Racial Disparities in Access to Pediatric Kidney Transplantation Since Share 35

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ABSTRACT

Share 35 was enacted in 2005 to shorten transplant wait times and provide high-quality donors to children with ESRD. To investigate the possible effect of this policy on racial disparities in access to pediatric transplantation, we analyzed data from the US Renal Data System before and after Share 35. Among 4766 pediatric patients with incident ESRD, the probability of receiving a deceased-donor kidney transplant increased 46% after Share 35, with Hispanics experiencing the greatest improvements (increases of 81% for Hispanics, 45% for blacks, and 37% for whites). On average, patients received a deceased-donor kidney transplant earlier after Share 35, but this finding varied by race: 63 days earlier for whites, 90 days earlier for blacks, and 201 days earlier for Hispanics. Furthermore, a shift from living- to deceased-donor sources occurred with Share 35 for all races, with a 25% reduction in living donors for whites compared with 48% and 46% reductions for Hispanics and blacks, respectively. In summary, Share 35 seems to have attenuated racial disparities in the time to and probability of children receiving a deceased-donor kidney transplant. These changes coincided with changes in the rates of living-donor sources, which vary by race. Future studies should explore how these changes may impact racial differences in long-term graft outcomes.

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On September 28, 2005, the United Network for Organ Sharing (UNOS) initiated Share 35, an allocation policy that preferentially offers kidneys from deceased donors less than 35 years of age to pediatric patients less than 18 years of age.[1] The intention of this policy was to provide pediatric patients with high-quality donors and shorten pediatric wait times. The Organ Procurement and Transplantation Network operated by UNOS is charged with ensuring "the effectiveness, efficiency and equity of organ sharing in the national system of organ allocation."[2]

Historically, black pediatric ESRD patients have reduced access to the waiting list, wait longer to receive a transplant, and are more likely to experience graft failure compared with white pediatric ESRD patients.[3–8] The racial differences observed in pediatric kidney transplantation are multifactorial and likely influenced by a complex mixture of biologic, immunologic, and socioeconomic factors. Some of the factors that have been thought to play a role include decreased rates of living-donor (LD) kidneys and pre-emptive transplantation, greater histocompatibility mismatches, and lower socioeconomic status (SES) among black versus white pediatric ESRD patients.[3,8–11] Little information has been reported on transplant access in Hispanic children with ESRD; however, the work by Leonard *et al.*[4] found a reduced rate of transplantation among Hispanic versus white pediatric incident dialysis patients. The work by Patzer *et al.*[8] recently reported reduced access to deceased-donor kidney transplantation (DDKT) for both black and

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Hispanic pediatric incident ESRD patients compared with whites, even after adjusting for individual and neighborhood-level measures of SES. However, disparities in access to the waiting list were mitigated in Hispanics with private health insurance.[8]

Since Share 35, pediatric ESRD patients have experienced shorter waiting times for DDKT, but the rate of LD transplants has decreased; additionally, the degree of HLA mismatch from DDKs is greater.[12–14] How the implementation of Share 35 has affected racial disparities in pediatric kidney transplant access has not yet been explored. The objective of this study was to examine how the Share 35 allocation policy impacted the racial disparities previously observed in pediatric kidney transplant wait-listing and transplant.

RESULTS

Study Population

There were several differences in clinical characteristics and baseline demographics between white versus Hispanic and black pediatric ESRD patients, but these differences persisted regardless of era (Table 1). Hispanics and blacks were older at incident ESRD ($P<0.0001$). Blacks were more likely to have FSGS or lupus nephritis compared with whites, who were more likely to have congenital or urologic disease ($P<0.0001$). Blacks had greater body mass index (BMI; $P<0.0001$) and lower serum albumin at incident ESRD ($P<0.01$). Blacks and Hispanics were more likely to have anemia ($P<0.01$) and less likely to have predialysis erythropoietin stimulating agents (ESAs) ($P<0.05$). Compared with whites, Hispanics and blacks were more likely to have public insurance and live in urban areas and poorer neighborhoods (all $P<0.001$). Over one-half of Hispanics and blacks lived in neighborhoods with ≥15% poverty compared with only 20% of whites living in these poorer areas ($P<0.0001$). The only statistically significant difference between eras was a greater proportion of patients with congenital–urologic disease in the Share 35 era.

