Expanded Prospective Payment System and Use of and Outcomes with Home Dialysis by Race and Ethnicity in the United States

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Abstract

Background and objectives We investigated whether the recent growth in home dialysis use was proportional among all racial/ethnic groups and also whether there were changes in racial/ethnic differences in home dialysis outcomes.

Design, setting, participants, & measurements This observational cohort study of US Renal Data System patients initiating dialysis from 2005 to 2013 used logistic regression to estimate racial/ethnic differences in home dialysis initiation over time, and used competing risk models to assess temporal changes in racial/ethnic differences in home dialysis outcomes, specifically: (*1*) transfer to in-center hemodialysis (HD), (2) mortality, and (*3*) transplantation.

Results Of the 523,526 patients initiating dialysis from 2005 to 2013, 55% were white, 28% black, 13% Hispanic, and 4% Asian. In the earliest era (2005–2007), 8.0% of white patients initiated dialysis with home modalities, as did a similar proportion of Asians (9.2%; adjusted odds ratio [aOR], 0.95; 95% confidence interval [95% CI], 0.86 to 1.05), whereas lower proportions of black [5.2%; aOR, 0.71; 95% CI, 0.66 to 0.76] and Hispanic (5.7%; aOR, 0.83; 95% CI, 0.86 to 0.93) patients did so. Over time, home dialysis use increased in all groups and racial/ethnic differences decreased (2011–2013: 10.6% of whites, 8.3% of blacks [aOR, 0.81; 95% CI, 0.77 to 0.85], 9.6% of Hispanics [aOR, 0.94; 95% CI, 0.86 to 1.00], 14.2% of Asians [aOR, 1.04; 95% CI, 0.86 to 1.12]). Compared with white patients, the risk of transferring to in-center HD was higher in blacks, similar in Hispanics, and lower in Asians; these differences remained stable over time. The mortality rate was lower for minority patients than for white patients; this difference increased over time. Transplantation rates were lower for blacks and similar for Hispanics and Asians; over time, the difference in transplantation rates between blacks and Hispanics versus whites increased.

Conclusions From 2005 to 2013, as home dialysis use increased, racial/ethnic differences in initiating home dialysis narrowed, without worsening rates of death or transfer to in-center HD in minority patients, as compared with white patients.

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Introduction

The use of home dialysis in the United States has increased over the last 10 years in the setting of payment reforms and educational efforts (1–3). Implemented in 2011, the expanded End Stage Renal Disease Prospective Payment System included newer injectable medications among the outpatient dialysis services composing a bundled payment and added payments for home dialysis training (4). This provided a financial incentive for dialysis providers to use home dialysis, which is associated with less intensive use of expensive injectable medications than in-center hemodialysis (HD) (5). At the same time, large dialysis organizations were expanding their home dialysis programs, and efforts to increase the training of physicians in home dialysis continued (3). Increased awareness of, and funding for, achievement of patient-centered outcomes also enhanced preexisting patient modality education programs (6).

Racial and ethnic disparities in United States home dialysis use have previously been well documented, with minority patients less likely to use home modalities than white patients (7–9). Health outcomes of patients on home dialysis also vary by race and ethnicity. For example, black patients who use home dialysis are more likely than white patients to transfer to in-center HD (7,10–15). Lower rates of both death and transplantation have also been demonstrated in minority patients compared with white patients (7).

It is not known whether the recent increase in home dialysis differed by racial/ethnic group or changed racial/ethnic differences in home dialysis outcomes. To evaluate the effects of the growth in home dialysis among different racial/ethnic groups, we examined

from 2005 to 2013 the temporal trends in racial/ethnic differences in initiating dialysis with home modalities, as well as home dialysis outcomes, including transfer to in-center HD, mortality, and kidney transplantation.

Materials and Methods

Data Source

We extracted patient-level and dialysis facility–level data from the US Renal Data System (USRDS), a national database of virtually all patients with ESKD. ZIP code–level factors were abstracted from the American Community Survey 5-year estimates, and hospital service area (HSA)–level variables were derived from the Dartmouth Atlas of Healthcare. Rural/urban status was determined *via* Rural-Urban Commuting Area (RUCA) codes version 3.0 (16).

Study Sample

To analyze initiation of home dialysis, we identified from the USRDS all patients ≥18 years old with ESKD who initiated maintenance dialysis with either in-center HD or home dialysis (peritoneal dialysis [PD] or home HD) on day 1 of dialysis between January 1, 2005 and December 31, 2013 with no history of kidney transplantation (Supplemental Figure 1). We excluded patients who were of non-Asian, nonblack, or nonwhite race because they would have composed an "other" racial category, and results for such a heterogeneous group would be difficult to interpret. There were also too few Hispanic blacks and Hispanic Asians to analyze separately, and we chose to exclude them from the Hispanic white group because they have been found to have different outcomes (17). We also excluded those with missing length of nephrology care as we felt it was a marker of poor data quality, as well as those missing ZIP codes because these were used to link to multiple neighborhood variables. The primary analysis was a complete case analysis. For survival analyses, we restricted the population to those who initiated home dialysis on day 1.

Exposure

The primary exposure of interest was race/ethnicity. We categorized patients as: white (non-Hispanic white), Hispanic (Hispanic white), black (non-Hispanic black), or Asian (non-Hispanic Asian) on the basis of the race and ethnicity reported on the Medical Evidence Report (Centers for Medicare and Medicaid Services [CMS] form 2728).

To examine temporal changes, we stratified analyses into three eras of equal duration (3 years) on the basis of patients' year of dialysis initiation: 2005–2007, 2008–2010, and 2011–2013.

Outcomes

The primary outcome of interest was the dialysis modality the patient used on day 1, either home dialysis or in-center HD, as reported in the USRDS detailed treatment history file.

