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Impacts of removing race from the calculation of the kidney donor profile index



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ABSTRACT

The kidney donor risk index (KDRI), standardized as the kidney donor profile index (KDPI), estimates graft failure risk for organ allocation and includes a coefficient for the Black donor race that could create disparities. This study used the Scientific Registry of Transplant Recipients data to recalculate KDRI coefficients with and without the Black race variable for deceased donor kidney transplants from 1995 to 2005 (n = 69 244). The recalculated coefficients were applied to deceased kidney donors from 2015 to 2021 (n = 72 926) to calculate KDPI. Removing the Black race variable had a negligible impact on the model's predictive ability. When the Black race variable was removed, the proportion of Black donors above KDPI 85%, a category with a higher risk of organ nonuse, declined from 31.09% to 17.75%, closer to the 15.68% above KDPI 85% among non-Black donors. KDPI represents percentiles relative to all other donors, so the number of Black donors moving below KDPI 86% was roughly equal to the number of non-Black donors moving above KDPI 85%. Removing the Black donor indicator from KDRI/KDPI may improve equity without substantial overall impact on the transplantation system, though further improvement may require the use of absolute measures of donor risk KDRI rather than relative measures of risk KDPI.

1. Introduction

As algorithms have gained influence in medical decision-making, attention has increased on the systemic bias, particularly racial or gender bias, that results from using these algorithms, also known as algorithmic bias. Algorithmic bias may include either failing to account for real differences between groups or giving too much weight to perceived or irrelevant differences between groups, such as when race is used as a proxy for presumed biologic differences.¹ An example of an algorithm failing to account for real differences between groups was one that did not identify sicker Black patients for specialty care on the basis of their recent medical costs because lower health care access meant that Black patients with the same need level as White patients often had substantially lower billing costs.² Remedying this bias required making

the difference in health care expenditure between White and Black patients with the same level of underlying need explicit in the algorithm.

By contrast, the estimation of kidney function using estimated glomerular filtration rate (eGFR) formulas that include an indicator for the Black race is an example of an algorithm for which the race coefficient is used as a proxy for presumed biologic differences, with unjust consequences. The eGFR equation, which includes a Black race coefficient that is presumed without evidence to represent muscle mass differences between the races, can be a barrier to preemptive kidney transplant listing for Black patients.^{3,4} Algorithms that include race coefficients are easier to identify and correct than algorithms that may fail to account for social or economic disparities an individual may experience based on their race, and cases like the eGFR have led to calls to examine the impacts of race coefficients identified in medical algorithms.

Abbreviations: DSA, donor service area; eGFR, estimated glomerular filtration rate; HLA, human leukocyte antigen; IBS, integrated Brier score; KDPI, kidney donor profile index; KDRI, kidney donor risk index; OPO, Organ Procurement Organization; OPTN, Organ Procurement and Transplantation Network; SRTR, Scientific Registry of Transplant Recipients.

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The kidney donor risk index (KDRI) and its standardized version, the kidney donor profile index (KDPI), are algorithms for estimating the quality of a kidney donated by a deceased organ donor. These algorithms currently include a Black race coefficient. The KDRI and KDPI were constructed as prediction scores for the risk of graft failure, given characteristics of the deceased kidney donor (eg, age and Black race) and the transplant (eg, cold ischemia time and a number of human leukocyte antigen [HLA] mismatches).⁵ However, there is evidence of a labeling effect in which higher KDPI kidneys have more challenges in placement and a higher risk of nonuse (kidney recovered for transplant but not transplanted, previously called “discard”).⁶ Recent studies have begun to examine the impact of setting the Black race coefficient to zero,⁷ or refitting the KDRI model without the Black race predictor.⁸ However, previous studies have not examined how these changes in KDRI would affect the standardized KDPI over time because KDPI tables are derived from the KDRI distribution of the previous year’s transplants. In particular, previous studies have used the KDRI-to-KDPI conversion table from a single year rather than recalculating the table for each year of transplants on the basis of their proposed race-free measures of KDRI. This can obscure the actual effect that removing the KDRI race variable would have because, in practice, the KDPI tables are recreated each year to reflect a changing donor population over time. Therefore, in this study, we take a counterfactual approach to ask what would happen if both KDRI and the KDPI annual conversion tables had been calculated without the Black race variable from the start. Specifically, this study (1) recreates, as closely as possible, the original analysis that estimated the KDRI coefficients and examines the change in predictive value and strengths of the other coefficients when removing race as a predictor from the models and (2) estimates changes that would occur in donor KDRI and in the proportion of donors classified as high risk (KDPI > 85%) if KDRI and KDPI were calculated from models without vs with the Black race predictor.

