed communities). In contrast, recipients from the highest distressed communities received donors from the lowest distress communities in 19.2% of the transplants as compared to 24.5% from the highest distressed communities. Adjusting for recipient DCI quintile did not significantly modify the association of the donor risk with overall or death-censored graft loss or patient death.

4. Discussion

The primary findings of the study demonstrate a significant association of deceased donor kidney nonutilization with the donor residential DCI. This association is consistent adjusted for known risk factors and stratified by donor race/ethnicity and KDPI. The proportion of donors from high distress communities was highly variable by mechanisms and circumstances of death. Nonutilization rates were higher for organ procurement organizations with a higher proportion of highly distressed communities. Management of donor kidneys including pump utilization, regional sharing, and cold ischemia time significantly varies by donor DCI. Transplanted donor kidneys from highly distressed communities experienced neither higher rates of DGF nor death-censored graft loss. Overall, the study indicates that the residential communities of deceased

Table 3
Risk-adjusted association of donor nonutilization by donor characteristics

Donor characteristic	Level	Nonutilization (%)	*P* value	Adjusted odds ratio[a]	95% confidence interval
Age	<18	6.6	<.001	1.57	1.45-1.71
	18-39	7.9		Reference	
	40-59	24.2		2.62	2.51-2.73
	>60	53.9		11.6	11.0-12.2
Gender	Female	23.0	<.001	1.35	1.30-1.39
	Male	17.9		Reference	
Race/ethnicity	Asian	22.2	<.001	0.90	0.82-1.00
	Black	23.0		1.08	1.03-1.13
	Hispanic	15.7		0.80	0.76-0.84
	White	20.0		Reference	
	Other	15.5		0.87	0.76-0.98
Blood type	A	20.2	<.001	1.07	1.03-1.11
	B	19.6		1.00	0.95-1.05
	AB	23.1		1.46	1.34-1.58
	O	19.5		Reference	
Donor type	DBD	19.2	<.001	Reference	
	DCD	22.7		2.04	1.97-2.13
High creatinine (>1.5mg/dL)	No	15.1	<.001	Reference	
	Yes	35.4		4.18	4.04-4.33
Donor cause of death as stroke	No	15.4	<.001	Reference	
	Yes	31.2		1.45	1.40-1.51
History of hypertension	No	11.8	<.001	Reference	
	Yes	36.8		1.94	1.87-2.01
History of diabetes	No	16.7	<.001	Reference	
	Yes	47.3		2.45	2.34-2.56
Meet CDC guidelines for high risk	No	20.5	<.001	Reference	
	Yes	17.4		1.08	1.03-1.13
Hepatitis C status	No	18.9	<.001	Reference	
	Yes	34.2		4.15	3.91-4.41
Residential Distressed Community Index	Q1	18.1	<.001	Reference	
	Q2	19.5		1.12	1.07-1.18
	Q3	19.9		1.13	1.07-1.19
	Q4	20.3		1.16	1.10-1.22
	Q5	21.6		1.22	1.16-1.28
Overall (n = 209 413)		19.9			

DBD, donor after brain death; DCD, donor after cardiac death.
[a] Model also adjusted for the year of donor recovery

