Social Determinants of Health and Race Disparities in Kidney Transplant

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Abstract

Background and objectives Black patients have a higher incidence of kidney failure but lower rate of deceased- and living-donor kidney transplantation compared with White patients, even after taking differences in comorbidities into account. We assessed whether social determinants of health (e.g., demographics, cultural, psychosocial, knowledge factors) could account for race differences in receiving deceased- and living-donor kidney transplantation.

Design, setting, participants, & measurements Via medical record review, we prospectively followed 1056 patients referred for kidney transplant (2010–2012), who completed an interview soon after kidney transplant evaluation, until their kidney transplant. We used multivariable competing risk models to estimate the cumulative incidence of receipt of any kidney transplant, deceased-donor transplant, or living-donor transplant, and the factors associated with each outcome.

Results Even after accounting for social determinants of health, Black patients had a lower likelihood of kidney transplant (subdistribution hazard ratio, 0.74; 95% confidence interval, 0.55 to 0.99) and living-donor transplant (subdistribution hazard ratio, 0.49; 95% confidence interval, 0.26 to 0.95), but not deceased-donor transplant (subdistribution hazard ratio, 0.92; 95% confidence interval, 0.67 to 1.26). Black race, older age, lower income, public insurance, more comorbidities, being transplanted before changes to the Kidney Allocation System, greater religiosity, less social support, less transplant knowledge, and fewer learning activities were each associated with a lower probability of any kidney transplant. Older age, more comorbidities, being transplanted before changes to the Kidney Allocation System, greater religiosity, less social support, and fewer learning activities were each associated with a lower probability of deceased-donor transplant. Black race, older age, lower income, public insurance, higher body mass index, dialysis before kidney transplant, not presenting with a potential living donor, religious objection to living-donor transplant, and less transplant knowledge were each associated with a lower probability of living-donor transplant.

Conclusions Race and social determinants of health are associated with the likelihood of undergoing kidney transplant.
Allocation System (KAS) has noted that decreases in racial disparities of deceased-donor transplant since KAS went into effect were short lived. Persistent disparities remain (14). National data and previous research demonstrate that disparities occur at every stage of the transplant process (i.e., referral, evaluation, transplantation, and post-transplant outcomes) (1,15), but different factors contribute to disparities in waitlisting versus receiving a transplant (2,4,16). Thus, it is important to determine which variables are associated with disparities in receiving a transplant, and the type of transplant received, independent of waitlisting (13,16).

To date, no previous work examined the influence of social determinants of health on disparities in receiving a kidney transplant in a prospective sample followed from evaluation initiation to receiving a transplant, as has been done in health behaviors and outcomes in other diseases (17–19). With few exceptions (8,20–26), little work has focused on transplantation, and what has been published is limited by small sample sizes, cross-sectional design, or a limited number and range of predictors (16,27–29). For example, research using Scientific Registry of Transplant Recipients data to model disparities in kidney transplant utilized only cross-sectional and retrospective data (30). Other work (14,29,31) has been limited to predicting disparities in transplant waitlisting with variables collected from national databases or medical records, without predicting time to transplant or type of transplant received. None of these studies assessed patient-reported and other social determinants of health at the time of transplant evaluation, and then followed the patients to predict receiving a transplant and type of transplant received.

We designed our study to address these limitations. We examined the extent to which social determinants of health account for race differences in receiving a kidney transplant and the type of transplant received. By focusing on patients already referred for transplant evaluation, we expand on previous work that examined the disparities present in the referral process and the probability of receiving a transplant (2,9,27,31,32).

Materials and Methods

Study Design

We conducted a prospective cohort study of patients at the University of Pittsburgh Medical Center (UPMC) Starzl Transplant Institute. Shortly after their transplant clinic evaluation appointment, participants completed an approximately 70-minute semistructured telephone interview, comprised of questions derived from existing validated measures, including self-reported race (9,33). We tracked patients via their electronic medical record until they either received a kidney transplant (at UPMC or another center) or experienced any of the following outcomes during the follow-up period: death, withdrawal from the waitlist, evaluation ongoing, closed before waitlist, or still awaiting kidney transplant. The Institutional Review Boards at the University of Pittsburgh and the University of New Mexico approved this study.

Study Sample

Inclusion criteria were: (1) kidney failure; (2) age 18 years and older; (3) English speaking; and (4) referred for kidney transplant evaluation. Because the majority of US recipients are first-time recipients (1), and to prevent patients’ previous experience with transplant from influencing current outcomes, we excluded patients with a previous history of kidney transplant (but not those with previous nonkidney transplants). Between March 2010 and October 2012, 1726 transplant candidates were referred to the UPMC Starzl Transplant Institute for transplant evaluation. The details regarding included and excluded patients are in Figure 1. Median follow-up time was 2.9 years (range, 1.3–4.7).