2. Materials and methods

2.1. Study population

This study used data from the Scientific Registry of Transplant Recipients (SRTRs). The SRTR system includes data on all donors, waitlisted candidates, and transplant recipients in the United States, submitted by the members of the Organ Procurement and Transplantation Network (OPTN) and has been described elsewhere.⁹ The Health Resources and Services Administration, US Department of Health and Human Services, provides oversight of the activities of the OPTN and SRTR contractors.

The July 2022 SRTR standard analysis files were used for the analyses, with the aim of matching as closely as possible the original 2009 KDRI analyses of Rao et al.⁵ The study cohort for recreating the KDRI coefficients (with and without Black race in the model) included 69 244 adults (18 years or older), blood-type compatible, deceased donor kidney transplants from January 1, 1995, through December 31, 2005. Transplants were excluded if the recipient had received a previous transplant or the kidney was part of a multiorgan transplant, or if predictor variables were missing or unreasonable, meaning donor height <76.2 cm or >213.4 cm, donor weight <5 kg or >136.4 kg, or donor serum creatinine <0.2 mg/dL or >8 mg/dL. Transplant recipient follow-up was administratively censored on May 1, 2006.

A cohort for validating the KDRI coefficients included 40 090 kidney transplants using the same exclusion criteria as the original cohort from January 1, 2006, through December 31, 2010, with follow-up through May 1, 2011.

A cohort of deceased donors for comparing KDRI and KDPI in recent years with and without the race variable included 72 926 deceased donors who had one or more kidneys recovered for transplant from January 1, 2015, through December 31, 2021. In addition, nonuse (kidneys recovered for transplant but not transplanted) was analyzed in 142 105 kidneys (right, left, or en bloc) recovered from these donors.

2.2. Variables

The outcome of interest was all-cause graft failure, defined as the earliest of death, center-reported graft loss, return to dialysis, or retransplant. Follow-up time was one plus the number of days from transplant to graft failure, center-reported loss to follow-up, or administrative censoring.

Predictor variables included donor age, donor Black race, donor serum creatinine, donor hypertension status, donor diabetes status, stroke as donor cause of death, donor height, donor weight, donation after circulatory death, donor antihepatitis C virus antibodies, number of HLA-B and HLA-DR mismatches, cold ischemia time, and en bloc or double kidney transplant. To accommodate nonlinear relations, continuous variables were modeled with linear splines as described in the original 2009 analysis.⁵ Stratifying variables were transplant center, recipient age in years, and recipient diabetes status. The original 2009 analysis also adjusted for recipient factors that were not explicitly specified.⁵ Recipient factors were, therefore, selected in their linear or categorical form using the backward selection as described therein⁵; recipient factors selected by this process were race, primary diagnosis, pretransplant blood transfusions, weight, peak panel reactive antibodies, years of dialysis, angina, peripheral vascular disease, hepatitis C virus status, and year of transplant.

2.3. Analytic approach

Cox proportional hazards models estimated coefficients for the full (donor and transplant characteristics) KDRI. Separate models were estimated with all predictors selected by Rao et al,⁵ and with all selected predictors except the Black race predictor. Models were stratified to allow separate baseline hazards for each combination of transplant center, recipient age, and recipient diabetes status.

