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Racial and Ethnic Disparities in Kidney Replacement Therapies Among Adults With Kidney Failure: An Observational Study of Variation by Patient Age

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Abstract

Rationale and Objective: Non-Hispanic Black and Hispanic patients present with kidney failure at younger ages than white patients. Younger patients are also more likely to receive transplants and home dialysis than in-center hemodialysis (ICHD), but it is unknown whether racial/ethnic disparities in treatment differ by age. We compared use of kidney replacement

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Prior Presentation: Preliminary findings of this study were presented previously at the American Society of Nephrology Kidney Week conference in October 2018.

Disclaimer: The data reported here have been supplied by the USRDS. The interpretation and reporting of these data are the responsibility of the authors and in no way should be seen as an official policy or interpretation of the U.S. government.

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therapies between racial/ethnic groups among patients with incident kidney failure, overall, and by age.

Study Design: Retrospective cohort study.

Setting and Participants: 830,402 U.S. adult (>21 years) patients initiating kidney failure treatment during 2011–2018.

Exposures: Patient race/ethnicity (non-Hispanic Black, non-Hispanic white, Hispanic, or other) and age group (22–44, 45–64, 65–74, or 75–99).

Outcome: Treatment modality (transplantation, peritoneal dialysis [PD], home hemodialysis [HHD], or ICHD) as of day 90 of treatment.

Analytical Approach: Differences in treatment modalities were quantified for patient subgroups defined by race/ethnicity and age. Log-binomial regression models were fit to estimate adjusted risk ratios (ARRs).

Results: Eighty-one percent of patients were treated with ICHD, 3.0% underwent transplantation (85% pre-emptive, 57% living donor), 10.5% were treated with PD, and 0.7% were treated with HHD. Absolute disparities in treatment were most pronounced among patients aged 22–44. Compared to non-Hispanic White patients whose percentages of treatment with transplantation, PD, and HHD were 10.9%, 19.0%, and 1.2%, non-Hispanic Black patients were less commonly treated with each modality (unadjusted percentages: 1.8%, 13.8%, and 0.6%, respectively) as were Hispanic patients (4.4%, 16.9%, and 0.5%, respectively; all differences $p<0.001$). After adjustment, the largest relative disparities were observed for transplantation; among the age group 22–44 and compared to non-Hispanic White patients, the ARRs for non-Hispanic Black and Hispanic patients were 0.21, 95% CI (0.19, 0.23) and 0.47, 95% CI (0.43, 0.51), respectively.

Limitations: Race/ethnicity data not self-reported.

Conclusions: Among adults with incident kidney failure, racial/ethnic disparities in transplantation and home dialysis use are most pronounced among the youngest adult patient age group.

Plain-language Summary

Research has shown wide racial/ethnic disparities in use of kidney transplantation and home dialysis, yet how age interacts with these disparities is unknown. We compared use of kidney replacement therapies between racial/ethnic groups among patients with incident kidney failure, within age strata, using registry data for 830,402 U.S. adults (>21 years) during 2011–2018. Absolute disparities in transplantation and home dialysis (outcomes measured at 90 days after treatment initiation) were most pronounced among patients aged 22–44. After adjusting for numerous patient-level factors, the largest disparities were observed for transplantation among adults age 22–44. These findings suggest that needs of younger adults should be emphasized in designing interventions to reduce disparities in access to preferred kidney replacement therapies.

Keywords

Kidney failure; transplantation; home dialysis; disparities; race/ethnicity; age

Introduction

Non-Hispanic Black and Hispanic patients, relative to non-Hispanic white patients, regularly receive lower-quality medical care and have poorer access to many medical services, particularly for kidney disease.[1] For most patients with kidney failure requiring replacement therapy (hereafter "kidney failure"), transplantation promises the best survival and quality of life outcomes among available kidney replacement therapies.[2–5] Among patients with kidney failure who do not receive pre-emptive transplantation (i.e., transplant before receiving dialysis treatment), peritoneal dialysis (PD) and home hemodialysis (HHD) are often preferred to in-center hemodialysis (ICHD); PD and HHD use are associated with greater flexibility and independence, and many home dialysis patients report better quality of life.[4–6] Moreover, several national policy changes pursuant to the 2019 executive order Advancing American Kidney Health have increasing use of transplantation and home dialysis as a central goal.[7] However, relative to non-Hispanic white patients, non-Hispanic Black and Hispanic kidney failure patients are 73% and 49% less likely to receive a transplant, respectively, and 15–25% less likely to receive PD.[2] Given that the incidence of kidney failure is nearly three times higher for Black individuals than for white individuals and 32% higher for Hispanic individuals than for non-Hispanic individuals,[2] these large disparities in treatment imply significant kidney failure treatment-related deficits in longevity and quality of life for racial/ethnic minorities nationally.

Importantly, age at kidney failure incidence varies meaningfully across racial/ethnic groups: in 2008, median age at incidence was 59.2, 60.2, and 66.8 for African American, Hispanic, and non-Hispanic white patients, respectively.[8] Younger patients are relatively more likely to undergo transplantation, PD, and HHD than older patients;[2] this is because older age is associated with several clinical contraindications for these preferred modalities and also because age informs patients' relative preferences among kidney failure treatment alternatives.[9–11] If racial/ethnic disparities in access to transplantation, PD, and HHD persist across all ages, the apparent, average disparities in treatment may be understated in analyses that do not effectively account for differences in age at incidence.

Only two previous studies have examined racial/ethnic disparities in kidney failure treatment by age group in adult patients.[12,13] The first study compared only self-reported transplant waitlisting outcomes of white and African American patients initiating treatment 30 years ago, and the second relied on data from one large dialysis organization. Consequently this latter study could neither capture pre-emptive kidney transplants (i.e., prior to any dialysis treatment) nor construct nationally representative estimates.[13] Notably, both studies assessed treatment disparities by age before the 2011 expansion of the Prospective Payment System in Medicare—the largest payer of kidney transplantation and dialysis services in the U.S.—led to a narrowing of racial/ethnic disparities in home dialysis treatment use.[14] In addition, no previous study has examined differences across age groups in racial/ethnic disparities in HHD use alongside transplantation and PD use or examined HHD use for Hispanic patients in this context. We use a retrospective cohort study and recent, national data to fill these gaps.

Materials and Methods

Data, sample, and measures

We used United States Renal Data System (USRDS) data to identify all U.S. adult patients whose first date of kidney failure treatment was between January 2011 and June 2018. This study focused on adult patients because of the high median age of kidney failure incidence and because kidney failure care is administered in a separate provider system for pediatric patients. We excluded patients under age 22 (computed for the year in which initial kidney failure treatment took place; 1.2% of patients) for these reasons. We also excluded patients older than 99 (0.01%) due to small sample limitations. Following USRDS's standard approach for tracking initial treatment modalities in annual reports, patients' treatment modalities—transplant, ICHD, PD (including continuous ambulatory peritoneal dialysis, continuous cycling peritoneal dialysis, and other peritoneal dialysis), HHD, or other—were identified at day 90 of therapy and limited to those used for at least 60 days.[2] We chose this approach to avoid measurement error during patients' early months of dialysis care due to unstable or temporary modality choices,[15,16] recognizing that transplants observed on or before day 90 of therapy would be disproportionately pre-emptive and living-donor transplants. We focus on outcomes at day 90 of therapy rather than at a later time point to limit survivor's bias (due to early mortality) and attrition bias (due to modality switches from home dialysis to ICHD). Patients identified as lost to follow-up (e.g., died before day 90) (n= 62,059, 6.9%), having discontinued dialysis (n=8,850, 1.0%) or recovered kidney function (n=1,798, 0.2%), or with any missing data (n=110, <0.01%) were excluded. The final analytic sample included 830,402 patients with incident kidney failure.