Among the patients who were transplanted with DDKT, there were several changes in donor quality and transplant characteristics by race and era (Table 2). First, the racial composition of pediatric transplant recipients changed, with proportionately more Hispanics comprising the transplant population in the Share 35 era (36.5% versus 26.7% in Share 35 versus pre-Share 35, $P=0.0012$). Second, in the Share 35 era, there were no longer significant differences by race in degree of HLA mismatching. The proportion of whites who received an HLA mismatch of five or six increased from 39.7% to 57.8% in the Share 35 era, representing a 46% increase, whereas the proportion of Hispanics and blacks receiving an HLA mismatch of five or six decreased nominally (6% and 3.4%, respectively; $P=0.03$). Third, although the mean cold ischemia time was similar by race in the pre-Share 35 era ($P=0.44$), since Share 35, whites have received DDKT with shorter cold ischemia times ($P<0.01$). Fourth, in the Share 35 era, the mean donor age declined by approximately 5 years across all races.

Access to DDKT

We examined the overall probability of receiving a DDKT and analyzed time from wait-listing to DDKT. We censored patients at time of LD transplant. A total of 748 patients were censored over the follow-up period from LD transplant, with significantly more LD transplants (58.4%) in the pre-Share 35 era versus Share 35 era (41.6%; $P<0.0001$). Among all wait-listed patients ($n=2962$), 53.4% of the study population received a DDKT during a median time from listing to transplant of 165 days.

Because we were primarily interested in race and era interaction, we examined the stratum-specific effects of race and era in a multivariable Cox proportional hazards model (Tables 3 and 4). Using the same model, Table 3 shows the effect of era on racial differences in access to DDKT (*i.e.*, era as the primary exposure), whereas Table 4 shows the effect of race within era (*i.e.*, race as the primary exposure). All racial groups experienced a greater rate of DDKT in the Share 35 era, but this finding was particularly notable for Hispanics, whose rate of receiving a DDKT during follow-up increased over 80% (hazard ratio [HR]=1.81, 95% confidence interval [CI]=1.48–2.21 for Hispanics; HR=1.45, 95% CI=1.17–1.79 for blacks; HR=1.37, 95% CI=1.16–1.63 for whites) (Table 3). In addition, all races experienced shorter time from wait-listing to DDKT in the Share 35 era. On average, pediatric patients received a DDKT 84 days earlier in the Share 35 era, but this finding varied by race, from 63 days shorter wait time for whites compared with 90 days shorter wait time for blacks and 201 days shorter wait time for Hispanics.

In crude Cox proportional hazards models, there was a significant race by era interaction ($P=0.02$), indicating that the racial distribution of DDKT changed from the pre- to post-Share 35 eras. In adjusted Cox models, Hispanics were 22% less likely to be transplanted with DDKT compared with whites in the pre-Share 35 era (HR=0.78, 95% CI=0.61–0.99), but after implementation of Share 35, Hispanics seemed equally likely to be transplanted compared with whites (HR=1.02, 95% CI=0.86–1.22). (Table 4) Blacks, however, were 18% less likely to be transplanted versus whites in the pre-Share 35 era (HR=0.82, 95% CI=0.67–1.02) and 10% less likely to be transplanted compared with whites after Share 35 (HR=0.90, 95% CI=0.74–1.00). Although the results for blacks were not statistically significant in either era, the point estimates suggest a modest improvement in DDKT access for blacks versus whites from the pre-Share 35 to Share 35 era. Multivariable-adjusted curves of time from wait-listing to transplant by race and era also support these findings; in the pre-Share 35 era, blacks and Hispanics had longer time to transplant compared with whites ($P<0.0001$), but we found no statistically significant difference in time from waitlist to transplant between racial/ethnic subgroups in the Share 35 era ($P=0.23$) (Figure 1).

Secondary Analyses

Overall Access to Transplant

Importantly, there was a shift from LD to DD transplants for all races in the Share 35 era, and this shift was greater among

Table 1. Demographic and clinical characteristics of study population by race and allocation era

