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ORIGINAL ARTICLE

The effect of race coefficients on preemptive listing for kidney transplantation

Mersema Abate[1,2], Nicholas Jandovitz[2,3], Jamie S. Hirsch[1,2,4], Nadine Breslin[3], Lawrence Lau[2,5], Ahmed E. Fahmy[2,5], Kenar D. Jhaveri[1,2], Safiya Richardson[6,7], Yaser Alsalmay[8], Anthony Baez[5], Akash Mishra[4], Siavash Bolourani[2,4,5], Santiago J. Miyara[4], Aaron Winnick[2,5], Gayatri Nair[1,2], Madhu C. Bhaskaran[1,2], Elliot Grodstein[2,5], Adam M. Kressel[5], Lewis W. Teperman[2,5], Ernesto P. Molmenti[1,2,4,5,6,7,8] and Vinay Nair[1,2,5]

[1]Department of Medicine, Norwell Health, Manhasset, NY, USA, [2]Donald and Barbara Zucker School of Medicine at Hofstra/Northwell, Northwell Health, Hempstead, NY, USA, [3]North Shore University Hospital, Department of Pharmacy, Northwell Health, Manhasset, NY, USA, [4]Feinstein Institutes for Medical Research, Northwell Health, Manhasset, NY, USA, [5]Department of Surgery, Northwell Health, Manhasset, NY, USA, [6]System-wide Division of Surgical Innovation, Northwell Health, New Hyde Park, NY, USA, [7]Department of Population Health, NYU Grossman School of Medicine, New York, NY, USA and [8]Department of Surgery, University of Chicago Medicine, Chicago, IL, USA

Correspondence to: Vinay Nair; E-mail: vnair5@northwell.edu

ABSTRACT

Background. Race coefficients of estimated glomerular filtration rate (eGFR) formulas may be partially responsible for racial inequality in preemptive listing for kidney transplantation.

Methods. We used the Scientific Registry of Transplant Recipients database to evaluate differences in racial distribution of preemptive listing before and after application of the Modification of Diet in Renal Disease (MDRD) and the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) race coefficients to all preemptively listed non-Black kidney transplant candidates (eGFR modulation). Odds of preemptive listing were calculated by race, with Black as the reference before and after eGFR modulation. Variables known to influence preemptive listing were included in the model.

Results. Among 385 087 kidney-alone transplant candidates from 1 January 2010 to 2 December 2020, 118 329 (30.7%) candidates were identified as preemptively listed (71.7% White, 19% Black, 7.8% Asian, 0.6% multi-racial, 0.6% Native American and 0.3% Pacific Islander). After eGFR modulation, non-Black patients with an eGFR $\geq$20 mL/min/1.73 m^2 were removed. Compared with Black candidates, the adjusted odds of preemptive listing for White candidates decreased from 2.01 [95% confidence interval (95% CI) 1.78–2.26] before eGFR modulation to 1.18 (95% CI 1.0–1.39; P = 0.046) with the MDRD and 1.37 (95% CI 1.18–1.58) with the CKD-EPI equations after adjusting for race coefficients.

Conclusions. Removing race coefficients in GFR estimation formulas may result in a more equitable distribution of Black candidates listed earlier on a preemptive basis.

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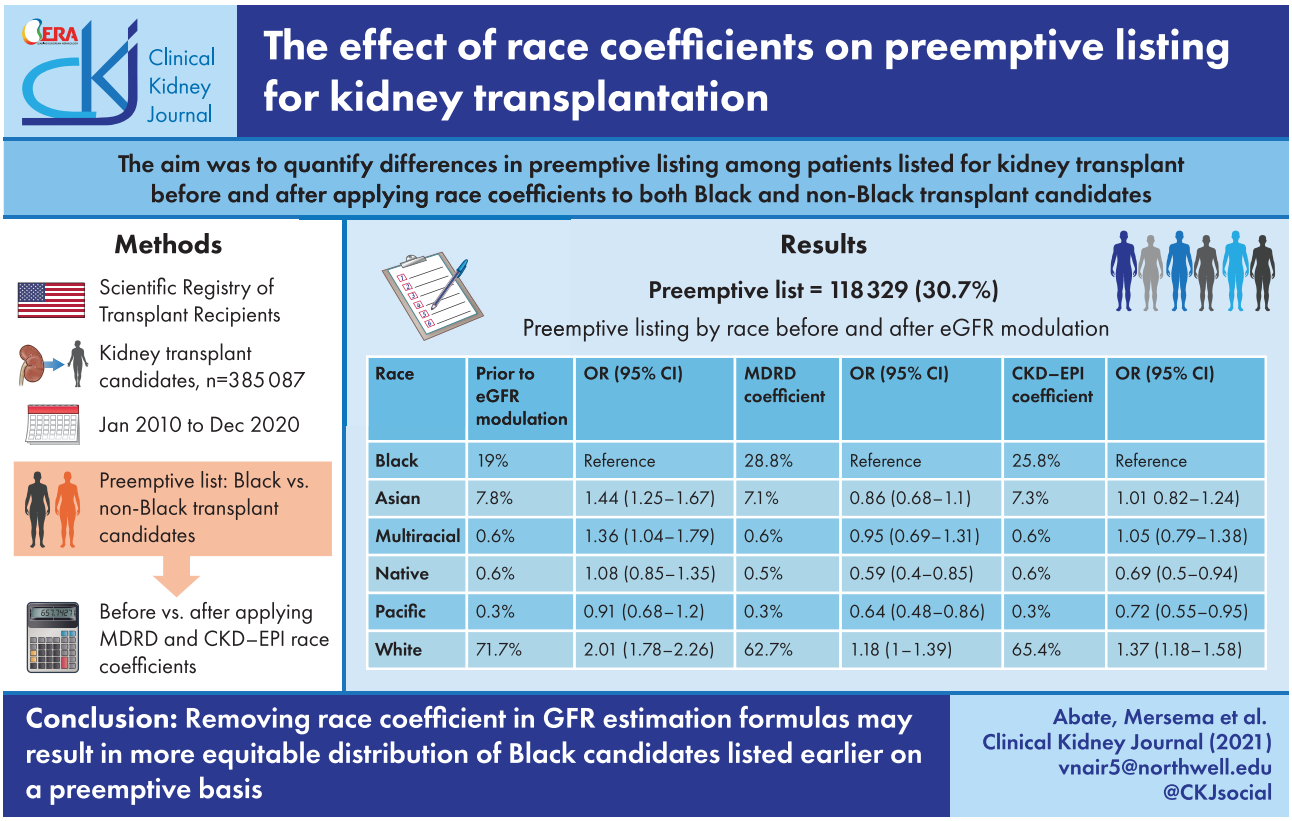
GRAPHICAL ABSTRACT



