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Younger black patients have a higher risk of infection mortality that is mostly non-dialysis related: A national study of cause-specific mortality among U.S. maintenance dialysis patients

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Abstract

Introduction—While it has been well documented that in the U.S., black and Hispanic dialysis patients have overall lower risks of death than white dialysis patients, little is known whether their lower risks are observed in cause-specific deaths. Additionally, recent research reported that younger black patients have a higher risk of death, but the source is unclear. Therefore, this study examined cause-specific deaths among US dialysis patients by race/ethnicity and age.

Methods—This national study included 1,255,640 incident dialysis patients between 1995 and 2010 in the USRDS. Five cause-specific mortality rates, including cardiovascular (CVD), infection, malignancy, other known causes (miscellaneous), and unknown, were compared across blacks, Hispanics, and whites overall and stratified by age groups.

Findings—After multiple adjustments, Hispanic patients had the lowest risk of mortality for every major cause in almost all ages. Compared with whites, blacks had a lower risk of death from CVD, malignancy and miscellaneous causes in most age groups, but not from infection. In fact, blacks had a higher risk of infection death than whites in ages 18-30 years (HR [95% CI] 1.94 [1.69-2.23]; $p < 0.001$), 31-40 years (HR 1.51 [1.40-1.63]; $p < 0.001$) and 41-50 years (HR 1.07 [1.02-1.12]; $p = 0.009$), which were partially attributed to their higher prevalence of AIDS

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nephropathy. For each race/ethnicity, more than two-thirds of infection deaths were due to non-dialysis related infections.

Discussion—Hispanics had the lowest risk for each major cause of death. Blacks were less likely to die than whites from most causes, except infection. The previously reported higher overall mortality rate for younger blacks is attributed to their two-fold higher infection mortality, which is mostly non-dialysis related, suggesting a new direction to improve their overall health status. Research is greatly needed to determine social and biological factors that account for the survival gap in dialysis among different racial/ethnic groups.

Keywords

Cardiovascular; dialysis related infection; non-dialysis related infection; racial/ethnic differences; USRDS

Introduction

Across the United States, more than 400,000 patients undergo chronic dialysis each year [1]. Despite the improvement in therapy and practice, the annual mortality rate of dialysis patients remains at a staggering 15-20%, which is 6.1-7.8 times higher than the general age-matched Medicare population [1]. However, dialysis mortality varies by racial subgroups [2-5]. According to a recent study that used the national dialysis population [6], the overall crude annual mortality rate for white dialysis patients is 30.4%, whereas the rates for blacks and Hispanics are 17.9% and 17.5% respectively. While racial differences in overall dialysis mortality have been established, little is known if such pattern is also observed in cause-specific deaths. In addition, recent studies have reported that black dialysis patients younger than 30-50 years old have a higher, rather than lower, risk of death than their white counterparts [6-8]. This emerging evidence has prompted speculations of whether the observed higher risk of death in younger black patients is primarily driven by a single or multiple causes of death. Given that minorities have historically received less medical care than whites [9-12], it can be posited that minorities are more likely to die from causes related to access to care. To better understand the underlying reasons for the racial survival differences, it is imperative to determine the major causes contributing to the mortality for each racial subgroup.

We therefore undertook this study to examine whether racial/ethnic subgroups differ in cause-specific mortality rates and whether these differences vary by age.

Materials and Methods

Data source and study population

This project was approved by the Institutional Review Board at the University of Virginia. Using the United States Renal Data System (USRDS) [13], we identified 1,332,670 adult patients (> 18 years) who began maintenance dialysis for the first time between April 1, 1995 and September 28, 2010 in the U.S. and had no prior kidney transplantation. We excluded 77,030 patients (5.8%) because of missing covariates. We also excluded Asians because the low number of Asian patients did not permit us to generate reliable age-stratified estimates.

The final cohort included 1,255,640 patients with 718,183 (57%) non-Hispanic whites, 380,557 (30%) non-Hispanic blacks and 156,900 (13%) Hispanics.

