



Reviewing Racial Disparities in Living Donor Kidney Transplantation: a Socioecological Approach

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Abstract

Despite kidney transplantation having superior outcomes to dialytic therapies, disparities continue to exist among rates of kidney transplantation between Black and non-Hispanic White patients, which cannot be explained by differences in individual characteristics. To better evaluate the persistent Black/White disparities in living kidney transplantation, we review the extant literature and include the critical factors and recent development in living kidney transplantation in the socioecological approach. We also emphasize the potential vertical and hierarchical associations among factors in the socioecological model. Specifically, this review explores the possibility that the relatively low living kidney transplantation among Blacks may be a consequence of individual, interpersonal, and structural inequalities in various social and cultural dimensions. At the individual level, the Black/White differences in socioeconomic conditions and transplant knowledge may account for the low transplantation rates among Blacks. Interpersonally, the relatively weak social support and poor communication between Black patients and their providers may contribute to disparities. At the structural level, the race-based glomerular filtration rate (GFR) calculation that is widely used to screen Black donors is a barrier to receiving living kidney transplantation. This factor is directly related to structural racism in the health care system but its potential impact on living donor transplantation is underexplored. Finally, this literature review emphasizes the current perspective that a race-free GFR should be considered and a multidisciplinary and interprofessional perspective is necessary to devise strategies and interventions to reduce the Black/White disparities in living donor kidney transplantation in the U.S.

Keywords Living donor kidney transplantation · Racial/ethnic disparities · Socioecological model · Structural racism

Introduction

Since the nascence of epidemiology as a field of academic study and the development of public health as an integral part of the prevention of disease, researchers have found that despite the profound progress made with improvements in sanitation and living conditions, persistent health disparities continue to exist along various social dimensions. This

is especially true in the United States (U.S.) with respect to chronic kidney disease. Chronic kidney disease (CKD) is a progressive condition that is frequently a complication of longstanding hypertension or diabetes mellitus and disproportionately affects Blacks compared to other ethnic groups. According to the 2021 Annual Report of the U.S. Renal Data System [1], the incidence of end-stage renal disease (ESRD) was higher in Blacks than in other racial or ethnic groups and was up to three times higher than in the non-Hispanic White population. An estimated 5000 patients die waiting for a kidney transplant each year with approximately 37,000 patients being added to the wait list and only ~23,600 patients successfully being transplanted in 2020 [2]. This annual increase in the wait list has presented significant challenges for the public health and nephrology communities given the importance of this life-sustaining intervention to patients who suffer from ESRD. Yet, despite kidney transplantation having superior outcomes to dialytic therapies, disparities in kidney transplantation between

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Black patients and non-Hispanic White patients continue to exist, an issue that has garnered increasing attention in the nephrology community. One prospective cohort study performed by Ng and colleagues [3] demonstrated that African-American patients were 25% less likely to be waitlisted for kidney transplantation than White patients after adjusting for medical factors and social determinants of health. A subsequent prospective cohort study published in 2021 by Wesselman and colleagues [4] demonstrated that after adjusting for various social determinants of health, Black patients were also less likely to receive a kidney transplant and living donor transplant than White patients.

The disparities in living donor kidney transplantation among Black patients compared to White patients have been increasingly evident over the past decade. According to the Organ Procurement and Transplantation Network 2020 Annual Data Report, 64% of all living donor transplants that occurred in the U.S. went to White patients compared to 11% to Black recipients and 16% to Hispanic patients in 2020 [2]. Given that Black patients represent 35% of all patients with kidney disease, the racial composition of living donor transplants further highlights the severity of racial disparities in living donor transplants [5].

Unfortunately, this disparity has only gotten worse with time. According to a study by Purnell and colleagues [6], national registry data has demonstrated that the 2-year incidence rate of living donor kidney transplantation increased to 11.4% in 2014 from 7.0% in 1995 in White patients, but actually decreased to 2.9% in 2014 from 3.4% in 1995 in Black patients [7]. Based on data from the National Healthcare Quality and Disparities Reports from the Department of Health and Human Services, only 12.6% of Black dialysis patients compared to 16.6% of White dialysis patients under age 70 were registered on a waiting list for transplantation or received a deceased donor kidney transplant within 1 year of dialysis initiation in 2017, despite a 3.5 to fourfold higher risk of kidney disease in non-Hispanic Black patients compared to non-Hispanic White patients [4, 8]. These studies warrant further intervention from policymakers and nephrologists alike to enhance equal access to this critical need for patients with ESRD.