To assess treatment modality, we created dichotomous outcome measures that mirror common decision-making hierarchies among the kidney failure treatment alternatives offered at many dialysis facilities: (1) any transplantation (pre-emptive or non-pre-emptive, living or deceased donor) versus all dialysis modalities, and then in parallel (2a) PD or HHD ("home dialysis") versus ICHD (excluding transplantation and other dialysis), (2b) PD versus ICHD (excluding transplantation, HHD, and other dialysis), and (2c) HHD versus ICHD (excluding transplantation, PD, and other dialysis). According to October 2020 Dialysis Facility Compare data, both PD and HHD training are offered at 27.4% of U.S. dialysis facilities, PD training only (no HHD training) is offered at 24.9% of facilities, and HHD training only (no PD training) is offered at 1.6% of facilities. Nearly half (46.1%) of facilities do not offer home dialysis training.

We used Medical Evidence Form (CMS-2728) data collected at incidence to identify patient race/ethnicity. We define and interpret race as a social construct, not a biological one.[17] Nevertheless, in Medical Evidence Form data, race/ethnicity is not self-reported but rather administratively reported. Race/ethnicity was coded as Hispanic if the patient was identified as Hispanic and, if not, was based on listed race. Using this information, our categorical race/ethnicity measure distinguished among the following groups: non-Hispanic white, non-Hispanic Black, Hispanic, and other race/ethnicity. Due to small sample sizes, Asian, Native American, unknown, and other racial/ethnic groups were included in the latter group.

Patient-level adjustors—predisposing and need-related characteristics in Andersen's framework of health services use[18]—were also derived from CMS-2728 data. These measures included age group indicators following USRDS standard age groupings (22–44, 45–64, 65–74, 75–99), sex (female versus male), principal assigned cause of kidney failure (categorical: diabetes, hypertension, glomerulonephritis, or other), and indicators for key comorbid conditions (heart disease [including atherosclerotic heart disease, peripheral vascular disease, congestive heart failure, or other cardiac disease], diabetes, hypertension), which are associated with patient prognosis and treatment use.[19–22]

Analysis

We compared unadjusted modality use between racial/ethnic groups both overall and stratified by age group. Next, we estimated log-binomial models (i.e., generalized linear models with a log link function and binomial distribution) of treatment use, likewise overall and by age group. Log-binomial models were preferred to logistic models because log-binomial models facilitate post-estimation development of risk ratios (see Supplement – Methods).[23,24] We controlled for year of kidney failure incidence to account for secular trends in technology and treatment availability (e.g., dialysate shortage for PD).

Model-based standardization was used to estimate the adjusted probability of each outcome for each racial/ethnic group as well as adjusted risk ratios (versus non-Hispanic white patients). Our estimates of adjusted probabilities, and associated confidence intervals were bootstrapped (100 iterations with 70% stratified random-draw samples by race to improve modeling efficiency). Furthermore, unadjusted and adjusted risk ratios of transplantation were compared to assess the importance of patients' predisposing and need-related characteristics in explaining any observed disparities in modality, both overall and by age.

In supplemental analyses, we explored whether pre-kidney failure insurance status (Medicare, Veterans Administration coverage, Medicaid, private insurance, or other) or pre-kidney failure nephrology care (any versus none)—enabling characteristics in Andersen's framework[18]—represented important confounders and potential mediators in our baseline log-binomial models by including them as additional covariates.

We performed all statistical analysis using R statistical software, version 3.5.3.[25] This project was deemed exempt-approved by the Emory Institutional Review Board. Obtaining individual-level informed consent was not feasible for this secondary data analysis because doing so would require re-identifying individual patient records.

Results

Of 830,402 patients with incident kidney failure in our sample (Table 1), non-Hispanic Black patients (26.4%) and Hispanic patients (15.2%) comprised the second and third largest racial/ethnic groups, respectively, after non-Hispanic white patients (52.0%). Age at kidney failure incidence was considerably older among non-Hispanic white patients (27.5% 75–99) than among non-Hispanic Black (15.0%), Hispanic (16.1%), or other (20.5%) patients (all p-values <0.001). Kidney failure etiology and comorbid conditions also varied substantially by race/ethnicity. Diabetes was the cause of kidney failure among Hispanic

(62.1%) and other (53.8%) patients disproportionately often. Non-Hispanic white patients were most likely to have comorbid heart disease (51.0%) and least likely to have comorbid hypertension (86.2%) (all p-values <0.001). Corresponding descriptive information about patient characteristics is presented by age band in Table S1 (Panels A-D).

As shown in Table 2 and Figure 1, across racial/ethnic groups 3.0% of patients received a transplant by day 90 of treatment, while 80.6% of patients used ICHD, 10.5% used PD, 0.7% used HHD, and 1.2% used other treatment modalities; 4.0% were not assigned to a treatment modality due to treatment instability (<60 days persistent). In unadjusted comparisons, transplantation was more common among non-Hispanic white patients (3.9%) than among non-Hispanic Black (1.1%) and Hispanic (1.8%) patients, though it was most common among patients of other race/ethnicity (6.2%). PD was also most common among other race/ethnicity (12.8%), followed by non-Hispanic white (11.5%), Hispanic (9.6%), and non-Hispanic Black (8.5%) patients. HHD was most common among non-Hispanic white patients (0.9%), followed by non-Hispanic Black (0.7%), other race/ethnicity (0.5%), and Hispanic (0.4%) patients. All unadjusted differences between each racial/ethnic group and non-Hispanic white were statistically significant (p<0.001).

Table 3 presents adjusted probabilities of transplantation, PD, and HHD across non-Hispanic white, non-Hispanic Black, and Hispanic racial/ethnic groups by age group after adjusting for patient-level covariates. Because of the differences in comparison groups across outcomes, Table 3's adjusted probabilities are comparable with the unadjusted risks of outcomes presented in Table 2 and Figure 1 only for the transplantation outcome. Overall, non-Hispanic white patients were the most likely to receive a transplant (3.5%) or to use PD versus ICHD (14.1%) or HHD versus ICHD (1.1%), while non-Hispanic Black patients were the least likely to receive a transplant (1.0%) or to use PD versus ICHD (8.3%), and Hispanic patients were the least likely to use HHD versus ICHD (0.5%) (all comparisons p<0.001); this pattern persisted for each treatment outcome and all age groups, except for HHD use among age 75–99. The largest absolute disparities (non-Hispanic Black and Hispanic as compared to non-Hispanic white) for transplant receipt, PD use, and HHD use were among patients age 22–44 (p<0.001). This is also the age group in which each treatment outcome was most common overall (p<0.001).

Table 3 also includes adjusted estimates of the risk ratios of transplantation, PD, and HHD across racial/ethnic groups by age group. The largest relative disparity in transplant receipt for non-Hispanic Black patients was among age 22–44 (adjusted risk ratio versus non-Hispanic whites [ARR] 0.21, 95% CI [0.19, 0.23]), while the disparities among other age groups were also large (ARRs 0.29–0.30). For Hispanic patients, the largest relative disparity in transplantation was likewise among age 22–44 (ARR 0.47, 95% CI [0.43, 0.51]), though the relative disparity was only marginally smaller in older age groups (ARRs 0.49–0.50).

