Longitudinal Study of Racial and Ethnic Differences in Developing End-Stage Renal Disease among Aged Medicare Beneficiaries

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Diabetes and hypertension are the leading causes of renal failure. This study investigated racial differences in developing ESRD by participants' diabetes and hypertension status. This longitudinal study included 1,306,825 Medicare beneficiaries who were aged ≥66 yr at the study start and followed up to 10 yr from January 1, 1993, for the development of ESRD or death. During the 10 yr, 0.93 patients per 100 received ESRD treatment. After adjustment for age and gender, among patients with diabetes, black patients were 2.4 to 2.7 times and other races/ethnicities 1.6 to 1.7 times more likely than white patients to develop ESRD. Among hypertensive patients, black patients were 2.5 to 2.9 and others 1.7 to 1.8 times more likely than white patients to develop ESRD. Among patients with neither diabetes nor hypertension, black patients were 3.5 and others 2.0 times more likely. Black men with diabetes were 1.9 to 2.1 and women 2.5 to 3.4 times more likely than their white counterparts to develop ESRD. Hypertensive black men were 2.1 to 2.2 and women 2.8 to 3.6 times more likely to develop ESRD. The same findings were noted in women of other races/ethnicities. Compared with white counterparts, mortality was higher for black patients in all cohorts but lower among patients with ESRD. Although they are leading causes for renal failure, diabetes and hypertension do not cause racial differences in developing ESRD. Minority women especially are at greater risk for ESRD than white women. Further studies are needed to determine whether earlier initiation of dialysis is a factor in higher ESRD incidence among minorities.

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Patients with ESRD rely on renal replacement therapy to prolong their lives. Despite significant advances in renal replacement therapy technique, mortality in patients with ESRD remains high. A national study in Scotland found that 14% of patients died within 90 d of the initiation of ESRD treatment (1). Data from the US Renal Data System (USRDS) indicate that 21% of incident patients with ESRD in the United States died within 1 yr after their first 90 d of ESRD treatment (2).

The cost of ESRD treatment is also high. Since 1972, all patients who have ESRD and are eligible for Social Security in the United States have been entitled to all Medicare benefits, regardless of age. In 2001, Medicare costs for the ESRD program were $15.4 billion; non-Medicare costs were an additional $7.7 billion (2). Although patients with ESRD compose only 1% of all Medicare beneficiaries, their care represents approximately 9% of all Medicare expenditures (3).

Diabetes is the leading cause of renal failure, followed by hypertension (2). Approximately 72% of US patients with ESRD had diabetes or hypertension as the primary cause for renal failure (2). National data also indicate that black and other minority individuals are more likely than white individuals to develop ESRD (2). However, research findings only partially explain the racial disparity that is observed (4,5). Diabetes and hypertension have usually been studied separately or treated as covariates in studies of risk factors for ESRD (6–8). In this study, we selected a cohort of Medicare beneficiaries and followed them for up to 10 yr. Our objective was to evaluate racial differences in the development of ESRD without case-mixed diabetes and hypertension.

Materials and Methods

Design and Data

We conducted a longitudinal study using data from the Medicare 5% Sample Standard Analytical Files. The 5% Sample consists of Medicare beneficiaries who have preselected digits in the last two positions of their Social Security Number. Because the last two digits of the Social Security Number are randomly assigned by the Social Security Administration, the 5% Sample is in effect a random sample of all Medicare beneficiaries. The Standard Analytical Files include data from outpatient, inpatient, skilled nursing facility, home health agency, and physician/supplier Medicare billing claims. We also used the Medicare Denominator File, which combines information on Medicare beneficiary entitlement status (from administrative enrollment records) with third-party payer information and group health plan enrollment infor-

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mation. Data on patients with treated ESRD were supplied by the USRDS, which maintains databases on all US patients with ESRD.

All patients in the 5% sample who received Medicare reimbursement services in 1992 were candidates for study. Participants must have been at least 65 yr of age by January 1, 1992 (and at least 66 yr of age at the study start on January 1, 1993). Age 65 is the eligibility requirement for Medicare coverage. Participants must have survived in 1992 and been alive and not receiving ESRD treatment on January 1, 1993. Those included (n = 1,306,825) were followed from January 1, 1993, for up to 10 yr.