To assess any change in risk discrimination or prediction accuracy from removing the Black race coefficient, concordance statistics¹⁰ and integrated Brier scores (IBSs)¹¹ were calculated in the validation cohort. A higher C statistic represents better risk discrimination; a lower IBS represents better prediction accuracy. For the IBS, both Cox proportional hazards models were re-estimated in the 1995–2005 data set with covariates for recipient age and center instead of strata to allow estimation of survival probabilities beyond the short follow-up times in some smaller strata. In addition, transplants at centers in the validation data set that did not perform transplants during the 1995–2005 cohort (n = 346) were excluded from IBS calculations because survival predictions were not available.

KDRI values were calculated from January 1, 2015, through December 31, 2021, deceased donor cohort separately with the donor coefficients from the fully recreated KDRI model and from the refitted model with the Black race predictor removed. Previous studies have applied published OPTN mapping tables to their recalculated KDRI values.^{7,8} However, as the recalculated KDRI values differ from those calculated in practice (because coefficients differ), it is inappropriate to apply OPTN’s published KDPI mapping tables from policy, which are created annually on the basis of a reference population of KDRI values calculated by the current race-inclusive formula. Therefore, new mapping tables were derived for this study and used to calculate KDPI on the basis of OPTN’s method.¹² Specifically, for each year of data, KDRI values were divided by the median donor-only KDRI of all donors recovered in that year. Cut points of that normalized KDRI for each integer percentile from 1 to 100 were calculated. These cut points were then applied to normalized KDRI (using the same median value) for all transplants starting June 1 of the following year to determine KDPI. For example, KDRI values for all donors recovered from June 1, 2019, through May 31, 2020, were first divided by the median KDRI across all deceased donor transplants in 2018 and then converted into KDPI percentages using the cut points determined from transplants in 2018.

The proportion of donors who would have KDPI >85% was calculated for the model with and the model without the Black race coefficient. KDPI >85% is the cut point for the highest-risk match run for kidneys and represents a higher risk of kidney nonuse.^{6,13} Univariable log-binomial models estimated the relative risk that the donor’s kidneys were classified as KDPI >85% for Black donors than non-Black donors. Two models were fit for KDPI derived with and without the Black race variable. In these models, a higher relative risk would mean that Black donors have a greater probability of being classified as KDPI >85% than non-Black donors. The difference in the proportion of donors who would have KDPI >85% between the models with and without the Black race variable was calculated for each organ procurement organization (OPO) and plotted by the OPO’s donor service area (DSA).

The potential impact of a KDPI without Black race on nonuse was estimated by a logistic regression model. Race-inclusive KDPI was a predictor, modeled by a natural cubic spline with 3 interior knots at values of 20%, 35%, and 85%—the match-run cut points in OPTN policy. Separate models were fit for Black and non-Black donors, both of which adjusted for all of the other donor factors in KDRI and policy period so that the direct effect of KDPI (the coefficient for KDPI) covers any “labeling” effect above and beyond the absolute donor risk. The policy period was defined as before vs after March 15, 2021, when the OPTN began offering kidneys within 250 nautical miles of a donor hospital, replacing DSA, which coincided with an increase in nonuse. The estimated coefficients were then applied to the same data set with KDPI calculated without the Black race predictor to compute counterfactual predicted probabilities of nonuse, assuming no changes in organ acceptance behavior resulting from race not being in the formula. These predicted probabilities were summed to get the total predicted nonuse under a race-free KDPI in the 2015–2021 era. The difference in total predicted nonuse between the models with and without the Black race variable was calculated for each OPO and plotted by DSA.

3. Results

3.1. Change in predictive value and strengths of other coefficients

On average, there was a negligible change to risk discrimination or prediction accuracy of the model when removing the Black race predictor. The model with all predictors had a C statistic of 0.621 and IBS of 0.1262, whereas the model without the Black race predictor had a C statistic of 0.620 and IBS of 0.1263 (Table 1). The all-predictor model had somewhat better prediction accuracy among non-Black donors (IBS = 0.1231) than among Black donors (IBS = 0.1463) but slightly worse risk discrimination among non-Black donors (C statistic = 0.619) than among Black donors (C statistic = 0.640). When removing the Black race variable, prediction accuracy and risk discrimination showed negligible change in both Black and non-Black donors (Table 1).