Keywords: CKD-EPI equation, ethnicity, GFR, kidney transplantation, MDRD

INTRODUCTION

Inequity and bias in present-day medicine can be particularly relevant to racial minorities [1, 2]. Equations that determine kidney function frequently contain race adjustment factors [3], which affect the timing and number of Black patients listed preemptively for kidney transplantation [4].

Preemptive kidney transplantation, where a patient receives a donor kidney prior to initiating dialysis, provides the best outcomes for patients with end-stage kidney disease (ESKD) [5]. Numerous studies have demonstrated a stark difference in the rates of preemptive transplantation in Black patients compared with White patients [6, 7]. Although many factors contribute to this discrepancy, recent focus has been on the Modification of Diet in Renal Disease (MDRD) and the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI), two common formulas used to calculate estimated glomerular filtration rate (eGFR) [8, 9]. During the development of both equations, a race coefficient for the African American race was developed to improve accuracy [10, 11]. These race coefficients result in a higher eGFR at any given creatinine for African American patients. Common practice has been to utilize the African American eGFR for all Black patients, which may result in less preemptive listing in Black patients, as wait time can only begin at a GFR of 20 mL/min/1.73 m^2 or less. Recent guidance from the National Kidney Foundation has called for the removal of race from eGFR equations, and a new CKD-EPI formula has been suggested [12, 13].

It is currently unclear how much of a difference removing race will make in preemptive listing rates. The coefficients for both estimating formulas are small (MDRD 1.212 and CKD-EPI 1.159) and may not substantially contribute to the disparity in preemptive listing when adjusted for other factors such as socioeconomic status. Utilizing the Scientific Registry of Transplant Recipients (SRTR), we quantified differences in preemptive listing among patients listed for kidney transplantation before and after applying race coefficients to both Black and non-Black transplant candidates.

MATERIALS AND METHODS

Data source

This study used data from the SRTR. The SRTR data system includes data on all donors, wait-listed candidates and transplant recipients in the USA, submitted by the members of the Organ Procurement and Transplantation Network (OPTN). The Health Resources and Services Administration (HRSA), US Department of Health and Human Services, provides oversight of the activities of the OPTN and the SRTR contractors. The data that were received were de-identified, and the researchers did not have access to any protected health information. The study did not meet the definition of human subject research, and therefore, Institutional Review Board review was not required.

Study population

Adult wait-listed candidates that were listed for kidney transplantation between 1 January 2010 and 2 December 2020 were

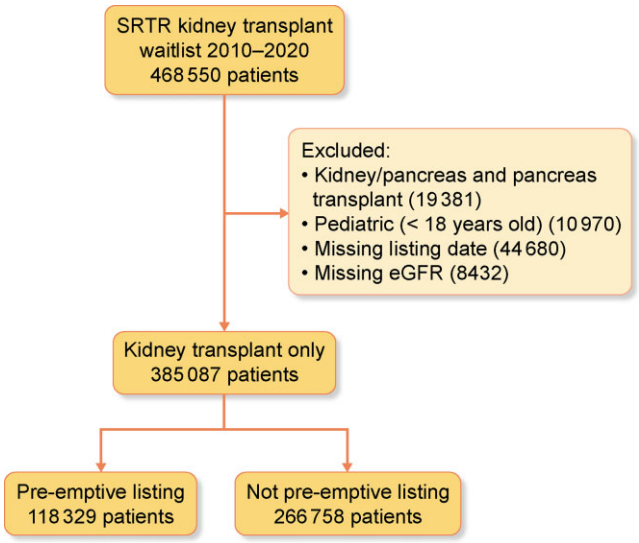


FIGURE 1: Study population.

identified. Candidates with missing listing date, those <18 years old at listing, those listed as preemptive without a GFR value, and those listed for combined organ transplantations were excluded (Figure 1). Candidates were categorized as preemptive if they did not require dialysis or if the listing date was prior to the dialysis initiation date, and non-preemptive if they were initiated on dialysis before the listing date.