Independent Variables

Independent variables included demographics, medical factors, culturally related factors, psychosocial characteristics, and transplant knowledge and education (see the complete list of variables in Table 1 and detailed descriptions, ranges, and psychometric properties in Supplemental Table 1).

Outcome Variables

Outcome variables were time from evaluation initiation to receiving a transplant, and type of transplant received. We accounted for all other possible outcomes, which resulted in 13 potential categories:

1. Received living-donor transplant: patient received a living-donor transplant (end point = transplant).
2. Received deceased-donor transplant: patient received a deceased-donor transplant (end point = transplant).
3. Transplanted at another center, transplant type unknown: patient received a transplant at a different center, but transplant type (living or deceased) unknown (end point = transplant receipt if known or date UPMC was informed of transplant, but type unknown because UPMC does not have access to the United Network for Organ Sharing [UNOS] data for other transplant centers, and participants could not be reached for verification, despite several attempts, n = 7).
4. Died before waitlisting: patient died before completing the transplant evaluation; did not receive a kidney transplant (end point = death).
5. Died after waitlisting: patient died while on the UNOS waitlist; did not receive a transplant (end point = death).
6. Still on waitlist: patient was accepted for transplant, added to the UNOS waitlist, and was still on the waitlist at the time of the final medical record review (active and inactive; end point = final medical record review).
8. Closed due to patient choice before waitlist: patient withdrew from the transplant evaluation process before being listed for transplant (end point = closure).
9. Closed due to patient choice after waitlist: patient withdrew from the UNOS waitlist after completing evaluation (end point = UNOS waitlist removal).
10. Closed due to incomplete evaluation: patient started an evaluation but was closed before being accepted or rejected due to incomplete evaluation (end point = closure).
11. Ineligible for transplant: patient completed the evaluation, but was determined ineligible by the transplant team (end point = ineligibility).
For time to receive any CIF of the three kidney transplant outcomes (any transplant, living or deceased) as a function of years from evaluation. Finally, given its important effect on outcomes, we performed variable selection using a backward procedure, removing variables with the highest P value >0.05 sequentially, unless they had subdistribution hazard ratios (SHRs) <0.5 or >2.0, until all remaining covariates were significant at the level of P<0.05 (41). We also examined multicollinearity among variables using variance inflation factors with a cutoff of 5, but found no such problems (data not shown). For each outcome, Model 1 included race/ethnicity as the only covariate; Model 2 included race/ethnicity and adjusted for demographics and medical/health factors; Model 3 included the covariates from Model 2 plus a variable to account for transplantation occurring before or after KAS, and the cultural, psychosocial, transplant knowledge, and education factors.
Table 1. Baseline characteristics by transplant status