Outcomes and covariates

The outcomes of interest were cause-specific mortality in five major categories: cardiovascular disease (CVD), infection, malignancy, other known causes (miscellaneous), and unknown/missing. These classifications were based on the CMS ESRD Death Notification form (CMS-2746) (see Supplemental Materials). In addition, we provided a descriptive summary of the subcategories within certain major causes: acute myocardial infarction (AMI), sudden cardiac arrest (SCA), other cardiac, and vascular/cerebrovascular (VASC+CBV) in CVD; dialysis-related and non-dialysis related within the infection category; behavior-related and non-behavior-related within the miscellaneous category. Survival time was calculated from the date of dialysis initiation to the earliest date of death, kidney transplant, or administrative end of study (September 30, 2010).

Race and ethnicity were obtained from the CMS Medical Evidence (ME) form (CMS-2728). The primary analyses of examining racial/ethnic differences in mortality were adjusted for the following covariates available on the ME form: age at ESRD onset, sex, employment status (at 6 months before ESRD), health insurance at ESRD onset (private, Medicare, or Medicaid/none), body mass index, estimated glomerular filtration rate (eGFR), 5 causes of ESRD (diabetes, hypertension, glomerulonephritis, others, unknown), first dialysis modality used at the initiation of dialysis (in-center/home hemodialysis or peritoneal dialysis), lifestyle behaviors (smoking, alcohol, drug dependence), immobility, and presence/absence of each comorbid condition (hypertension, diabetes, cardiac failure, atherosclerotic heart diseases, other cardiac diseases, cerebrovascular disease, peripheral vascular disease, chronic obstructive pulmonary disease, cancer), as well as pre-ESRD use of erythropoiesis-stimulating agents (ESAs). In ad hoc analyses, the “others” category of ESRD causes was further divided into AIDS nephropathy and non-AIDS nephropathy, in order to explore additional reasons for the higher mortality in younger black patients. Additionally, two pre-ESRD care indicators, nephrologist care and vascular access type used for the first outpatient dialysis, were examined in the subset of patients who had these data since 2005 (n=501,367).

Statistical analyses

We calculated the cause-specific mortality rate, expressed as the number of deaths due to the specific cause per 1000 patient-years, for each racial/ethnic subgroup. There are several statistical models available for analyzing competing risks data that address distinct questions. The objective of our study was to understand the implications of race/ethnicity on cause-specific mortality risk among patients remaining on dialysis. Therefore, we utilized Cox regression with the cause-specific hazard approach, in which the competing risks (i.e., kidney transplants and deaths from causes other than the specific cause being investigated) were censored and race/ethnicity was related to the cause-specific hazard for death. For each major cause being investigated, we obtained the cause-specific hazard ratios (HR) of blacks and Hispanics vs. whites for the entire cohort and then for each of the seven age groups (18-30, 31-40, 41-50, 51-60, 61-70, 71-80, >80 years at ESRD onset). We chose these seven

age groups in order to facilitate the comparison of the present results with prior findings [6]. Primary analyses were adjusted for the demographic and clinical covariates described above, as well as the year of ESRD onset to account for the secular trend in mortality and census regions to account for possible regional differences. Because infection-related mortality rates were found to be substantially higher for blacks than whites, to better understand this phenomenon, we performed additional analyses to further adjust for AIDS nephropathy as a separate category from the “others” category of ESRD causes. We further examined whether the aggregated HRs of infection mortality for the 1995-2010 study period differed by earlier (1995-2000) and recent (2001-2007) periods, both restricted to fixed 3 years of follow-up.

We performed a number of sensitivity analyses to examine the robustness of our findings. First, we evaluated the effects of the missing/unknown causes of deaths. We repeated the cause-specific hazard models for CVD death in which all deaths with missing or unknown cause are assumed to be CVD deaths, and separately, in which they are all assumed to be infection deaths. Second, we evaluated the influence of the two pre-ESRD care indicators, nephrologist care and vascular access type used for the first outpatient dialysis, by including them in the models for patients who had these data after 2005.