Data collection

Candidate sociodemographic characteristics of interest included age at listing, sex, race (Black, White, Asian, multi-racial, Native American or Pacific Islander), ethnicity (Hispanic versus non-Hispanic), physical capacity (no limitations, limited mobility, wheelchair or more limited), employment history, highest level of education completed, insurance (private, Medicare, Medicaid, and so on) and comorbid conditions. Only the comorbid conditions diabetes mellitus (DM), peripheral vascular disease (PVD) and previous kidney transplant were collected due to the high occurrence of missing data for all other comorbid conditions.

GFR identification and modulation

The SRTR reports GFR at the time of listing for patients not on dialysis (preemptively listed). Kidney function is either as listed creatinine clearance or GFR. Patients without a GFR value, including those with only a creatinine clearance, were excluded.

We assumed that the African American race coefficient was applied to all Black patients when calculating eGFR with both MDRD and CKD-EPI equations, as was standard practice. The SRTR does not report which formula was used to determine eGFR. As listing eGFR values for Black candidates must be 20 mL/min/1.73 m^2 or less, removing the race coefficients for Black patients would not help us ascertain their impact on preemptive listing. Therefore, in order to neutralize the effect of race coefficients, we applied the race coefficient to all preemptively listed non-Black patients. This allowed an apples-to-apples comparison utilizing essentially equivalent GFR measurements between Black and non-Black patients. We created two cohorts, one based on the MDRD race coefficient and the other based on the CKD-EPI race coefficient. Accordingly, we recalculated eGFR for non-Black patients by multiplying the listed eGFR with the MDRD race coefficient (1.212) and the CKD-EPI race coefficient (1.159). Once a new eGFR was calculated for each cohort, we removed all non-Black candidates whose newly adjusted eGFR exceeded 20 mL/min/1.73 m^2, as they not would have qualified for preemptive listing.

For statistical analysis, there were a total of five cohorts: (cohort 1) total wait-listed candidates; (cohort 2) non-preemptive-listed candidates; (cohort 3) preemptive-listed candidates; (cohort 4) preemptive Black and non-Black candidates with eGFR ≤20 mL/min/1.73 m^2 after applying the MDRD race coefficient; and (cohort 5) preemptive Black and non-Black candidates with eGFR ≤20 mL/min/1.73 m^2 after applying the CKD-EPI race coefficient.

Statistical analysis

Continuous variables were expressed as median with interquartile range (IQR) and compared with using the Mann–Whitney test. Categorical variables were expressed as percentages and compared with using the Chi-squared test. Preemptive listing for Black versus non-Black races was calculated for each of the 11 regions in the USA as defined by the United Network of Organ Sharing (UNOS) (Figure 2).

To understand the impact of race on preemptive listing, four logistic regression models (univariable and multivariable) were constructed using pre-specified covariates found to impact listing [6, 7]. First, univariable logistic regression was performed using preemptive listing as the dependent variable and race as the independent variable (Model 1). Model 2 evaluated the impact of additional baseline covariates (age and sex) on Model 1. Model 3 added comorbidities (DM and PVD) and physical activity to Model 2. Model 4 (the final model) evaluated the impact of socioeconomic factors (employment history, education level and insurance) added to the prior models. All models were adjusted for the cluster effect of the UNOS listing region. The final logistic regression model was also performed for cohorts 4 and 5 (preemptive Black and non-Black candidates with eGFR ≤20 mL/min/1.73 m^2 after applying the MDRD and the CKD-EPI race coefficient, respectively). Odds ratios with 95% confidence intervals for different models are reported. All analyses were performed using STATA/IC 16.1 (StataCorp LP, College Station, TX, USA), with values of $P \leq 0.05$ considered statistically significant.