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total</th>
<th>Received a Transplant&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Died&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Censored&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic characteristics&lt;sup&gt;d&lt;/sup&gt;</strong></td>
<td></td>
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<tr>
<td>Race/ethnicity</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Non-Hispanic White, n (%)</td>
<td>789 (75)</td>
<td>298 (82)</td>
<td>309 (75)</td>
<td>182 (65)</td>
</tr>
<tr>
<td>Non-Hispanic Black, n (%)</td>
<td>267 (25)</td>
<td>65 (18)</td>
<td>104 (25)</td>
<td>98 (35)</td>
</tr>
<tr>
<td>Sex (female), n (%)</td>
<td>406 (38)</td>
<td>141 (39)</td>
<td>146 (35)</td>
<td>119 (43)</td>
</tr>
<tr>
<td>Age (in yr), mean (SD)</td>
<td>57 ± 13</td>
<td>52 ± 14</td>
<td>61 ± 12</td>
<td>56 ± 13</td>
</tr>
<tr>
<td>Education (≥high school), n (%)</td>
<td>496 (47)</td>
<td>147 (41)</td>
<td>212 (51)</td>
<td>137 (49)</td>
</tr>
<tr>
<td>Household income (&lt;US$50,000), n (%)</td>
<td>739 (74)</td>
<td>214 (62)</td>
<td>316 (81)</td>
<td>209 (79)</td>
</tr>
<tr>
<td>Insurance status, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public only</td>
<td>277 (26)</td>
<td>148 (41)</td>
<td>62 (15)</td>
<td>67 (24)</td>
</tr>
<tr>
<td>Private only</td>
<td>370 (35)</td>
<td>98 (27)</td>
<td>152 (37)</td>
<td>120 (43)</td>
</tr>
<tr>
<td>Public and private</td>
<td>400 (38)</td>
<td>113 (31)</td>
<td>194 (48)</td>
<td>93 (33)</td>
</tr>
<tr>
<td>Occupation (≥skilled manual worker), n (%)</td>
<td>512 (49)</td>
<td>190 (52)</td>
<td>201 (49)</td>
<td>121 (43)</td>
</tr>
<tr>
<td>Marital status (not married), n (%)</td>
<td>512 (48)</td>
<td>171 (47)</td>
<td>195 (47)</td>
<td>146 (52)</td>
</tr>
<tr>
<td>Final status after KAS, n (%)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>428 (41)</td>
<td>130 (36)</td>
<td>166 (40)</td>
<td>132 (47)</td>
</tr>
<tr>
<td><strong>Medical factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI, mean (SD)</td>
<td>29.6 ± 6.3</td>
<td>29.3 ± 6.2</td>
<td>29.6 ± 6.3</td>
<td>29.9 ± 6.3</td>
</tr>
<tr>
<td>Charlson Comorbidity Index, median (IQR)</td>
<td>4.0 (3.0–5.0)</td>
<td>4.0 (2.0–4.0)</td>
<td>5.0 (4.0–6.0)</td>
<td>4.0 (2.0–5.0)</td>
</tr>
<tr>
<td>Type of dialysis, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>366 (35)</td>
<td>168 (46)</td>
<td>87 (21)</td>
<td>111 (39)</td>
</tr>
<tr>
<td>Hemodialysis</td>
<td>583 (55)</td>
<td>158 (44)</td>
<td>277 (67)</td>
<td>148 (53)</td>
</tr>
<tr>
<td>Peritoneal dialysis</td>
<td>107 (10)</td>
<td>37 (10)</td>
<td>49 (12)</td>
<td>21 (8)</td>
</tr>
<tr>
<td>Dialysis duration in yr, median (IQR)</td>
<td>0.2 (0.0–0.7)</td>
<td>0.2 (0.0–0.7)</td>
<td>0.3 (0.1–0.9)</td>
<td>0.2 (0.0–0.7)</td>
</tr>
<tr>
<td>Burden of kidney disease (range: 1–5), median (IQR)</td>
<td>4.0 (3.0–4.7)</td>
<td>3.7 (3.0–4.3)</td>
<td>4.0 (3.0–4.7)</td>
<td>3.7 (3.0–4.7)</td>
</tr>
<tr>
<td>No. of potential donors, median (IQR)</td>
<td>17 (11–29)</td>
<td>20 (12–30)</td>
<td>15 (10–28)</td>
<td>18 (10–27)</td>
</tr>
<tr>
<td>Have a potential living donor at T1 (yes), n (%)</td>
<td>556 (54)</td>
<td>225 (64)</td>
<td>183 (46)</td>
<td>148 (54)</td>
</tr>
<tr>
<td><strong>Cultural factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experience of discrimination (any), n (%)</td>
<td>268 (26)</td>
<td>70 (19)</td>
<td>119 (29)</td>
<td>79 (28)</td>
</tr>
<tr>