Results

Patient characteristics

Patient characteristics at maintenance dialysis initiation are presented in Table 1. In all age groups, compared with whites, blacks and Hispanics had higher percentages of being uninsured and unemployed, and lower percentages of pre-ESRD care (ESAs and nephrologist care) and arteriovenous fistula (AVF) use for their first dialysis. In ages >50 years, both black and Hispanics had lower prevalence of various cardiac diseases but higher prevalence of hypertension and diabetes than their white counterparts. However, in ages <30 years, Hispanics, but not blacks, had lower prevalence than whites on many of the comorbid conditions. Percentages of AIDS nephropathy-related ESRD were especially higher for blacks than whites and Hispanics, particularly for ages <50 years (Table S1).

Causes of death

Over a median follow-up of 22.9 months, death occurred in 62.4% of the entire study population, and 67.7% in whites, 57.2% in blacks, and 50.7% in Hispanics. Overall, among the four known cause categories examined (CVD, infection, malignancy, miscellaneous), CVD was the most common cause of death (48.0%), followed by miscellaneous (16.1%) and infection (12.3%) (Table 2). For each race/ethnicity, CVD remained the most common cause throughout all age groups. However, the second and third most common causes of death varied by race/ethnicity. For whites, miscellaneous (15.6-21.1% across age groups) was second and infection (10.1-12.6%) was third in all age groups. For blacks, infection (13.4-18.4%) was second in ages <80 years while miscellaneous (11.5-14.3%) was third. For Hispanics, infection was tied with miscellaneous in <50 years whereas miscellaneous was second in >50 years. Notably, blacks had a slightly lower or comparable percentage of CVD deaths compared to the other two racial/ethnic groups, but a substantially higher percentage of infection deaths.

We further divided the major causes into subcategories. Among the CVD deaths, SCA was the most common (22.8% of total deaths), followed by other cardiac (12.8%). In the infection category, non-dialysis-related infection (8.8% of total deaths) was much more common than dialysis-related infection (3.5%). In the miscellaneous category, non-behavior-related deaths (10.6%) were far more frequent than behavior-related deaths (5.5%). These patterns remained consistent across each race/ethnicity, regardless of age.

Of note, for each race/ethnicity, more than two-thirds of infection deaths were non-dialysis-related. The percentage of death due to non-dialysis related infection was substantially higher for younger blacks (< 50 years) than their two other racial/ethnic counterparts.

Cause-specific mortality rates

Table 3 presents crude cause-specific mortality rates by race/ethnicity and age. Among the three racial/ethnic groups, whites generally had the highest rates of mortality from most major causes, except for infection and unknown/missing causes. Blacks had the highest rates due to infection in the youngest two age groups and unknown/missing in ages 18-30 years old. Figure 1 presents the cause-specific HRs of blacks and Hispanics vs. whites, respectively, adjusted for the factors mentioned above. Consistent with previous findings [6], Hispanics had lower all-cause mortality rates in all age groups (HRs from 0.60 to 0.83) than their white counterparts, while black patients had lower all-cause mortality rates in all ages (HRs from 0.72 to 0.97) except 18-30 years (HR = 1.17) (Figure 1A). Regarding cause-specific deaths, Hispanics had a lower risk of death from every major cause than their white counterparts in almost all age groups (all HRs <1, except ages >80 years for infection). Black patients had a lower risk of death from CVD, malignancy, and miscellaneous category than whites in most age groups. However, black patients had a higher risk of death from infection in four of the seven age groups, three of which in ages < 50 years (HR [95% CI]: 1.94 [1.69-2.23], $p < 0.001$ in age 18-30 years; 1.51 [1.40-1.63], $p < 0.001$ in age 31-40 years; 1.07 [1.02-1.12], $p = 0.009$ in age 41-50 years), and one in age >80 years (1.07 [1.02-1.13], $p = 0.003$). This mortality difference (blacks vs. whites) for the whole period was more pronounced for the first 6 months after initiating dialysis; HR = 3.70 ($p < 0.001$) in age 18-30, HR = 2.67 ($p < 0.001$) in age 31-40, and HR = 1.38 ($p < 0.001$) in age 41-50. By calendar year, the higher black-to-white HRs for three-year infection mortality in these younger age groups decreased in the recent period (2001-2007) compared to the earlier period (1995-2000), but they still persisted and remained strongly significant. In addition, blacks had a higher risk of death from the unknown cause in age groups of 18-30 years and 31-40 years.