The model recreating the original Rao⁵ analysis (Table 2, column 2) came relatively close to the original coefficients (Table 2, column 1). However, when the Black race predictor was removed from the model, the biggest relative changes in the other coefficients were for donor serum creatinine (11.12% stronger in its linear association and 11.02% stronger for the greater than 1.5 spline) (Table 2, columns 3–4).

3.2. Change in donor KDRI and proportion of donors with KDPI >85%

The raw KDRI was slightly higher for donors from January 1, 2015, through December 31, 2021, when calculated from the donor coefficients of models that included all predictors (mean [standard deviation [SD]] KDRI = 1.37 [0.49]), as compared with models without the Black race predictor (mean [SD] KDRI = 1.33 [0.46]). For Black donors, the average KDRI decreased substantially after removing the Black race predictor (KDRI with all predictors: mean [SD] = 1.62 [0.58]; KDRI without Black predictor: mean [SD] = 1.33 [0.48]). There was no substantial change in raw KDRI for non-Black donors after removing the Black race predictor

Table 1

Comparing the closest recreation of the original kidney donor risk index (KDRI) and refitted race-free KDRI in graft failure risk discrimination and prediction among kidney transplants in 2006–2010 (N = 40 090).

Measure	Closest recreation of the original coefficients			Closest recreation without race variable		
	Black donors only (n = 5512)	Non-Black donors only (n = 34 578)	All donors (N = 40 090)	Black donors only (n = 5512)	Non-Black donors only (n = 34 578)	All donors (N = 40 090)
C statistic (higher is better)	0.640	0.619	0.621	0.640	0.616	0.620
Integrated Brier score (lower is better)	0.1463	0.1231	0.1262	0.1457	0.1233	0.1263

For concordance statistics, relative risks were compared within strata (recipient age, diabetes status, and transplant center). For integrated Brier score, both models were refit with fixed effects for center and recipient age instead of strata, and transplants at centers not in the original 1995–2005 data set were excluded from the validation set (n = 346 excluded).

(KDRI with all predictors: mean [SD] = 1.33 [0.46]; KDRI without Black predictor: mean [SD] = 1.33 [0.45]).

Using KDPI calculated from the model that included the Black race predictor, there were 11 604 (15.91%) donors from January 1, 2015, through December 31, 2021, with KDPI >85%, including 3397 (31.09%) Black donors and 8207 (13.24%) non-Black donors, a 2.35 (95% confidence interval, 2.27–2.43)-fold greater risk of having KDPI >85% for Black donors. By contrast, using KDPI calculated from the model without the Black race predictor, there were 11 659 (15.99%) donors in the same period with KDPI >85%, including 1939 (17.75%, down from 31.09%) Black donors and 9720 (15.68%, up from 13.24%) non-Black donors, representing a 1.13 (95% confidence interval, 1.08–1.18)-fold greater risk of having KDPI >85% for Black donors. Therefore, removing the Black race predictor brought the chance of Black donors having KDPI >85% closer to parity with, yet still significantly higher than, non-Black donors—decreasing from 135% to 13% increased risk of being classified as KDPI >85%.

Changes in proportions of donors with KDPI >85% were not consistent across geographies. When removing the Black race predictor, DSAs in the southeastern US tended to have fewer donors classified as KDPI >85%, whereas DSAs in the northern and western US tended to have more donors classified as KDPI >85%, though no DSA saw their proportion increase by more than 3% points. The biggest decreases in KDPI >85% were in Mississippi (–5.2% absolute change) and Puerto Rico (–7.1% absolute change) (Fig. 1).