	Pre-Share 35 Era (*n*=2299; 48.2%)				Share 35 Era (*n*=2467; 51.8%)				*P* Value for Era Difference
	White (*n*=1026; 44.6%)	Hispanic (*n*=625; 27.2%)	Black (*n*=648; 28.2%)	*P* Value	White (*n*=1065; 43.2%)	Hispanic (*n*=813; 33.0%)	Black (*n*=589; 23.9%)	*P* Value	
Mean age (years ± SD)	9.5±5.9	10.7±5.4	11.7±5.3	<0.01	9.8±6.2	11.1±5.6	11.5±5.6	<0.01	0.34
Age group (years)				<0.01				<0.01	0.05
<1	137 (13.4%)	44 (7.0%)	51 (7.9%)		170 (16.0%)	71 (8.7%)	40 (6.8%)		
1–5	165 (16.1%)	81 (13.0%)	52 (8.0%)		141 (13.2%)	92 (11.3%)	76 (12.9%)		
6–10	174 (17.0%)	125 (20.0%)	96 (14.8%)		153 (14.4%)	121 (14.9%)	79 (13.4%)		
11–17	550 (53.6%)	375 (60.0%)	449 (69.3%)		601 (56.4%)	529 (65.1%)	394 (66.9%)		
Male sex	591 (57.6%)	334 (53.4%)	360 (55.6%)	0.25	603 (56.6%)	461 (56.7%)	342 (58.1%)	0.83	0.16
Cause of ESRD				<0.01				<0.01	0.03
GN	112 (10.9%)	84 (13.4%)	67 (10.3%)		77 (7.2%)	102 (12.6%)	45 (7.6%)		
secondary GN	81 (7.9%)	34 (5.4%)	23 (3.6%)		89 (8.4%)	33 (4.1%)	28 (4.8%)		
congenital–urologic disease	417 (40.6%)	199 (31.8%)	166 (25.6%)		488 (45.8%)	280 (34.4%)	178 (30.2%)		
FSGS	112 (10.9%)	75 (12.0%)	136 (21.0%)		112 (10.5%)	87 (10.7%)	144 (24.5%)		
lupus	17 (1.7%)	31 (5.0%)	61 (9.4%)		13 (1.2%)	41 (5.0%)	8 (8.2%)		
other	287 (28.0%)	202 (32.3%)	195 (30.1%)		286 (26.9%)	270 (33.2%)	46 (24.8%)		
BMI (quartiles)				<0.01				<0.01	0.73
<16.8	236 (23.0%)	142 (22.7%)	105 (16.2%)		244 (22.9%)	165 (20.3%)	115 (19.5%)		
16.8–19.5	268 (26.1%)	151 (24.2%)	133 (20.5%)		251 (23.6%)	184 (22.6%)	114 (19.4%)		
19.5–23.7	205 (20.0%)	150 (24.0%)	147 (22.7%)		217 (20.4%)	181 (22.3%)	141 (23.9%)		
>23.7	185 (18.0%)	130 (20.8%)	206 (31.8%)		195 (18.3%)	195 (24.0%)	164 (27.8%)		
unknown	132 (12.9%)	52 (8.3%)	57 (8.8%)		158 (14.8%)	88 (10.8%)	55 (9.3%)		
Serum albumin <3.5 g/dl	630 (61.4%)	378 (60.5%)	463 (71.5%)	<0.01	578 (54.3%)	466 (57.3%)	366 (62.1%)	<0.01	0.19
Hemoglobin<11 g/dl	703 (68.5%)	477 (76.3%)	508 (78.4%)	<0.01	730 (68.5%)	592 (72.8%)	443 (75.2%)	<0.01	0.19
Predialysis ESA	469 (45.7%)	248 (39.7%)	255 (39.4%)	<0.05	491 (46.1%)	330 (40.6%)	232 (39.4%)	<0.05	0.69
Health insurance at dialysis initiation				<0.01				<0.01	0.17
public	363 (35.3%)	332 (53.1%)	373 (57.6%)		389 (36.5%)	452 (55.6%)	375 (63.7%)		
private	469 (45.7%)	110 (17.6%)	157 (24.2%)		538 (50.5%)	126 (15.5%)	154 (26.2%)		
other	156 (15.2%)	98 (15.7%)	90 (13.9%)		115 (10.8%)	131 (16.1%)	44 (7.5%)		
none	38 (3.7%)	85 (13.6%)	28 (4.3%)		23 (2.2%)	104 (12.8%)	16 (2.7%)		
Neighborhood poverty (zip code below poverty)				<0.01				<0.01	0.15
0%–4.9%	208 (20.3%)	32 (5.1%)	32 (4.9%)		251 (23.6%)	34 (4.2%)	53 (9.0%)		
5%–9.9%	336 (32.8%)	91 (14.6%)	124 (19.1%)		371 (34.8%)	140 (17.2%)	95 (16.1%)		
10%–14.9%	223 (21.7%)	113 (18.1%)	114 (17.6%)		200 (18.8%)	148 (18.2%)	102 (17.3%)		
15%–19.9%	114 (11.1%)	108 (17.3%)	104 (16.1%)		105 (9.9%)	158 (19.4%)	94 (16.0%)		
>20%	110 (10.7%)	260 (41.6%)	244 (37.7%)		102 (9.6%)	305 (37.5%)	216 (36.7%)		
missing	35 (3.4%)	21 (3.4%)	30 (4.6%)		36 (3.4%)	28 (3.4%)	29 (4.9%)		
Degree of rurality				<0.01				<0.01	0.98
urban	727 (70.9%)	540 (86.4%)	560 (86.4%)		760 (71.4%)	692 (85.1%)	496 (84.2%)		
rural	291 (28.3%)	57 (9.1%)	85 (13.1%)		294 (27.6%)	95 (11.7%)	87 (14.8%)		
unknown	8 (0.8%)	28 (4.5%)	3 (0.5%)		11 (1.0%)	26 (3.2%)	6 (1.0%)		