Adjustment for the ESRD cause of AIDS nephropathy

The HRs of infection death for blacks vs. whites were greatly attenuated from 1.94 to 1.30 in age 18-30 years and from 1.51 to 1.09 in age 31-40 years, and reversed from 1.07 to 0.90 in age 41-50 years (Table S2). The adjustment led to a less dramatic attenuation for the other 4 major causes of death in ages < 50 years (Table S2). There were almost no changes in ages >50 years for all five causes. In contrast to blacks, the mortality risks for Hispanics vs. whites were slightly attenuated for infection death but did not change for the other major causes of death, after adjustment for AIDS nephropathy.

Sensitivity analysis

Overall, 19.5% of the deaths were unknown or missing causes. When these unknown/missing were assumed to be CVD, the lower risk of death from CVD for both blacks and Hispanics than whites did not change. When all unknown/missing causes were assumed to be infection, the higher risks of death from infection for blacks previously noted in the youngest three age groups were noted in the youngest two age groups. Additional adjustment for pre-ESRD nephrologist care and vascular access type for the group of patients since 2005 had only a modest effect on the racial difference in infection death (Table S3).

Discussion

This national study of 1,255,640 dialysis patients followed for survival has revealed the following important findings: (1) While CVD was expectedly the major cause of deaths for each race/ethnicity, the most common non-CVD cause of death differed as follows: infection in black patients in ages 80 years, miscellaneous in white patients in all age groups, infection and miscellaneous in younger Hispanics (< 50 years), and miscellaneous in older Hispanics. (2) Consistent with their overall survival advantage, compared to whites, Hispanics had a lower risk of death from every major cause in almost all age groups, which could not be attributed to the patient case mix and measured clinical factors available. (3) In contrast, black patients generally had a lower mortality risk from most major causes, except for infection; blacks 18-50 years old had up to a two-fold higher risk of death due to infection than their white counterparts even after multiple adjustments. Thus, the previously reported higher all-cause mortality in blacks younger than 30 years old was mainly driven by infection deaths, which were in part attributed to their higher prevalence of AIDS nephropathy. Of note, for each race/ethnicity, their infection deaths were comprised mostly of non-dialysis related reasons. To our knowledge, only one prior study has focused specifically on racial differences in cause-specific deaths, but it did not separate infection into dialysis-related and non-dialysis-related deaths [14], nor examined age modifications or included Hispanic ethnicity in the dialysis population, which has diversified significantly over the last 20 years.

Cardiovascular mortality has long been considered the leading cause of death in dialysis patients as a consequence of their higher prevalence of cardiovascular diseases and associated risk factors, such as hypertension and diabetes, than the general population [15-18]. Our study, drawn from the diverse national dialysis population, reveals for the first time that cardiovascular remained as the overall leading cause of death in each race/ethnicity, accounting for 43-52% of all dialysis deaths throughout the age groups (Table 2). Our findings also build on the recent report by de Jager et al., which showed that the excess mortality in a European dialysis cohort was not specifically a result of increased cardiovascular mortality, since non-cardiovascular causes were also higher in dialysis patients than the general population [19]. Besides the aforementioned cardiovascular risk factors, the presence of many comorbid conditions and persistent azotemia in dialysis patients likely contributes to their overall susceptibility to non-cardiovascular diseases, such as infection [20-22], in addition to cardiovascular diseases.