RESULTS

Characteristics of preemptive versus non-preemptive listed transplant candidates

Between 1 January 2010 and 2 December 2020, 385 087 adults were listed for kidney transplant alone, with 118 329 (30.7%) being listed preemptively. Characteristics of transplant candidates on the wait list, stratified by preemptive and non-preemptive listings, are shown in Table 1. There were statistically significant differences among age, sex, race, ethnicity, educational status, physical capacity, working for income, insurance and comorbid conditions except previous transplant. Preemptive-listed patients were older than non-preemptive (56 versus 53 years; $P < 0.001$). Although males were more likely to be listed for a kidney transplant (62 versus 38% females; $P < 0.001$), and females were more likely to be listed preemptively (34 versus

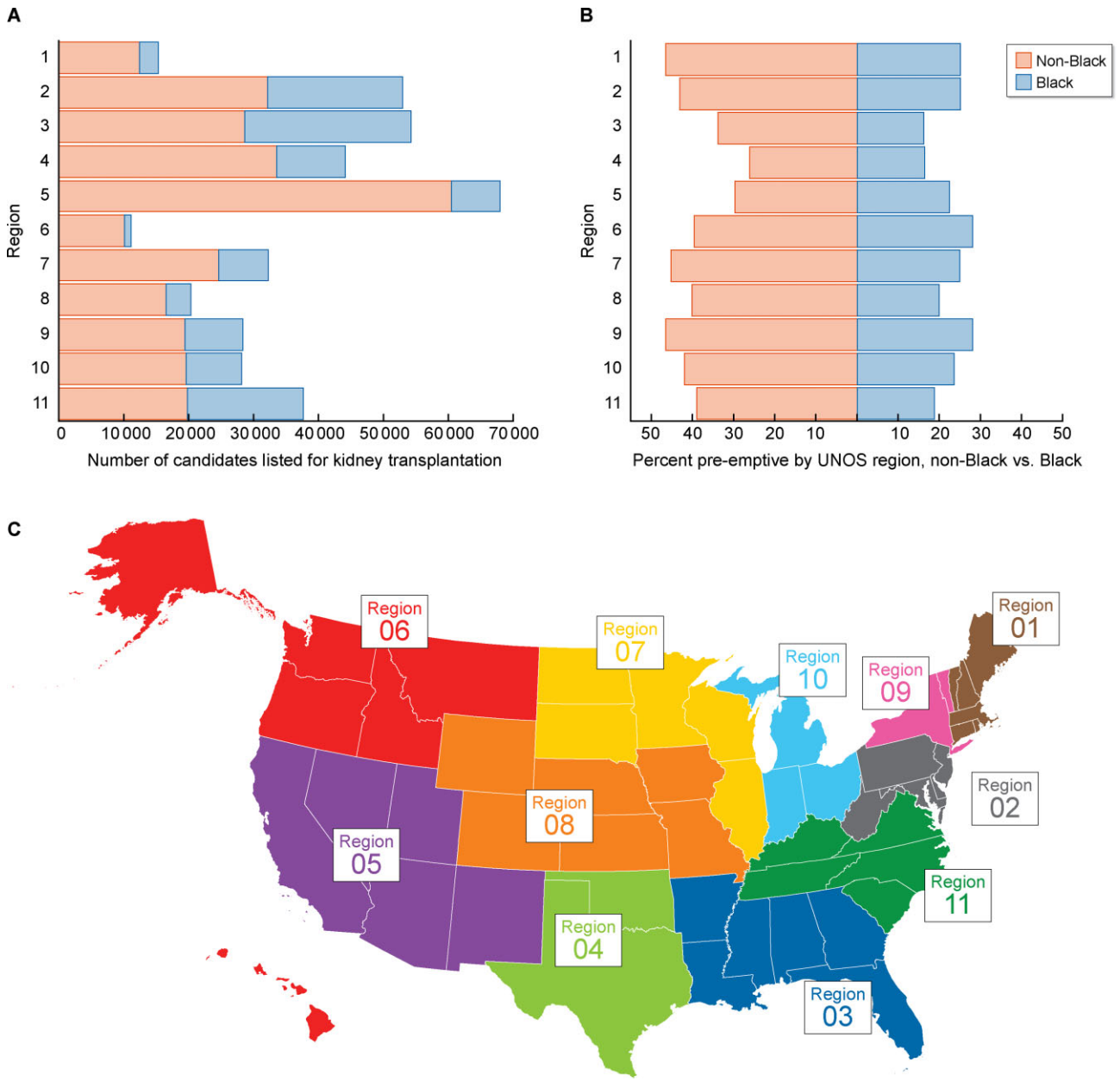


FIGURE 2: (**A**) Number of non-Black versus Black candidates listed for kidney transplantation by UNOS region from 2010 to 2020. (**B**) Percentage of non-Black versus Black patients preemptively listed for kidney transplantation by UNOS region from 2010 to 2020. (**C**) Map of UNOS regions obtained from the US Organ Procurement and Transplant Network. https://optn.transplant.hrsa.gov/about/regions/.

29%; $P < 0.001$). White candidates were overrepresented in the preemptive listing (72% of the group, compared with 61% overall listing), whereas Black candidates comprised 19% of preemptive listings (29% overall listing), and the proportion of Hispanic candidates in the preemptive list was only 12% (18% overall listing). In both preemptive and non-preemptive groups, only 0.5% of Hispanic patients were also documented as Black, limiting subanalysis. Other races maintained a similar proportion of overall and preemptive listings. Patients with higher levels of education, those working for an income and those with private insurance were more likely to be listed preemptively. Patients with DM, PVD and with more limited physical capacity were less likely to be listed preemptively. In all 11 UNOS-based regions of the USA, Black transplant candidates were less likely to be listed preemptively (Figure 2).