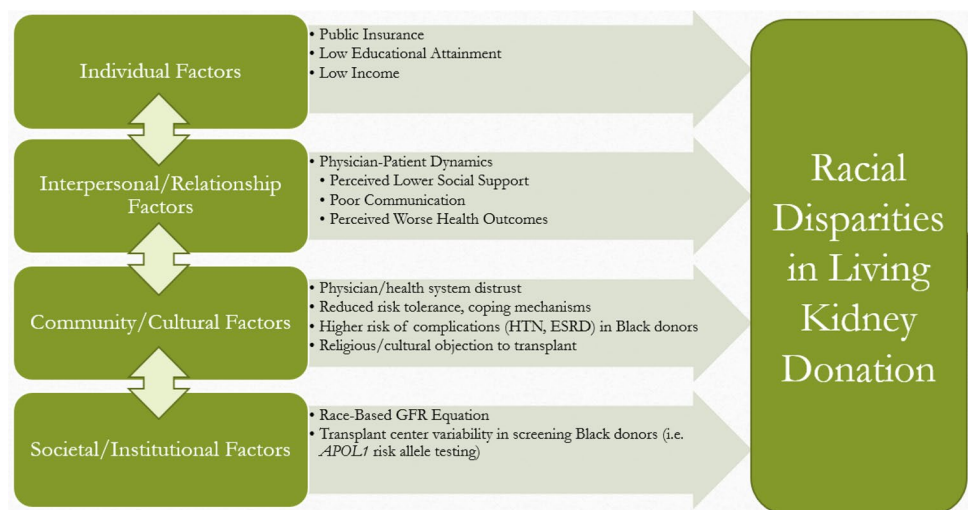
To address this disparity, a comprehensive study exploring factors that underlie and maintain it must be at the heart of any intervention. Purnell and colleagues [6] suggested using a theoretical framework that examined the recipient/donor-level barriers, health care provider and health system level barriers, and population/community-level barriers at various stages of the transplant evaluation cycle to understand the racial/ethnic disparities in access to living kidney transplantation. In Diderichsen et al.'s [9] seminal work, "The Social Basis of Disparities in Health," the authors propose a socioecological framework to study the upstream and downstream mechanisms within an individuals' contextual environment to explain disparities in health outcomes.

This socioecological approach to understanding barriers in achieving health equity has been adopted in previous research because it serves as a foundational model for racial/ethnic health disparities research. For example, Arriola [10] utilizes a similar approach to identifying how racism in its various forms (internalized racism, personally mediated racism, and institutionalized racism) influences access to renal transplantation. Many individual factors, interpersonal/relationship factors, community/cultural factors, and societal/institutional factors exist that maintain the current disparity in living donor kidney transplantation that has persisted between Black and non-Hispanic White patients. Indeed, Wesselman and colleagues [4] showed that despite Black patients having a 72% lower likelihood of receiving a living donor kidney transplant when using race as the only covariate, this was attenuated to 51% when controlling for other demographics, medical/health factors, and psychosocial, educational, cultural, transplant knowledge factors, suggesting the benefit of a multilateral approach.

The need for novel ways to approach this issue is pressing and calls are being made within the nephrology community to develop new national strategies to rethink how to reduce these increasing disparities, especially in light of the disproportionate effect of the COVID-19 pandemic on Black communities [11, 12]. Our literature review utilizes a socioecological framework to explain racial/ethnic disparities in living donor kidney transplantation as we argue that such an approach might be better able to address these factors by informing more multifaceted, comprehensive interventions that target the entire context surrounding an individual, rather than single factors. Compared with prior studies, this review highlights the potential vertical and horizontal associations among factors [4, 6]. Explicitly, the vertical relationships *across levels* suggest that societal factors may have a spillover effect down to the interpersonal or individual level and vice versa. The horizontal associations indicate that the factors at the same level are not mutually independent and the intersectionality of these factors may amplify the effect of each factor on living donor kidney transplants. Such associations are not commonly acknowledged in the literature and we explain them below.