For survival analyses, outcomes of interest were transfer to in-center HD for at least 30 days, all-cause mortality, and kidney transplantation.

Covariates

We ascertained demographics, comorbidities, laboratory values, and individual-level socioeconomic factors from the Medical Evidence Report (Supplemental Table 1A, Table 1). These variables have previously been shown to be associated with modality selection (18).

We used patient ZIP codes to ascertain neighborhood variables from the American Community Survey 5-year estimates (Supplemental Material, Supplemental Table 1A, Table 1). Urban neighborhoods were defined on the basis of categorization as metropolitan using RUCA codes. We chose neighborhood-level covariates previously shown to be associated with clinical outcomes among different racial and ethnic groups on dialysis (19–24).

The Dartmouth Atlas was used to determine health service area (HSA) levels of access to healthcare (Supplemental Table 1A). We calculated the number of PD facilities with at least 20 patients and the number of home HD units in the HSA using the USRDS ESRD Facility Survey (form number CMS-2744) to account for changes in access to home dialysis over time (25). We categorized the geographic location of patients by United States census division to capture regional variation in provider culture, and included local trends in healthcare spending as the total Medicare reimbursement per enrollee in the HSA. Using the Facility Survey, we designated dialysis facilities as for-profit, non-profit, or unknown. For patients on PD, we also categorized their facilities as large if they treated at least 20 patients on PD, because they have been associated with better outcomes (26–32).

Statistical Analyses

We tabulated patient characteristics by race/ethnicity using percentages and means (±SD) or medians (interquartile range), as appropriate.

We used logistic regression to estimate the ratio of the odds of initiating dialysis with home dialysis (versus in-center HD) in each of the minority groups to the odds for white patients. To test for temporal changes in racial/ethnic differences in home dialysis initiation, we examined contrasts between the earliest and latest eras of initiation (2005–2007 versus 2011–2013) for each minority group compared with whites. For analysis, we categorized the variables as noted in Supplemental Table 1B. The number of large PD programs and the number of home HD units in an HSA were log transformed for analysis. We ran unadjusted analyses and analyses adjusted for demographics, medical factors, and socioeconomic factors shown in Table 1 and Supplemental Table 1A. We tested for the presence of a three-way interaction between Medicare status, era, and race/ethnicity in the full model.

We used Fine and Gray competing risk regression to estimate the hazard ratio of each of the three outcomes (transfer to in-center HD, mortality, and transplantation) for each minority group compared with white patients, treating the other two outcomes as competing risks, acknowledging that the other events can either prevent or modify the risk of the outcome of interest (33). We followed patients starting from day 1 of dialysis and censored them for loss to follow-up, recovery of kidney function, and the end of the follow-up period (June 30, 2015). To assess changes in disparities over time, we tested for an interaction between era of initiation and race/ethnicity. We ran unadjusted analyses and analyses adjusted for demographics, medical factors, and socioeconomic factors shown in Table 1 and Supplemental Table 1.

Table 1. Select characteristics of adult patients initiating home dialysis from 2005 to 2013 on day 1 of dialysis, by era and race/ethnicity

Characteristic	Year of Dialysis											
	2005–2007 *n*=11,432				2008–2010 *n*=13,617				2011–2013 *n*=17,461			
	White *n*=7287	Black *n*=2437	Hispanic *n*=1102	Asian *n*=606	White *n*=8235	Black *n*=2997	Hispanic *n*=1531	Asian *n*=854	White *n*=10,118	Black *n*=3843	Hispanic *n*=2313	Asian *n*=1187
Demographics												
Median age (Q1–Q3), yr	62 (52–73)	54 (44–63)	55 (42–65)	59 (47–68)	63 (52–72)	55 (44–64)	55 (44–65)	58 (47–68)	63 (53–73)	55 (44–64)	55 (44–64)	61 (49–70)
Men, %	57	47	52	55	59	50	56	52	60	49	58	53
Peritoneal dialysis, %	98	97	99	99	99	98	99	99	98	98	98	100
Home hemodialysis, %	1.7	2.7	1.4	0.8	1.5	2.1	1.1	1.5	2.0	2.3	1.6	0.4
Medical factors												
Diabetes, %	47	47	54	46	46	49	56	44	49	50	61	53
Atherosclerotic heart disease, %	21	10	11	10	19	9	10	12	16	7	9	9
Heart failure, %	21	15	13	11	19	16	12	12	18	15	12	11
Cerebrovascular disease, %	7	7	4	4	7	6	5	5	6	5	4	4
Need help with ADLs, %	5	4	4	2	4	3	4	3	5	4	5	5
Mean BMI (SD), kg/m^2	28.3 (6.2)	29.6 (6.6)	28.4 (5.9)	25.5 (4.9)	28.8 (6.2)	30.1 (6.7)	29.0 (5.9)	25.5 (5.2)	29.1 (6.3)	29.9 (6.5)	29.0 (6.0)	26.2 (5.2)
Individual-level socioeconomic factors, %												
No nephrology referral predialysis	9	12	17	12	7	11	15	8	7	12	17	8
Employer health plan	46	49	39	49	43	47	37	49	38	43	36	45
Medicaid	10	19	28	21	10	18	26	19	11	19	23	18
Medicare	47	30	28	27	45	30	27	27	53	38	35	36
Uninsured	5	10	13	5	6	10	13	5	6	11	14	5
Unemployed	11	20	23	16	12	21	26	16	14	24	30	19

Table 1. (Continued)