3.3. Change in kidney nonuse

Among kidneys recovered from deceased donors for transplant from January 1, 2015, through December 30, 2021, there were 112 881 (79.4%) transplants and 29 224 (20.6%) instances of nonuse. Of the transplants, 37 174 (32.9%) were in Black recipients, and 75 707 (67.1%) were in non-Black recipients. Of the Black recipients, 7610 (20.5%) received a kidney from a Black donor, whereas 8574 (11.3%) of non-Black recipients received a kidney from a Black donor. In logistic regression models that included KDPI and all the KDRI donor factors separately for Black and non-Black donors, nonlinear KDPI showed significant association with nonuse beyond the components of KDRI in both Black (P = .0009) and non-Black donors (P = .004), indicating some “labeling” effect of KDPI. Applying this model to KDPI calculated without the Black race predictor, we predicted minimal overall change in nonuse

Table 2
Original and updated kidney donor risk index coefficients.

Variable	Original coefficients	Closest recreation of original coefficients	Closest recreation without race variable	Coefficient percent change when removing race variable (%)
Donor age <18 spline	-0.019	-0.018	-0.019	4.68
Donor age >50 spline	0.013	0.012	0.011	-4.97
Donor Black race	0.011	0.012	0.012	-1.26
Donor creatinine	0.179	0.201	NA	100
Donor creatinine >1.5 spline	0.220	0.197	0.218	11.12
Donor hypertension	-0.209	-0.200	-0.223	11.02
Donor diabetes	0.126	0.137	0.150	8.99
Cause of donor death: stroke	0.130	0.154	0.150	-1.98
Donor height <80 spline	0.088	0.090	0.096	7.32
Donor weight <80 spline	-0.046	-0.048	-0.047	-1.50
Donation after cardiac death	-0.020	-0.021	-0.021	-0.94%
Donor anti-HCV antigens	0.133	0.117	0.105	-9.88
Zero HLA-B mismatches	0.240	0.247	0.243	-1.75
One HLA-B mismatch	-0.077	-0.092	-0.096	4.58
Zero HLA-DR mismatches	-0.061	-0.052	-0.051	-3.54
Two HLA-DR mismatches	-0.130	-0.146	-0.147	0.79
Cold ischemia time	0.076	0.048	0.048	1.05
En bloc transplant	0.005	0.004	0.004	-0.95
Double kidney transplant	-0.364	-0.369	-0.363	-1.45
	-0.148	-0.161	-0.159	-1.00

HCV, hepatitis C virus; HLA, human leukocyte antigen.

in the 2015–2021 cohort (32 more total instances of nonuse above the 29 224 observed instances of nonuse), with 353 fewer instances of nonuse among Black donors and 385 more instances of nonuse among non-Black donors.

Changes in predicted kidney nonuse were not consistent across geographies. When removing the Black race predictor, DSAs in the southeastern US tended to have slightly less predicted nonuse, whereas DSAs in the northern and western US tended to have slightly more predicted nonuse, though no DSA saw their predicted nonuse increase by more than 0.3 of a percentage point. The biggest decreases in predicted nonuse were observed in Mississippi (-0.5% absolute change) and Puerto Rico (-0.6% absolute change). (Fig. 2)

4. Discussion

This study found that removing the Black race predictor from the estimation of coefficients for KDRI does not substantially change the model’s predictive value. There would be more parity between Black and non-Black donors in KDRI and KDPI if the Black race predictor were removed from the estimation of coefficients. However, KDPI is a zero-sum measure, meaning that the number of Black donors moving to KDPI of 85% or lower would be offset by an almost equal number of non-Black donors moving to KDPI >85%. When removing the Black race predictor, the total number of donors with KDPI >85% was only slightly higher than when KDPI was calculated from models including the Black race predictor, and models predicted minimal change in the use of recovered kidneys under race-free KDPI, though there were geographic differences in predicted changes in percent with KDPI >85% and in predicted nonuse. Removing the Black race predictor seems to improve parity without increasing the risk of nonuse overall, though additional changes to the process for calculating KDPI may be necessary to reduce disparities further.