Using a national dialysis population, our study found that in each racial/ethnic group, the majority of the infections-related deaths were unexpectedly non-dialysis-related, rather than dialysis-related as commonly thought. Carrero et al. reported higher rates of non-cardiovascular deaths, including infections, among women compared to men, but did not stratify infections as dialysis-related or not [23]. Prior, single-site retrospective studies have also reported that most infections among their ESRD patients were not related to dialysis and included causes such as pervasive exposure to antibiotics and pneumonia [21, 22]. Although dialysis-related infections have widely been recognized as a major component of the infection burden in ESRD patients, non-dialysis-related infection deaths deserve greater attention by clinicians and the clinical research community.

While in the general US population blacks have an estimated lifespan that is 4-5 years shorter than their white counterparts [24], black dialysis patients experience an overall survival advantage over white dialysis patients [5-8]. Blacks younger than 30 years old on dialysis, on the contrary, have a higher risk of death than their white counterparts even after adjusting for case mix and measured clinical factors [6-8]. The present study reveals that this higher risk was driven by their two-fold higher risk of death from infection (Figure 1). Furthermore, we unexpectedly found that the mortality due to infection remained higher in blacks through 50 years of age, which has been masked in previous studies on all-cause mortality. While the exact reason for this racial difference is unclear, a greater burden of infection deaths in minority patients may be related to access to care. Black dialysis patients receive less than optimal medical care compared to whites, such as delayed referral to the nephrologist [10, 25] and lower rates of AVF at dialysis initiation [11, 26]. Limited social support networks and maladaptive lifestyle behaviour may also contribute to worse infection outcomes among younger black dialysis patients [27, 28]. However, younger Hispanic dialysis patients had a better overall survival in all age groups than white patients [6, 29], yet they have the lowest rates of health insurance (Table 1) and no particular advantage in access to dialysis care [30, 31]. In fact, the present analysis is the first national study to show that the survival advantage of Hispanic dialysis patients generally holds true for all causes of death and across all age groups. Given similar socioeconomic profiles (Table 1), the substantially better survival in young Hispanic dialysis patients than in young black dialysis patients is perplexing and warrants further investigation. The higher prevalence of APOL1 ESRD risk alleles and associated HIV-related ESRD in blacks [32, 33] could predispose to the higher infection mortality that we observed, especially given the lower CD4 counts and higher viral load for young black patients during the pre-ESRD period [34].

Another explanation for the higher infection mortality in black patients observed in the present study might have been differential vaccination rates, which cannot be substantiated because the data are unavailable. However, a previous study showed that the vaccination rate for influenza was lower for black dialysis patients than whites dialysis patients; further, dialysis patients who did not receive the vaccination had a higher risk of infection-related death than those who received it [35]. Another potential source of the higher infection mortality in black patients might have been due to hepatitis C, which has been shown to be associated with an increased risk of mortality on dialysis [36]. It has been reported that in the general population, black patients have higher prevalence of hepatitis C infection [37], although this disparity has yet to be reported in the dialysis population. Further research is

needed to elucidate the biologic and system-level factors that account for the higher infection mortality rate in black dialysis patients.

The present findings should be viewed with some limitations. Misclassification of cause of death may be present. In addition, 19.5% of deaths were missing or unknown causes. While the impact of unknown causes on the findings is not clear, we performed the sensitivity analyses in which all unknown/missing causes were classified as either CVD or infection and did not find a dramatic change in our conclusions. Another limitation is that our adjusted analyses were limited to the covariates that were collected in CMS-2728 form. Other factors, such as longitudinal changes in serum chemistry, anemia, vascular access and process of care as well as serum biomarkers were not examined, because these data are not available in the USRDS. Finally, the option of selecting Indian Subcontinent, Mid-East/Arabian, or Other on the 1997 Medical Evidence form may not have been evenly distributed across the more limited options after 2005. However, it is unlikely that any redistribution of this small cohort would significantly affect our results.