Patterns of relative disparities in HHD use were similar to those for transplant. The largest relative disparities in HHD use for Hispanic patients were among younger age groups (ARR for age 22–44: 0.34, 95% CI [0.27, 0.43]); these disparities were smaller among age 65–74 and eliminated among age 75–99 (ARR 0.93, 95% CI [0.77, 1.13]). Similarly, for

non-Hispanic Black patients, the largest disparities were among younger age groups (ARR for age 22–44: 0.45, 95% CI [0.38, 0.54]). For non-Hispanic Black patients, this disparity was flipped among age 75–99 (ARR 1.38, 95% CI [1.21, 1.58]).

Patterns of relative disparities in PD use differed from those observed for transplant and HHD. The relative disparity in PD use for non-Hispanic Black patients was larger among older age groups (ARR for age 75–99: 0.48, 95% CI [0.45, 0.51]) than among younger age groups (ARR for age 22–44: 0.65, 95% CI [0.63, 0.67]). Age-trends in PD disparities for Hispanic patients were similar.

Corresponding results for the combined home dialysis outcome (PD or HHD versus ICHD) are presented in Table S2. Absolute and relative disparities in home dialysis use were comparable to those observed for PD use (Table 3).

Comparing unadjusted (Table 2) and adjusted results (Table 3) for transplant, we found that racial/ethnic disparities were narrowed somewhat after adjustment for key patient factors, though the adjusted disparities' magnitude remained large.

Supplemental analyses are presented among the Supplemental Materials. When adjusting for pre-kidney failure insurance status, the disparities were narrowed most among younger cohorts (age 22–44 and 45–64). Separately, when adjusting for pre-kidney failure nephrology care, racial/ethnic disparities in transplantation and PD use (though not HHD use) were narrowed across all age groups.

Discussion

While non-Hispanic Black and Hispanic individuals are disproportionately represented among U.S. adults with kidney failure due to high incidence rates and rapid kidney disease progression,[2] our results affirm that there are very large racial/ethnic disparities in access to kidney transplantation, PD use, and HHD use.[2,14,26–33] We advance the literature by identifying for the first time that the absolute and relative racial/ethnic disparities (versus non-Hispanic white patients) in two kidney failure treatments often preferred to ICHD are most pronounced among younger patients. During 2011–2018, the largest relative disparity was in transplantation for patients age 22–44: non-Hispanic Black patients were 79% less likely than non-Hispanic white patients to receive a transplant, and Hispanic patients were 53% less likely, after adjusting for patient characteristics. Relative disparities in HHD use were also largest among younger patients. These findings suggest that average disparities in transplant and HHD treatment are understated in analyses that do not account for differences in age at incidence of kidney failure because, on average, Black and Hispanic patients are younger at incidence than non-Hispanic white patients.[8] Moreover, programs and interventions to improve equity in treatment for Black and Hispanic adults with incident kidney failure may have the greatest potential when focused on the needs and barriers faced by younger individuals – those who stand to gain the most in accumulated life expectancy and quality of life when receiving a preferred kidney failure treatment.[34,35]

These age-trends in kidney failure treatment disparities may be explained, in part, by differences in patient complexity across race/ethnicity and the different treatments.

Older patients of all racial/ethnic groups are more likely to have one or more clinical contraindications to transplant or HHD.[11,36–38] Consequently, when nephrologists weigh treatment alternatives for older patients, they must place greater weight on clinical considerations versus other considerations (e.g., social support[39,40]). Therefore nephrologists' treatment recommendations may be more comparable across racial/ethnic groups in older patients, leading to reduced relative disparities in treatment among them. Of note, some factors (e.g., body-mass index) may differ in the strength of their relationship with transplant versus with home dialysis. Among younger patients, the wider *absolute* disparities are driven both by these trends in relative disparities and also by younger patients' greater use of these treatment options overall (e.g., 6.8% of patients aged 22–44 received a transplant versus 0.3% of patients aged 75–99 in our sample).[10,41] Indeed, if relative racial/ethnic disparities in transplant access were identical across age groups, absolute disparities would still be wider among younger patients.

Our supplemental analyses suggest racial/ethnic differences in insurance coverage and other determinants of access to care among younger individuals are among the mechanisms that contribute to the greater relative disparities we observe among younger patients. In these analyses, we found that controlling for pre-kidney failure insurance coverage or pre-kidney failure nephrology care narrowed our estimates of relative disparities most among younger patients (e.g., adjusted risk ratios of transplant among Hispanic individuals [versus non-Hispanic white individuals] age 22–44: 0.56 or 0.54, respectively, versus 0.47 without these adjustments). This is consistent with prior evidence that non-Hispanic Black and Hispanic individuals under age 65 (and so not Medicare-eligible based on age) are more likely than non-Hispanic white individuals to be uninsured or Medicaid-insured prior to kidney failure.[42] This is also true in our sample (see Table S1). These racial/ethnic differences in pre-kidney failure insurance coverage may, in turn, lead to poorer access to regular nephrology care, appropriate care for other comorbid conditions, and education about treatment alternatives among racial/ethnic minority patients, inhibiting their access to preferred treatments.[43,44] Policy measures that expand access to pre-kidney failure nephrology care, potentially including expanded Medicare eligibility to individuals under age 65 with stage IV or V chronic kidney disease, could narrow these gaps in access to transplant and home dialysis.

We also hypothesized relative disparities in PD use by race/ethnicity would be wider among younger patients. Yet relative disparities in PD use were widest among older patients. This divergent trend may be attributed significantly to competing treatment risks and selection bias. Many non-Hispanic white patients who receive transplants would otherwise be good candidates for home dialysis; indeed, many patients considered strong candidates for transplant are directed to PD on a temporary basis.[45] If these non-Hispanic white patients did not receive a transplant, they would be disproportionately likely to receive PD treatment, leading us to observe wider disparities in access to home dialysis (even compared to the already large disparities we observe in our data), especially among younger patients. Thus the very wide racial/ethnic disparities in transplant receipt among younger patients may lead us to underestimate disparities in PD use among younger patients. Further study will be needed to more fully explain the age-gradient in PD use disparities, potentially including competing risks models (e.g., Fine and Gray[46]) and other analyses at the patient

or community levels, accounting for differences in psychosocial factors associated with improved access to transplant and PD. Such analyses are likely to underscore the importance of addressing intersectional deficits in financial access, transportation, social support, and other barriers to home dialysis among younger patients with kidney failure. Similarly, dialysis facility-level analyses may explore community-level social factors that could influence whether dialysis facilities make PD or HHD available in younger and racially/ethnically segregated communities.

Recent changes in Medicare payment policy—notably including the 2011 expansion of the Prospective Payment System—and revisions to the national kidney allocation system have expanded access to home dialysis[47,48] and reduced disparities in transplant access among patients waitlisted for a deceased donor transplant.[49,50] However, as our results and other studies show, large disparities persist in many aspects of kidney failure care across most age groups.[51] For example, our study illustrates persistent disparities in receipt of pre-emptive, living donor transplants. Due to our focus on 90-day treatment outcomes, 85% of transplants observed in our study are pre-emptive, and 57% are living-donor.[52] Further study is needed to identify the mechanisms that contribute to large disparities in transplantation and HHD use among younger adult patients. Such evidence could inform how policy mechanisms, including payment reforms and other initiatives launched under the Advancing American Kidney Health executive order,[7] may improve equity in kidney failure treatment across racial/ethnic groups.