Table 2. Characteristics of patients transplanted with DD kidneys by race and era

	Pre-Share 35 Era (*n*=637; 40.0%)				Share 35 Era (*n*=954; 60.0%)				*P* Value for Era Difference
	White (*n*=272; 42.7%)	Hispanic (*n*=170; 26.7%)	Black (*n*=195; 30.6%)	*P* Value	White (*n*=370; 38.8%)	Hispanic (*n*=348; 36.5%)	Black (*n*=236; 24.7%)	*P* Value	
Mean age at transplant ± SD (years)	11.7±5.6	11.9±5.1	12.9±4.9	<0.01	12.0±5.2	11.6±5.3	12.9±4.9	<0.01	<0.01
Peak PRA				0.56				0.06	0.12
0	192 (70.6%)	117 (68.8%)	147 (75.4%)		274 (74.1%)	271 (77.9%)	161 (68.2%)		
1–20	51 (18.8%)	31 (18.2%)	31 (15.9%)		69 (18.6%)	42 (12.1%)	48 (20.3%)		
>20	15 (5.5%)	9 (5.3%)	11 (5.6%)		22 (5.9%)	29 (8.3%)	22 (9.3%)		
missing	14 (5.1%)	13 (7.6%)	6 (3.1%)		5 (1.4%)	6 (1.7%)	5 (2.1%)		
HLA mismatch				<0.01				0.05	0.01
0	18 (6.6%)	4 (2.4%)	6 (3.1%)		9 (2.4%)	6 (1.7%)	2 (0.8%)		
1	1 (0.3%)	2 (1.2%)	0		1 (0.3%)	2 (0.6%)	0		
2	9 (3.3%)	2 (1.2%)	3 (1.5%)		8 (2.2%)	5 (1.4%)	1 (0.4%)		
3	47 (17.3%)	18 (10.6%)	14 (7.2%)		40 (10.8%)	40 (11.5%)	14 (5.9%)		
4	83 (30.5%)	39 (22.9%)	51 (26.2%)		92 (24.9%)	108 (31%)	70 (29.7%)		
5	80 (29.4%)	59 (34.7%)	81 (41.5%)		145 (39.2%)	104 (29.9%)	91 (38.6%)		
6	28 (10.3%)	31 (18.2%)	39 (20%)		69 (18.6%)	69 (19.8%)	49 (20.8%)		
unknown	6 (2.2%)	15 (8.8%)	1 (0.5%)		6 (1.6%)	14 (4%)	9 (3.8%)		
Mean cold ischemia time (hours)	15.8±7.4	15.4±8.3	16.3±8.7	0.44	12.9±7.1	15.7±11.8	16.5±12.2	<0.01	<0.01
Mean donor age^2 ± SD (years)	25.7±12.9	26.2±13.4	25.4±11.8	0.52	20.9±7.3	20.9±7.8	20.4±7.9	0.55	<0.01

PRA, plasma renin activity.

Table 3. Multivariable analysis for time to DDKT after wait-listing: Effect of Share 35 allocation era by race

Time from Wait-Listing to Transplant[a]	Median Time to Event ± Interquartile Range (days)	Crude HR (95% CI; Share 35 versus Pre-Share 35)	Adjusted HR (95% CI; Share 35 versus Pre-Share 35)	*P* Value for Adjusted HR
All patients who were wait-listed and received DDKT (*n*=1583)				
pre-Share 35 era	216 (83, 485)	Referent	Referent	
Share 35 era	132 (49, 304)	1.47 (1.33–1.62)	1.46 (1.32–1.63)	<0.01
Whites				
pre-Share 35 era	163 (59,399)	Referent	Referent	
Share 35 era	100 (43, 251)	1.31 (1.12–1.53)	1.37 (1.16–1.63)	<0.01
Hispanics				
pre-Share 35 era	370 (142, 561)	Referent	Referent	
Share 35 era	169 (68, 376)	1.86 (1.54–2.23)	1.81 (1.48–2.21)	<0.01
Blacks				
pre-Share 35 era	219 (93, 498)	Referent	Referent	
Share 35 era	129 (44, 298)	1.37 (1.13–1.66)	1.45 (1.17–1.79)	<0.01

[a]Adjusted for age, etiology of ESRD, sex, OPO region, BMI, blood type, PPRA, insurance, and neighborhood poverty.