Definitions

Data on race and ethnicity were drawn from the Denominator File. Because of small sample sizes in some minority groups, three race/ethnicity groups were used: white, black, and other. Those with Hispanic ethnicity were included in the "other" group; therefore, "white" and "black" refer to non-Hispanic white and non-Hispanic black, respectively.

Death information (specifically, date of death) also was drawn from the Denominator File. The Medicare program receives death information from several sources. The most common are the Social Security Administration and the Railroad Retirement Board. In addition, hospitals and nursing homes provide death information in claims for care. Given that these sources are legally required to report all deaths, mortality ascertainment is reliable.

At the initiation of a patient's ESRD treatment, a Medical Evidence Report (Centers for Medicare & Medicaid Services CMS-2728) is completed for patient registration and Medicare entitlement. Data on individual patients in Medicare claims and in USRDS databases were matched through use of the unique Health Insurance Claim Number and Beneficiary Identification Code.

Diabetes and hypertension status in the participants was determined using Medicare claims. The condition that was recorded in 1992 claims was defined as the baseline condition. The condition that was recorded from January 1, 1993, to the date of ESRD, death, or up to 10 yr was defined as the follow-up condition. The validation of diabetes and hypertension coded in Medicare claims data has been conducted (9,10). Chronic kidney disease (CKD) and heart disease were also determined using Medicare claims; the codes in claims data were validated previously (11,12).

Statistical Analyses

All data were analyzed using SAS (SAS Institute, Cary, NC). Logistic regression was used to analyze data on the status of diabetes and hypertension at baseline. The model was diagnosed for validity. Overdispersion was adjusted using the method proposed by Williams, in Allison (13, p 108). Cox proportional hazards modeling was used to analyze data on risks for diabetes and hypertension during follow-up and risks for developing ESRD or dying during the 10-yr follow-up period. The proportional hazards property was examined by graphing survival curves stratified by race. Separate analyses were conducted for the development of ESRD and death according to participants' status of diabetes and hypertension: Baseline diabetes, follow-up diabetes, nondiabetes, baseline hypertension, follow-up hypertension, nonhypertension, and nondiabetes-hypertension. Because patients with another disease may have died of that disease before experiencing kidney failure, we censored death in the estimation of risk and probability for developing ESRD. Explanatory variables were age, gender, and race. Hypertension was included as a covariate in the analysis of patients with diabetes, and diabetes was included in the analysis of patients with hypertension. In the analysis of patients with newly developed or diagnosed diabetes or hypertension during follow-up, a time-dependent variable for diabetes or hypertension was included in the statistical model. For death, heart disease was included in the model as a comorbid condition.

Results

Table 1 presents patient characteristics. Of the included patients (n = 1,306,825) at the beginning of follow-up, 89.1% were white, 7.2% were black, and 3.7% were of other race or ethnicity. Most patients were women (61.7%). Mean age at the beginning of follow-up was 76.0 yr. Patients of other race and ethnicity were younger (75.4 yr) than white patients (76.1 yr) and black patients (75.9 yr). Average age was 75.1 yr for men and 76.6 yr for women. Percentages of age groups were 27.0% for 66 to 70 yr, 26.4% for 71 to 75 yr, 24.1% for 76 to 81 yr, and 22.5% for 82 yr and older.

Overall percentages of diabetes and hypertension were 37.4 and 72.4%, respectively (Table 1). Baseline diabetes and hypertension (*i.e.*, diagnosed in 1992) were 16.2 and 38.0%, respectively. Newly developed or diagnosed diabetes and hypertension during follow-up were 21.2 and 34.4%, respectively. Black patients and patients of other races/ethnicities showed greater proportions of diabetes and hypertension. Black patients also showed higher proportions of death and ESRD or CKD. Overall, 0.93 per 100 patients received ESRD treatment during the 10-yr study period.

After adjustment for age and gender, black patients were 2.0 and 1.5 times more likely than white patients to have diabetes at baseline and during follow-up and 2.0 and 1.1 times more likely to have hypertension at baseline and during follow-up, respectively (Figure 1). Others were 1.6 and 1.4 times more likely than white patients to have diabetes at baseline and during follow-up and 1.1 times more likely than white patients to have hypertension at baseline but 1.1 times less likely than white patients to have hypertension during follow-up.