<td>Perceived racism (range: 1–5), median (IQR)</td>
<td>2.3 (2.0–2.8)</td>
<td>2.3 (2.0–2.5)</td>
<td>2.3 (2.0–2.8)</td>
<td>2.4 (2.0–2.8)</td>
</tr>
<tr>
<td>Medical mistrust (range: 1–5), mean (SD)</td>
<td>2.4 ± 0.5</td>
<td>2.4 ± 0.5</td>
<td>2.5 ± 0.5</td>
<td>2.5 ± 0.5</td>
</tr>
<tr>
<td>Trust in physician (range: 1–5), mean (SD)</td>
<td>2.2 ± 0.5</td>
<td>2.2 ± 0.5</td>
<td>2.2 ± 0.5</td>
<td>2.2 ± 0.5</td>
</tr>
<tr>
<td>Family loyalty (range: 8–80), mean (SD)</td>
<td>49.8 ± 9.4</td>
<td>49.5 ± 9.6</td>
<td>49.6 ± 9.2</td>
<td>50.7 ± 9.5</td>
</tr>
<tr>
<td>Religious objection to living-donor kidney transplant, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No objection</td>
<td>361 (35)</td>
<td>139 (39)</td>
<td>135 (34)</td>
<td>87 (31)</td>
</tr>
<tr>
<td>Mixed (neutral + no objection)</td>
<td>100 (10)</td>
<td>32 (9)</td>
<td>50 (12)</td>
<td>18 (6)</td>
</tr>
<tr>
<td>Any objection</td>
<td>580 (56)</td>
<td>189 (53)</td>
<td>218 (54)</td>
<td>173 (62)</td>
</tr>
<tr>
<td>Overall religiosity (range: 1–9), median (IQR)</td>
<td>7.0 (4.5–9.0)</td>
<td>6.0 (4.0–8.5)</td>
<td>7.0 (5.0–9.0)</td>
<td>7.5 (5.0–9.0)</td>
</tr>
<tr>
<td><strong>Psychosocial characteristics</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Social support (range: 12–48), median (IQR)</td>
<td>44.0</td>
<td>45.0</td>
<td>44.0</td>
<td>43.0</td>
</tr>
<tr>
<td>Self-esteem (range: 1–4), median (IQR)</td>
<td>3.1 (2.9–3.5)</td>
<td>3.1 (2.9–3.6)</td>
<td>3.0 (2.8–3.5)</td>
<td>3.1 (2.8–3.5)</td>
</tr>
<tr>
<td>Mastery (range: 1–4), median (IQR)</td>
<td>3.0 (2.7–3.1)</td>
<td>3.0 (2.9–3.1)</td>
<td>2.9 (2.7–3.1)</td>
<td>3.0 (2.7–3.1)</td>
</tr>
<tr>
<td>Internal locus of control (range: 1–6), mean (SD)</td>
<td>4.0 ± 1.1</td>
<td>3.8 ± 1.1</td>
<td>4.1 ± 1.0</td>
<td>4.1 ± 1.1</td>
</tr>
<tr>
<td>External locus of control (range: 1–6), mean (SD)</td>
<td>3.4 ± 0.8</td>
<td>3.3 ± 0.7</td>
<td>3.5 ± 0.9</td>
<td>3.5 ± 0.8</td>
</tr>
<tr>
<td>Anxiety (≥moderate), n (%)</td>
<td>47 (4)</td>
<td>13 (4)</td>
<td>21 (5)</td>
<td>13 (5)</td>
</tr>
<tr>
<td>Depression (≥moderate), n (%)</td>
<td>42 (4)</td>
<td>11 (3)</td>
<td>20 (5)</td>
<td>11 (4)</td>
</tr>
<tr>
<td><strong>Transplant knowledge and education</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transplant knowledge (range: 0–27), median (IQR)</td>
<td>22.0</td>
<td>23.0</td>
<td>21.0</td>
<td>21.0</td>
</tr>
<tr>
<td>No. learning activities (range: 0–8), median (IQR)</td>
<td>5.0 (3.0–6.0)</td>
<td>5.0 (4.0–6.0)</td>
<td>4.0 (3.0–5.0)</td>
<td>4.0 (3.0–5.0)</td>
</tr>
<tr>
<td>Total h of learning activities (range: 0–185), median (IQR)</td>
<td>10.3</td>
<td>12.0</td>
<td>10.0</td>
<td>9.5</td>
</tr>
<tr>
<td>Transplant concerns (range: 0–30), mean (SD)</td>
<td>10.9 ± 4.7</td>
<td>10.9 ± 4.8</td>
<td>10.9 ± 4.5</td>
<td>10.8 ± 4.9</td>
</tr>
<tr>
<td>Donor preference, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deceased donor</td>
<td>135 (13)</td>
<td>46 (13)</td>
<td>50 (12)</td>
<td>39 (14)</td>
</tr>
<tr>
<td>Living donor</td>
<td>815 (77)</td>
<td>287 (79)</td>
<td>313 (76)</td>
<td>215 (77)</td>
</tr>
<tr>
<td>No preference</td>
<td>104 (10)</td>
<td>29 (8)</td>
<td>49 (12)</td>
<td>26 (9)</td>
</tr>
<tr>
<td>Willing to accept living donor volunteer, n (%)</td>
<td>934 (90)</td>
<td>333 (93)</td>
<td>355 (88)</td>
<td>246 (90)</td>
</tr>
<tr>
<td>Willing to ask for living donor donation, n (%)</td>
<td>582 (57)</td>
<td>205 (56)</td>
<td>222 (56)</td>
<td>155 (57)</td>
</tr>
</tbody>
</table>