Table 4. Multivariable analysis for time to DDKT after wait-listing: Effect of race in pre-Share 35 and Share 35 eras

Time from Wait-Listing to Transplant[a]	Median Time to Event ± Interquartile Range (days)	Crude HR[b] (95% CI; Minority Race/Ethnicity versus White Race)	Adjusted HR[b] (95% CI; Minority Race/Ethnicity versus White Race)	*P* Value for Adjusted HR
Pre-Share 35 era				
white	163 (59, 399)	Referent	Referent	
Hispanic	370 (142, 561)	0.61 (0.50–0.74)	0.78 (0.61–0.99)	0.04
black	219 (93, 498)	0.88 (0.74–1.06)	0.82 (0.67–1.02)	0.07
Share 35 era				
white	100 (43, 251)	Referent	Referent	
Hispanic	169 (68, 376)	0.90 (0.78–1.05)	1.02 (0.86–1.22)	0.82
black	129 (44, 298)	0.97 (0.82–1.14)	0.90 (0.74–1.00)	0.27

[a]Adjusted for age, etiology of ESRD, sex, OPO region, BMI, blood type, PPRA, insurance, and neighborhood poverty.
[b]Overall *P* value for race × era difference (*P*=0.02 in crude model; *P*=0.11 in adjusted model).

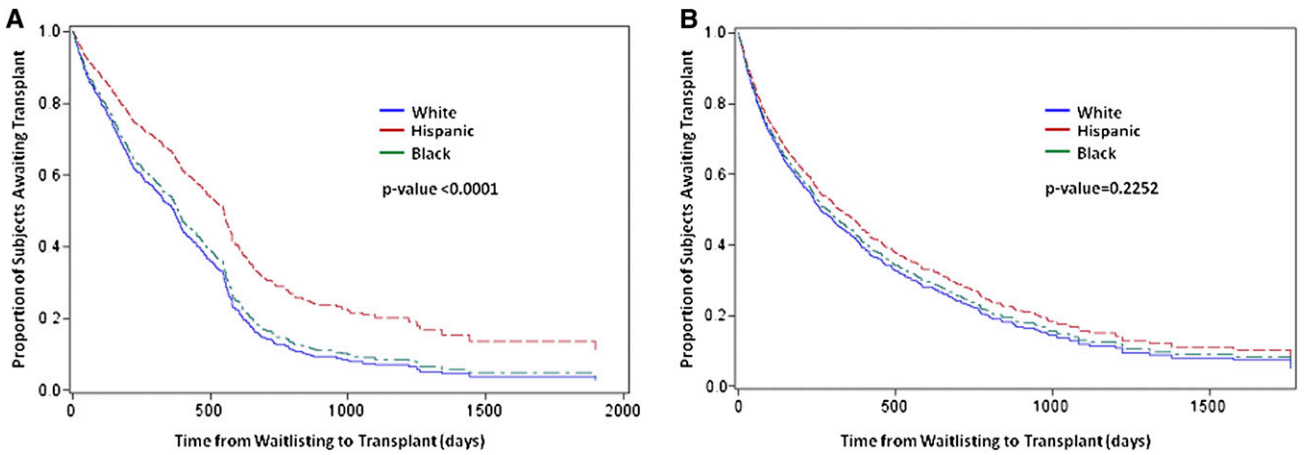

Figure 1. Adjusted survival curves for time from wait-listing to DDKT by race/ethnicity. (A) Pre-Share 35 era. (B) Share 35 era. Values are adjusted for age, etiology of ESRD, sex, OPO region, BMI, blood type, PPRA, insurance, and neighborhood poverty.

blacks and Hispanics, with a 24.6% reduction in LD for whites versus 48.4% and 45.5% reductions in LD for Hispanics and blacks, respectively. We examined whether this shift from LD to DD resulted in greater overall access to transplant by considering the number of incident ESRD patients within each race and era (Table 1) and calculating the proportion of these patients who received a transplant (LD or DD) during our designated follow-up periods (Figure 2). Among whites, 72.5% of