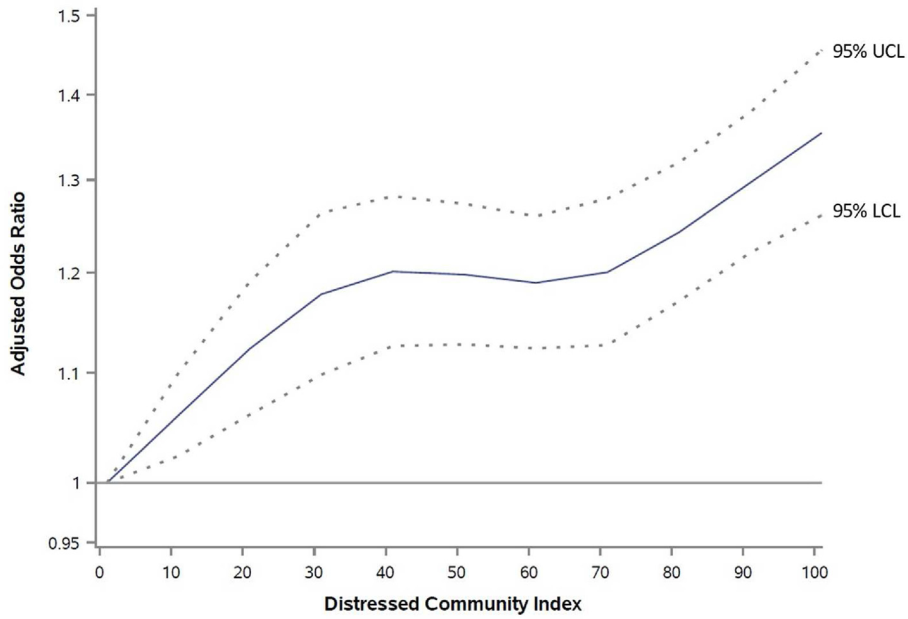

Figure 1. Adjusted odds ratio of kidney nonutilization by donor residential Distressed Community Index. Model adjusted for year of donor recovery, blood type, age, race or ethnicity, gender, donor after brain death or cardiac death, high terminal creatinine, history of hypertension, history of diabetes, stroke as cause of death, donor meeting the criteria for CDC high-risk, and hepatitis C status. LCL, lower confidence limit; UCL, upper confidence limit.

donors is a significant novel risk factor associated with donor kidney utilization. The causes of decreased utilization may be related to underlying comorbidities and logistical barriers and/or acceptance decisions related to donor kidneys from higher risk communities. Importantly, our findings also represent inequities in donor utilization that need to be attenuated on behalf of donors and donor families. Further understanding of mechanisms of disproportionate utilization rates of donor kidneys from high distress communities are needed to improve donor equity and processes of care and enhance transplant opportunities.

The association of donor kidney utilization with the donor distress community index may be explained by numerous factors. Donors from higher distress communities were more likely to be Black, had a history of hypertension and diabetes, were hepatis-C positive, had high terminal creatinine levels, and met prior CDC guidelines for high risk of disease transmission, which have previously been demonstrated to increase donor kidney discard.[3,5,6,9,13,31,32] Although these factors were accounted for in multivariable models for this study, they may also suggest a higher prevalence of other comorbities that are not available in these data yet impact the assessment of donor viability. This potential

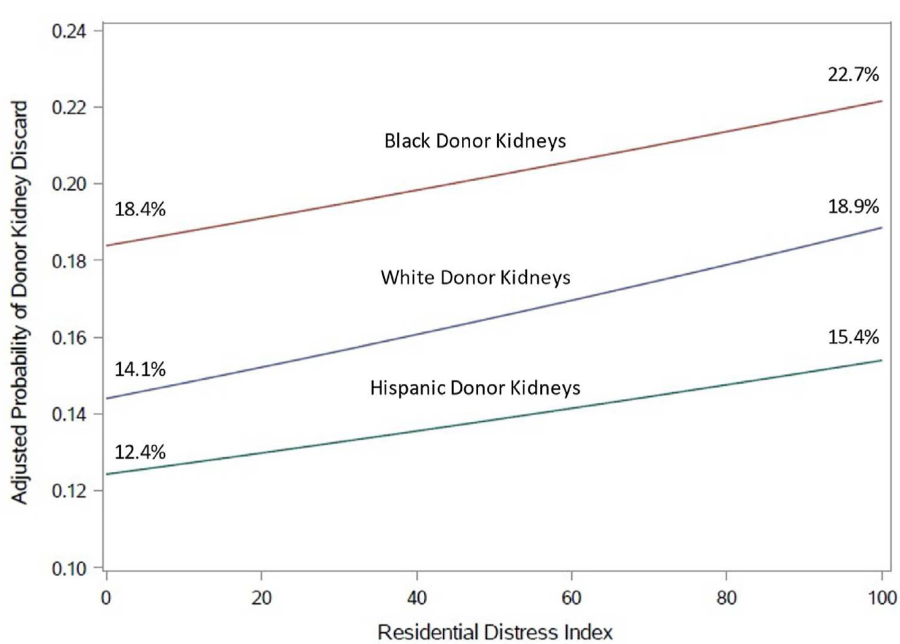

Figure 2. Adjusted proportion of kidney nonutilization by donor residential Distressed Community Index. Adjusted for age, sex, race, and zip code of donor residential distressed community.