<sup>a</sup> Includes recipients who received a transplant at the time of data analysis.
<sup>b</sup> Includes recipients who died after obtaining a transplant.
<sup>c</sup> Includes recipients who were censored due to follow-up loss.
<sup>d</sup> Includes recipients who received a transplant at the time of data analysis.
<sup>e</sup> Includes recipients who received a transplant at the time of data analysis.
Table 1. (Continued)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total</th>
<th>Received a Transplant&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Died&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Censored&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years from evaluation to final follow-up, mean (range)</td>
<td>3.1 (0.003–8.5)</td>
<td>2.8 (0.07–7.7)</td>
<td>3.3 (0.06–8.2)</td>
<td>3.4 (0.003–8.5)</td>
</tr>
</tbody>
</table>

KAS, Kidney Allocation System; IQR, interquartile range, i.e., the interval between the 25th and 75th percentiles; UPMC, University of Pittsburgh Medical Center; UNOS, United Network for Organ Sharing.

<sup>a</sup>Includes receiving a living-donor transplant at UPMC (n=109; White=100, Black=9), deceased-donor transplant at UPMC (n=218; White=167, Black=51), living-donor transplant at another center (n=15; White=14, Black=1), deceased-donor transplant at another center (n=14; White=12, Black=2), unknown transplant type at another center (n=7; White=5, Black=2). Unknown transplant type because UPMC does not have access to the UNOS data for other transplant centers, and participants could not be reached for verification, despite several attempts.

<sup>b</sup>Died before or after waitlist but before receiving a transplant.

<sup>c</sup>Censoring includes closed by patient choice (n=26–13 before waitlisting and 13 after waitlisting), clinic rejected (n=28), clinic removed patient from waiting list (n=56), transferred to another center (n=19), still in transplant evaluation (n=8), incomplete evaluation (n=114), or still on waitlist (n=29).

<sup>d</sup>n=1 missing for transplant concerns; n=2 missing for occupation, transplant knowledge, donor preference; n=4 missing for family loyalty score; n=5 missing in medical mistrust index, trust in physician; n=6 missing in total social support; n=7 missing for internal and external locus of control, experienced discrimination in health care; n=8 missing for self-esteem scale; n=9 missing for total h engaged in learning activities; n=9 missing for insurance type; n=10 missing for racism in health care; n=15 missing for religious objection to living-donor kidney transplant; n=19 for willing to accept living donor volunteer; n=31 for having living donor; n=32 for willing to ask for living donor donation; n=53 missing/unknown for income.

<sup>e</sup>Final status after KAS refers to whether the patient’s ultimate outcome (i.e., transplant, died, censored) occurred either before or after the KAS policy changes of 2014 to all of the tables that include this variable.

Results

Descriptive Statistics by Transplant Status

Table 1 shows the descriptive statistics of covariates grouped by outcome (covariates grouped by race are available in Ng et al. 2019). Of the 789 White patients, 298 (38%) received a transplant, 309 (39%) died before transplant, and 183 (23%) were censored. Of the 267 Black patients, 65 (24%) received a transplant, 104 (39%) died before transplant, and 98 (37%) were censored for the same reasons listed above (see Table 1, Note A for a breakdown of transplant type by race).

Figure 2 shows that the cumulative incidence of receiving a living-donor transplant increased quickly in the first 2 years and stabilized thereafter, but deceased-donor transplant steadily increased over time. Figure 3 displays the persistent disparity between White and Black patients in living-donor transplant, and but no such disparity in deceased-donor transplant.
Multivariable Association Between Independent Variables and Receiving a Transplant

Tables 2–4 include the final multivariable results for each outcome (see Supplemental Table 2 for results of the univariable models). The value of each significant SHR for a given continuous variable indicates the likelihood of the outcome with a one-unit change in that variable.

For receipt of any type of kidney transplant (Table 2), Black race was associated with a lower probability of transplant, although there was a modest attenuation of the relationship with the inclusion of other factors. With the addition of demographics, medical, cultural, psychosocial, and knowledge factors, we found that Black race, older age, lower income, public insurance, having more comorbidities, being transplanted pre-KAS, higher religiosity, less social support, less transplant knowledge, and engaging in fewer learning activities were each associated with a lower probability of any kidney transplant.