Although other conceptual frameworks may address the factors that underlie these racial disparities, by using a socioecological framework, a hierarchical structure may be clearly demonstrated, especially given recent work by the NKF-ASN Task Force to reassess the inclusion of race in the estimation of glomerular filtration rate, a process that may have potential implications on the timing of referral for renal transplantation and racial disparities in kidney transplantation [13]. Figure 1 demonstrates the socioecological framework of this review. We will first focus on the individual factors, followed by interpersonal level and community/cultural determinants, and, finally, discuss societal/

Fig. 1 Theoretical framework—using a socioecological approach to rethink racial disparities in LDKT



institutional factors that contribute to maintaining the racial disparities witnessed in living donor kidney transplantation. As discussed previously, factors at one level may interact with others at another level, which is shown by the double arrows in Fig. 1.

Individual Factors

Diderichsen et al. [9] describe how an individual's "social position" can be characterized by factors that are independent of the individual that possesses them. Factors such as an individual's insurance status, income, and educational attainment can all influence an individual's access to finite resources, especially when there is an unequal distribution of these resources in society [9]. These individual factors can provide important context to the etiology of any existing health disparities, and although many are not modifiable, those factors that are modifiable can subsequently serve as meaningful targets for intervention.

Insurance status is an important modifiable individual factor that has been at the heart of larger federal policy interventions, such as the Affordable Care Act. Although individuals with ESRD are often covered by Medicare, disparities in living donor kidney transplantation based on insurance status have persisted. A single-center study by Reeves-Daniel and colleagues [14] in 2013 showed that among patients who received living donor kidneys, those with private insurance were 3.4 times as likely as individuals without private insurance to receive a living donor kidney transplant. Among African-American recipients, those with private insurance were 18.3 times as likely as those without private insurance to receive a living donor kidney transplant [14]. In contrast, recipients with Medicaid were found to be 75% less likely to receive a living donor kidney transplant [14]. There were no African-American recipients with Medicaid in this cohort.

Despite the majority of this cohort (91%) having Medicare, the authors' study suggests that a recipient's insurance status was associated with living donor kidney transplantation, specifically, those having private insurance being more likely to receive a living donor kidney and those with Medicaid being less likely to receive one [14]. Similarly, Johansen and colleagues [15] found that patients without private insurance were less likely to be assessed for kidney transplantation compared to those with private insurance.

Racial disparities in insurance coverage have been studied in the literature and corroborated by national census data. A study by Sohn [16] found that African-Americans had persistently lower insurance coverage compared to non-Hispanic Whites at all ages. Citing the Bureau of Labor Statistics, Sohn [16] noted that unemployment rates were higher and job loss more prevalent in African-Americans than non-Hispanic Whites. Despite programs such as the Consolidated Budget Reconciliation Act (COBRA) that provide insurance coverage during events leading to insurance loss and need-based insurance programs such as Medicaid, the racial disparities in insurance coverage persisted [16]. Based on a report published by the U.S. Census Bureau, in 2019, non-Hispanic Whites (5.2%) were also found to have lower uninsured rates compared to Blacks (9.6%) [17]. Addressing these disparities in uninsurance and underinsurance rates may serve as a key target for improving equity in living donor kidney transplantation.

Several other individual factors may also contribute to the racial disparities witnessed in living donor kidney transplantation. While public insurance was found to be associated with lower rates of living donor kidney transplantation in their study, Wesselman and colleagues [4] found that income and transplant knowledge were independently associated with rates of living donor kidney transplantation. Recipients who engaged in learning activities or who had more transplant knowledge were found to be 12% more likely to

receive a living donor kidney transplant compared to those who did not [4]. Conversely, individuals whose income fell below \$50,000 per year were found to be 41% less likely to receive a living donor kidney transplant [4]. Similarly, a UK-based multicenter, case–control study by Bailey and colleagues [18] comparing recipients of living donor kidney transplant (LDKT) and deceased donor kidney transplant (DDKT) found that individuals with higher socioeconomic status (SES) as defined by higher educational attainment and income were more likely to receive a living donor kidney transplant compared to a deceased donor kidney transplant (adjusted odds ratio (OR) of 1.48 for university education versus no university education, adjusted OR of 1.14 per £1000 increase in salary).