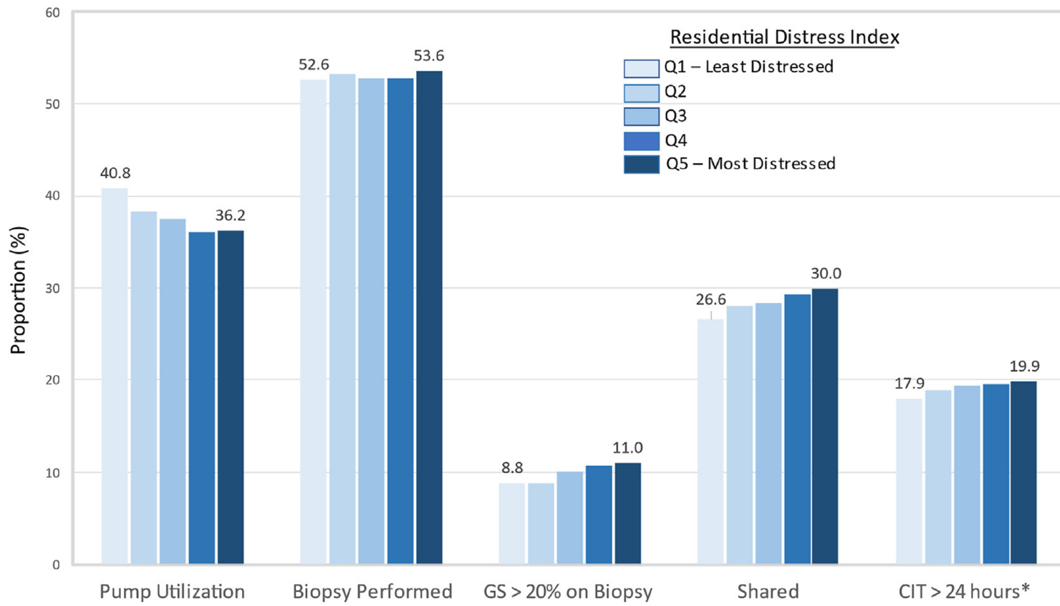

Figure 3. Donor kidney management by donor residential Distressed Community Index. CIT, cold ischemia time; GS, glomerulosclerosis. n = 110 010 (53%) with biopsy reading available and CIT available for transplants only (n = 165 317, n = 2287 missing). Shared indicates that the donor was shared outside of the local region.

association is plausible given a higher rate of comorbidities in the general population residing in higher deprivation communities.[17,33-35] The higher distressed community may also be a proxy for donor hospital resources or care, social support for donors, and timeliness of care. In addition, both the circumstances and mechanisms of death that were documented for deceased donors varied significantly by the donor residential distress community level. Deceased donors from higher distress communities were more likely to die by homicide and gunshot wounds than donors from lower distress communities. This may suggest that the mode of death either complicates the donation process or leads to other unmeasured risk factors or acceptance decisions that affect donor utilization.

The results of the study suggest that the association of the donor distress community index and nonutilization rates is not a linear relationship. Rather, the risks were particularly elevated at the highest distressed community level, including the adjusted risk of nonutilization exceeding 30% relative to the lowest distress communities. The magnitude of the risk of nonutilization of kidney donors from high distress communities was more than other known risk factors such as death of donors due to cerebrovascular accident, donors with proteinuria, and donor procured on the weekend.[7,8] Thus, further research and understanding of sources of disparate risks of organ nonutilization may be best targeted among the highest distress communities. This may involve further understanding of the environments in which donors have resided