For deceased-donor transplant (Table 3), race was NS in the univariable results or when forced into the model for multivariable analyses. Final model results show that older age, having more comorbidities, being transplanted pre-KAS, higher religiosity, less social support, and engaging in fewer learning activities were each associated with a lower probability of deceased-donor transplant. Because our analysis showed no racial disparities for deceased-donor transplant (as expected given US data [1]), we conducted a sensitivity analysis using medical record data to determine patient status in 2014 (pre-KAS) and in 2018 (post-KAS). We treated KAS as an exposure variable because the policy was uniformly applied to all patients. For deceased-donor transplant outcomes, we found that racial differences decreased from 2014 to 2018 (SHR 0.68 [95% CI, 0.41 to 1.15]; P = 0.15 for 2014; SHR, 0.91 [95% CI, 0.68 to 1.24]; P = 0.53 for 2018). However, this result was not a statistically significant racial disparity at either time point.

For living-donor transplant (Table 4), Black race was associated with a lower probability of transplant in univariable and multivariable analyses. Final model results show that older age, lower income, public insurance, higher body mass index, being on dialysis, not presenting with a potential living donor at evaluation, having religious objections to living-donor transplant, and less transplant knowledge were each associated with a lower probability of receiving living-donor transplant (13).

Discussion

To the best of our knowledge, ours is the first prospective examination of the influence of a comprehensive set of...
<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subdistribution Hazard Ratio</td>
<td>95% Confidence Interval</td>
<td>Subdistribution Hazard Ratio</td>
</tr>
<tr>
<td><strong>Model 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic White</td>
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<td>1 (ref)</td>
<td>1 (ref)</td>
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<tr>
<td></td>
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<tr>
<td>Charlson Comorbidity Index</td>
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<td>Type of dialysis</td>
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<tr>
<td><strong>Model 3</strong></td>
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<tr>
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<td></td>
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<tr>
<td>No. learning activitiesd</td>
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Higher value, greater amount (or higher score) on a particular variable. KAS, Kidney Allocation System; SHR, subdistribution hazard ratio.

*Main event, received a transplant; competing event, died, censoring, still on waitlist or other removal.

Sample size used for Models 1, 2, and 3: n=997 (i.e., those with complete data on all variables; 346 received a transplant, 385 died, 266 censored).

Final status after KAS refers to whether the patient’s ultimate outcome (i.e., transplant, died, censored) occurred either before or after the KAS policy changes of 2014 to all of the tables that include this variable.

The SHR for these variables are per one-point higher in each scale.
<table>
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<th>Variables</th>
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<th></th>
<th></th>
<th>Model 2</th>
<th></th>
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<th>Model 3</th>
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<td>Subdistribution Hazard Ratio</td>
<td>95% Confidence Interval</td>
<td>Subdistribution Hazard Ratio</td>
<td>95% Confidence Interval</td>
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<td>1 (ref)</td>
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<td>Final status after KASc</td>
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<tr>
<td>Overall religiosityd</td>
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<td>0.88 to 0.98</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Social supportd</td>
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<td>1.00 to 1.05</td>
<td></td>
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<td></td>
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<tr>
<td>Transplant knowledge and education</td>
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<td></td>
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<td>Number of learning activitiesd</td>
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<td>1.02 to 1.19</td>
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</tbody>
</table>

Higher value, greater amount (or higher score) on a particular variable. KAS, Kidney Allocation System; DDKT, deceased-donor kidney transplant; LDKT, living-donor kidney transplant; SHR, subdistribution hazard ratio.

aMain event, received DDKT; competing event, LDKT, died; censoring, still on waitlist or other removal; missing, unknown donor type.
bSample size used for Models 1, 2, and 3: n=1036 (i.e., those with complete data on all variables; 231 received a transplant, 525 died, 280 censored).
cFinal status after KAS refers to whether the patient’s ultimate outcome (i.e., transplant, died, censored) occurred either before or after the KAS policy changes of 2014 to all of the tables that include this variable.
dThe SHR for these variables are per one-point higher in each scale.
social determinants of health on undergoing kidney transplantation in a large population (14–16,25,29,31,42,43). In our study of 1056 patients evaluated for transplant, we found that racial disparities in transplant persisted in overall rates of transplant and living-donor transplant, but not for deceased-donor transplant, even after controlling for medical factors and age, income, presenting to evaluation with a potential living donor, KAS implementation in 2014, social support, and transplant knowledge. Although our sample of patients was older and had a larger proportion of White patients than the US population of transplant candidates, it was equivalent in the proportion of women and patients on dialysis (1). It also builds on our previous study (13), which focused on disparities in waitlisting for transplant. The current work tracked patients through 2018 to study disparities in receiving a kidney transplant and the type of transplant received, distinct steps in the transplantation process that have been shown to have different rates of disparities, with potentially different factors influencing outcomes at those steps (1,2,4,15,16).