In summary, using a national dialysis population, we found that CVD remained as the major cause of death for each racial/ethnic group regardless of age, reinforcing the need to reduce the prevalence of cardiovascular diseases and their associated risk factors for all dialysis patients. Importantly, we also found that non-dialysis-related infections comprised most of the infection-related deaths in dialysis patients of each race/ethnicity. Additionally, we found that the previously reported higher overall mortality rate for younger blacks is attributed to their twofold higher rate of mortality due to infection, mostly from non-dialysis-related causes, suggesting a new direction to improve their overall health status. There remains a great need to explore key social and biological factors that account for racial/ethnic survival differences and to develop innovations to improve outcomes for all patients on dialysis.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Figure 1. Adjusted hazard ratios of death for blacks and Hispanics compared with whites by age group for all-cause and 5 major causes of death

The error bars represent 95% confidence intervals. The hazard ratios were adjusted for the following covariates: age, sex, employment, insurance at ESRD onset, body mass index, estimated GFR, 5 categories of ESRD cause (diabetes, hypertension, GN, others, and unknown), and presence of comorbid conditions (hypertension, diabetes, cardiac failure, atherosclerotic heart disease, other cardiac disease, cerebrovascular disease, peripheral vascular disease, chronic obstructive pulmonary disease, and cancer), immobility, lifestyle behaviors (smoking, alcohol, and drug dependence), dialysis modality, pre-ESRD use of

erythropoiesis-stimulating agents, year of ESRD onset, and census regions (Northeast, Midwest, South, and West).

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Table 1

Patient Characteristics

Characteristics	Age 18-30 yr (n= 39,959)			Age 31-50 yr (n= 225,702)			Age >50 yr (n= 989,979)		
	White	Black	Hispanic	White	Black	Hispanic	White	Black	Hispanic
Patients (n)	14,848	16,535	8,576	91,734	99,520	34,448	611,601	264,502	113,876
Age (yr), mean±SD	25.2±3.6	25.6±3.4	24.8±3.7	42.9±5.4	42.5±5.5	42.6±5.6	70.7±10.0	66.3±9.8	66.3±9.6
Men (%)	57.5	50.4	57.1	60.5	57.1	60.8	56.8	46.1	52.5
BMI (kg/m ²), mean±SD	25.8±7.0	28.1±8.7	25.6±6.6	28.5±8.1	29.2±8.5	28.4±7.5	27.6±7.2	28.1±7.6	27.3±6.6
eGFR (ml/min per 1.73 m ²), mean±SD	8.2±4.4	8.1±4.5	7.2±4.2	8.9±4.3	8.4±4.3	8.3±4.2	10.4±4.8	10.0±4.7	9.8±4.6
Employed at 6 mons before ESRD (%)	71.9	59.3	63.7	77.3	64.8	66.3	91.9	82.2	79.7
No insurance at ESRD onset (%)	18.7	27.7	33.0	12.6	22.6	25.4	5.1	8.3	13.4
Current smoker (%)	8.9	5.1	2.8	12.1	9.4	3.7	5.5	5.4	2.2
Hemodialysis (%)	84.0	91.6	90.1	84.8	92.6	91.9	92.5	95.6	95.3
Cause of ESRD (%)									
Diabetes	22.0	18.5	14.1	45.4	31.7	51.3	41.7	50.4	67.7
Hypertension	9.1	27.4	18.7	11.5	36.2	17.7	29.8	35.1	19.0
Glomerulonephritis	30.5	22.3	31.9	14.7	11.4	12.6	7.2	4.1	3.7
Others	33.3	27.9	23.8	24.9	17.6	14.0	16.8	7.8	7.0
Unknown	5.1	3.9	11.4	3.5	3.1	4.5	4.5	2.6	2.5
Comorbidity									
Hypertension (%)	67.7	77.0	69.8	75.9	82.9	79.9	78.7	86.0	82.3
Diabetes (%)	22.7	21.1	15.3	47.2	36.9	52.7	49.0	58.0	69.2
Cardiac failure (%)	6.9	10.0	6.7	16.6	18.8	16.3	40.0	33.6	33.4
Atherosclerotic heart disease (%)	1.9	1.3	1.0	11.8	6.5	7.5	35.5	20.2	23.1
Other cardiac diseases (%)	2.8	3.1	2.3	5.2	4.6	3.7	15.5	9.0	8.5
Cerebrovascular disease (%)	1.4	1.7	0.9	4.6	4.7	3.2	11.1	11.8	8.4
Peripheral vascular disease (%)	1.8	1.8	1.2	8.9	4.7	6.8	19.2	12.2	14.1
COPD (%)	0.6	0.6	0.4	3.9	2.1	1.2	12.8	6.3	4.4
Cancer (%)	1.3	0.5	0.6	3.1	1.6	1.3	9.6	6.0	3.8