Racial disparities with respect to income and educational attainment continue to persist in the U.S. According to the Department of Health and Human Services' Office of Minority Health [19], only 87.2% of non-Hispanic Blacks had obtained a high school diploma or higher compared to 93.3% of non-Hispanic Whites. Similarly, only 22.6% of non-Hispanic Blacks had earned a Bachelor's degree or higher compared to 36.9% of non-Hispanic Whites [19]. Although transplant knowledge can only be inferentially related to educational attainment, educational measures and interventions can broadly potentially serve as targets for reducing this disparity. The Census Bureau also found that while the average median household income for non-Hispanic Blacks was \$43,771 (below the studied threshold of \$50,000 in Wesselman et al.'s [4] study), the average median household income for non-Hispanic Whites was higher at \$71,664 [19]. Policy interventions to increase this median household income such as a higher minimum wage might also be considered to improve rates of living donor kidney transplantation among Black patients.

Drawing upon the concept of intersectionality, patients with low income and low educational attainment may have the lowest odds to have a living donor kidney transplant, compared with their counterparts who have either high income or high educational attainment [20]. As the sociology literature has widely documented that Blacks tend to have lower income and educational attainment than Whites, Blacks are more likely to experience the potential amplifying effect of intersectionality, which is an underexplored topic in the literature [21, 22].

Interpersonal/Relationship Factors

Despite the racial disparities in the individual factors discussed, it remains critical to consider interpersonal and relationship factors that facilitate and maintain racial/ethnic disparities in living kidney transplant. Although both deceased donors and living donors can be used in kidney

transplantation, living kidney donation is unique in that individuals with ESRD can receive kidney transplants faster and avoid utilizing the kidney allocation system used for deceased donor kidney transplantation. However, the process of soliciting potential donors can prove challenging psychologically and emotionally and can be dependent on both strong social and family support for the patient and collaborative engagement with the patient's health care team. A significant amount of research has been done to study these interpersonal factors and their influence on fueling the existing racial disparities in living donor kidney transplantation.

The importance of strong psychosocial support during living donor kidney transplantation cannot be overstated. Davis and colleagues [23] performed a small qualitative study in 20 Black donors and recipients to determine interpersonal and intrapersonal barriers to live kidney donation and noted several common themes. Among donors, common barriers included negative responses from others regarding their willingness to donate and an initial refusal of the recipient to accept a live kidney offer. Recipients identified a refusal to approach living donors due to fear of rejection or damaging their relationships and a denial and avoidance regarding their health condition as common barriers. However, both donors and recipients acknowledged that strong social support was instrumental in facilitating a successful transplant process.

Strong social support during the kidney transplantation process appears to play a large role in the referral patterns of health care providers and nephrologists. Bartolomeo and colleagues [24] performed a study to determine nephrologists' perception of factors to exclude patients from kidney transplant evaluation and found that the primary reasons for exclusion were patient's inadequate social support (44%), limited understanding of the process due to inadequate education (32%), and age over 65 years old (26%). Similarly, Ghahramani and colleagues [25] conducted a qualitative study comparing urban and rural nephrologists' perception of patient candidacy for transplantation and found that rural nephrologists noted support as a predominant theme. Yet, despite these findings, there has been limited data to suggest that Black patients have been shown to have less social support than their non-Hispanic White counterparts. On the contrary, a multicenter, cross-sectional study by Gillespie and colleagues [26] showed that there were no disparities noted in social network size by race or sex and that Black patients did not make fewer donor requests than White patients in their study cohort. While there is no clear evidence supporting that Blacks receive less support than Whites, the extant literature suggests that improving social support should increase the chance of living kidney transplantation. Extending this knowledge stream to Blacks' disadvantage in receiving living donor kidney transplants, social support should be strengthened among this population.

The role of provider and the importance of the provider-patient interpersonal relationship must be accounted for when examining disparities in living donor kidney transplantation given the referral system that exists in the U.S. There are many provider-level factors that may contribute to reduced transplant referral rates in certain communities. Sandal and colleagues [27] performed a qualitative study in Canada to identify common provider-level themes that could explain barriers to live kidney transplantation. These were determined to be lack of communication between dialysis and transplant teams, lack of common referral guidelines, role perception and lack of interdisciplinary involvement, limited education and training of health care personnel, negative attitudes of some health care providers towards live kidney transplantation, and patient-level barriers as identified by the health care providers. Furthermore, in a study of 278 nephrologists from four different U.S. regions, Ayanian and colleagues [28] found that physicians were less likely to believe that renal transplantation improves survival for Black patients as compared to White patients. As emphasized and highlighted by Purnell and colleagues [6] in their conceptual framework on approaching disparities in minorities' access to LDKT, provider-level factors cannot be dismissed if we are to mitigate the racial inequities encountered in live kidney transplantation.