In line with previous work, we found that Black patients were more than 50% less likely to receive a living-donor transplant (9,15,27,44). Although our previous research demonstrated a lower likelihood of waitlisting for Black patients (13), we found no race differences in receiving a deceased-donor transplant. This finding is most likely due to the influence of KAS and other national policy changes (e.g., elimination of HLA-B matching requirement, credit for time on dialysis) (14,34) on deceased-donor transplant, thus making all patients more likely to receive a transplant, regardless of race.

Consistent with secondary cross-sectional analyses of national data examining kidney transplant outcomes that

<table>
<thead>
<tr>
<th>Table 4. Fine-Gray proportional subdistribution hazards model for time from evaluation to receiving a living-donor kidney transplant* (n=961)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
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<td>-----------</td>
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<tr>
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<tr>
<td>Model 1</td>
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<td>Non-Hispanic Black</td>
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<tr>
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<tr>
<td>Peritoneal dialysis</td>
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<tr>
<td>Model 3</td>
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<td>Any objection</td>
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<td>Transplant knowledge and education</td>
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<tr>
<td>Transplant knowledge</td>
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</tbody>
</table>

Higher value, greater amount (or higher score) on a particular variable. BMI, body mass index; DDKT, deceased-donor kidney transplant; LDKT, living-donor kidney transplant; SHR, subdistribution hazard ratio.

*aMain event, received LDKT; competing event, DDKT, died; censoring, still on waitlist or other removal; missing, unknown donor type.

*Sample size used for Models 1, 2, and 3: n=961 (i.e., those with complete data on all variables; 117 received a transplant, 585 died, 259 censored).

*The SHR for this variable is per one-point higher in the scale.
showed a bolus effect on reducing deceased-donor transplant disparities post-KAS changes (14,43), our prospective cohort showed a reduction in racial differences for deceased-donor transplant. In our case, however, the racial difference was NS at either time point (see Figure 3). As expected, the revision of the KAS policy in December 2014 (which focused on policies regarding deceased organ allocation) affected rates of deceased-donor transplant but not living-donor transplant. Thus, Figure 3 also demonstrates that living-donor transplant disparities persisted across the entire period. Being transplanted after KAS implementation increased the likelihood of overall transplant and deceased-donor transplant (Tables 2 and 3). This study confirms previous work (34) regarding the notable influence of KAS on transplant outcomes and reduction of racial disparities.

In addition to variables known to be associated with disparities in transplant outcomes (e.g., age, body mass index, comorbid conditions such as diabetes and heart disease, dialysis, income or insurance status) (7,27,33,45,46), we identified several social determinants of health that were associated with type of transplant received, including religiosity, social support, and transplant knowledge. Religious objection to living-donor transplant and overall religiosity were both significant independent variables for our patient population. Patients expressing religious objections to living-donor transplant were significantly less likely to receive living-donor transplant. If these individuals felt that their faith community would not agree with their transplant choice, this objection would logically play a major role in their choice of whether to proceed with transplantation (9,47). Transplant teams should consider the utility of screening for religious objections to kidney transplant and have resources available to inform patients about the support of organ donation from the governing bodies of the major world religions (48).

Similar to the benefits of a strong sense of social support found in other clinical and community-dwelling populations (49,50), we found that a sense of greater social support was associated with a higher likelihood of any kidney transplant and deceased-donor transplant. Prior work demonstrated that patients may not pursue transplant for fear of discussing the topic with their friends and family (51). We believe that social support is an asset because it may minimize these fears and lead to higher rates of transplant, supporting the notion that strong social support enables patients to attend to their health care needs. Further, a sense of social support can ensure that patients receive a transplant in a timely manner and the post-transplant care they need (52–54). Other studies suggest social support is associated with higher rates of patients completing pretransplant evaluations (55) and the rate of transplant waitlisting for disadvantaged patients (56). Although social support was not significantly associated with living-donor transplant, we speculate that presenting with a potential living donor at transplant evaluation is, arguably, one of the strongest forms of social support one person can provide to another. This association left little room for social support to stand out as a significant variable associated with living-donor transplant.

Finally, we found that those with greater transplant knowledge or those who engaged in more learning activities were more likely to receive any kidney transplant, deceased-donor transplant, or living-donor transplant. These outcomes support our previous research (9,13,17,33), and others’ work (51,57–59), demonstrating the importance of transplant knowledge to increase rates of transplantation and improve overall patient experience (44). It also suggests that living-donor transplant rates could increase with the implementation of living-donor transplant educational programming that encourages individuals to identify potential living donors (11,51,59,60).