Median eGFR in mL/min/1.73 m^2 at listing was different amongst races: 15.1 in Asian, 15.0 in Black, 16.0 in multi-racial, 16.0 in Native American, 14.0 in Pacific Islander and 16.0 in White transplant candidates ($P < 0.001$).

Effect of the MDRD and the CKD-EPI race coefficient on preemptive listing

To assess the effect of race coefficients in preemptive listings, we recalculated eGFR in all non-Black transplant candidates with the MDRD race coefficient (cohort 4), and separately,

Table 1. Baseline characteristics

	Total N = 385 087	Non-preemptive N = 266 758	Preemptive N = 118 329	P-value
Age at listing (years), median (IQR)	54 (44–62)	53 (43–62)	56 (45–64)	<0.001
Male, *n* (%)	237 779 (61.7)	169 509 (63.5)	68 270 (57.7)	<0.001
Race, *n* (%)				<0.001
Asian	28 358 (7.4)	19 085 (7.2)	9273 (7.8)	
Black	112 718 (29.3)	90 275 (33.8)	22 443 (19)	
Multi-racial	2518 (0.7)	1809 (0.7)	709 (0.6)	
Native	3635 (0.9)	2909 (1.1)	726 (0.6)	
Pacific	1810 (0.5)	1431 (0.5)	379 (0.3)	
White	236 048 (61.3)	151 249 (56.7)	84 799 (71.7)	
Hispanic ethnicity, *n* (%)	69 801 (18.1)	55 628 (20.9)	14 173 (12)	<0.001
Educational status, *n* (%)				<0.001
None	2088 (0.5)	1745 (0.7)	343 (0.3)	
Grade school	21 967 (5.7)	18 417 (6.9)	3550 (3)	
High school/GED	142 839 (37.1)	106 515 (39.9)	36 324 (30.7)	
College/technical school	97 880 (25.4)	68 298 (25.6)	29 582 (25)	
Associate/bachelor	74 067 (19.2)	45 031 (16.9)	29 036 (24.5)	
Post college graduate	32 575 (8.5)	17 447 (6.5)	15 128 (12.8)	
Missing	13 671 (3.6)	9305 (3.5)	4366 (3.7)	
Physical capacity, *n* (%)				<0.001
No limitations	123 280 (32)	86 538 (32.4)	36 742 (31.4)	
Limited mobility	12 723 (3.3)	10 500 (3.9)	2223 (1.9)	
Wheelchair or more limited	747 (0.2)	651 (0.2)	96 (0.1)	
Missing	248 337 (64.5)	169 069 (63.4)	79 268 (67)	
Working for income, *n* (%)				<0.001
No	243 750 (63.3)	188 576 (70.7)	55 174 (46.6)	
Unknown	8997 (2.3)	6265 (2.3)	2732 (2.3)	
Yes	130 135 (33.8)	70 498 (26.4)	59 637 (50.4)	
Insurance, *n* (%)				<0.001
Private	163 114 (42.4)	89 992 (33.7)	73 122 (61.8)	
Medicare	179 874 (46.7)	147 542 (55.3)	32 332 (27.3)	
Medicaid	30 096 (7.8)	21 461 (8)	8635 (7.3)	
Other	10 219 (2.7)	6645 (2.5)	3574 (3)	
Diabetes, *n* (%)	166 907 (43.3)	124 309 (46.6)	42 603 (36)	<0.001
Prior kidney transplant, *n* (%)	45 367 (11.8)	31 577 (11.8)	13 790 (11.7)	0.1
Peripheral vascular disease, *n* (%)				<0.001
No	346 503 (90)	237 495 (89)	109 008 (92.1)	
Unknown	3909 (1)	2915 (1.1)	994 (0.8)	
Yes	32 887 (8.5)	25 228 (9.5)	7659 (6.5)	
Missing	1788 (0.5)	1120 (0.4)	668 (0.6)	

GED: General Educational Development.

with the CKD-EPI race coefficient (cohort 5). As described in the methods, we removed all candidates from the transplant waitlist in whom the new calculated eGFR increased to above 20 mL/min/1.73 m^2. The number of preemptively listed non-Black transplant candidates decreased, and racial differences in preemptive listings decreased. The effect was higher with the MDRD versus the CKD-EPI race coefficient. When the MDRD race coefficient was applied to all non-Black candidates, Black transplant candidates comprised 33% of listed patients and 29% of preemptive-listed candidates, while White transplant candidates comprised 58% of listed patients and 63% of preemptive listings. When the CKD-EPI race coefficient was applied to all non-Black candidates, Black transplant candidates comprised 32% of listed patients and 26% of preemptive-listed candidates, while White transplant candidates comprised 59% of listed patients and 65% of preemptive listings. Preemptive listing in all races without eGFR modulation, compared with modulation with the MDRD and the CKD-EPI race coefficient, can be seen in Table 2.