Prior to the referral, evaluation, and screening of potential living donors, the engagement of the health care team with the dialysis patient and his or her family to consider living donor kidney transplantation is critical. However, Boulware and colleagues [29] found that in a cross-sectional study of African-American patients undergoing dialysis, universal patient-physician discussion of live kidney transplantation did not occur despite patient preferences indicating interest in it. Questionnaires used to collect data from prevalent dialysis patients and their families found that although the majority of patients desired transplantation (76%) and most patients (93%), spouses (91%), and children (88%) had knowledge of live kidney transplantation, there was a large incongruence of discussions of living transplantation between physicians and their patients (68%), the patients' spouses (41%), and the patients' children (31%). These findings demonstrate that although a lack of knowledge regarding living donor kidney transplantation may partially contribute to the disparities, the role of collaborative discussion between health care providers, patients, and their families may serve as an area for ongoing intervention.

Similar to the individual factors, the aforementioned interpersonal factors may interact with one another. For example, even if there is a strong physician-patient relationship, its effect on living donor kidney transplant may be lessened due to poor communication or low perceived social support. It is important to consider these factors simultaneously in empirical research and doing so should improve our

understanding of racial disparities in living donor kidney transplant.

Community/Cultural Factors

In order to better understand the etiology of the existing racial disparities in living donor kidney transplantation, we must also examine any cultural factors within the Black community that may contribute to maintaining the inequities noted. As we have grown quite accustomed to the post-coronavirus disease 2019 (COVID-19) era, misinformation regarding the COVID-19 vaccine leading to vaccine hesitancy has underscored our response to the spread of COVID-19 globally and within all of our communities. Clearly, individual behaviors and motivations towards vaccination have limited its efficacy as a preventative measure, but these individual behaviors have deeper origins in certain communities, especially the Black community where historical atrocities such as the Tuskegee experiments may continue to inform public perceptions towards the medical establishment and create distrust among the Black community towards it [30].

Bajaj and Stanford [30] astutely raised concerns over whether the Black community would embrace the vaccination effort and volunteer for COVID-19 vaccination in their opinion piece published in the *New England Journal of Medicine*. The authors highlighted a NAACP survey done in November 2020 that showed that only 14% of Black respondents trusted the vaccine's safety and only 18% would definitely get vaccinated [30]. In addition to historical atrocities such as Tuskegee, the authors suggest that a feeling of institutionalized racism and racial disparities throughout health care may cause further distrust among the Black population, which is substantiated by an improvement in infant mortality rates when Black infants are cared for by Black providers rather than White providers and improved BP control among Black men following a barbershop-based community intervention compared to a control group [30]. Alsan and colleagues found that a COVID prevention message delivered by a Black physician led to increased information-seeking behavior among Black patients who viewed it, which further suggests that underlying trust between provider and patient may have a large impact on the emotional response and motivation of the patient to respond to health information [30]. Notably, Armstrong and colleagues [31] measured fidelity-based trust among survey respondents and found that on univariate analysis, physician distrust was higher among Black and Hispanic patients, although this relationship varies by SES and geographic variation.

The racial disparity in LDKT has led many investigators to study whether attitudes and behaviors towards LDKT might explain this transplantation disparity, especially with regard to health literacy and trust in health care. Vilme and

colleagues [32] performed a cross-sectional secondary analysis of baseline data from three separate randomized clinical trials among African-Americans with CKD and reviewed responses of survey data to determine interest in LDKT and explore potential facilitators and barriers to LDKT by reviewing survey responses attributed to health literacy and trust in medical care. The authors concluded, however, that trust in ethical care was high among the cohorts they studied, which would suggest that negative attitudes and behaviors towards LDKT were not likely factors that significantly influenced this observed disparity in kidney transplantation [32]. Despite these findings, the importance of trust in health care cannot be understated. In a questionnaire-based study of determinants of willingness to donate living and cadaveric organs by Boulware and colleagues [33], only mistrust in hospitals and concerns about discrimination were found to be independently associated with lower odds (50–60%) of willingness to donate living related organs after adjusting for confounders such as demographics and SES. However, in a prospective study performed by Ng and colleagues [3], the authors found that disparities in kidney transplantation between African-Americans and non-Hispanic Whites persisted even after adjusting for medical distrust, a factor that was more prevalent in African-Americans than non-Hispanic Whites at baseline. Further studies may be necessary to better elucidate the role of medical mistrust and its contribution to disparities in living donor kidney transplantation.