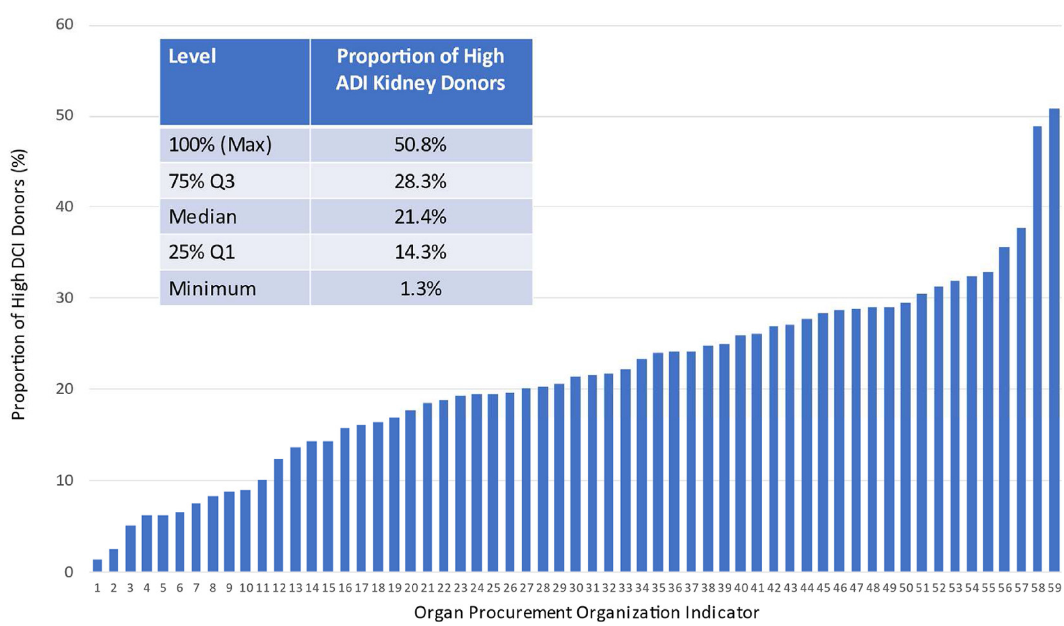

Figure 4. Proportion of high Distressed Community Index donors by organ procurement organization. High DCI indicates top quintile. DCI, Distressed Community Index.

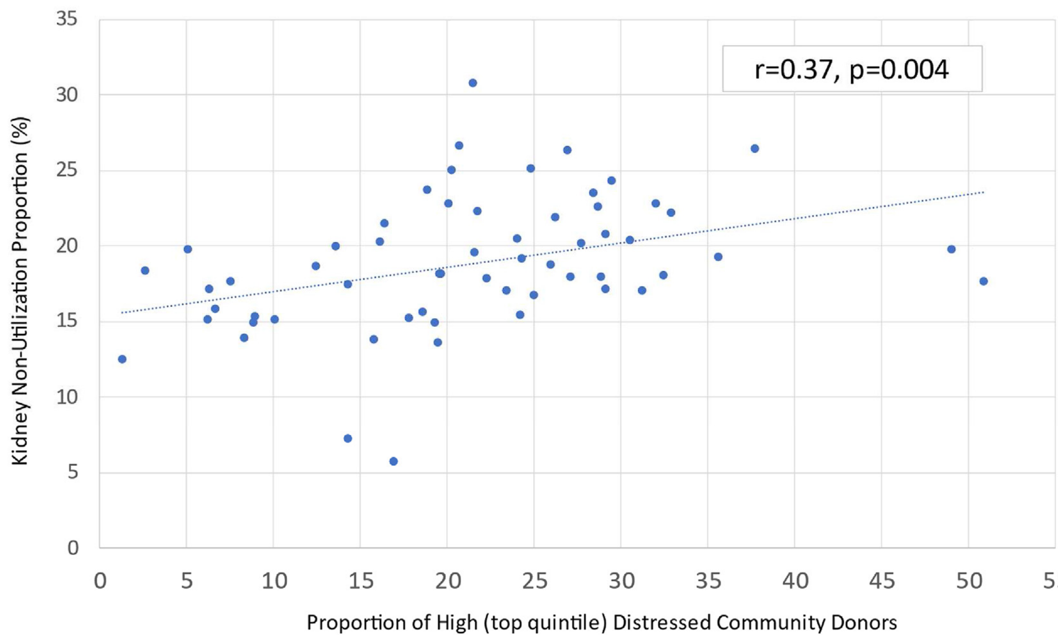

Figure 5. Proportion of high Distressed Community Index donors by nonutilization rate by organ procurement organization. Dots represent individual organ procurement organizations.

that contribute to nonutilization, underlying risks of populations residing in these communities, donor hospital processes of care, and interactions with OPOs and transplant centers in the region. However, these varied rates of nonutilization represent important inequities to donors and donor families that require prospective evaluation.