Univariable and multivariable logistic regression

We performed four logistic regression models to understand the interplay between race and preemptive listing. In each model, even following progressive adjustments for sex, co-morbidities, physical functioning and socioeconomic differences, race was highly associated with the odds of preemptive listing. In the fully adjusted model (Model 4), the effect of race was lessened but still present (Table 3). We performed sub-analyses with only male patients (Supplementary data, Table S1) and only female patients (Supplementary data, Table S2). Findings were similar to the full analysis (male plus female). The fully adjusted logistic regression model (Model 4) was performed on the MDRD and the CKD-EPI coefficient adjusted eGFR cohorts. The odds of preemptive listing for non-Black transplant candidates significantly decreased with the application of the MDRD and the CKD-EPI race coefficients. Compared with Black candidates, the adjusted odds of preemptive listing for White candidates was 2.01 (95% CI 1.78–2.26; $P < 0.001$) before eGFR modulation, 1.18 (95% CI 1.0–

Table 2. Preemptive listing by race before and after eGFR modulation

	Prior to eGFR modulation N = 118 329	MDRD coefficient[a] N = 77 915	CKD-EPI coefficient[b] N = 87 096
Asian	9273 (7.8%)	5514 (7.1%)	6389 (7.3%)
Black	22 443 (19%)	22 443 (28.8%)	22 443 (25.8%)
Multi-racial	709 (0.6%)	476 (0.6%)	528 (0.6%)
Native American	726 (0.6%)	401 (0.5%)	478 (0.6%)
Pacific Islander	379 (0.3%)	251 (0.3%)	289 (0.3%)
White	84 799 (71.7%)	48 830 (62.7%)	56 969 (65.4%)

[a]The MDRD race coefficient (1.212) was applied to non-Black patients. Non-Black patients with recalculated eGFR > 20 mL/min/1.73 m^2 were removed.
[b]The CKD-EPI race coefficient (1.159) was applied to non-Black patients. Non-Black patients with recalculated eGFR > 20 mL/min/1.73 m^2 were removed.

Table 3. Logistic regression models with stepwise addition of covariates

	Model 1	Model 2	Model 3	Model 4
Race				
Black	Ref	Ref	Ref	Ref
Asian	OR 1.96** (1.66–2.3)	OR 1.93** (1.63–2.28)	OR 1.79** (1.53–2.1)	OR 1.44** (1.25–1.67)
Multi-racial	OR 1.58** (1.29–1.93)	OR 1.61** (1.32–1.96)	OR 1.66** (1.37–2.01)	OR 1.36* (1.04-–1.79)
Native	OR 1.01 (0.72–1.4)	OR 0.99 (0.71–1.4)	OR 0.98 (0.76–1.26)	OR 1.08 (0.85–1.35)
Pacific	OR 1.06 (0.88–1.29)	OR 1.06 (0.87–1.29)	OR 1.02 (0.77–1.36)	OR 0.91 (0.68–1.2)
White	OR 2.26** (1.83–2.79)	OR 2.24** (1.82–2.76)	OR 2.14** (1.79–2.54)	OR 2.01** (1.78–2.26)
Female		OR 1.34** (1.33–1.35)	OR 1.27** (1.24–1.3)	OR 1.41** (1.38–1.45)
Age		OR 1.01** (1.009–1.014)	OR 1.02** (1.01–1.02)	OR 1.03** (1.026-1.031)
Diabetes			OR 0.59** (0.54–0.65)	OR 0.66** (0.62–0.71)
PVD			OR 0.87** (0.83–0.91)	OR 0.91** (0.88–0.95)
Physical capacity				
No limit			Ref	Ref
Limited			OR 0.52** (0.47–0.58)	OR 0.7** (0.63–0.79)
Wheelchair or more limited			OR 0.39** (0.32–0.47)	OR 0.56** (0.47–0.66)
Education				
None				OR 0.5** (0.38–0.67)
Grade school				OR 0.57** (0.44–0.73)
High school				Ref
Attend college/technical school				OR 1.12** (1.08–1.17)
Associate/bachelor degree				OR 1.31** (1.21–1.41)
Post-college graduate degree				OR 1.59** (1.51–1.67)
Work for income				
No				Ref
Unknown				OR 1.21 (0.97–1.52)
Yes				OR 2.08** (1.97–2.21)
Insurance				
Medicare				Ref
Private				OR 3.13** (2.89–3.39)
Medicaid				OR 2.59** (1.88–3.57)
Other				OR 3.37** (2.46–4.63)

Model 1: impact of race on preemptive listing, unadjusted.
Model 2: adjusted for age and sex.
Model 3: adjusted for age, sex, diabetes, PVD and physical activity.
Model 4: adjusted for age, sex, diabetes, PVD, physical activity, education, work for income and insurance.
*P < 0.05; **P < 0.001.