Characteristic	Year of Dialysis											
	2005–2007 *n*=11,432				2008–2010 *n*=13,617				2011–2013 *n*=17,461			
	White *n*=7287	Black *n*=2437	Hispanic *n*=1102	Asian *n*=606	White *n*=8235	Black *n*=2997	Hispanic *n*=1531	Asian *n*=854	White *n*=10,118	Black *n*=3843	Hispanic *n*=2313	Asian *n*=1187
Regional-level socioeconomic factors												
Mean percentage of ZIP code below poverty line (SD), %	13 (8)	21 (11)	19 (10)	11 (7)	13 (8)	20 (10)	19 (10)	11 (7)	14 (8)	21 (11)	19 (10)	13 (7)
Median percentage of ZIP code with <HS diploma (Q1–Q3), %	12 (8–18)	18 (11–24)	24 (15–33)	11 (7–19)	12 (8–18)	18 (11–24)	23 (14–34)	12 (7–19)	12 (8–18)	17 (11–23)	22 (13–33)	12 (8–21)
Large PD unit, %[a]	61	65	67	69	57	61	75	70	57	65	67	77
For-profit dialysis unit, %[b]	77	81	78	68	79	80	82	72	84	83	85	79
Urban ZIP code, %	74	87	90	95	75	86	87	95	76	88	89	95
Census division, %												
Pacific	10	7	35	59	12	8	36	60	13	8	36	61
East South Central	8	13	1	1	9	16	1	1	9	14	1	2
West South Central	8	13	1	1	9	16	1	1	9	14	1	2
Mountain	7	1	10	4	7	1	11	4	7	2	11	5
New England	6	4	3	4	6	3	3	4	5	3	2	3
South Atlantic	20	36	9	8	20	35	8	10	19	34	8	9
West North Central	8	3	2	2	7	3	1	2	7	3	1	2
East North Central	20	16	6	7	18	13	6	6	18	14	6	6
Middle Atlantic	12	10	8	9	12	9	6	9	12	8	6	8

Q1, first quartile; Q3, third quartile; ADLs, activities of daily living; BMI, body mass index; HS, high school; PD, peritoneal dialysis.
[a]Reported for those on PD on day 1. Large units were defined as having at least 20 patients on PD.
[b]This was unknown for white patients, *n*=5517 (2%); black patients, *n*=4505 (3%); Hispanic patients, *n*=1034 (2%); Asian patients, *n*=362 (2%).

Table 2. Select characteristics of adult patients initiating in-center dialysis from 2005 to 2013 on day 1 of dialysis, by era and race/ethnicity

Characteristic	Year of Dialysis											
	2005–2007 (*n*=152015)				2008–2010 (*n*=172334)				2011–2013 (*n*=156667)			
	White (*n*=83,578)	Black (*n*=44,214)	Hispanic (*n*=18,274)	Asian (*n*=5949)	White (*n*=92,911)	Black (*n*=49,320)	Hispanic (*n*=22,551)	Asian (*n*=7552)	White (*n*=85,162)	Black (*n*=42,555)	Hispanic (*n*=21,770)	Asian (*n*=7180)
Demographics												
Median age (Q1–Q3), yr	70 (59–78)	59 (49–70)	61 (50–71)	64 (53–75)	69 (59–78)	60 (50–70)	60 (50–71)	64 (54–75)	69 (59–78)	61 (51–70)	61 (51–71)	65 (54–75)
Men, %	59	52	57	55	60	54	58	57	61	55	59	57
Medical factors												
Diabetes, %	51	53	65	57	52	56	68	60	55	58	70	63
Atherosclerotic heart disease, %	30	15	19	21	28	15	18	20	25	14	15	16
Heart failure, %	38	31	30	27	36	31	28	27	35	30	26	25
Cerebrovascular disease, %	11	11	8	9	10	11	8	9	10	11	8	7
Need help with ADLs, %	12	10	10	8	13	11	11	10	14	12	12	11
Mean BMI (SD), kg/m^2	28.2 (6.8)	28.6 (7.1)	28.0 (6.3)	25.4 (5.8)	28.8 (6.9)	29.1 (7.2)	28.5 (6.4)	26.0 (6.0)	29.2 (7.0)	29.4 (7.2)	28.8 (6.5)	26.2 (6.0)
Individual-level socioeconomic factors, %												
No nephrology referral predialysis	33	39	40	32	32	39	42	32	29	35	38	29
Employer health plan	28	24	19	28	26	23	18	25	22	20	16	22
Medicaid	16	34	41	37	16	33	41	37	18	34	40	37
Medicare	64	46	42	42	61	44	39	43	66	52	47	49
Uninsured	4	12	13	7	4	11	13	7	4	10	13	7
Unemployed	12	29	26	24	13	29	28	25	15	30	31	27

Table 2. (Continued)

Characteristic	Year of Dialysis											
	2005–2007 (*n*=152015)				2008–2010 (*n*=172334)				2011–2013 (*n*=156667)			
	White (*n*=83,578)	Black (*n*=44,214)	Hispanic (*n*=18,274)	Asian (*n*=5949)	White (*n*=92,911)	Black (*n*=49,320)	Hispanic (*n*=22,551)	Asian (*n*=7552)	White (*n*=85,162)	Black (*n*=42,555)	Hispanic (*n*=21,770)	Asian (*n*=7180)
Regional-level socioeconomic factors												
Mean percentage of ZIP code below poverty line (SD), %	14 (8)	23 (11)	21 (11)	13 (8)	14 (8)	22 (11)	21 (11)	13 (8)	14 (8)	22 (11)	22 (11)	14 (9)
Median percentage of ZIP code with <HS diploma (Q1–Q3), %	14 (8)	20 (9)	27 (14)	17 (11)	14 (8)	20 (9)	27 (14)	17 (11	14 (8)	19 (9)	27 (14)	17 (11)
Large PD unit, %[a]	61	65	67	69	57	61	65	70	57	65	67	77
For-profit dialysis unit, %[b]	73	74	81	75	75	78	83	76	79	81	86	79
Urban ZIP code, %	77	87	89	95	77	87	90	95	76	87	89	94
Census division, %												
Pacific	10	5	28	55	11	6	30	58	11	6	29	56
East South Central	7	11	1	1	7	12	0	1	7	12	1	1
West South Central	9	12	31	5	9	13	31	4	10	13	32	5
Mountain	6	1	12	5	6	2	12	5	6	2	11	5
New England	6	2	2	3	6	2	2	2	5	2	2	2
South Atlantic	17	33	7	8	17	32	6	7	17	33	7	7
West North Central	8	3	2	2	7	3	1	3	7	3	2	2
East North Central	19	15	6	6	19	14	6	5	19	13	5	5
Middle Atlantic	19	18	13	16	18	17	12	15	19	17	12	17