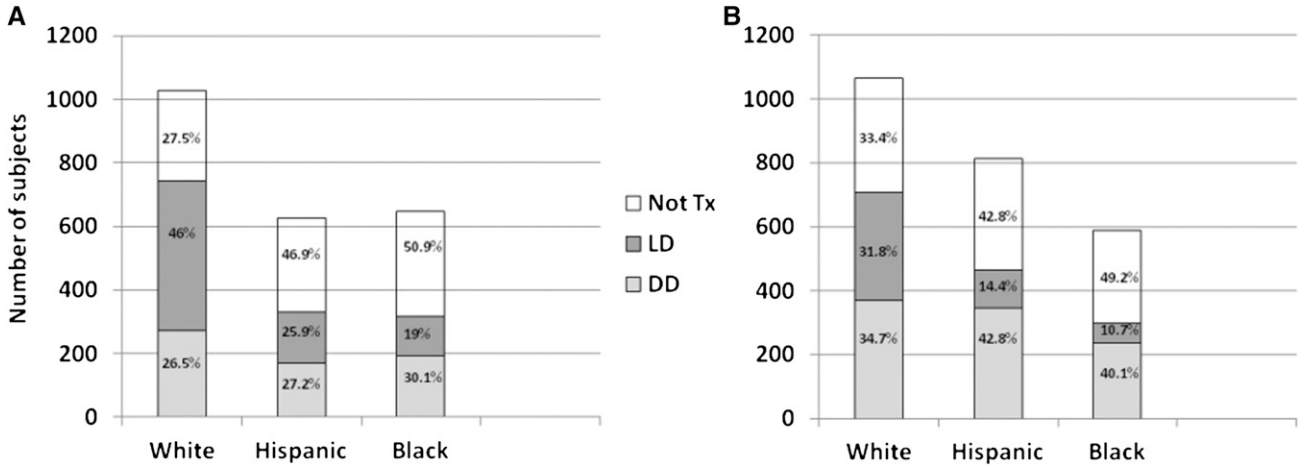

Figure 2. Access to transplant overall among pediatric incident ESRD by race/ethnicity and era. (A) Pre-Share 35 era. (B) Share 35 era.

incident ESRD patients in the pre-Share 35 era were transplanted (26.5% DD and 46% LD) compared with 66.5% of whites with incident ESRD in the Share 35 era (34.7% DD and 31.8% LD). For Hispanic incident ESRD patients, 53.1% (27.2% DD and 25.9% LD) were transplanted in the pre-Share 35 era versus 57.2% (42.8% DD and 14.4% LD) in the Share 35 era. For blacks with incident ESRD, 49.1% (30.1% DD and 19% LD) were transplanted in the pre-Share 35 era versus 50.8% (40.1% DD and 10.7% LD) in the Share 35 era. These numbers represent a proportional change of 43% more DDKT for whites since Share 35, 46% more DDKT for Hispanics since Share 35, and 29% more DDKT for blacks since Share 35. These changes in the distribution of LD versus DD and overall transplant access were all highly significant by race and era ($P<0.0001$).

Sensitivity Analyses

We performed several additional analyses in which we excluded LD transplant recipients and pre-emptive transplants. We also conducted additional multivariable-adjusted analyses that specifically adjusted for time of entry into the study cohort for each patient (in days) to account for temporal confounding by unmeasured factors that may have impacted the outcome independent of Share 35. Notably, the results of all of these sensitivity analyses were consistent with our main findings (data not shown).

DISCUSSION

This study is the first to examine racial disparities in access to pediatric kidney transplantation with respect to a national policy implemented to increase high-quality DDs and shorten wait times among the pediatric population. We found that, in the Share 35 versus pre-Share 35 era, all pediatric patients were significantly more likely to receive a DDKT after being waitlisted (HR=1.46, 95% CI=1.32–1.63). The probability of being transplanted improved the most for Hispanics (HR=1.81, 95% CI=1.48–2.21). Waiting times for transplants were also shorter for all races in the Share 35 era, but this improvement varied greatly by race, from 63 days shorter wait time for whites, 90 days shorter wait time for blacks, and 201 days shorter wait time for Hispanics compared with the pre-Share 35 era. Moreover, although the probability of being transplanted with a DDKT was lower for Hispanics and blacks in the pre-Share 35 era, this finding was attenuated in the Share 35 era (Table 4). These findings taken together suggest that, since Share 35, racial disparities in access to DDKT have been mitigated to some extent.

Shorter waiting times for all pediatric incident ESRD patients and less difference in waiting times between blacks, Hispanics, and whites may be seen as positive outcomes of Share 35 in many respects. Blacks and Hispanics are more likely to be older, be obese, have more anemia, and have less ESA exposure at incident ESRD, suggesting potential later referral. Thus, shorter time to transplant may be particularly beneficial to blacks and Hispanics by minimizing the comorbidities associated with long-standing CKD and dialysis.[15–20]

In addition, Share 35 may have helped overcome some of the socioeconomic barriers that are greater for Hispanics and blacks compared with whites. According to US Census data from 2010, 17.9% of families with children less than 18 years of age were below the poverty level.[21] This finding included 23.3% of black families versus 22.2% of Hispanic families and 7.1% of white, non-Hispanic families. Thus, this US Renal Data System (USRDS) pediatric ESRD cohort seems to have a higher prevalence of poverty compared with the general US population. This findings is consistent with adult studies that also show a higher prevalence of renal disease among the poor and particularly, among racial/ethnic minorities.[22–24]

We found two interesting findings with regard to the previous reports of increased HLA mismatching and shift from DD to LD in the Share 35 era.[12–14] First, since Share 35, there are fewer differences in the degree of HLA mismatch between races,

but this finding seems to be primarily driven by whites receiving poorer HLA matches in the Share 35 era (Table 2). It remains unclear whether the benefits of shorter wait times and younger donors since Share 35 outweigh the risks of higher immunologic discordance between pediatric recipients and donors. Some data suggest that younger-aged donors may be more important than HLA matching.[25] However, in our dataset, the mean donor age among DDs only improved from 25–26 years of age in the pre-Share 35 era to 20–21 years of age in the Share 35 era, and this finding was fairly consistent across races. The difference in comorbidities between these two ages may be nominal. Additional studies will be needed to clarify the long-term impact of these changes in HLA matching across racial subgroups.