This analysis has some notable limitations. First, we identify initial treatment modality as of day 90, restricting our analysis to patients who survive the first 90 days on treatment for kidney failure. Patients with kidney failure who experience early mortality are disproportionately older, white, and undergoing ICHD treatment.[2] Thus re-including these patients' initial treatment experience in our analysis would reduce the apparent racial/ethnic differences in home dialysis use on average. However, our main findings of disparities, particularly the larger disparities among younger patients, would not be meaningfully affected. Of note, disparities in home dialysis use at a later time point (e.g., day 365 of treatment) would be driven by the same mechanisms underlying the disparities we observe at day 90 as well as mechanisms related to modality switching. Second, we exclude pediatric patients from our analysis because they are treated in a separate pediatric nephrology system, although disparities persist in this population also.[53] Third, our measure of race/ethnicity and numerous covariates (e.g., patient comorbidities), are derived from the Medical Evidence form (CMS-2728). Because the form is typically completed by a clinician or staff person rather than the patient, we do not have access to self-reported race/ethnicity, which is preferred.[54] Moreover, comorbidities may be underreported in these data,[55] and we do not adjust for other potentially relevant patient factors—residual kidney function, echocardiography results, preferences, and psychosocial characteristics—or provider factors—treatment preferences, training in home dialysis, staffing constraints—that may affect treatment use differentially by patient race/ethnicity.[51] USRDS data do not capture these factors. Fourth, while we show that insurance status and nephrology care prior to kidney failure can explain part of the disparities we observe, it should be a priority of future research to uncover the mechanisms that most strongly explain these disparities and to identify interventions that can mitigate their impacts. Finally, our analysis is substantially

limited to non-Hispanic Black, Hispanic, and non-Hispanic white patients because of small cell sizes among other racial/ethnic subgroups. Asian Americans are a potentially important race/ethnicity subgroup to examine in future analyses, as they have many advantaged socioeconomic characteristics on average, and so may be more likely than other racial/ethnic minorities to undergo transplantation or home dialysis treatment.[28]

Relative and absolute racial/ethnic disparities in preferred kidney failure treatments are generally the worst among younger patients, particularly those aged 22–44. Using this information, interventions to reduce disparities in access to preferred kidney replacement therapies can be targeted to younger patient groups who stand to gain the most in accumulated life expectancy and quality of life when receiving a preferred kidney failure treatment.[34,35] Nevertheless, given the ubiquity of racial/ethnic disparities in access to high-quality kidney failure care, such interventions should not be targeted exclusively to a single age group.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Smedley BD, Stith AY, Nelson AR, eds. Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care. Washington, DC: Institute of Medicine (US) Committee on Understanding and Eliminating Racial and Ethnic Disparities in Health Care. National Academies Press, 2003.
2. United States Renal Data System (USRDS). 2020 USRDS Annual Data Report: Epidemiology of kidney disease in the United States. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2020.
3. Wolfe RA, Ashby VB, Milford EL, Ojo AO, Ettenger RE, Agodoa LYC, Held PJ, Port FK. Comparison of mortality in all patients on dialysis, patients on dialysis awaiting transplantation, and recipients of a first cadaveric transplant. N Engl J Med. 1999;341(23):1725–1730. doi:10.1056/NEJM199912023412303 [PubMed: 10580071]
4. Evans RW, Manninen DL, Garrison LP Jr, Hart LG, Blagg CR, Gutman RA, Hull AR, Lowrie EG. The quality of life of patients with end-stage renal disease. N Engl J Med. 1985;312(9):553–559. doi:10.1056/NEJM198502283120905 [PubMed: 3918267]
5. Simmons RG, Abress L. Quality-of-life issues for end-stage renal disease patients. Am J Kidney Dis. 1990;15(3):201–208. doi:10.1016/S0272-6386(12)80763-3 [PubMed: 2305760]

6. Diaz-Buxo JA, Lowrie EG, Lew NL, Zhang H, Lazarus JM. Quality-of-life evaluation using Short Form 36: comparison in hemodialysis and peritoneal dialysis patients. Am J Kidney Dis. 2000;35(2):293–300. doi:10.1016/S0272-6386(00)70339-8 [PubMed: 10676729]
7. Advancing American Kidney Health. Department of Health and Human Services. 10 Jul. 2019. https://aspe.hhs.gov/system/files/pdf/262046/AdvancingAmericanKidneyHealth.pdf
8. United States Renal Data System (USRDS). USRDS 2010 Annual Data Report. Ann Arbor, MI, 2010.
9. Gordon EJ. Patients' decisions for treatment of end-stage renal disease and their implications for access to transplantation. Soc Sci Med. 2001;53(8):971–987. doi:10.1016/S0277-9536(00)00397-X [PubMed: 11556779]
10. Knoll GA. Kidney transplantation in the older adult. Am J Kidney Dis. 2013;61(5):790–797. doi:10.1053/j.ajkd.2012.08.049 [PubMed: 23261121]
11. Puttarajappa CM, Schinstock CA, Wu CM, Leca N, Kumar V, Vasudev BS, Hariharan S. KDOQI US Commentary on the KDIGO Clinical Practice Guideline on the Evaluation and Management of Candidates for Kidney Transplantation. Am J Kidney Dis. 2021;77(6):P833–856. doi:10.1053/j.ajkd.2020.11.017
12. Garg PP, Diener-West M, Powe NR. Reducing racial disparities in transplant activation: Whom should we target? Am J Kidney Dis. 2001;37(5):921–931. doi:10.1016/S027-26386(05)80007-1 [PubMed: 11325673]
13. Rhee CM, Lertdumrongluk P, Streja E, Park J, Moradi H, Lau WL, Norris KC, Nissenson AR, Amin AN, Kovesdy CP, Kalantar-Zadeh K. Impact of age, race and ethnicity on dialysis patient survival and kidney transplantation disparities. Am J Neph. 2014;39(3):183–194. doi:10.1159/000358497
14. Shen JI, Erickson KF, Chen L, Vangala S, Leng L, Shah A, Saxena AB, Perl J, Norris KC. Expanded prospective payment system and use of and outcomes with home dialysis by race and ethnicity in the United States. Clin J Am Soc Nephrol. 2019;14(8):1200–1212. doi:10.2215/CJN.00290119 [PubMed: 31320318]
15. Keating PT, Walsh M, Ribic CM, Brimble KS. The impact of patient preference on dialysis modality and hemodialysis vascular access. BMC Nephrol. 2014;15(1):38. doi:10.1186/1471-2369-15-38 [PubMed: 24558955]
16. Wolfe RA, Port FK, Hawthorne VM, Guire KE. A comparison of survival among dialytic therapies of choice: in-center hemodialysis versus continuous ambulatory peritoneal dialysis at home. Am J Kidney Dis. 1990;15(5):433–440. doi:10.1016/S0272-6386(12)70361-X [PubMed: 2333865]
17. Fontanarosa PB, Bauchner H. Race, Ancestry, and Medical Research. JAMA. 2018;320(15):1539–1540. doi:10.1001/jama.2018.14438 [PubMed: 30264148]
18. Andersen RM. Revisiting the behavioral model and access to medical care: does it matter? J Health Soc Behav. 1995;36(1):1–10. doi:10.2307/2137284 [PubMed: 7738325]
19. Deber RB, Blidner IN, Carr LM, Barnsley JM. The impact of selected patient characteristics on practitioners' treatment recommendations for end-stage renal disease. Med Care. 1985:95–109. doi:10.1097/00005650-198502000-00001 [PubMed: 3883067]
20. Held PJ, Port FK, Turenne MN, Gaylin DS, Hamburger RJ, Wolfe RA. Continuous ambulatory peritoneal dialysis and hemodialysis: Comparison of patient mortality with adjustment for comorbid conditions. Kidney Int. 1994;45(4):1163–1169. doi:10.1038/ki.1994.154 [PubMed: 8007587]
21. Winkelmayer WC, Glynn RJ, Mittleman MA, Levin R, Pliskin JS, Avorn J. Comparing mortality of elderly patients on hemodialysis versus peritoneal dialysis: a propensity score approach. J Am Soc Nephrol. 2002;13(9):2353–2362. doi:10.1097/01.ASN.0000025785.41314.76 [PubMed: 12191980]
22. Waterman AD, Peipert JD, Hyland SS, McCabe MS, Schenk EA, Liu J. Modifiable patient characteristics and racial disparities in evaluation completion and living donor transplant. Clin J Am Soc Nephrol. 2013;8(6):995–1002. doi:10.2215/CJN.08880812 [PubMed: 23520044]
23. Norton EC, Dowd BE, Maciejewski ML. Odds ratios—current best practice and use. JAMA. 2018;320(1):84–85. doi:10.1001/jama.2018.6971 [PubMed: 29971384]