Figure 2 presents relative risks for death in all cohorts (A) and in those who developed ESRD (B) after adjustment for age, gender, and cardiac disease. In the overall study cohort (Figure 2A), black patients in all diabetes and hypertension status groups were more likely than white patients to die during the follow-up period, whereas among patients with ESRD (Figure 2B), black patients were less likely than white patients to die (95% confidence interval crosses 1.0 in the follow-up diabetes, nonhypertension, and nondiabetes-hypertension groups). Patients of other races/ethnicities in the overall cohort and among patients with ESRD were less likely than white patients to die during the follow-up period (95% confidence interval crosses 1.0 among patients with ESRD in the follow-up diabetes and nondiabetes-hypertension groups). Older age, male gender, and cardiac disease were associated with greater risks for death in all groups. Further analysis of all cohort data separating patients by CKD status showed that black patients with and without CKD had higher risks for death than their white counterparts in each category of diabetes and hypertension status.

After adjustment for age and gender, differences in cumulative probabilities of developing ESRD among patients with and without diabetes or hypertension were substantial (Figure 3). In

Table 1. Characteristics of patients[a]

Characteristics	*n*	Person-Years	Death		ESRD or CKD	
			n	Rate[b]	*n*	Rate[b]
All cohorts						
all	1,306,825	9,656,989	655,945	6.8	378,232	3.9
race						
white	1,163,868	8,611,176	583,510	6.8	329,133	3.8
black	94,511	675,238	50,917	7.5	34,704	5.1
other	48,446	370,575	21,518	5.8	14,395	3.9
gender						
men	500,787	3,543,487	275,193	7.8	171,020	4.8
women	806,038	6,113,502	380,752	6.2	207,212	3.4
age (yr)						
66 to 70	352,971	3,064,490	98,878	3.2	91,441	3.0
71 to 75	345,419	2,809,141	135,364	4.8	101,109	3.6
76 to 81	314,808	2,263,247	178,694	7.9	99,994	4.4
≥82	293,627	1,520,111	243,009	16.0	85,688	5.6
Baseline diabetes						
all	211,132	1,374,282	134,805	9.8	87,719	6.4
race						
white	175,313	1,130,795	113,445	10.0	71,138	6.3
black	25,049	166,848	15,474	9.3	11,963	7.2
other	10,770	76,639	5886	7.7	4618	6.0
Baseline hypertension						
all	496,418	3,680,531	256,116	7.0	179,024	4.9
race						
white	426,300	3,165,324	219,909	6.9	149,742	4.7
black	51,016	368,036	27,490	7.5	22,041	6.0
other	19,102	147,172	8717	5.9	7241	4.9
no diabetes or hypertension at baseline						
all	710,709	5,346,635	335,197	6.3	163,135	3.1
race						
white	651,490	4,907,406	307,012	6.3	148,641	3.0
black	34,916	250,941	18,154	7.2	9232	3.7
other	24,303	188,288	10,031	5.3	5262	2.8

[a]CKD, chronic kidney disease.
[b]Cases per 100 person-years.

patients with baseline diabetes, the cumulative 10-yr likelihood of developing ESRD was 2.6% in white patients, 6.7% in black patients, and 4.7% in others. Corresponding probabilities in those with baseline hypertension were 1.4% in white patients, 3.8% in black patients, and 2.5% in others. The probabilities for ESRD in those with follow-up diabetes were 0.7% in white patients, 1.9% in black patients, and 1.1% in others and in those with follow-up hypertension were 0.6% in white patients, 1.8% in black patients, and 1.1% in others. The probabilities for ESRD during the study period for those with no diabetes were 0.5% in white patients, 1.8% in black patients, and 0.9% in others and for those with no hypertension were 0.4% in white patients, 1.3% in black patients, and 0.8% in others. The probabilities for ESRD in those with neither diabetes nor hypertension were 0.3% in white patients, 1.3% in black patients, and 0.7% in others (data are not shown in Figure 3).

After adjustment for age and gender, black patients and patients of other races/ethnicities were more likely than white patients to develop ESRD (Figure 4). Compared with their white counterparts, black patients with baseline diabetes were 2.4 times, with follow-up diabetes 2.7 times, and with no diabetes 2.8 times more likely to develop ESRD. Black patients with baseline hypertension were 2.5 times, with follow-up hypertension 2.9 times, and with no hypertension 3.1 times more likely to develop ESRD than their white counterparts. Black patients with neither diabetes nor hypertension were 3.5 times more likely to develop ESRD than their white counterparts. Patients of other races/ethnicities were also more likely than