Q1, first quartile; Q3, third quartile; ADLs, activities of daily living; BMI, body mass index; HS, high school; PD, peritoneal dialysis.
[a]Reported for those on PD on day 1. Large units were defined as having at least 20 patients on PD. Only included as a covariate in models restricted to PD patients.
[b]This was unknown for white patients, *n*=5517 (2%); black patients, *n*=4505 (3%); Hispanic patients, *n*=1034 (2%); Asian patients, *n*=362 (2%).

Sensitivity Analyses

Because many patients change modalities in the first 90 days of dialysis, we performed sensitivity analyses in which the outcome was the modality on day 90 as determined by the condensed treatment history in the USRDS. Similarly, for the analogous survival analyses we defined the home dialysis cohort by their modality on day 90, which we treated as the index date.

We also estimated the hazard ratios of transferring to in-center HD and of death within the first 90 days, from day 91 to year 1, and from year 1 to year 3 of dialysis and determined whether these transfer and death rates increased over the eras. We also ran separate sensitivity analyses restricted to patients on PD and to patients on home HD, because these populations can be quite distinct. For analyses of racial/ethnic differences in the initiation of home HD, we also adjusted for use of catheter on day 1 of dialysis; however, the low number of patients did not allow us to run meaningful analyses of transfer and death. For the PD-limited outcome analyses we also adjusted for and looked for effect modification by the size of the PD facility. Finally, to ensure that missing data did not lead to bias, as a sensitivity analysis we used multiple imputation to impute missing variables other than race/ethnicity, length of nephrology care, and ZIP code.

All analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC). The Institutional Review Board of the Los Angeles Biomedical Institute at Harbor-UCLA Medical Center approved the study and waived the requirement for written consent owing to the deidentified nature of the data. The clinical and research activities being reported are consistent with the Principles of the Declaration of Istanbul as outlined in the "Declaration of Istanbul on Organ Trafficking and Transplant Tourism."

Results

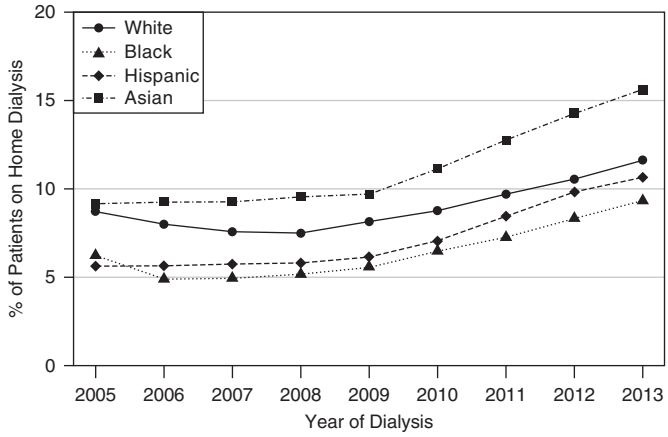
Patient Characteristics

Of 523,526 patients, 55% were white, 28% black, 13% Hispanic, and 4% Asian (Supplemental Tables 1A and 2A, Tables 1 and 2). Minority patients were younger than white patients. Of all of the racial/ethnic groups, whites had the highest prevalence of comorbidities, other than hypertension and diabetes. Black patients had the highest body mass index (BMI), whereas Asians had the lowest. Black and Hispanic patients were the least likely to have seen a nephrologist before starting dialysis, and most likely to live in poorer neighborhoods with lower levels of education. All minority groups had high levels of unemployment, Medicaid coverage, and residence in urban neighborhoods. These trends were consistent in both in-center HD and home dialysis populations.

Over time, Hispanic and Asian patients made up slightly larger proportions of the dialysis population. Although the prevalence of diabetes and hypertension increased and the average BMI rose over the eras, the prevalence of other comorbidities dropped. The increase in diabetes over time was more substantial among Hispanics and Asians than among blacks and whites.

Temporal Changes in Racial/Ethnic Differences in Initiation of Dialysis with Home Dialysis

From the earliest to the most recent era, both the absolute number and the rate of initiation of dialysis with home dialysis increased in all groups (Figure 1), with the unadjusted difference in home dialysis use narrowing among black and Hispanic patients (odds ratio [OR] [95% confidence interval (95% CI)] from earliest to latest era, blacks: 0.63 [0.60 to 0.66] to 0.76 [0.73 to 0.79], $P<0.001$; Hispanics: 0.69 [0.65 to 0.74] to 0.89 [0.85 to 0.94], $P<0.001$) and



	N (%) on Home Dialysis			Absolute Change from 2005-2007 to 2011-2013	% Change from 2005-2007 to 2011-2013
	2005-2007	2008-2010	2011-2013		
all	11432 (7.0%)	13617 (7.3%)	17461 (10.0%)	3.0%	43.4%
White	7287 (8.0%)	8235 (8.1%)	10118 (10.6%)	2.6%	32.4%
Black	2437 (5.2%)	2997 (5.7%)	3843 (8.3%)	3.1%	58.6%
Hispanic	1102 (5.7%)	1531 (6.4%)	2313 (9.6%)	3.9%	68.9%
Asian	606 (9.2%)	854 (10.2%)	1187 (14.2%)	4.9%	53.5%

Figure 1. | **Home dialysis initiation increased in every racial/ethnic group over time.**

increasing for Asian patients compared with white patients (OR [95% CI]: 1.17 [1.07 to 1.27] to 1.39 [1.30 to 1.49], P=0.002) (Figure 2A, Supplemental Table 3). These trends persisted in adjusted analyses. Patterns did not differ during this time period by Medicare insurance; racial/ethnic differences improved among all minority groups over time irrespective of their Medicare status (Figure 2B, Supplemental Table 3).