Ours was a single-center study, and the significant independent variables we identified may not generalize to patients at all transplant centers. However, this study highlighted the need to focus on social determinants of health in addition to race to reduce disparity in receiving a kidney transplant. This need would exist in transplant centers that experience any racial disparities, regardless of specific racial or ethnic composition. A second limitation was the lack of data on transplant type (living or deceased donor) for seven of our 1056 participants. However, when we conducted a sensitivity analysis excluding those with an unknown transplant type, we found no difference for the reported results (see Supplemental Table 3). Further, we did not distinguish between active and inactive patients on the waitlist, and were unable to determine racial differences in the proportion of inactive patients.

In addition, when examining medical covariates, we did not examine and control for living donor genotypes as a possible covariate of disparities for living-donor transplant. Genotyping of potential living donors for the APOL1 kidney risk variant remains a controversial issue and could further perpetuate racial disparity in living-donor transplant between Black and White patients (61,62). However, genotyping of potential living donors was not in standard practice at UPMC during the time of this study, and thus could not have contributed to the racial disparity seen in our living-donor transplant results, as no living donor was deemed ineligible due to their APOL1 status. Similarly, we did not include panel reactive antibodies (PRA), which may contribute to racial ethnic differences in deceased-donor transplant, as Black patients tend to have higher antibody levels (32), in our primary analyses. These data were not collected routinely at UPMC during evaluation and were not considered among the criteria for transplant acceptance by the team. Given that our goal was to determine which variables available at evaluation are associated with type of transplant received, and in line with other research focused on this research question (16), PRA would not fit these criteria. However, because these values are important to the clinical evaluation of patients accepted for transplant, and to the extent that other centers continue to observe racial differences in deceased-donor transplant, we added PRA and blood type to our primary analyses in Supplemental Tables 4–8 so that interested readers can explore those variables in this subset of patients. Adding these covariates did not change the overall effect of the key social determinants of health identified in our main analyses. However, their statistical significance decreased due to the smaller sample size.
Reasons for disparities in transplant are complex. Examining medical and social determinants of health in recipients and donors are equally important for these efforts. Additional factors that warrant consideration in future studies of social determinants of transplant disparities include time from kidney failure diagnosis to referral, county/state of residence, family adaptability (63), quantifying risks to potential living donors (64–68), and perceived urgency by patients and potential donors.

Our data suggest a critical need for transplant centers to identify and intervene on social determinants for at-risk populations. As previous research suggests, the most effective programs may include kidney transplant education, providing community-based workshops on kidney transplant and living donation, strengthening patients’ social support networks, and deploying media campaigns to increase awareness of transplant options (11,51,60). This body of work offers a springboard for development of new effective programs may include kidney transplant education, providing community-based workshops on kidney transplant and living donation, strengthening patients’ social support networks, and deploying media campaigns to increase awareness of transplant options (11,51,60). This body of work offers a springboard for development of new interventions that promote equitable and effective transplantation care for all patients with kidney failure. Developing interventions focused on transplant knowledge, religious objection to living-donor transplant, and social support may enhance equal access to kidney transplant because transplant teams can use these risk factors to target patients who may need more support to ensure they receive a transplant.

Disclosures

All authors have nothing to disclose.

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Supplemental Material

This article contains the following supplemental material online at http://cjasn.asnjournals.org/lookup/suppl/doi:10.2215/CJN.04860420/-/DCSupplemental.

Supplemental Table 1. Potential independent variables associated with transplant and type of transplant received.

Supplemental Table 2. Univariable Fine-Gray proportional subdistribution hazard model for time from evaluation to transplant.

Supplemental Table 3. Sensitivity analysis: Fine-Gray proportional subdistribution hazard model for time from evaluation to transplant excluding patients who had unknown transplant type (n=7 of 1056).

Supplemental Table 4. Blood group and panel reactive antibodies (PRA) by transplant status.

Supplemental Table 5. Univariable Fine-Gray proportional subdistribution hazard model for time from evaluation to transplant: blood group and PRA.

Supplemental Table 6. Fine-Gray proportional subdistribution hazards model for time from evaluation to receiving any transplant: blood group and PRA.

Supplemental Table 7. Fine-Gray proportional subdistribution hazards model for time from evaluation to receiving a deceased-donor kidney transplant: blood group and PRA.

Supplemental Table 8. Fine-Gray proportional subdistribution hazards model for time from evaluation to receiving a living-donor kidney transplant: blood group and PRA.

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