24. Williamson T, Eliasziw M, Fick GH. Log-binomial models: exploring failed convergence. Emerg. Themes Epidemiology. 2013;10(1):1–10. doi:10.1186/1742-7622-10-14
25. R: A Language and Environment for Statistical Computing [computer program]. Vienna, Austria: R Foundation for Statistical Computing; 2017.
26. Epstein AM, Ayanian JZ, Keogh JH, Noonan SJ, Armistead N, Cleary PD, Weissman JS, David-Kasdan JA, Carlson D, Fuller J. Racial disparities in access to renal transplantation—clinically appropriate or due to underuse or overuse? N Engl J Med. 2000;343(21):1537–1544. doi:10.1056/NEJM200011233432106 [PubMed: 11087884]
27. Held PJ, Pauly MV, Bovbjerg RR, Newmann J, Salvatierra O. Access to kidney transplantation: has the United States eliminated income and racial differences? Arch Intern Med. 1988;148(12):2594–2600. doi:10.1001/archinte.1988.00380120056011 [PubMed: 3058072]
28. Eggers PW. Racial differences in access to kidney transplantation. Health Care Financ Rev. 1995;17(2):89. [PubMed: 10157383]
29. Sequist TD, Narva AS, Stiles SK, Karp SK, Cass A, Ayanian JZ. Access to renal transplantation among American Indians and Hispanics. Am J Kidney Dis. 2004;44(2):344–352. doi:10.1053/j.ajkd.2004.04.039 [PubMed: 15264194]
30. Mehrotra R, Soohoo M, Rivara MB, Himmelfarb J, Cheung AK, Arah OA, Nissenson AR, Ravel V, Streja E, Kuttykrishnan S. Racial and ethnic disparities in use of and outcomes with home dialysis in the United States. J Am Soc Nephrol. 2016;27(7):2123–2134. doi:10.1681/ASN.2015050472 [PubMed: 26657565]
31. Wallace EL, Lea J, Chaudhary NS, Griffin R, Hammelman E, Cohen J, Sloand JA. Home dialysis utilization among racial and ethnic minorities in the United States at the national, regional, and state level. Perit Dial Int. 2017;37(1):21–29. doi:10.3747/pdi.2016.00025 [PubMed: 27680759]
32. Barker-Cummings C, McClellan W, Soucie JM, Krisher J. Ethnic differences in the use of peritoneal dialysis as initial treatment for end-stage renal disease. JAMA. 1995;274(23):1858–1862. doi:10.1001/jama.1995.03530230044028 [PubMed: 7500535]
33. Patzer RE, Amaral S, Wasse H, Volkova N, Kleinbaum D, McClellan WM. Neighborhood poverty and racial disparities in kidney transplant waitlisting. J Am Soc Nephrol.2009;20(6):1333–1340. doi:10.1681/ASN.2008030335 [PubMed: 19339381]
34. Kucirka LM, Grams ME, Lessler J, Hall EC, James N, Massie AB, Montgomery RA, Segev DL. Age and racial disparities in dialysis survival. JAMA. 2011;306(6):620.doi:10.1001/jama.2011.1127 [PubMed: 21828325]
35. Yan G, Norris KC, Alison JY, Ma JZ, Greene T, Yu W, Cheung AK. The relationship of age, race, and ethnicity with survival in dialysis patients. Clin J Am Soc Nephrol. 2013;8(6):953–961. doi:10.2215/CJN.09180912 [PubMed: 23539227]
36. Martins PN, Pratschke J, Pascher A, Fritsche L, Frei U, Neuhaus P, Tullius SG. Age and immune response in organ transplantation. Transplant. 2005;79(2):127–132. doi:10.1097/01.TP.0000146258.79425.04
37. Palomar R, Ruiz JC, Zubimendi JA, Cotorruelo JG, De Francisco AL, Rodrigo E, Sanz S, Fernández-Fresnedo G, Arias M. Acute rejection in the elderly recipient: influence of age in the outcome of kidney transplantation. Int Urol Nephrol. 2002;33(1):145–148. doi:10.1023/A:1014470403858 [PubMed: 12090322]
38. Wu C, Shapiro R, Tan H, Basu A, Smetanka C, Morgan C, Shah N, McCauley J, Unruh M. Kidney transplantation in elderly people: the influence of recipient comorbidity and living kidney donors. J Am Geriatr Soc. 2008;56(2):231–238. doi:10.1111/j.1532-5415.2007.01542.x [PubMed: 18070005]
39. Shen JI, Chen L, Vangala S, Leng L, Shah A, Saxena AB, Perl J, Norris K. Socioeconomic factors and racial and ethnic differences in the initiation of home dialysis. Kidney Med.2020;2(2):105–115. doi:10.1016/j.xkme.2019.11.006 [PubMed: 32734231]
40. Van Ryn M, Burke J. The effect of patient race and socio-economic status on physicians' perceptions of patients. Soc Sci Med. 2000;50(6):813–828. doi:10.1016/S0277-9536(99)00338-X [PubMed: 10695979]
41. Pipkin M, Eggers PW, Larive B, Rocco MV, Stokes JB, Suri RS, Lockridge RS, Frequent Hemodialysis Network Trial Group. Recruitment and training for home hemodialysis: experience

and lessons from the Nocturnal Dialysis Trial. Clin J Am Soc Nephrol. 2010;5(9):1614–1620. doi:10.2215/CJN.02440310 [PubMed: 20576829]