Similar to previous studies,^{7,8} our results show that removing the Black race coefficient improves parity in KDRI between Black and non-Black donors. However, both previous studies failed to capture all the nuance of the conversion of KDRI to KDPI and failed to make a comparison of changes in Black donor KDPI classification to non-Black donor KDPI classification. Our study confirms the zero-sum nature of KDPI—that improvements of KDPI classification among one subgroup, in this case, Black donors, are offset by adverse reclassification in other subgroups, which is also reflected in the predicted decrease in nonuse among Black donors being offset by a roughly equal predicted increase in nonuse among non-Black donors. Decreases in KDPI and nonuse for Black donors might have some benefit for Black recipients because Black donor kidneys are somewhat more likely, because of HLA matching, to go to Black recipients. This potential benefit may be partially blunted, however, because most Black recipients (79.5% from 2015 through 2021) received kidneys from non-Black donors, although this study gives some preliminary evidence that changing to a race-free KDPI may not

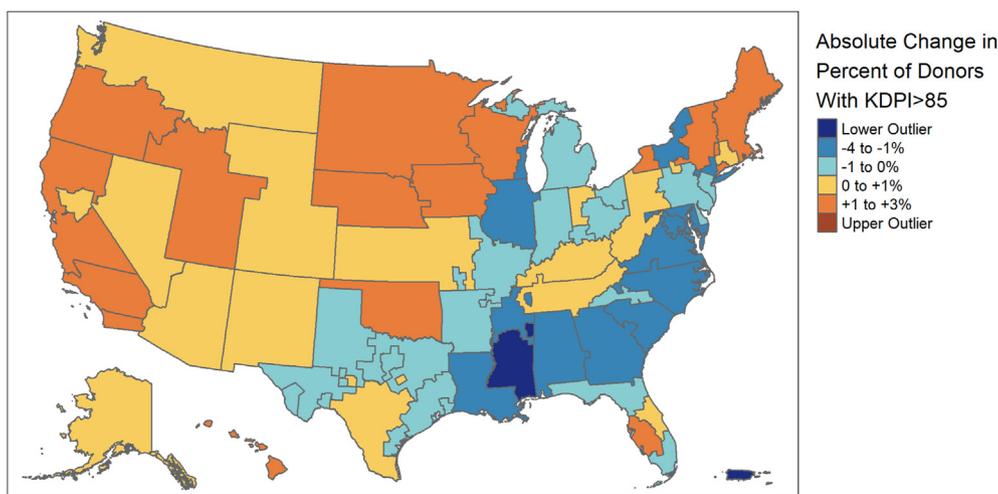


Figure 1. Difference in percent of donors classified as KDPI >85% between KDPI from models estimated without and with the Black race coefficient by organ procurement organization donation service area. KDPI, kidney donor profile index.

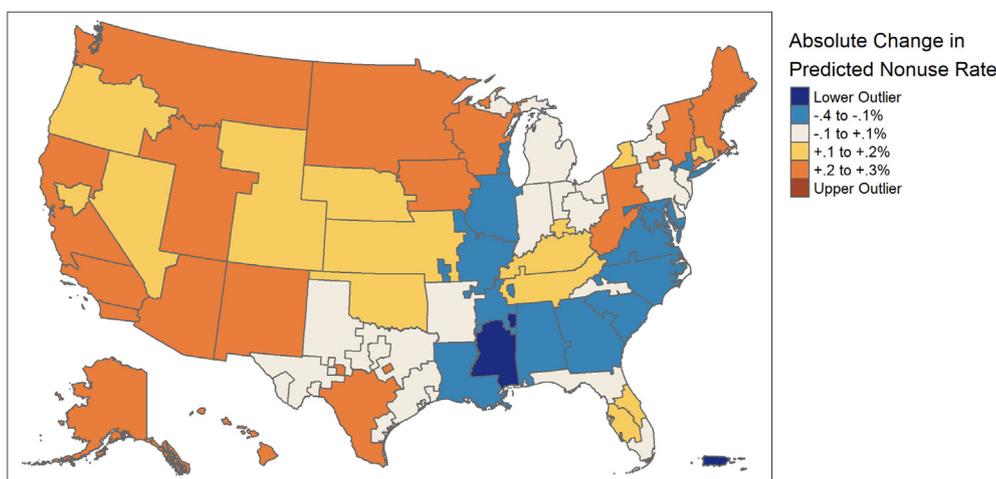


Figure 2. Difference in estimated kidney nonuse predicted from models estimated without and with the Black race coefficient by organ procurement organization donation service area.

substantially change overall nonuse numbers. However, the prevalence of future risk factors is difficult to predict, and our nonuse model cannot fully account for changes in offer acceptance behavior that could accompany changes to KDPI calculation.