Other cultural factors have also been studied to help define the source of the inequities noted in LDKT and provide insight into targets for interventions. Killian and colleagues [34] conducted a cross-sectional study to assess the role of community-level vulnerability in LDKT racial disparities using census tract-level social vulnerability index (SVI) scores and rates of LDKT among various racial and ethnic groups. They found that recipients who lived in more vulnerable communities (higher SVI) had a lower likelihood of receiving a living donor kidney transplant, a finding that was worse among Black recipients. Perceived information adequacy was also found to be an important factor in pursuit of LDKT by African-American transplant candidates. Cabacungan and colleagues [35] found that although a minority of respondents (39%) felt “very well” or “extremely well” informed about LDKT, those that did were 2.83 times more likely to have “intermediate” or “high” pursuit of LDKT.

Cultural differences in coping with the need for kidney transplantation, willingness to ask for live organ donation, and risk tolerance in the Black community may also be factors that sustain the racial disparities noted in LDKT. A study performed by Lunsford and colleagues [36] that examined differences in coping mechanisms between African-Americans and non-African-Americans showed that potential African-American recipients were more likely to deny the need for transplantation and were less accepting than non-African-Americans. Despite these findings, the authors did not find a racial difference in willingness

to ask for live organ donation. Racial differences in risk tolerance may also contribute to the inequities in living donor kidney transplantation. A study by Thiessen and colleagues [37] found that Black donors were 75% less likely to accept a medium risk versus a low risk of post-donation kidney failure than White donors.

That being said, racial differences in living donor health outcomes also may play a role in shaping the racial disparities in LDKT. Lentine and colleagues [38] found that after kidney donation, Black donors had higher rates of hypertension, chronic kidney disease, ESRD, and diabetes than White donors, although these findings were similar to the higher prevalence of those conditions between races in the general population. Muzaale and colleagues [39] performed a retrospective cohort study comparing the cumulative incidence and lifetime risk of ESRD in living kidney donors and low risk, non-donors and found that while all donors had an increased risk of ESRD compared to non-donors, Black donors had the highest absolute risk increase compared to both White and Hispanic donors.

Finally, cultural differences with respect to religion and religiosity may contribute to differences noted in LDKT within the Black community. In their study, Lunsford and colleagues [36] found that Black individuals were more likely to use religion as a coping mechanism than White individuals. Wesselman and colleagues [4] found that individuals with religious objection to living donor kidney transplant were 38% less likely to receive a LDKT. Similarly, in a study that examined racial disparities in deceased donor kidney transplantation, Ozminkowski and colleagues [40] found that non-White patients were 2.5 times as likely to have religious objections to transplantation and uneasiness about receiving cadaveric organ than White patients. Although these findings may not be applicable to live kidney transplantation, further study is likely warranted to determine the role of religion and religiosity as a possible cultural factor that may underlie the racial disparities noted in LDKT.

The community/cultural factors may have a spillover effect on both individual and interpersonal factors, which is the vertical associations among factors. Take health care system distrust for example, the relatively high distrust among Blacks is likely to be translated into poor physician–patient dynamics as patients may not trust the recommendations or adhere to prescription by physicians. Such cross-level interactions have not received much attention, but this gap should be filled in future studies.