Of note, we observed a shift from LDs to DDs among all racial subgroups; however, we noted a larger decline in LD rates among blacks and Hispanics compared with whites. From our data, we were unable to address why this shift in donor source occurred. We have no data on whether family or provider decision making about use of LDs has changed with the enactment of the Share 35 policy. Additional studies are needed to understand why this shift in donor source has occurred and why it has varied by race. Additionally, because the Scientific Registry of Transplant Recipients data continue to show significantly better long-term transplant outcomes for LD versus DD kidney transplant recipients (10-year graft survival of 59.3% for LD versus 43.3% for DD), more longitudinal data will be needed to understand the impact of this shift on long-term allograft outcomes.[26]

Moreover, although more incident ESRD pediatric patients overall were transplanted in the Share 35 era with DD or LD, access to transplant varied by race, with many more Hispanic incident ESRD patients being transplanted since Share 35 versus pre-Share 35, a stable proportion of black incident ESRD patients being transplanted, and fewer white incident ESRD patients receiving a transplant. The decrease in white patients transplanted was primarily driven by lower rates of LD transplantation.

As a cohort study, this analysis has several limitations. First, we are unable to elucidate causality. Although we tried to account for time trends in our analysis, we cannot exclude residual confounding. We used baseline serum albumin, hemoglobin, and ESA use as proxies for general health status but did not have data on health status during follow-up time. We have no data on patients' nonadherence, which may have precluded wait-listing or transplantation. Second, regarding our measures of SES, we used residential zip code data and insurance status as our proxies for poverty, which likely do not completely account for a patient's SES. Third, we excluded patients of other races besides whites, Hispanics, and blacks because of their heterogeneity and small numbers. We, thus, cannot provide valuable insight into how these smaller racial subgroups have been affected by Share 35.

However, our study has several strengths. First, our study is the first to our knowledge to take a comprehensive look at how the Share 35 allocation policy has impacted racial disparity in access to DDKT considering both how waiting times and the quality of donors have changed in the Share 35 era. Second, we considered the spectrum of biologic, immunologic, and socioeconomic factors that might impact transplant access. In particular, we examined SES by neighborhood-level poverty in addition to insurance status. We used the USRDS database, which is virtually complete and includes all incident ESRD patients within the United States with excellent follow-up data on transplantation reported to USRDS by UNOS.

An additional challenge of this study was to determine how to analyze patients who received a pre-emptive transplant or an LD transplant. These patients are different than the general population of pediatric ESRD who are listed for a DDKT after dialysis initiation, because they are more likely to have had pre-ESRD care and perhaps, more resources for LDs. We chose to exclude pre-emptively transplanted patients (who entered the cohort on the day of transplant), because they had no prior dialysis and no access to the waiting list. However, we included all patients who began dialysis or were pre-emptively wait-listed and later transplanted, regardless of donor source. Because several studies had previously noted the shift from LD to DD, we wished to more accurately understand trends in overall access to transplant (LD and DD). Of note, we conducted rigorous and varied analyses to consider and exclude these patients, and we found consistent results, particularly with respect to improved transplant access for Hispanics in the Share 35 era.

In conclusion, since implementation of the UNOS Share 35 allocation policy, pediatric incident ESRD patients have experienced shorter waiting times for DDKT, and there is less difference in waiting times between racial subgroups, with Hispanics experiencing the greatest declines in wait times. However, whites may be receiving more HLA-discordant DD kidneys and proportionately fewer transplants (LD and DD) overall than in the pre-Share 35 era. These observations prevailed even after adjusting for SES. Additional study is needed over time to better understand how these changes will impact racial disparities in long-term transplant outcomes.

CONCISE METHODS

Study Design and Patient Population

We examined a cohort of all incident ESRD patients less than 18 years of age at ESRD start in two equal follow-up periods: before the initiation of the Share 35 allocation policy (pre-Share 35) and after the initiation of Share 35 (Share 35). We defined the pre-Share 35 cohort as all patients initiating dialysis from September 28, 2001 to September 27, 2004 followed through September 27, 2005, and we defined the Share 35 cohort from September 28, 2005 to September 27, 2008 followed through September 27, 2009. We examined how racial disparities in transplant access were influenced by the Share 35 policy by analyzing time from wait-listing to transplant.