1.39; P = 0.046) with the MDRD race coefficient and 1.37 (95% CI 1.18–1.58; P = 0.001) with the CKD-EPI race coefficient (Table 4). Although differences in preemptive listings persisted in the final model, the magnitude of the difference was lower after eGFR modulation. The odds of listing for Native Americans and Pacific Islanders decreased after race correction [1.08 and 0.91 (before modulation) to 0.59 and 0.64 (the MDRD coefficient) and 0.69 and 0.72 (the CKD-EPI coefficient), respectively]. There was minimal to no change in the odds ratio of the other predictors of preemptive listing. We performed the same analysis with only male patients (Supplementary data, Table S3) and only female patients (Supplementary data, Table S4). Findings were similar to those seen in Table 4. *P < 0.05; **P < 0.001.

DISCUSSION

Several factors have been found to impact the odds of preemptive listing for kidney transplantation in the USA [6, 7]. In our study, we aimed at reverting any potential bias based on race-adjusting coefficients for the calculation of GFR. Our data suggest that eGFR estimation formulas are a significant but

Table 4. Multivariable analysis of factors associated with preemptive listing of kidney transplant candidates before and after eGFR modulation

	Preemptive listing prior to eGFR modulation			MDRD coefficient			CKD-EPI coefficient		
	Odds ratio	Confidence interval	P-value	Odds ratio	Confidence interval	P-value	Odds ratio	Confidence interval	P-value
Race									
Black	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Asian	1.44	1.25–1.67	<0.001	0.86	0.68–1.1	0.24	1.01	0.82–1.24	0.96
Multi-racial	1.36	1.04–1.79	0.03	0.95	0.69–1.31	0.75	1.05	0.79–1.38	0.75
Native	1.08	0.85–1.35	0.54	0.59	0.4–0.85	0.005	0.69	0.5–0.94	0.018
Pacific	0.91	0.68–1.2	0.5	0.64	0.48–0.86	0.003	0.72	0.55–0.95	0.019
White	2.01	1.78–2.26	<0.001	1.18	1–1.39	0.046	1.37	1.18–1.58	<0.001
Female	1.41	1.38–1.45	<0.001	1.47	1.42–1.53	<0.001	1.46	1.42–1.51	<0.001
Age	1.03	1.026–1.031	<0.001	1.03	1.025–1.029	<0.001	1.03	1.025–1.031	<0.001
Diabetes	0.66	0.62–0.71	<0.001	0.68	0.63–0.73	<0.001	0.67	0.63–0.72	<0.001
PVD	0.91	0.88–0.95	<0.001	0.91	0.87–0.95	<0.001	0.91	0.87–0.95	<0.001
Education									
None	0.5	0.38–0.67	<0.001	0.5	0.34–0.74	<0.001	0.54	0.4–0.75	<0.001
Grade school	0.57	0.44–0.73	<0.001	0.58	0.47–0.73	<0.001	0.58	0.46–0.73	<0.001
High school	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Attend college/technical school	1.12	1.08–1.17	<0.001	1.1	1.06–1.14	<0.001	1.11	1.07–1.15	<0.001
Associate/bachelor degree	1.31	1.21–1.41	<0.001	1.27	1.19–1.35	<0.001	1.28	1.2–1.37	<0.001
Post college graduate degree	1.59	1.51–1.67	<0.001	1.51	1.42–1.61	<0.001	1.53	1.44–1.63	<0.001
Physical capacity									
No limit	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Limited	0.7	0.63–0.79	<0.001	0.7	0.62–0.8	<0.001	0.7	0.63–0.79	<0.001
Wheelchair or more limited	0.56	0.47–0.66	<0.001	0.52	0.4–0.69	<0.001	0.55	0.46–0.66	<0.001
Work for income									
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Unknown	1.21	0.97–1.52	0.09	1.27	1.01–1.6	0.041	1.22	0.97–1.53	0.089
Yes	2.08	1.97–2.21	<0.001	2.1	1.97–2.23	<0.001	2.09	1.96–2.33	<0.001
Insurance									
medicare	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Private	3.13	2.89–3.39	<0.001	3.06	2.84–3.28	<0.001	3.07	2.84–3.31	<0.001
Medicaid	2.59	1.88–3.57	<0.001	2.71	2.02–3.64	<0.001	2.68	1.99–3.62	<0.001
Other	3.37	2.46–4.63	<0.001	3.41	2.53–4.61	<0.001	3.43	2.56–4.59	<0.001

modifiable factor. Based on our final model, the 2-fold increased likelihood of White patients being listed preemptively for transplant decreased to 18% and 37% increased odds of preemptive listing after we applied the MDRD and the CKD-EPI race coefficients to non-Black patients, respectively. Asians, who were also more likely to be listed preemptively, showed no difference after applying the race coefficients.

We opted to apply the MDRD and the CKD-EPI race coefficients to non-Blacks rather than removing the eGFR coefficient factor for Blacks. This approach was prompted by the finding that the SRTR database contains only the GFR at listing rather than values leading up to listing, and that the most common GFR estimating formulas used over the study period were the MDRD and the CKD-EPI equations. Applying the race coefficient factor to non-Black candidates allowed us to develop an equitable scenario between Black and non-Black candidates. Those non-Black candidates in whom the recalculated eGFR increased above 20 mL/min/1.73 m^2 were removed from the preemptive-listed group. Although these patients would likely have been listed preemptively at a later date, our goal was to determine equity at the specific listing time for all races. In addition, a recent study on Black patients with CKD observed that when the CKD-EPI race coefficient was excluded, the median time to reach a GFR of 20 mL/min/1.73 m^2 or less occurred 1.9 years earlier than when it was included in the calculation [14]. Given that the 5-year mortality rate on dialysis is close to 60%, a period of 2 years represents a considerable potential decrease in life expectancy.