The results of the study also illustrate that there are variations in donor management associated with the donor residential distress community. Deceased donors from higher distressed communities had lower utilization of pulsatile perfusion, and were more likely to be shared beyond local regions with longer cold ischemia time among recipients. These results may suggest that there are logistical barriers to facilitating transportation for these donors and more donor kidney offers required for acceptance of these organs. Interestingly, donor biopsies were used relatively uniformly by the donor distress community. However, among donor kidneys that were biopsied, there were higher rates of glomerulosclerosis among donors in higher distressed communities. High glomerulosclerosis measures have been shown to increase donor nonutilization, but mixed evidence was available as to whether biopsy findings impact the risk among recipients and overall donor quality.[11,36] Thus, biopsy measures may be the one mediating factor that disproportionally affects variation in nonutilization rates by DCI. It is also of interest to consider why donors from higher risk communities systematically have higher glomerulosclerosis levels. Risk factors for glomerulosclerosis may include infectious diseases, diabetes, obesity,

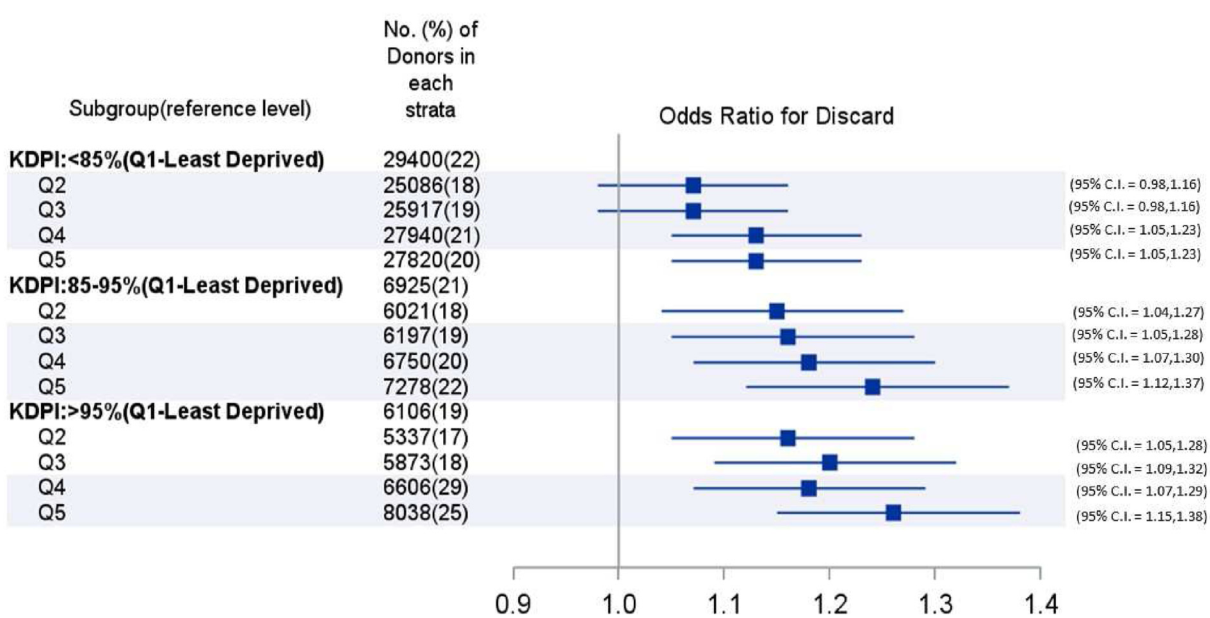

Figure 6. Adjusted likelihood of kidney nonutilization by Distressed Community Index stratified by kidney donor profile index. Results based on generalized estimating equations with robust variance estimates accounting for repeated donors; models adjusted for the year of donor recovery, blood type, donor age, donor race/ethnicity, donor gender, donor after brain or cardiac death, donor history of hypertension or diabetes, donor categorized as CDC high-risk for disease transmission, and donor hepatitis C status.