Societal/Institutional Factors

As institutional policies in kidney disease and transplantation may be a potential source for the most broad-reaching interventions, examination of systemic and structural

racism in the context of transplantation is essential. Race is a social construct, not a biologic one; therefore, the nephrology community has taken a renewed interest in scrutinizing its use in medical decision-making as a potential source of inequity. Interestingly, the social meaning of race has been directly implicated to be at the heart of this disparity. The classification of chronic kidney disease has historically focused on estimated glomerular filtration rate (or eGFR as it is more commonly referred) as the key discriminator of the different stages of kidney disease and is commonly calculated by using a patient's serum creatinine level, age, sex, and race (Black or non-Black) into the CKD-EPI calculator. The CKD-EPI equation was developed in 2009 to standardize traditional serum creatinine-based measures of kidney function and the incorporation of race was instituted due to the finding that Black individuals tended to have a 16% higher eGFR for the same level of serum creatinine [41]. Other than providing the means for classification for the stages of chronic kidney disease, a patient's eGFR has also been used as a means for prompting referral to a nephrologist, initiating key clinical guidelines for kidney disease management and, more pertinent to this discussion, for prompting a kidney transplant evaluation [41].

Most kidney transplant centers will not place a patient on the kidney transplant wait list or allow patients to accrue time on the wait list until the patient's eGFR is less than 20 cc/min/1.73m², and delays in referral and placement on kidney transplant wait lists have a significant impact on a patient's ability to receive a kidney transplant [41]. Additionally, this threshold is also used for the timing of living donor kidney transplantation as well with the majority of transplant centers in one study using either less than 25 cc/min/1.73m² (30%) or less than 20 cc/min/1.73m² (38%) as their threshold [42]. As such, a patient who identifies as Black may be disadvantaged in a system that may overestimate his or her kidney function which has brought considerable attention to the structural racism that this means of calculating kidney function has been implicated in and has been one of the main discussions in the nephrology community. This practice of applying population-level data to the individual may be contributing to maintaining the racial disparities witnessed in LDKT. In fact, many health care institutions have been conscientious of this racialized definition of kidney disease and have used the non-Black eGFR obtained from the CKD-EPI equation for all patients admitted to their hospitals. In a retrospective cohort study of an African-American-only patient population performed by Yap and colleagues [43], the authors found that a substantial number of patients would be reclassified to higher CKD stages when the race-removed CKD-EPI and race-removed CKD-MDRD equations were used.

The effects of removing race from eGFR calculations have significant implications in the transplant community as well. Hoenig and colleagues [44] found that after discarding the race coefficient to assess eGFR in a single transplant center study, they noted an increase in the number of Black patients who were listed for preemptive kidney transplantation compared to the total number of Black patients listed, with nine patients gaining an average of 457 days of wait time. Doshi and colleagues [45] performed a survey study to assess opinions on using a race-based eGFR equation in kidney transplant evaluation and found that a majority of transplant centers surveyed had removed (15%) or planned to remove race (46%) from eGFR calculators. However, this current practice risks underestimating the kidney function of Black patients with potential risks to clinical management and public health [46]. Indeed, after reviewing the effects of exclusion of race in eGFR equations, Delgado and colleagues [13] noted that while Black adults may benefit from earlier transplant referral, the authors suggested that decisions made at higher eGFR thresholds, such as living kidney donor evaluation, may also be affected.

Transplant center variability in the screening of Black living kidney donors, especially in regards to *APOL1* allele testing, also has been implicated as an institutional factor that may contribute to the racial disparities in living donor kidney transplantation. African-Americans have a higher incidence of chronic kidney disease than those of European ancestry, and studies have demonstrated that the *APOL1* genotype may be at least partially responsible for the excess disease risk between African-Americans and European-Americans with respect to non-diabetic chronic kidney disease [47]. African-Americans with the *APOL1* genotype have also been shown to progress at an earlier age to ESRD. Similarly, Reeves-Daniel and colleagues [48] also found that deceased donor kidney transplants with two *APOL1* risk variants have an increased rate of failure when transplanted compared to transplanted kidneys with no or only one risk variant.

Despite this, the use of *APOL1* genetic testing has not been universally implemented in the transplant community, nor do transplant centers universally consider these genotypes in living donor transplant evaluation [49]. Given the known risks of possessing two high-risk *APOL1* variants, it has been proposed that living donors should not only be counseled on the risks of the *APOL1* genotype, but also offered genetic testing for those donors that report African ancestry [49]. By incorporating the use of genetic testing in living donor transplant evaluation, the racial disparities seen in living donor kidney transplantation may potentially be reduced by potentially expanding the donor pool for Black patients. Further research is likely needed to determine the long-term effect of universally offering *APOL1* testing on rates of living donor kidney transplantation in the Black population.