The race coefficient was introduced in both the MDRD and the CKD-EPI formulas [9–11]. However, race represents a social construct and is not biologically determined. In the MDRD development dataset, the determination of Black race was largely based on skin color or (even more worrisome and biased) the perception of the person documenting it. In the CKD-EPI development dataset, Black race was self-reported (again, subject to inaccuracy and lacking a biological basis). Because the studies were conducted in the USA, the assumption was that Black patients in the studies were African American (not including non-Black Africans living in the USA). In addition, these equations assume that Black patients are a homogenous group and do not account for ethnic differences or inter-racial status. In fact, the African American race coefficient does not perform well in African populations [15]. The low reporting of Hispanic Black patients in the SRTR dataset also suggests either a poor appreciation of race versus ethnicity or that those patients prefer to identify by either race or ethnicity rather than both. Others have also previously challenged the lack of biological data to support the race coefficient. An analysis of the chronic renal insufficiency cohort study by Zelnick *et al.* [14] found CKD-EPI to overestimate eGFR when compared with iothalamate measured GFR. The eGFR was overestimated by 5 mL/min/1.73 m^2 in patients with a measured GFR between 20

and 25 mL/min/1.73 m^2. This study highlights the evolution of race and illustrates why it should not be a metric for a biological test. Accordingly, after review of the existing data, the National Kidney Foundation has suggested the immediate removal of race from GFR estimating formulas [12]. In addition, a new CKD-EPI formula has been created, which does not include race [13].

Although our data suggest that removing race from GFR estimation formulas will improve disparities in preemptive listing, they are not the sole cause of inequity. Prior studies suggest that insurance type and socioeconomic factors predict preemptive transplantation [6]. Concordant with prior publications, we found several independent factors associated with preemptive listing. Patients with higher levels of education and those who worked for income were more likely to be listed preemptively. This is not surprising, as patients with more education and financial means may be more likely to seek out and pursue transplant evaluation more vigorously. Similarly, patients with private insurance were more likely to be listed preemptively. Candidates on Medicare were least likely to receive a preemptive transplant, likely because the majority obtained Medicare by starting dialysis. In addition, Medicare alone is not sufficient to cover all transplant-related costs. Greater health policy efforts need to be undertaken to improve access for less fortunate individuals. In addition, indices of health including diabetes, PVD and limited mobility were negatively associated with preemptive listing. It is interesting that despite women being less likely to be listed for transplant, those who were listed were more likely to be listed preemptively. The odds ratios for these factors remained significant after adjusting for the race coefficient, again suggesting independence from an eGFR-related bias. When we added these factors to our final model, race remained a significant predictor of preemptive listing. The odds of listing for Native Americans and Pacific Islanders, which were equivalent to Black patients before eGFR modulation, decreased after race correction. Therefore, if GFR coefficients are no longer used for Black patients, the absolute number of Native Americans and Pacific Islanders listed preemptively will remain constant, but the relative proportion may decrease.

Our study suffers from several limitations. It is unclear what formula transplant programs used when calculating eGFR, and whether they included the race coefficient or not. That being said, the most commonly used estimating formulas are the CKD-EPI and the MDRD. Although recent controversy may have resulted in some centers no longer applying the race coefficients, they have been previously accepted and unchallenged for years. In an attempt to provide a better assessment, we applied the race coefficient for all other races, guaranteeing an equalizing approach among all those we were certain had not been initially disadvantaged.

In conclusion, our data show significant racial disparities derived from the inclusion of race coefficients when calculating an eGFR at the time of preemptive listing of Black kidney transplant candidates. Preemptive listing rates more closely mirrored waitlist rates per race when all races were subject to the Black race GFR calculation coefficients. Residual differences suggest other factors outside of this scope of this study should also be investigated. Future prospective studies should re-evaluate preemptive listing rates in the upcoming era without the inclusion of race in GFR estimation formulas.

SUPPLEMENTARY DATA

Supplementary data are available at *ckj* online.

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CONFLICT OF INTEREST STATEMENT

K.D.J. is a consultant for Astex Pharmaceuticals, Natera, GlaxoSmithKline, ChemoCentryx, Chinook and Travere Therapeutics, a paid contributor to UpToDate.com, and receives honorarium from ISN and ASN.

DATA AVAILABILITY STATEMENT

The data reported here have been supplied by the Hennepin Healthcare Research Institute as the contractor for the Scientific Registry of Transplant Recipients (SRTR). The interpretation and reporting of these data are the responsibility of the author(s) and in no way should be seen as an official policy of or interpretation by the SRTR or the US Government.

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