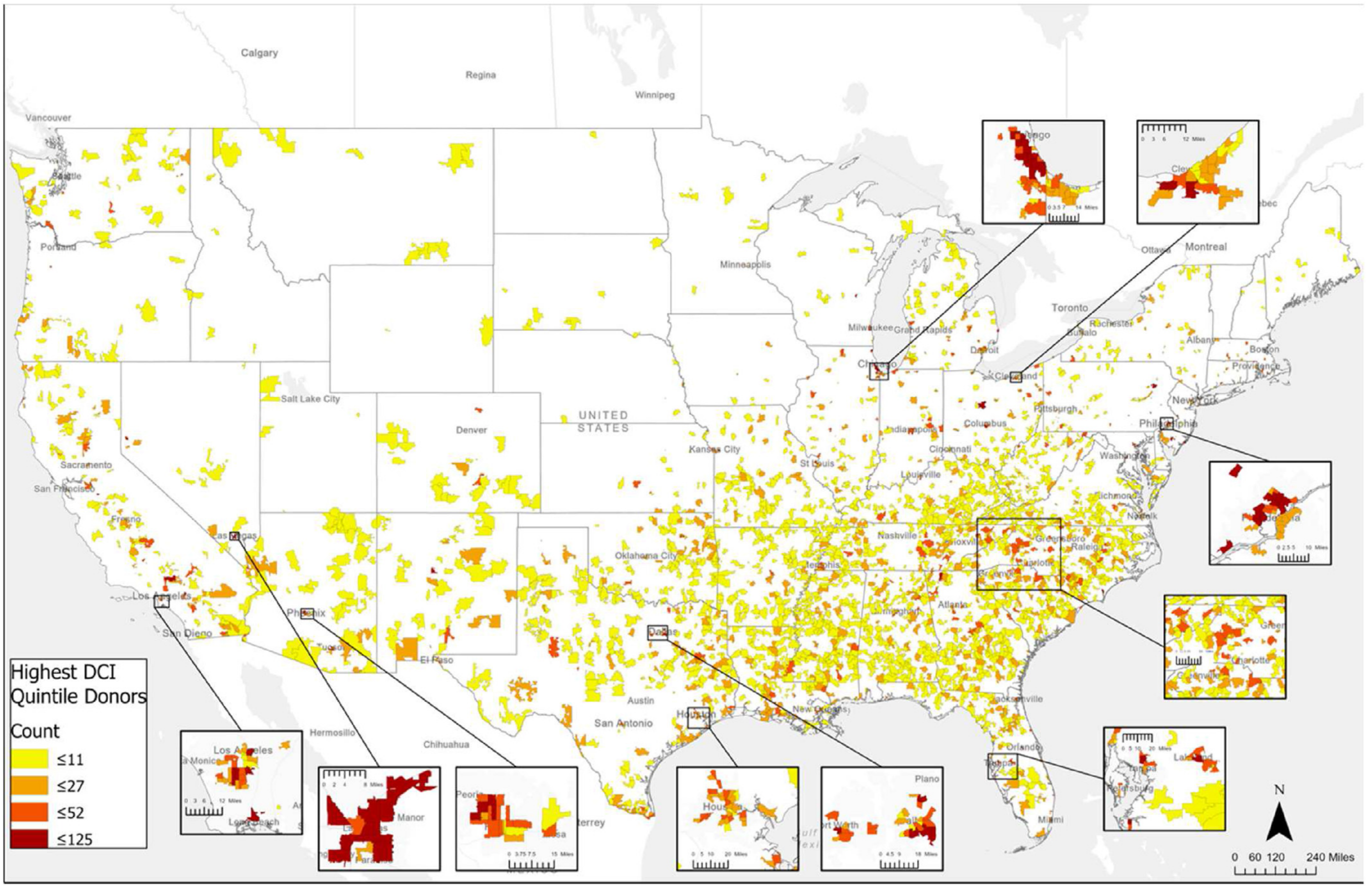

Figure 7. Kidney donors residing in zip code tabulation areas classified in the highest quintile of the distressed communities index (n = 45 019 kidneys in 3656 ZCTAs)