42. Kaiser Family Foundation. Health Coverage & Uninsured. State Health Facts 2020; https://www.kff.org/state-category/health-coverage-uninsured/. Accessed 6 Feb. 2020.
43. Prakash S, Rodriguez RA, Austin PC, Saskin R, Fernandez A, Moist LM, O'Hare AM. Racial composition of residential areas associates with access to pre-ESRD nephrology care. J Am Soc Nephrol. 2010;21(7):1192–1199. doi:10.1681/ASN.2009101008 [PubMed: 20558541]
44. Johansen KL, Zhang R, Huang Y, Patzer RE, Kutner NG. Association of race and insurance type with delayed assessment for kidney transplantation among patients initiating dialysis in the United States. Clin J Am Soc Nephrol. 2012;7(9):1490–1497.doi:10.2215/CJN.13151211 [PubMed: 22837273]
45. Issa N, Lankireddy S, Kukla A. Should peritoneal dialysis be the preferred therapy pre-kidney transplantation. Adv Perit Dial. 2012;28:89–93. [PubMed: 23311221]
46. Fine JP, Gray RJ. A proportional hazards model for the subdistribution of a competing risk. J Am Stat Assoc. 1999;94(446):496–509. doi:10.2307/2670170
47. Turenne M, Baker R, Pearson J, Cogan C, Mukhopadhyay P, Cope E. Payment reform and health disparities: changes in dialysis modality under the new Medicare dialysis payment system. Health Serv Res. 2018;53(3):1430–1457. doi:10.1111/1475-6773.12713 [PubMed: 28560726]
48. Lin E, Cheng XS, Chin K-K, Zubair T, Chertow GM, Bendavid E, Bhattacharya J. Home dialysis in the Prospective Payment System era. J Am Soc Nephrol. 2017;28(10):2993–3004. doi:10.1681/ASN.2017010041 [PubMed: 28490435]
49. Melanson TA, Hockenberry JM, Plantinga L, Basu M, Pastan SO, Mohan S, Howard DH, Patzer RE. New kidney allocation system associated with increased rates of transplants among Black and Hispanic patients. Health Affairs. 2017;36(6):1078–1085. doi:10.1377/hlthaff.2016.1625 [PubMed: 28583967]
50. Zhang X, Melanson TA, Plantinga LC, Basu M, Pastan SO, Mohan S, Howard DH, Hockenberry JM, Garber MD, Patzer RE. Racial/ethnic disparities in waitlisting for deceased donor kidney transplantation 1 year after implementation of the new national kidney allocation system. Am J Transplant. 2018;18(8):1936–1946. doi:10.1111/ajt.14748 [PubMed: 29603644]
51. Norris KC, Williams SF, Rhee CM, Nicholas SB, Kovesdy CP, Kalantar- Zadeh K, Boulware EL. Hemodialysis disparities in African Americans: the deeply integrated concept of race in the social fabric of our society. Semin Dial. 2017;30(3):213–223. doi:10.1111/sdi.12589 [PubMed: 28281281]
52. King KL, Husain SA, Jin Z, Brennan C, Mohan S. Trends in disparities in preemptive kidney transplantation in the United States. Clin J Am Soc Nephrol. 2019;14(10):1500–1511. doi:10.2215/CJN.03140319 [PubMed: 31413065]
53. Patzer R, Amaral S, Klein M, Kutner N, Perryman JP, Gazmararian JA, McClellan WM. Racial disparities in pediatric access to kidney transplantation: does socioeconomic status play a role? Am J Transplant. 2012;12(2):369–378. doi:10.1111/j.1600-6143.2011.03888.x [PubMed: 22226039]
54. Jarrín OF, Nyandege AN, Grafova IB, Dong X, Lin H. Validity of race and ethnicity codes in Medicare administrative data compared with gold-standard self-reported race collected during routine home health care visits. Med Care. 2020;58(1):e1–e8. doi:10.1097/MLR.0000000000001216 [PubMed: 31688554]
55. Longenecker JC, Coresh J, Klag MJ, Levey AS, Martin AA, Fink NE, Powe NR. Validation of comorbid conditions on the end-stage renal disease medical evidence report: the CHOICE study. J Am Soc Nephrol. 2000;11(3):520–529. doi:10.1681/ASN.V113520 [PubMed: 10703676]

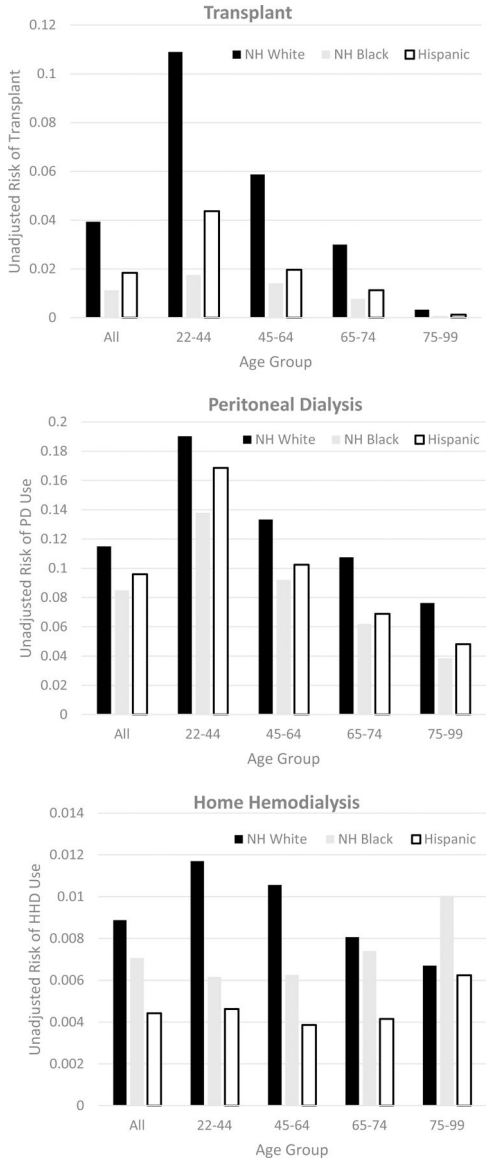

Figure 1: Unadjusted Risks of Transplantation (A), Peritoneal Dialysis (B), and Home Hemodialysis (C) by Race/ethnicity and Age, 2011–2018

Notes: Outcomes identified at 90 days after start of kidney failure treatment. NH = non-Hispanic, ICHD = in-center hemodialysis, PD = peritoneal dialysis, HHD = home hemodialysis. Transplantation at day 90 disproportionately comprises pre-emptive and living donor kidney transplants.

Table 1:

Baseline Characteristics of U.S. Adult Patients with Incident Kidney Failure Requiring Replacement Therapy by Race/Ethnicity, 2011–2018

Variables	Overall	Non-Hispanic white	Non-Hispanic Black	Hispanic	Other
Patients, No. (%)	830402 (100.0)	431772 (52.0)	218816 (26.4)	126096 (15.2)	53718 (6.5)
Age Group, No. (%)					
22–44	98730 (11.9)	35363 (8.2)	36163 (16.5)	19020 (15.1)	8184 (15.2)
45–64	334643 (40.3)	153830 (35.6)	100729 (46.2)	58076 (46.1)	22008 (41.0)
65–74	214359 (25.8)	124013 (28.7)	49165 (22.5)	28647 (22.7)	12534 (23.3)
75–99	182670 (22.0)	118566 (27.5)	32759 (15.0)	20353 (16.1)	10992 (20.5)
Sex, No. (%)					
Female	349040 (42.0)	172544 (40.0)	101593 (46.4)	51432 (40.8)	23471 (43.7)
Male	481362 (58.0)	259228 (60.0)	117223 (53.6)	74664 (59.2)	30247 (56.3)
Attributed Cause of Kidney Failure, No. (%)					
Diabetes mellitus	387767 (46.7)	185698 (43.0)	94893 (43.4)	78291 (62.1)	28885 (53.8)
Hypertension	238716 (28.7)	115784 (26.8)	85217 (38.9)	26217 (20.8)	11498 (21.4)
Glomerulonephritis	62485 (7.5)	35144 (8.1)	13814 (6.3)	8444 (6.7)	5083 (9.5)
Other	141434 (17.0)	95146 (22.0)	24892 (11.4)	13144 (10.4)	8252 (15.4)
Comorbidity, No. (%)					
Heart Disease	372937 (46.2)	213800 (51.0)	90162 (42.1)	49967 (40.3)	19008 (38.0)
Diabetes Mellitus	471331 (58.4)	230215 (54.9)	123068 (57.5)	85732 (69.1)	32316 (64.7)
Hypertension	712457 (88.3)	361272 (86.2)	195372 (91.3)	110961 (89.4)	44852 (89.8)
Insurance Pre-Kidney Failure, No. (%)					
Medicaid	99289 (12.4)	32123 (7.7)	34622 (16.3)	23711 (19.2)	8833 (17.8)
Medicare	495145 (61.8)	287701 (69.2)	118604 (55.8)	63816 (51.8)	25024 (50.4)
Private	111227 (13.9)	58052 (14.0)	30002 (14.1)	15030 (12.2)	8143 (16.4)
Veteran’s Administration	7176 (0.9)	3543 (0.9)	2700 (1.3)	672 (0.5)	261 (0.5)
Other	45317 (5.7)	20637 (5.0)	10641 (5.0)	9242 (7.5)	4797 (9.7)
None	43311 (5.4)	13908 (3.3)	16054 (7.6)	10805 (8.8)	2544 (5.1)
Pre-Kidney Failure Nephrology Care, No. (%)	519317 (64.2)	287961 (68.6)	127256 (59.3)	71035 (57.1)	33065 (66.1)