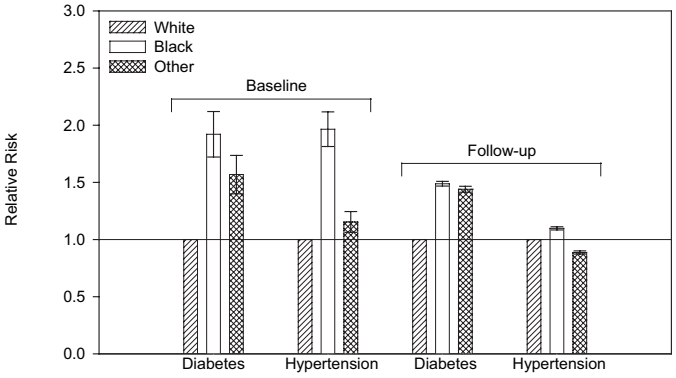

Figure 1. Relative risks for diabetes and hypertension by race after adjustment for age and gender. White patients are the referent. Lines at the tops of bars represent 95% confidence intervals (CI).

white patients to develop ESRD: 1.7 times more likely for those with baseline diabetes, 1.6 times for those with follow-up diabetes, and 1.7 times for those with no diabetes and 1.7 times for those with baseline hypertension, 1.8 times for those with follow-up hypertension, and 1.9 times for those with no hypertension. In patients with neither diabetes nor hypertension, others were 2.0 times more likely to develop ESRD than white patients. In patients who were classified by diabetes (baseline, follow-up, or none), those with hypertension at baseline were more likely to develop ESRD than those without hypertension. In patients who were classified by hypertension (baseline, follow-up, or none), those with diabetes at baseline were more likely to develop ESRD than those without diabetes. Older age and female gender were associated with less likelihood of ESRD.

Table 2 shows racial differences in developing ESRD by gender after adjustment for age. Except for black patients with no hypertension, magnitude of risk for developing ESRD was much greater in black women than black men compared with their white counterparts. Higher risk for ESRD in women than in men was also found in other races/ethnicities.

Discussion

Although diabetes and hypertension are the leading causes of renal failure and black patients are more likely to have diabetes and hypertension, on a relative basis, black patients and those of other races/ethnicities had greater risk for ESRD than their white counterparts regardless of diabetes and hypertension status. Greater risks for ESRD in minority races in all groups as classified by diabetes and hypertension status suggest that diabetes and hypertension are likely not the leading causes for the racial difference in developing ESRD. Although earlier studies showed that diabetes and hypertension cannot completely explain racial disparities in developing ESRD, these two factors were usually examined either separately or as covariates (6–8). Our study evaluated both factors simultaneously with longitudinal individual-level data.

A previous study from the USRDS using Medicare data indicates that black patients and patients of other races and ethnicities have greater risks for CKD than white patients, and

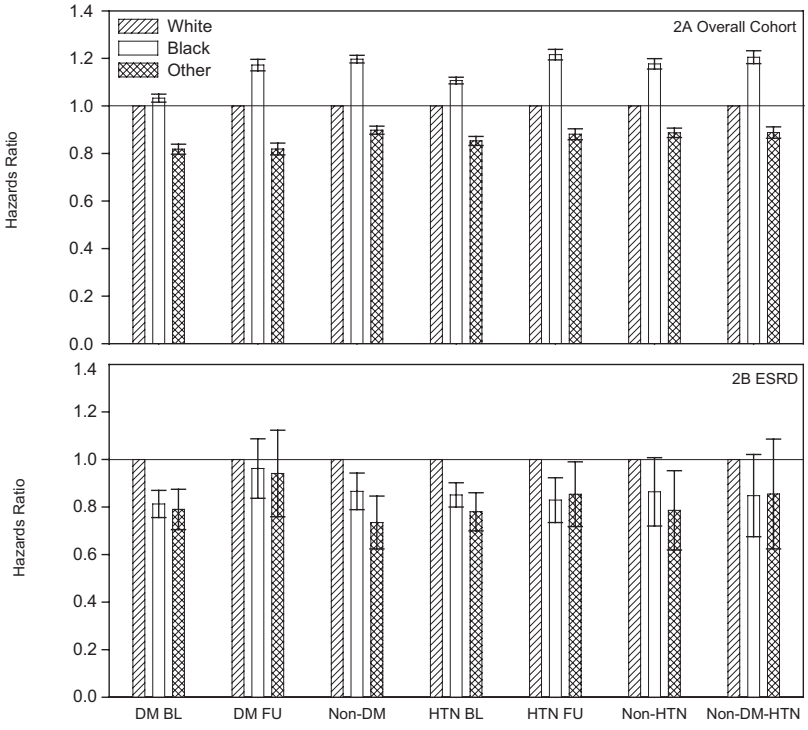

Figure 2. Hazards ratios (HR) for death by race for the overall cohort (A) and for patients who developed ESRD (B) after adjustment for age, gender, and heart disease. White patients are the referent. Lines at the tops of bars represent 95% CI. BL, baseline; DM, diabetes; FU, follow-up; HTN, hypertension.