Our study also, however, shows that predicted changes in the percent of donors with KDPI >85% and predicted changes in nonuse were not geographically consistent. This is a further shortcoming of the zero-sum nature of KDPI: it is a zero-sum measure nationally, which creates the possibility that it will not be zero-sum in smaller geographies. Fortunately, no DSA in the 2015–2021 cohort would experience a strong adverse effect of switching to a KDPI without the Black race predictor, with a maximum increase in KDPI >85% of 3 percentage points and a maximum increase in predicted kidney nonuse of 0.3 percentage points.

There should be continued study to understand the reasons that the Black race coefficient was significant in the original KDRI model, whether social (eg, accumulated effects of racism) or biologic (eg, *APOL1* gene variants) and particularly how and in what form the race variable, codifying a social construct, is collinear with multiple individual-level variables. Race is a crude proxy for ancestry, which in turn is a crude proxy for whether a donor has 2 risk alleles at *APOL1*.¹⁵ The ongoing, prospective APOLLO (The *APOL1* Long-Term Kidney Transplantation Outcomes Network) study will determine the impact of donor *APOL1* gene variants on allograft outcomes. If more proximal social or biologic measures are associated with allograft outcomes, it might be worthwhile considering them in risk models, though using race as a proxy for these social or biologic measures would introduce ecologic bias when applying the models to individual-level prediction as individuals that identify with a racial group do not experience social or biologic measures equally.

Finally, although our study considered what would happen to a fixed number of kidney donors if the Black race predictor had never been used to calculate KDRI, we recognize that removing the Black race coefficient from the KDRI might reduce barriers to donation among possible Black donors and lead to an increased total number of donors. Interviews and focus groups with Black potential blood/plasma donors¹⁶ and among high school-aged potential organ donors¹⁷ revealed that the perceived “desirability” of donations from Black donors and concerns about “wastefulness” (a concept that included both organ nonuse as well as the possibility that a donated organ may not improve a recipient’s condition or could even harm them) hinder willingness to donate. Information on the decision to remove the Black race coefficient from KDRI and the impact on the classification and nonuse of organs from Black donors may be added to culturally sensitive interventions¹⁸ for increasing donation rates in Black communities to remedy these barriers.

Given these considerations, we suggest that if the Black race coefficient is removed from KDRI and KDPI calculations, the use of KDRI and

KDPI in practice should also be reviewed. We suggest bringing the process closer to an absolute measure of risk, for example, by using KDRI directly, to avoid the unintended consequences of a labeling effect and recalculating models to predict KDRI each year, similar to how SRTR recalculates risk-adjustment models for their program-specific reports twice yearly. Although such a recalculated KDRI might need to be standardized in some way to be easily interpretable by clinicians, it would at least be based on current data that reflect current practice. Any decision to update the calculation of KDRI and KDPI for use in organ allocation policies would be the purview of the OPTN.

Medical algorithms may create systemic bias by failing to account for real differences between groups or by overemphasizing irrelevant differences between groups; this should be kept in mind when rethinking each algorithm. There is no universal way to remove bias from algorithms. KDPI is a relative measure that has implications for both possible kidney donors and possible kidney recipients. We recommend revising the way KDPI is calculated when removing the Black race coefficient and continuing qualitative research with Black recipients about their attitudes toward removing the donor race coefficient in light of possible risks and benefits. Additional research on potential impacts to access and outcomes for Black candidates and recipients under a race-free measure of kidney donor risk (eg, through simulation) is necessary before any changes are made to the way KDRI and KDPI are currently used.

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6. Disclosure

The authors of this manuscript have conflicts of interest to disclose as described by the American Journal of Transplantation. A.K.I. has

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Data availability

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

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