To assess the effect of early modality changes on the results, we repeated the analysis defining modality at day 90 of dialysis (Supplemental Tables 4, A and B and 5, A and B). Although the use of home dialysis was even lower among minority patients compared with white patients when measured at 90 days, the temporal trend in the attenuation of the differences over time was the same (Supplemental Table 6B). Results of sensitivity analyses restricting home dialysis to PD were not materially different (Supplemental Table 6, A and B). In the earliest era Hispanic patients were less likely to initiate with home HD on day 1, but there was no statistically significant difference in the rates of home HD initiation for black and Asian as compared with white patients (Supplemental Table 6, A and B). There were no statistically significant temporal changes in these trends for home HD.

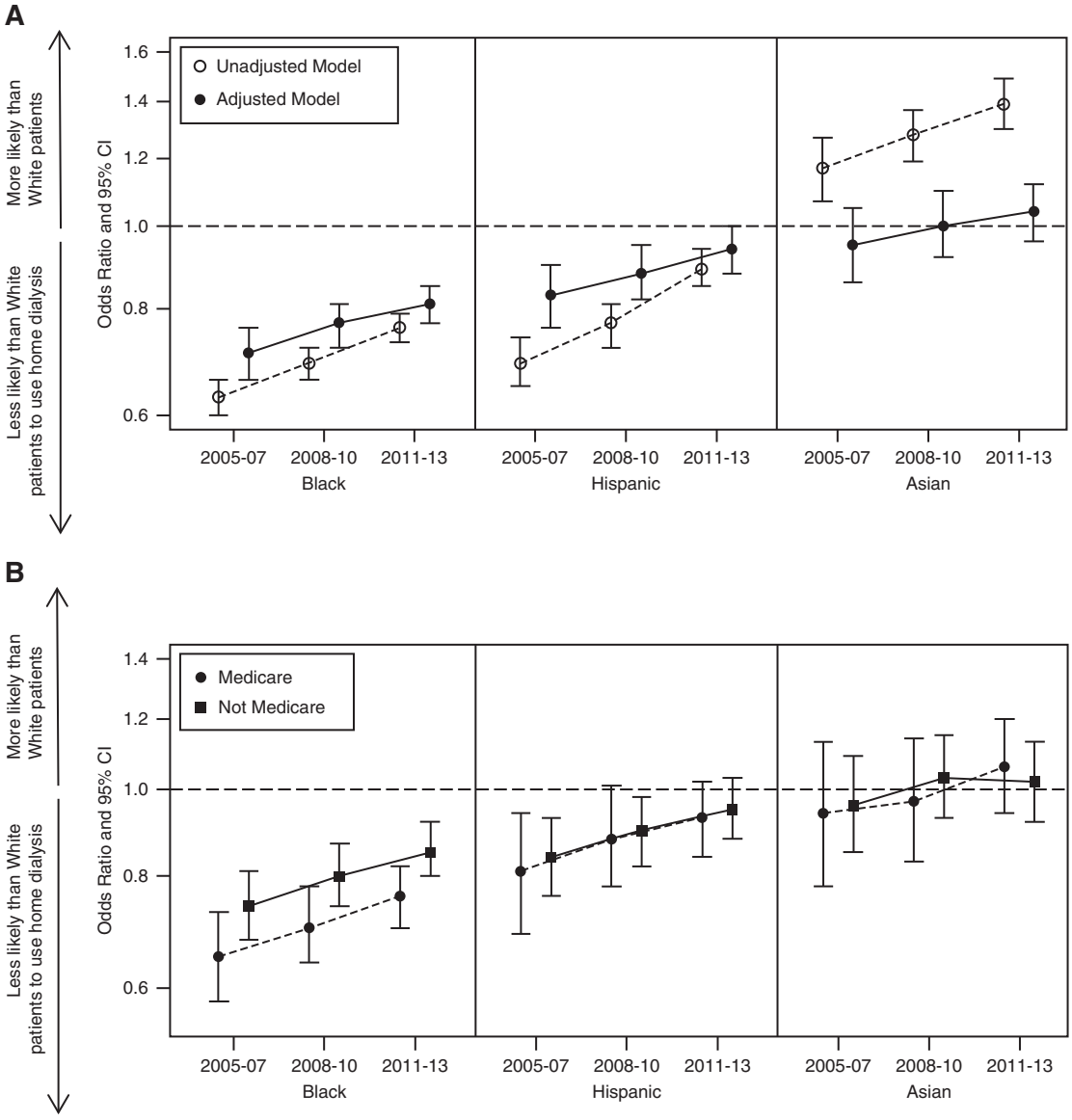


Figure 2. | **Racial/ethnic differences in initiation of dialysis with home dialysis decreased over time.** Odds ratios of initiating dialysis with home modalities (versus in-center hemodialysis) in minority patients (versus white patients), by era. (A) Overall results. P values for comparisons between first versus last era: P<0.001 for unadjusted and adjusted black and Hispanic models; P=0.002 for unadjusted and P=0.02 for adjusted Asian models. (B) Adjusted results, by Medicare status. P=0.54 for interaction term between Medicare status, era, and race/ethnicity. Adjusted models included: individual level: age, sex, comorbidities, body mass index, laboratory values, predialysis nephrologist care, insurance, employment; neighborhood level: poverty, education level, racial/ethnic composition, linguistic isolation, number of home dialysis units and nephrologists, Census Division, urban/rural; profit status of facility. 95% CI, 95% confidence interval.