A total of 6058 pediatric patients (<18 years) initiated dialysis from September 28, 2001 to September 28, 2004 or between September 28, 2005 and September 28, 2008. Patients were excluded from

this study if they had a previous transplant (n=251). We also excluded patients of race/ethnicity other than white non-Hispanic (white), black, or white Hispanic (Hispanic; n=725) because of small numbers within other racial/ethnic categories. In addition, patients with a start date of entry into the cohort that was the date of transplant (*i.e.*, patient had no prior dialysis and no access to the waiting list) were defined as pre-emptive transplants and excluded from analyses (n=316), leaving a total study population of 4766 pediatric ESRD patients; of these patients, 2299 patients were in the preallocation era, and 2467 patients were in the postallocation era.

Data

ESRD clinical and demographic data as well as wait-listing and transplant events were obtained from the USRDS patient and medical evidence, wait-listing, transplant, and transplant follow-up files. Poverty data were obtained from Census 2000 summary file 3 data linked with patient's residential zip code at the time of ESRD start. Rural Urban Commuting Area codes were obtained from the Community Health Status Indicators Project.

Analyses

Baseline clinical characteristics and demographics were examined for the entire study population and those patients wait-listed and transplanted with DDKT. These data were compared separately by race and era using ANOVA for ordinal variables, chi-squared test for categorical covariates, and *t* tests or nonparametric equivalents of the *t* test for continuous variables. We also compared the racial distribution of covariates by era using ANOVA for continuous variables and a logistic model for categorical variables. Covariates included age, sex, and etiology of ESRD (cystic/congenital/urologic, FSGS, lupus, GN, or secondary GN). We also examined several clinical variables, including mean hemoglobin, serum albumin, and erythropoietin use at incident ESRD (yes/no), BMI (quartiles), peak panel reactive antibody (PPRA; 0, 1–20, or >20), ABO blood type, and HLA matching. We examined donor type (LD versus DD) and cold ischemia time for transplant analyses.

We used two proxies for SES, including health insurance status at dialysis initiation (public, private, other, or none) and neighborhood poverty (the percentage of the population in the subject's residential zip code living below the poverty level). Additionally, we investigated several geographic variables, including degree of urbanity of a patient's residence and Organ Procurement Organization region (OPO; regions 1–11). Patient residential zip code data were classified into Rural Urban Commuting Areas codes and linked with Census 2000 data on neighborhood poverty.

We examined access to DDKT after wait-listing before and after the UNOS Share 35 allocation policy implementation among all pediatric incident dialysis ESRD patients <18 years of age. The primary outcome variable was time from wait-listing to DDKT. The primary exposure was the Share 35 allocation cohort (pre- or postallocation policy change). The secondary exposure variable was race/ethnicity. Incident ESRD was defined as the earliest of the following dates: first ESRD service, dialysis, or start date at Centers for Medicare & Medicaid Services 2728 provider. Wait-listing was classified as yes versus no, regardless of inactive or active status; however, we considered whether a patient was inactive at any time on the waiting list (yes versus no). To assess whether racial disparities varied by Share 35 era, we examined interaction between race/ethnicity and Share 35 era using multivariable-adjusted Cox proportional hazards models and the likelihood ratio test for significance. We calculated the multivariable, stratum-specific effects of both race/ethnicity and Share 35 era to examine both racial and era differences in transplant access. We evaluated confounding by comparing meaningful changes in point estimates from a full model containing all *a priori* covariates to all other potential models. We included patients who were pre-emptively wait-listed (*i.e.*, were placed on the DD waiting list before initiation of dialysis [n=239]) and counted their time to listing as 1 day. Wait-listed patients were censored at death, LD transplant, or end of era.

Patients who were placed on the waiting list but later received LD transplants were censored at the time of LD transplant in this study. Because of evidence that rates of LD transplants have declined post-Share 35, we performed a subanalysis to examine changes in the distribution of donor type (LD versus DD) by race between eras. To reduce the potential impact of confounding by time trends that may have occurred over the follow-up period independent from the Share 35 policy, we conducted additional multivariable-adjusted analyses that specifically adjusted for time of entry into the study cohort (number of days since study start; centered at the median time of follow-up) for each patient. We also used the robust sandwich variance estimator using zip code as the cluster variable to examine neighborhood poverty and individual level covariates simultaneously while accounting for potential correlation of patients within neighborhoods.[27]

For all analyses, a two-tailed P value<0.05 was considered statistically significant. SAS 9.2 was used for all statistical analyses. This study was approved by the Emory Institutional Review Board and USRDS.

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DISCLOSURES

None.

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