Future Directions

By summarizing the known and overlooked factors associated with the racial disparities in living donor kidney transplantation into a socioecological model, this review may shed some light on the development of interventions to address these inequities. It is well understood in the nephrology community that living kidney donation has many barriers to access due to the days of lost work and productivity for the donor, potential losses in income and uncompensated costs, transportation costs, and medical follow-up care required. These barriers are often exacerbated by disparities in income, education, and health care access, which often disproportionately affects Black and ethnic minority patients. Living donors often face higher premiums following kidney donation or denial of insurance coverage based on their organ donation status in addition to having no federal protection from loss of employment following kidney donation due to lost time at work for recovery [50].

Fortunately, legislation is currently in process to hopefully reduce financial disincentives to donation. The Living Donor Protection Act of 2021, introduced by Representatives Nadler (D-NY) and Beutler (R-WA), aims to reduce barriers to living donation by prohibiting insurance companies from denying coverage to individuals who are kidney donors or increasing premiums [50]. The law will also ensure that individuals are able to use Family and Medical Leave Act (FMLA) time to recover from kidney transplantation to hopefully minimize disparities based on socioeconomic status for kidney donation [50].

By addressing the inequities in our current practice of living kidney donation due to socioeconomic factors that often disproportionately affect Blacks and minorities, patients will hopefully have an equal opportunity to give this ultimate gift of life, which is currently the gold standard treatment for end-stage renal disease. Minimizing the financial burden and hardship imposed by living kidney donation will hopefully reduce the dependence on the deceased donor pool and spark increased interest among family members of patients with end-stage renal disease that may have been less willing to volunteer due to personal financial stress or underemployment. If passed into law, further research will be needed to determine the impact on rates of living kidney donation rates among Black and minority patients and its effect on reducing the growing disparity we are currently witnessing.

Additionally, a new equation based on serum creatinine level and cystatin C (another biomarker used for estimation of eGFR) has been promoted and validated that does not include race as a factor and has been praised by the nephrology community as an improved and reliable means of calculating eGFR that may lessen the disparities seen in kidney transplantation and other racial inequities seen in the

management of chronic kidney disease [46]. This landmark study published by Inker and colleagues [46] in the *New England Journal of Medicine* is likely to have significant implications for the promotion of health equality in chronic kidney disease and transplant medicine. The Organ Procurement and Transplantation Network (OPTN) recently implemented a policy establishing a new requirement, effective July 27, 2022, that mandates the use of a race-neutral eGFR calculation at all transplant hospitals for use in transplant determinations [51]. Future studies using this new equation and following the implementation of this new policy will likely be warranted to determine its impact on reducing the racial disparities witnessed in the provision of care of patients with chronic kidney disease and those in need of kidney transplantation.

While policy interventions at the national level may be the most far-reaching, interventions at each level of the socioecological framework will be necessary to bridge these gaps. However, by understanding the multilayered and multidimensional factors that contribute to the racial disparities in living donor kidney transplantation, we may be better informed on how and where to target our efforts. Using the socioecological approach to view this complex issue, it is clear that no single intervention will likely fully bridge the divide to achieve equity in living donor kidney transplantation; however, by reviewing the various factors that contribute to this disparity using such a framework, we might be able to adjust how we approach this issue (especially the vertical and horizontal associations among factors) and identify targets underlying this broad socioecological framework. Efforts should be made to make health care personnel accountable and cognizant of personal biases and improve communication regarding living donor kidney transplantation with patients and families. Policymakers should enact legislation to protect donors and improve equity with regard to insurance status and income. Transplant centers should standardize screening procedures for donor candidates. Fortunately, efforts are already underway given the recent aforementioned OPTN policy change and the ongoing *APOLI* Long-term Kidney Transplantation Outcomes Network (APOLLO) study, the results of which will likely inform future policy implications regarding universal *APOLI* testing [52]. It will take a multidisciplinary approach between patients, health care professionals, and policymakers to address this crucial issue, but with careful attention to the causes of this racial disparity, we will hopefully create a future that is more equitable for all people with chronic kidney disease.

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commented on previous versions of the manuscript. Both authors read and approved the final manuscript.

Data Availability This paper is a review of published data, the reader is encouraged to contact the authors of these papers regarding data availability.

Declarations

Ethics Approval This literature review did not require ethics approval.

Competing Interests The authors declare no competing interests.

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