Variables	Overall	Non-Hispanic white	Non-Hispanic Black	Hispanic	Other
Year of Kidney Failure Incidence, No. (%)					
2011	103739 (12.5)	53621 (12.4)	28172 (12.9)	16062 (12.7)	5884 (11.0)
2012	105768 (12.7)	55229 (12.8)	28279 (12.9)	16081 (12.8)	6179 (11.5)
2013	108463 (13.1)	56819 (13.2)	28677 (13.1)	16593 (13.2)	6374 (11.9)
2014	111304 (13.4)	57497 (13.3)	29867 (13.6)	16831 (13.3)	7109 (13.2)
2015	115084 (13.9)	59571 (13.8)	30470 (13.9)	17483 (13.9)	7560 (14.1)
2016	115762 (13.9)	60255 (14.0)	29952 (13.7)	17529 (13.9)	8026 (14.9)
2017	115473 (13.9)	60179 (13.9)	29790 (13.6)	17299 (13.7)	8205 (15.3)
2018	54809 (6.6)	28601 (6.6)	13609 (6.2)	8218 (6.5)	4381 (8.2)

Notes: NH = Non-Hispanic. T-tests and chi-squared tests were used to compare all characteristics of non-Hispanic Black, Hispanic, and other race/ethnicity groups with non-Hispanic white patients: $p<0.001$ for all tests.

Table 2:

Treatment Outcomes at Day 90 of Treatment for U.S. Adult Patients with Incident Kidney Failure by Race/Ethnicity and Age Group, Unadjusted, 2011–2018

Age Group	Treatment at Day 90 of Therapy, No. (%)	Overall	Non-Hispanic white	Non-Hispanic Black	Hispanic	Other
All	Transplant	25152 (3.0)	17020 (3.9)	2464 (1.1)	2322 (1.8)	3346 (6.2)
	In-center hemodialysis	669268 (80.6)	333123 (77.2)	188444 (86.1)	106307 (84.3)	41394 (77.1)
	Peritoneal dialysis	87168 (10.5)	49645 (11.5)	18563 (8.5)	12105 (9.6)	6855 (12.8)
	Home hemodialysis	6190 (0.7)	3835 (0.9)	1547 (0.7)	558 (0.4)	250 (0.5)
	Other treatment	9609 (1.2)	5794 (1.3)	2017 (0.9)	1166 (0.9)	632 (1.2)
	Unstable modality (excluded from subsequent analyses)	33015 (4.0)	22355 (5.2)	5781 (2.6)	3638 (2.9)	1241 (2.3)
	N	830402	431772	218816	126096	53718
22–44	Transplant	6729 (6.8)	3854 (10.9)	635 (1.8)	831 (4.4)	1409 (17.2)
	In-center hemodialysis	69895 (70.8)	21769 (61.6)	28918 (80.0)	14243 (74.9)	4965 (60.7)
	Peritoneal dialysis	16355 (16.6)	6730 (19.0)	4986 (13.8)	3208 (16.9)	1431 (17.5)
	Home hemodialysis	775 (0.8)	414 (1.2)	223 (0.6)	88 (0.5)	50 (0.6)
	Other treatment	1183 (1.2)	540 (1.5)	326 (0.9)	193 (1.0)	124 (1.5)
	Unstable modality (excluded from subsequent analyses)	3793 (3.8)	2056 (5.8)	1075 (3.0)	457 (2.4)	205 (2.5)
	N	98730	35363	36163	19020	8184
45–64	Transplant	13167 (3.9)	9043 (5.9)	1422 (1.4)	1142 (2.0)	1560 (7.1)
	In-center hemodialysis	263523 (78.7)	112266 (73.0)	85831 (85.2)	48801 (84.0)	16625 (75.5)
	Peritoneal dialysis	38733 (11.6)	20527 (13.3)	9273 (9.2)	5946 (10.2)	2987 (13.6)
	Home hemodialysis	2571 (0.8)	1625 (1.1)	631 (0.6)	224 (0.4)	91 (0.4)
	Other treatment	3804 (1.1)	2116 (1.4)	920 (0.9)	535 (0.9)	233 (1.1)
	Unstable modality (excluded from subsequent analyses)	12845 (3.8)	8253 (5.4)	2652 (2.6)	1428 (2.5)	512 (2.3)
	N	334643	153830	100729	58076	22008
65–74	Transplant	4776 (2.2)	3725 (3.0)	381 (0.8)	323 (1.1)	347 (2.8)
	In-center hemodialysis	176872 (82.5)	97893 (78.9)	43721 (88.9)	25079 (87.5)	10179 (81.2)
	Peritoneal dialysis	19895 (9.3)	13334 (10.8)	3043 (6.2)	1972 (6.9)	1546 (12.3)
	Home hemodialysis	1542 (0.7)	1001 (0.8)	364 (0.7)	119 (0.4)	58 (0.5)
	Other treatment	2632 (1.2)	1782 (1.4)	457 (0.9)	250 (0.9)	143 (1.1)
	Unstable modality (excluded from subsequent analyses)	8642 (4.0)	6278 (5.1)	1199 (2.4)	904 (3.2)	261 (2.1)
	N	214359	124013	49165	28647	12534
75–99	Transplant	480 (0.3)	398 (0.3)	26 (0.1)	26 (0.1)	30 (0.3)
	In-center hemodialysis	158978 (87.0)	101195 (85.3)	29974 (91.5)	18184 (89.3)	9625 (87.6)
	Peritoneal dialysis	12185 (6.7)	9054 (7.6)	1261 (3.8)	979 (4.8)	891 (8.1)

Age Group	Treatment at Day 90 of Therapy, No. (%)	Overall	Non-Hispanic white	Non-Hispanic Black	Hispanic	Other
	Home hemodialysis	1302 (0.7)	795 (0.7)	329 (1.0)	127 (0.6)	51 (0.5)
	Other treatment	1990 (1.1)	1356 (1.1)	314 (1.0)	188 (0.9)	132 (1.2)
	Unstable modality (excluded from subsequent analyses)	7735 (4.2)	5768 (4.9)	855 (2.6)	849 (4.2)	263 (2.4)
	N	182670	118566	32759	20353	10992

Notes: NH = Non-Hispanic. T-tests were used to compare all characteristics of non-Hispanic Black, Hispanic, and other race/ethnicity groups with non-Hispanic white patients: $p<0.001$ for all tests. Transplantation at day 90 consists principally of pre-emptive (i.e., prior to receiving any dialysis treatment; 21,351/25,152 = 85%) and living donor (14,279/25,152 = 57%) kidney transplants.