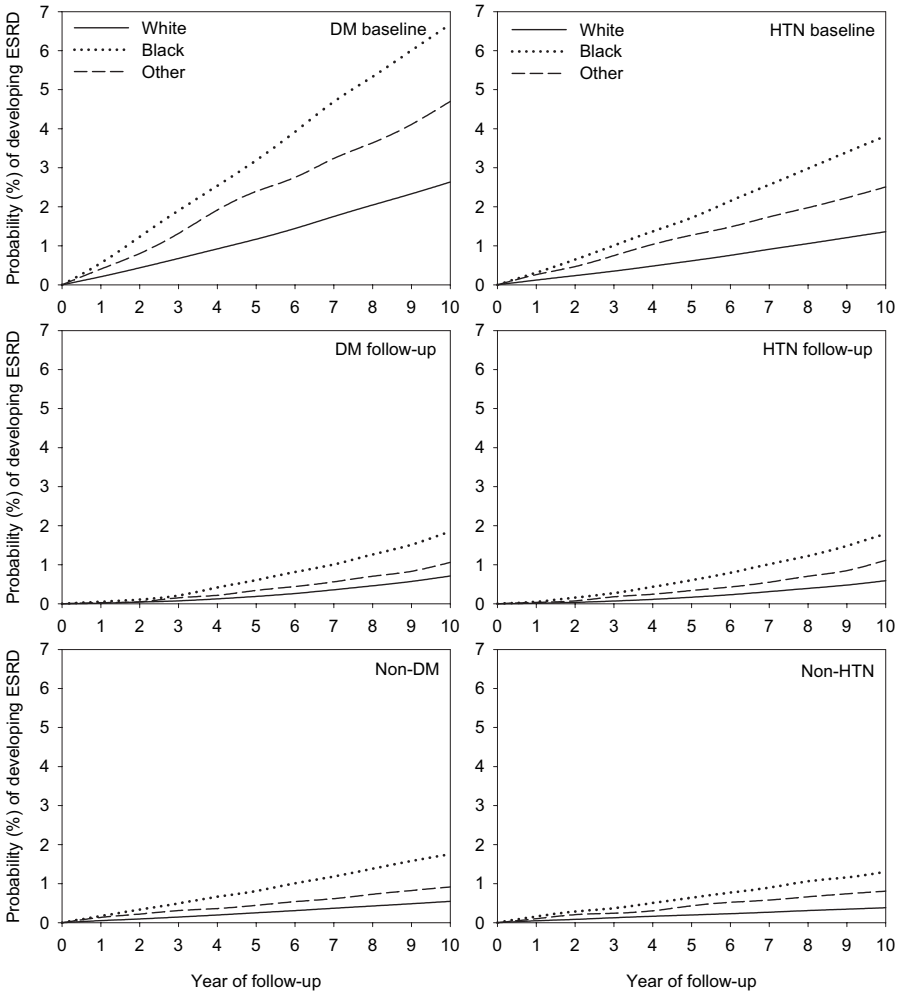

Figure 3. Cumulative probability of developing ESRD by race after adjustment for age and gender.