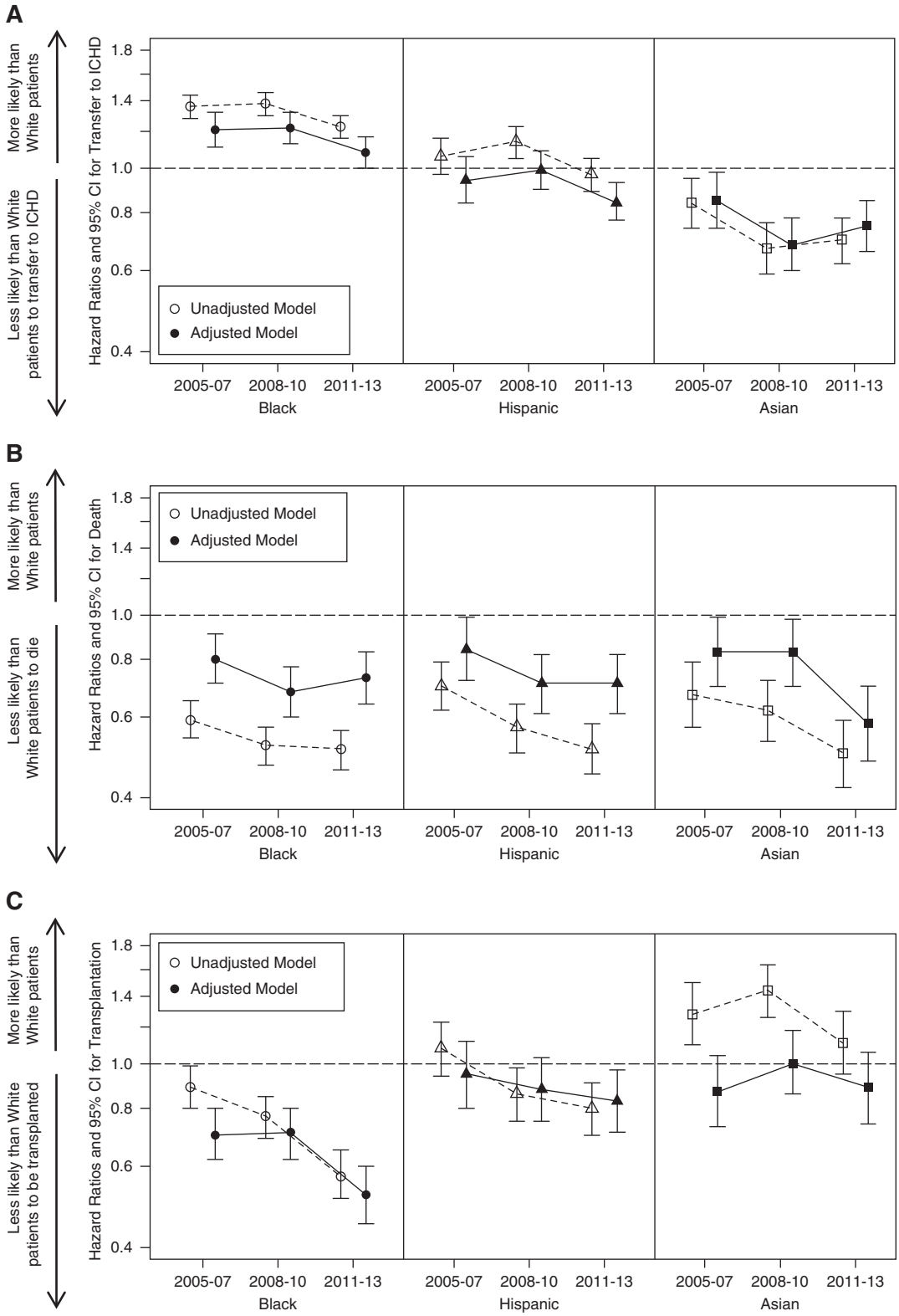


Figure 3. | **Temporal changes in racial/ethnic differences in clinical outcomes among patients on home dialysis varied depending on the outcome.** Hazard ratios and 95% confidence intervals of outcomes in minority patients versus white patients, by era. (A) Association between race/ethnicity and transfer to in-center hemodialysis (ICHD). $P>0.05$ for all models. (B) Association between race/ethnicity and mortality. $P=0.07$ for unadjusted and $P=0.01$ for adjusted black models; $P=0.002$ for unadjusted and adjusted Hispanic models; $P=0.06$ for unadjusted and $P=0.01$ for adjusted Asian models. (C) Association between race/ethnicity and kidney transplantation. $P<0.001$ for unadjusted and adjusted black models; $P=0.01$ for unadjusted and adjusted Hispanic models; $P>0.05$ for unadjusted and adjusted Asian models. All *P* values are comparisons between the hazard ratio in the first versus last era for the specified minority group versus whites. *Cont.*

Temporal Changes in Racial/Ethnic Differences in Outcomes

Transfer to In-Center HD. Among all racial/ethnic groups, the unadjusted rate of transferring to in-center HD decreased over the eras, from 21 to 19 transfers per 100 person-years. In the earliest era, blacks were more likely, Hispanic patients just as likely, and Asian patients less likely to transfer to in-center HD than white patients. These differences did not change significantly over time for black, Hispanic, or Asian patients compared with white patients (Figure 3A, Supplemental Table 7). Similar patterns were observed in the adjusted analyses.