and autoimmune disorders.[37-43] Thus, high distress communities may disproportionately be represented by donors with additional comorbid conditions that may influence both the donor viability and/or perception of risk by decision-makers involved in organ acceptance decisions.

Another important finding of the study is that the incidence of donors from high distress communities varies substantially by donor service area and associated OPOs ranging from 1% to 50%. Moreover, there is a positive correlation between OPOs serving higher distressed communities and nonutilization rates. These results may suggest underlying factors that influence donor utilization between regions of the country; namely, those related to the community and distress conditions that may impact direct comparisons of OPO performance assessment, which has recently increased in scrutiny from the Centers for Medicare and Medicaid (CMS).[44] Prospectively, it will be important to understand that variations in donor utilization by distress community are associated with actual performance of providers (suggesting that OPOs that serve higher distressed communities systematically have lower quality), or alternatively the underlying risks of donors that may not be directly attributable to processes and quality of care by donor hospitals or OPOs such as those used in CMS assessments.

Importantly, despite the significant increased risk of nonutilization among donors from higher distressed communities, recipients of donor kidneys had relatively similar clinical outcomes. There was no significant increase in delayed graft function or death-censored graft loss based on the donor community distress level and a modest association of overall graft loss adjusted for other known risk factors. However, this modest increased risk of overall graft loss does not appear proportional to the >20% increased risk in donor kidney nonutilization, and many nonutilized donor kidneys may have provided a significant survival advantage to transplant candidates relative to maintenance dialysis.

There are several important limitations of the study that should be considered in the context of the findings. As noted, there are likely additional characteristics of donors and donor kidneys that are not known in these data that influence organ offer decision-making and in turn the results, and they should be investigated prospectively. Notably, we selected DCI as a measure of socioeconomic and environmental conditions, which has also been shown to be associated with surgical patient outcomes.[17] However, other measures of social deprivation, economic conditions, and access to health care based on different factors or weights of factors characterizing the community risks may provide different estimated effects. Reasons for donor turndown are not well codified in these data, and the primary reason for nonutilization in this study was “recipients not found,” which is redundant and not instructive as to the specific mechanisms. Zip code–level measurements are fraught with potential ecological fallacies such that each donor kidney from a high distress community in this context may not exhibit characteristics of the zip code area level. However, to the extent that the risks of donor kidney utilization extend to the community and system-level factors, this limitation is not relevant. As such, further research identifying the specific mechanisms of these risks is needed. In addition, timing of offer decisions and data describing processes of care for organ procurement are limited in the database and would require further study.

Overall, the study identified a novel factor associated with donor nonutilization in the US. The specific mechanisms of nonutilization and characteristics of donors from high distress community are important for prospective research. Opportunities to utilize a higher proportion of donor kidneys, attenuate inequities in nonutilization, and provide more transplant opportunities for candidates are a high priority, and these