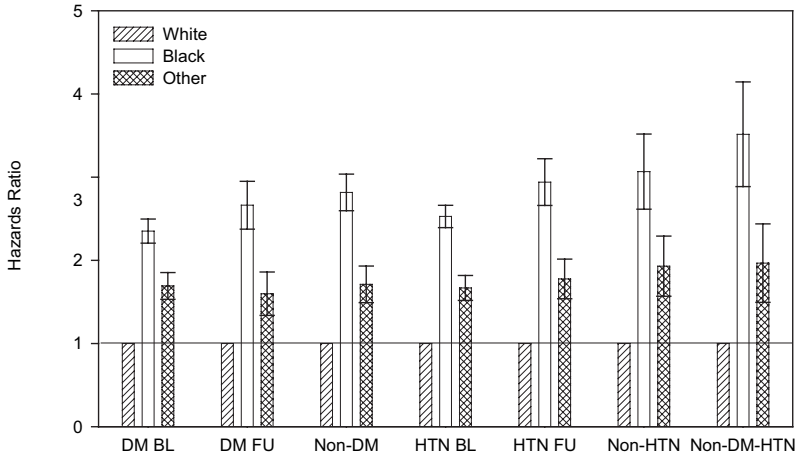

Figure 4. HR for ESRD by race after adjustment for age and gender. White patients are the referent. Lines at the tops of bars represent 95% CI.

the presence of CKD could not completely explain a higher risk for ESRD in these groups than in white patients (14). In the present study, we also found that black patients and patients of other races and ethnicities had greater risks for CKD than white patients, risks very similar to those for ESRD (data not shown). A study using National Health and Nutrition Examination Survey (NHANES) data, however, indicated that CKD in black patients is not greater than in white patients even after adjust-

Table 2. Hazards ratio for ESRD by gender and race after adjustment for age[a]

Characteristics	White	Black		Other	
		Men	Women	Men	Women
Diabetes baseline	1.0	2.12 (1.90 to 2.36)	2.50 (2.31 to 2.71)	1.41 (1.20 to 1.66)	1.90 (1.68 to 2.16)
Diabetes follow-up	1.0	1.93 (1.61 to 2.33)	3.41 (2.94 to 3.95)	1.27 (0.98 to 1.66)	2.01 (1.58 to 2.57)
Nondiabetes	1.0	2.27 (2.01 to 2.55)	3.53 (3.15 to 3.94)	1.55 (1.29 to 1.86)	1.95 (1.58 to 2.40)
HTN baseline	1.0	2.05 (1.87 to 2.25)	2.82 (2.63 to 3.02)	1.37 (1.18 to 1.59)	1.93 (1.70 to 2.18)
HTN follow-up	1.0	2.22 (1.90 to 2.60)	3.62 (3.17 to 4.13)	1.50 (1.21 to 1.86)	2.04 (1.68 to 2.49)
Non-HTN	1.0	3.07 (2.51 to 3.76)	2.94 (2.28 to 3.80)	1.74 (1.32 to 2.30)	2.16 (1.58 to 2.95)
Nondiabetes-HTN	1.0	3.27 (2.55 to 4.19)	4.03 (2.91 to 5.57)	1.83 (1.29 to 2.59)	2.24 (1.43 to 3.50)

[a]HTN, hypertension.

ment for age, hypertension, and diabetes (15). The possible explanations for this inconsistency between Medicare data and NHANES data are that (*1*) diseases and conditions that are coded in Medicare claims are usually severe cases and therefore mild CKD is less likely to be coded in Medicare claims (11,12,16) and (*2*) GFR as calculated using the equation developed by the Modification of Diet in Renal Disease (MDRD) tends to be underestimated, particularly when used in healthy individuals (17–19), and therefore prevalence of CKD as derived from the estimated GFR (eGFR) in the general population using NHANES data was likely overestimated.

The discrepancy that is inherent in using eGFR to define renal function was further demonstrated by McClellan *et al.* (20), who estimated CKD prevalence using the two most commonly used equations. Using the MDRD equation, GFR estimates showed that CKD was more prevalent in white than in black participants at all levels of GFR, 50 to 59, 40 to 49, 30 to 39, and 20 to 29 ml/min per 1.73 m^2. Using the Cockcroft-Gault equation, however, estimated creatinine clearance indicated that CKD was more prevalent in black than in white participants at each level of impaired kidney function. The discrepancy in estimates of CKD prevalence at stages 3 and 4 on the basis of these two equations was reported previously using NHANES III data (15).

The higher mortality among black than white patients of all cohorts that was observed in this study is consistent with US national data (21,22). Racial disparity in mortality and life expectancy in the United States did not change between 1982 and 2001, which cannot be explained by income or basic health care access and utilization factors alone (22). Similarly, several studies have demonstrated that socioeconomic status, access to health care, CKD prevalence, and risk factors for comorbid conditions such as diabetes and hypertension cannot explain more ESRD among black than white patients (23–26). Higher mortality among black patients suggests that longevity is not a contributor to their higher ESRD incidences. Higher mortality among black than white patients was found not only in patients without CKD but also in those with CKD. Weiner *et al.* (27), analyzing large community-based cohort studies, reported significantly higher mortality in black patients with CKD than in white patients with CKD, further suggesting that survival of patients with CKD cannot explain higher ESRD incidence in black than white patients.