In sensitivity analyses where follow-up time was restricted, both the difference in transfer rates between black and white patients and trends in the racial/ethnic differences in transfer to in-center HD over time were NS (Supplemental Table 8, A–C).

All-Cause Mortality. The unadjusted mortality rate for patients in every racial and ethnic group improved slightly over time, from 13 to ten deaths per 100 person-years. In the earliest era, all of the minority groups had a lower risk of death than white patients. This difference in survival increased over time for all minority groups. Although the racial/ethnic differences were attenuated after adjustment for various factors, the temporal trend of an increasing difference in survival rates between minority and white patients was still present and significant in the adjusted models (OR [95% CI] versus whites, blacks: 0.80 [0.71 to 0.91] to 0.73 [0.64 to 0.83], P=0.01; Hispanics: 0.84 [0.72 to 0.99] to 0.71 [0.61 to 0.82], P=0.002; Asians: 0.83 [0.70 to 0.99] to 0.58 [0.48 to 0.70], $P<0.01$) (Figure 3B, Supplemental Table 9A).

In sensitivity analyses there were no significant adjusted differences in survival in the first 90 days of dialysis among all racial/ethnic groups in the earliest era (Supplemental Table 9B). From day 91 to year 1 of dialysis, only Asians had a lower adjusted mortality rate than white patients in the earliest era (Supplemental Table 9C). From year 1 to year 3 of dialysis, both black and Asian patients had lower adjusted mortality rates than white patients in the earliest era (Supplemental Table 9D). There were no significant temporal changes in these differences.

Kidney Transplantation. The unadjusted transplantation rate decreased for all patients over the eras, from nine to seven transplants per 100 person-years. The disparity in transplantation for black versus white patients in the first era also increased by the third era (OR [95% CI]: 0.89 [0.80 to 0.99] to 0.57 [0.51 to 0.65], $P<0.001$) (Figure 3C, Supplemental Table 10). Hispanic patients, who in earlier eras had similar transplantation rates as white patients, were significantly less likely to be transplanted in the most recent era (1.08 [0.94 to 1.23] to 0.80 [0.70 to 0.91], P=0.01). Asian patients continued to have similar transplantation rates as white patients over time. Similar temporal trends were observed in adjusted analyses.

Sensitivity Analyses. Results for the outcome analyses were not materially different in sensitivity analyses defining modality at day 90 of dialysis and restricting the cohort to patients on PD (Supplemental Tables 11 and 12), by the size of the PD facility or when repeated using multiple imputation to account for missing data (Supplemental Tables 13–16).

Discussion

We found that racial/ethnic differences in initiating home dialysis decreased over time from 2005 to 2013, although, in the most recent era, blacks were still less likely to use home dialysis as the initial modality than other groups. Racial/ethnic differences in transfer to in-center HD did not change over time. However, minority patients had even lower adjusted mortality and kidney transplantation rates than white patients in recent years.

Differences in home dialysis use in the United States have been well documented, but the reasons for these differences are unclear (7–9,34). They could be explained in part by racial/ethnic variation in the prevalence of medical and socioeconomic factors that are viewed as high-risk for home dialysis failure. For instance, diabetes, high BMI, unemployment, and poverty are all associated with lower rates of home dialysis initiation, and are also more common in black and Hispanic patients (7,9,18). Conversely, Asians and whites tend to have medical and socioeconomic characteristics that are associated with higher rates of home dialysis use. Of note, adjusting for such factors attenuated, but did not eliminate, the racial/ethnic disparity in home dialysis initiation for black and Hispanic patients in the earliest era. It is unclear what amount of residual disparity might be due to patient or provider preference for a certain modality.

Importantly, our study shows that as the rate of initiation of dialysis with home modalities rose over time, it increased even more among minority patients. The rise in average BMI and prevalence of diabetes among home dialysis patients signals an increased willingness to put patients with obesity and diabetes on home dialysis. Because a higher proportion of black and Hispanic patients have these traits compared with white patients, they may have had a greater relative boost in home dialysis rates.

Changes in these measured characteristics cannot completely explain the improvement in disparities, however, because the ORs increased over time even after adjustment for these factors. This may reflect a decrease in the bias against home modalities for minority patients independent of measured medical and socioeconomic factors. However, we cannot tell whether it was primarily a change in patient or physician preference that led to this improvement, and the extent to which dialysis providers may have had a role. No matter the mechanism(s), the temporal improvement in disparities shows that the racially/ethnically specific attitudes that may have restricted home dialysis use among minorities in the past are not insurmountable. Also, the improvements were not restricted to patients

Figure 3. | *Continued.* Adjusted models included: individual level: age, sex, comorbidities, body mass index, laboratory values, predialysis nephrologist care, insurance, employment; neighborhood level: poverty, education level, racial/ethnic composition, linguistic isolation, number of home dialysis units and nephrologists, Census Division, urban/rural; profit status of facility. 95% CI, 95% confidence interval.

with Medicare coverage. This could indicate that any effect of payment reform was able to spill over and benefit patients regardless of their insurance status. Finally, the improvements did not plateau. Increased use of home dialysis among minorities may have had a positive feedback effect, with minority patients in later eras more likely to choose home modalities because of increased exposure to it in their own communities.

Notably, there were no significant temporal changes in the relative rates of transfer to in-center HD among minorities compared with white patients, even during the first 90 days of dialysis, the highest-risk period of transfer. This suggests that, when minority patients who may previously have been perceived as marginal candidates for home dialysis are given the opportunity to utilize home modalities, they fair as well as other patients in their racial/ethnic group. Although large PD units were associated with lower overall rates of transfer to in-center HD, there was no difference in either the baseline or temporal trend in disparities among patients in small versus large PD units. Units of all sizes will need to improve the black-white disparity in transfer rates, and future research should focus on temporal changes in disparities in cause-specific transfer rates (13,35–39).