Table 4
Recipient characteristics by deceased donor-Distressed Community Index

Recipient characteristic	Level (n)	Donor residential Distressed Community Index					P value
		Q1 (%)	Q2 (%)	Q3 (%)	Q4 (%)	Q5 (%)	
Age, y	<18 (7068)	22.9	17.1	18.0	20.6	21.5	.01
	18-49 (58 880)	21.3	18.0	19.1	20.6	21.0	
	50-59 (42 878)	21.3	18.3	18.8	20.4	21.3	
	>60 (58 778)	21.5	18.5	18.8	20.3	20.9	
Sex	Female (66 866)	21.3	18.3	18.9	20.5	21.1	.78
	Male (100 738)	21.5	18.2	18.9	20.4	21.0	
Race/Ethnicity	Asian (11 638)	24.1	19.7	19.2	19.8	17.3	<.001
	Black (55 076)	19.8	17.2	18.0	20.7	24.3	
	Hispanic (30 293)	22.1	17.5	19.2	21.1	20.2	
	White (66 951)	22.0	19.0	19.5	20.1	19.5	
	Other (3646)	23.2	19.5	18.6	19.0	19.8	
Body mass index (kg/m^2)[a]	13-20 (12 089)	23.2	17.8	19.0	20.4	19.6	<.001
	21-25 (41 774)	21.6	18.5	18.9	20.2	20.8	
	26-30 (53 035)	21.1	18.5	18.8	20.6	21.1	
	31-35 (38 004)	21.5	17.8	19.0	20.3	21.5	
	>35 (20 030)	21.0	17.9	18.8	20.9	21.5	
Primary insurance	Private (39 225)	22.0	18.5	19.4	20.2	20.0	<.001
	Medicare (111 137)	21.3	18.1	18.6	20.5	21.6	
	Medicaid (12 583)	21.0	18.1	19.4	21.2	20.4	
	Other (4659)	22.0	18.4	20.9	20.7	17.9	
Primary diagnosis	Glomerulonephritis (36 682)	21.9	18.6	19.0	20.3	20.3	<.001
	Diabetes (45 924)	21.5	17.8	18.8	20.5	21.4	
	PKD (12 542)	21.6	19.5	19.0	19.7	20.2	
	Hypertension (37 734)	20.5	17.8	18.7	20.7	22.4	
	Other (34 722)	21.9	18.4	19.0	20.5	20.2	
Cold ischemia time (% h)[a]	0-24 (133 746)	82.2	81.2	80.6	80.5	80.1	<.001
	>24 (31 571)	17.9	18.8	19.4	19.5	19.9	
CPRA[a]	0% (89 870)	53.7	54.2	53.1	54.4	52.8	<.001
	1-30% (26 801)	16.1	15.7	16.4	15.5	16.2	
	>30% (50 831)	30.1	30.1	30.4	30.1	31.0	
Pretransplant dialysis time (mo)	0 (20 087)	12.2	11.8	12.1	12.2	11.6	<.001
	1-36 (55 765)	32.9	34.4	33.5	33.2	32.5	
	>36 (91 752)	54.9	53.9	54.3	54.6	55.9	
Total (n = 167 604)		21.4%	18.2%	18.9%	20.4%	21.1%	

[a] Missing data or outside of range: BMI (n = 2672), cold ischemia time (n = 2287), and CPRA (n = 102).CPRA, calculated panel reactive antibody percentage; PKD, polycystic kidney disease.

Table 5
Adjusted hazard of posttransplant delayed graft function, overall graft loss, and death-censored graft loss and death

Donor residential Distressed Community Index	Adjusted odds of delayed graft function[a]	95% CI	Adjusted hazard for overall graft loss[a]	95% CI	Adjusted hazard for patient death[a]	95% CI	Adjusted hazard for death-censored graft loss[a]	95% CI
Q1	Reference		Reference		Reference		Reference	
Q2	0.98	0.94-1.02	0.99	0.95-1.04	0.98	0.93-1.03	1.00	0.94-1.07
Q3	0.99	0.95-1.03	1.04	1.00-1.08	1.06	1.01-1.11	1.01	0.95-1.07
Q4	0.97	0.93-1.01	1.02	0.98-1.07	1.01	0.96-1.06	1.04	0.98-1.10
Q5	0.93	0.89-0.97	1.05	1.01-1.10	1.06	1.01-1.12	1.04	0.97-1.10

[a] Models adjusted for the year of transplant, donor age, blood type, donor race, donor gender, donation after brain or cardiac death, donor history of hypertension and diabetes, donor hepatitis C status, donor cause of death, recipient race, recipient age, cold ischemia time, recipient primary diagnosis, recipient panel reactive antibody percentage, pretransplant dialysis time, and recipient primary insurance.

findings may provide insights into an important context for the improvement of the transplant system.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajt.2023.03.019.

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Data availability statement

Data are available from the Scientific Registry of Transplant Recipients.

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