Although mortality was higher among black than white patients in all cohorts, mortality among black patients with ESRD was lower than among white patients with ESRD. Better survival of black patients with ESRD, even after adjustment for body mass index, comorbid conditions, and other risk factors, has been well established in the past two decades (28–30). An answer is needed to explain the reason that black patients have higher mortality in the general population but higher ESRD incidence and lower mortality in the ESRD population. After finding faster growth of ESRD incidence than CKD prevalence in the United States, Hsu *et al.* (31) raised the issue of more liberal entry into ESRD treatment programs. If black patients initiated dialysis earlier than white patients, then this would explain why black patients have higher ESRD incidence and higher mortality in the US general population. Despite higher mortality (competing risk), earlier initiation of dialysis would include more black patients in dialysis. It would also explain why black patients have better survival in the ESRD population. In studying mortality outcomes of patients with ESRD, Korevaar and others (32,33) demonstrated that lead-time bias, or earlier initiation of dialysis, resulted in better survival when survival time is counted from the date of dialysis initiation.

Did black patients start dialysis earlier than white patients? An earlier study showed that black patients have higher serum creatinine or lower eGFR than white patients at the initiation of ESRD treatment (34). National data also showed higher levels of serum creatinine or lower levels of eGFR in black than white patients at ESRD initiation from 1995 through 2004 (2). As discussed previously and noted in the previous study (34), determination of kidney function by eGFR has limitations, and black individuals physiologically have higher serum creatinine than white individuals. In practice, serum creatinine or GFR is not the sole criterion for dialysis initiation. Uremic symptoms such as lethargy, anorexia, nausea, and volume overload are important determinants for timing of dialysis initiation (33,35). Therefore, further studies are needed regarding factors that are related to and effects of dialysis initiation timing.

This study also found gender differences within racial disparities in risk for developing ESRD. Although men were more

likely to develop ESRD than women, black women and women of other races/ethnicities were much more likely to develop ESRD than white women, compared with black and other men relative to white men. Such a finding has not been reported in previous observational studies. A similar finding was recently reported in a simulation study (36). These results suggest that minority women are at much greater risk for ESRD. A possible explanation is obesity or overweight. Data from NHANES III show that prevalence of overweight white men and women is 32.0 and 33.5%, respectively, whereas the prevalence of black men and women is 31.8 and 49.2%, respectively (37). Data from NHANES 1999 to 2000 indicate that the prevalence of obesity in white men and women who are 60 yr and older is 34.3 and 33.3%, respectively, whereas the prevalence is 26.4 and 50.2% in black counterparts and 29.7 and 41.0% in Mexican American counterparts (38). Because obesity is a major risk factor for CKD (39), more obesity and overweight among minority women likely contributes to more kidney failure.

The retrospective nature of this study is a limitation. Diseases or conditions that are recorded in Medicare claims are usually underreported, as discussed previously. Other limitations include lack of biochemical data, information regarding lifestyle risk factors such as smoking, and socioeconomic status information. Medicare beneficiaries who did not receive reimbursable services during 1992 were not included in the study, possibly causing a selection bias. Medicare patients are older; therefore, the results are unlikely to be applicable to the younger population. However, because the ESRD rate in the general population is low (incidence rate of 336 per million population in 2002 [2]), a longitudinal or cohort study in the general population would not be practical. This study drew data from the Medicare 5% Sample, which is a random sample of all Medicare beneficiaries. Because Medicare beneficiaries who are 65 yr or older are essentially the same as people in the general population, the results are extremely robust. Furthermore, this study is based on individual data with 10 yr of follow-up. Investigating diabetes, hypertension, mortality, and ESRD that occurred in the 10-yr period is strength of the study.

Conclusion

Although diabetes and hypertension are the leading causes of renal failure, they are not the primary reasons for the racial difference in developing ESRD. Minority women in particular are at greater risk for ESRD than white women. Black patients have greater risk than white patients for death and developing ESRD in all cohorts, but black patients with ESRD have lower mortality than white patients with ESRD. These findings require further study to determine whether earlier initiation of ESRD treatment is a factor.

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Disclosures

None.

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