We unexpectedly found that, over time, minority patients on home dialysis had even lower risks of death compared with white patients using a competing risk analysis accounting for the lower transplantation rates. The reason for such a change is unclear. It is worth noting, however, that over time the mortality rate dropped among all patients, so the increased difference in death rates between minority and white patients did not stem from a rise in absolute mortality rates for white patients on home dialysis. Finally, we found that the disparity in kidney transplantation among blacks and Hispanics on home dialysis versus their white counterparts became larger over time. This is consistent with a recent study by Purnell *et al.* (40), which found that racial/ethnic disparities in living donor kidney transplantation had increased over time from 1995–1999 to 2010–2014.

This study has limitations. We did not have data on physician and patient attitudes toward certain modalities, nor did we have information on what kind of education patients received about the different modalities. Thus, we could not parse whether it was primarily changes in patient or physician preferences or changes at the level of dialysis providers that drove the increase in home dialysis use, nor could we pinpoint which interventions might have been responsible for the growth. We also could not measure and thus could not adjust for housing insecurity. These results are also not applicable to patients who may have switched from in-center HD to home dialysis after day 90 of dialysis. Race/ethnicity is primarily a social construct and may reflect a large number of additional unmeasured sociocultural factors. These results may not be generalizable to other countries, which may have different racial and ethnic groups and distinct barriers to home dialysis. These limitations should be balanced against the strengths of this study, which include a nationally representative cohort of patients and examination of trends over 9 years.

In conclusion, we found that from 2005 to 2013, when overall home dialysis use increased, racial/ethnic differences in the initiation of dialysis with home modalities narrowed without any deleterious effect in relative rates of transfer to in-center HD and death. However, disparities in kidney transplantation did increase but were consistent with trends seen in the larger ESKD population. This suggests that it is possible to both start more people on home dialysis and reduce racial/ethnic differences in home dialysis use while improving overall patient outcomes.

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Supplemental Material

This article contains the following supplemental material online at http://cjasn.asnjournals.org/lookup/suppl/doi:10.2215/CJN.00290119/-/DCSupplemental.

Supplemental Methods. Calculation of expected number of occupants per room.

Supplemental Figure 1. Study population selection from the US Renal Data System. We identified a cohort of adult patients who

were initiated on dialysis from 2005 to 2013, who were of Asian, black, or white race.

Supplemental Table 1, A and B. Characteristics of adult patients initiating home dialysis from 2005 to 2013 on day 1 of dialysis, by era.

Supplemental Table 2, A and B. Characteristics of adult patients initiating in-center hemodialysis from 2005 to 2013 on day 1 of dialysis, by era.

Supplemental Table 3. Odds ratios (ORs) and 95% confidence intervals (95% CIs) for initiating home dialysis (versus in-center hemodialysis) on day 1 for minority groups (versus whites), by era.

Supplemental Table 4, A and B. Characteristics of adult patients on home dialysis from 2005 to 2013 on day 90 of dialysis.

Supplemental Table 5, A and B. Characteristics of adult patients on in-center dialysis from 2005 to 2013 on day 90 of dialysis.

Supplemental Table 6, A and B. Temporal changes in initiating home dialysis (versus in-center hemodialysis) on day 90, peritoneal dialysis (PD) (versus in-center hemodialysis) on day 1, and home hemodialysis (home HD) (versus in-center hemodialysis) on day 1 for minority groups (versus whites), by era.

Supplemental Table 7. Hazard ratios (HRs) and 95% confidence intervals (95% CIs) for transferring to in-center hemodialysis for minority groups (versus whites) who were on home dialysis on day 1 of dialysis, by era.

Supplemental Table 8, A, B, and C. Hazard ratios (HRs) and 95% confidence intervals (95% CIs) for transferring to in-center hemodialysis in various follow-up periods for minority groups (versus whites) who were on home dialysis on day 1 of dialysis, by era.

Supplemental Table 9, A, B, C, and D. Hazard ratios (HRs) and 95% confidence intervals (95% CIs) for death in various follow-up periods for minority groups (versus whites) who were on home dialysis on day 1 of dialysis, by era.

Supplemental Table 10. Hazard ratios (HRs) and 95% confidence intervals (95% CIs) for kidney transplantation for minority groups (versus whites) who were on home dialysis on day 1 of dialysis, by era.

Supplemental Table 11. Adjusted hazard ratios (HRs) and 95% confidence intervals (95% CIs) for outcomes for minority groups (versus whites) who were on home dialysis on day 90 of dialysis, by era.

Supplemental Table 12. Adjusted hazard ratios (HRs) and 95% confidence intervals (95% CIs) for outcomes for minority groups (versus whites) who were on peritoneal dialysis on day 1 of dialysis, by era.

Supplemental Table 13. Odds ratios (ORs) and 95% confidence intervals (95% CIs) for initiating home dialysis (versus in-center hemodialysis) on day 1 for minority groups (versus whites), by era, using multiple imputation for missing data.

Supplemental Table 14. Hazard ratios (HRs) and 95% confidence intervals (95% CIs) for transferring to in-center hemodialysis for minority groups (versus whites) who were on home dialysis on day 1 of dialysis, by era, using multiple imputation for missing data.

Supplemental Table 15. Hazard ratios (HRs) and 95% confidence intervals (95% CIs) for death for minority groups (versus whites) who were on home dialysis on day 1 of dialysis, by era, using multiple imputation for missing data.

Supplemental Table 16. Hazard ratios (HRs) and 95% confidence intervals (95% CIs) for kidney transplantation for minority groups (versus whites) who were on home dialysis on day 1 of dialysis, by era, using multiple imputation for missing data.

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