Table 3.

Adjusted Probabilities and Adjusted Risk Ratios (versus Non-Hispanic White Patients) of Transplantation, Peritoneal Dialysis, and Home Hemodialysis, by Race/ethnicity and Age, 2011–2018

Outcome *(Sample)*	Race/Ethnicity	All		Age 22–44		Age 45–64		Age 65–74		Age 75–99	
		AP	**ARR**	**AP**	**ARR**	**AP**	**ARR**	**AP**	**ARR**	**AP**	**ARR**
Transplant *(all kidney failure patients, n=807,222)*	NH white (95% CI)	**3.5%** (3.5%, 3.6%)	--	**8.7%** (8.4%, 9.0%)	--	**4.6%** (4.5%, 4.7%)	--	**2.3%** (2.2%, 2.4%)	--	**0.3%** (0.2%, 0.3%)	--
	NH Black (95% CI)	**1.0%** (0.9%, 1.0%)	**0.27** (0.26, 0.28)	**1.8%** (1.6%, 2.0%)	**0.21** (0.19, 0.23)	**1.4%** (1.3%, 1.5%)	**0.30** (0.29, 0.32)	**0.7%** (0.6%, 0.8%)	**0.29** (0.26, 0.33)	**0.1%** (0.0%, 0.1%)	**0.29** (0.19, 0.45)
	Hispanic (95% CI)	**1.7%** (1.6%, 1.8%)	**0.48** (0.46, 0.50)	**4.1%** (3.8%, 4.4%)	**0.47** (0.43, 0.51)	**2.2%** (2.1%, 2.4%)	**0.49** (0.46, 0.52)	**1.2%** (1.0%, 1.3%)	**0.50** (0.44, 0.56)	**0.1%** (0.1%, 0.2%)	**0.49** (0.32, 0.75)
	Other (95% CI)	**2.2%** (2.1%, 2.4%)	**0.63** (0.60, 0.67)	**5.7%** (5.2%, 6.2%)	**0.66** (0.60, 0.72)	**2.7%** (2.4%, 2.9%)	**0.59** (0.54, 0.65)	**1.7%** (1.5%, 1.9%)	**0.72** (0.63, 0.83)	**0.2%** (0.1%, 0.3%)	**0.63** (0.39, 1.02)
Peritoneal Dialysis *(PD and ICHD patients, n=745,691)*	NH white (95% CI)	**14.1%** (14.0%, 14.3%)	--	**23.5%** (23.0%, 24.0%)	--	**15.7%** (15.5%, 15.9%)	--	**12.3%** (12.1%, 12.5%)	--	**8.3%** (8.1%, 8.5%)	--
	NH Black (95% CI)	**8.3%** (8.1%, 8.4%)	**0.59** (0.58, 0.60)	**15.3%** (14.8%, 15.8%)	**0.65** (0.63, 0.67)	**9.7%** (9.5%, 9.9%)	**0.62** (0.61, 0.63)	**6.4%** (6.1%, 6.7%)	**0.52** (0.50, 0.54)	**4.0%** (3.7%, 4.2%)	**0.48** (0.45, 0.51)
	Hispanic (95% CI)	**9.5%** (9.3%, 9.7%)	**0.68** (0.66, 0.69)	**18.1%** (17.4%, 18.9%)	**0.77** (0.75, 0.80)	**10.8%** (10.5%, 11.1%)	**0.69** (0.67, 0.71)	**7.3%** (6.8%, 7.7%)	**0.59** (0.56, 0.62)	**5.0%** (4.7%, 5.4%)	**0.61** (0.57, 0.65)
	Other (95% CI)	**13.3%** (12.9%, 13.6%)	**0.94** (0.92, 0.96)	**21.4%** (20.2%, 22.4%)	**0.92** (0.88, 0.97)	**14.6%** (13.8%, 15.2%)	**0.93** (0.90, 0.96)	**12.5%** (11.9%, 13.1%)	**1.02** (0.97, 1.07)	**8.0%** (7.5%, 8.6%)	**0.98** (0.91, 1.04)
Home Hemodialysis *(HHD and ICHD patients, n=665,496)*	NH white (95% CI)	**1.1%** (1.1%, 1.2%)	--	**1.7%** (1.6%, 1.9%)	--	**1.4%** (1.3%, 1.5%)	--	**1.0%** (0.9%, 1.1%)	--	**0.8%** (0.7%, 0.8%)	--
	NH Black (95% CI)	**0.8%** (0.7%, 0.8%)	**0.68** (0.64, 0.73)	**0.8%** (0.7%, 0.9%)	**0.45** (0.38, 0.54)	**0.7%** (0.7%, 0.8%)	**0.53** (0.48, 0.58)	**0.8%** (0.7%, 0.9%)	**0.82** (0.72, 0.93)	**1.0%** (0.9%, 1.2%)	**1.38** (1.21, 1.58)
	Hispanic (95% CI)	**0.5%** (0.5%, 0.6%)	**0.45** (0.41, 0.50)	**0.6%** (0.4%, 0.8%)	**0.34** (0.27, 0.43)	**0.5%** (0.4%, 0.5%)	**0.34** (0.30, 0.39)	**0.5%** (0.4%, 0.6%)	**0.48** (0.39, 0.58)	**0.7%** (0.6%, 0.9%)	**0.93** (0.77, 1.13)

Outcome *(Sample)*	Race/Ethnicity	All		Age 22–44		Age 45–64		Age 65–74		Age 75–99	
		AP	**ARR**	**AP**	**ARR**	**AP**	**ARR**	**AP**	**ARR**	**AP**	**ARR**
	Other (95% CI)	**0.6%** (0.5%, 0.7%)	**0.53** (0.47, 0.60)	**1.0%** (0.6%, 1.3%)	**0.55** (0.41, 0.74)	**0.5%** (0.4%, 0.7%)	**0.40** (0.32, 0.49)	**0.6%** (0.4%, 0.8%)	**0.59** (0.45, 0.77)	**0.5%** (0.4%, 0.8%)	**0.73** (0.55, 0.97)

Notes: Outcomes identified at 90 days of therapy; adjusted probabilities and 95% CI estimated using bootstrapping methods (100 iterations, each iteration draw 70% random sample stratified by race); adjusted risk ratios estimated using adjusted log-binomial regression model results; models are adjusted for sex, cause of kidney failure (diabetes mellitus, Glomerulonephritis, Hypertension, Other), presence of comorbidities (heart disease, diabetes mellitus, hypertension), year of kidney failure incidence. Non-Hispanic white used as reference group. AP = adjusted probability, ARR = adjusted risk ratio (non-Hispanic white reference group), NH = Non-Hispanic, CI = confidence intervals, PD = peritoneal dialysis, ICHD = in-center hemodialysis, HHD = home hemodialysis. Transplantation at day 90 consists principally of pre-emptive (i.e., prior to receiving any dialysis treatment; 21,351/25,152 = 85%) and living donor (14,279/25,152 = 57%) kidney transplants. Because of the differences in comparison groups across outcomes, the adjusted probabilities presented in this table are comparable with the unadjusted risks of outcomes presented in Table 2 and Figure 1 only for the transplantation outcome.