Characteristics	Age 18-30 yr (n= 39,959)				Age 31-50 yr (n= 225,702)				Age >50 yr (n= 989,979)			
	White	Black	Hispanic		White	Black	Hispanic		White	Black	Hispanic	
Immobility (%)	1.8	1.3	1.0		2.9	2.0	2.3		6.3	6.5	5.7	
Pre-ESRD care												
ESA use before ESRD (%)	26.5	17.6	17.8		29.3	20.3	22.1		31.3	27.0	25.5	
Nephrologist care before ESRD (%) ^a	55.2	44.4	37.7		59.9	48.7	46.8		61.8	56.5	51.0	
Vascular access for the first hemodialysis session (%)^a												
AVF	8.6	5.8	6.6		13.4	10.3	10.4		14.3	12.6	11.7	
Graft	1.7	1.9	1.1		2.3	3.2	1.9		3.0	5.6	3.0	
Catheter	75.3	85.0	82.0		70.7	78.8	79.4		75.1	76.7	80.2	
Others	14.5	7.3	10.2		13.6	7.6	8.2		7.6	5.0	5.1	

Abbreviations: BMI, body mass index; COPD, chronic obstructive pulmonary disease; ESA, erythropoietin-stimulating agents; AVF, arteriovenous fistula.

^aFor patients who completed the new Centers for Medicare & Medicaid Services Medical Evidence form since 2005.

Table 2

Percentages of deaths due to different causes by race/ethnicity and age

	Overall	Age 18-30 yr (total = 8,275)			Age 31-40 yr (total = 24,821)			Age 41-50 yr (total = 63,361)			Age 51-60 yr (total = 126,056)			Age 61-70 yr (total=199,947)			Age 71-80 yr (total = 240,271)			Age >80 yr (total= 120,637)			
		W	B	H	W	B	H	W	B	H	W	B	H	W	B	H	W	B	H	W	B	H	
Deaths (n)	783,368	2624	4654	997	9072	12996	2753	26456	29120	7785	63430	45915	16711	120062	56479	23406	171274	48673	20324	93010	19992	7635	
Causes of death (%)																							
CVD	48.0	47.4	43.5	44.6	48.7	44.5	47.0	48.5	47.3	50.1	48.8	48.9	52.0	48.4	49.5	51.0	47.7	47.4	49.5	45.9	46.1	47.1	
AMI	6.5	3.7	2.9	3.3	6.1	4.0	5.9	7.5	5.4	7.3	7.7	6.5	8.5	7.4	7.0	8.1	6.3	6.2	6.9	5.2	5.1	5.4	
SCA	22.8	25.0	24.1	25.6	24.3	24.0	24.0	23.7	25.4	24.7	23.3	25.8	25.6	21.5	25.3	24.8	20.7	24.6	23.8	20.5	25.2	24.0	
Other cardiac	12.8	11.4	9.5	6.9	11.1	9.0	9.2	11.2	8.7	10.4	12.4	9.5	10.1	14.0	10.4	11.5	15.2	10.5	12.7	15.6	10.6	12.6	
VASC+CBV	5.9	7.4	7.0	8.8	7.2	7.2	7.9	6.1	7.7	7.8	5.4	7.1	7.8	5.6	6.8	6.6	5.4	6.1	6.0	4.7	5.1	5.1	
Infection	12.3	11.9	17.7	14.2	12.6	18.4	15.3	12.6	15.9	14.5	12.3	13.9	13.1	11.7	13.7	13.6	10.8	13.9	12.6	10.1	13.4	12.0	
Dialysis related	3.5	3.1	3.1	3.2	3.8	3.1	4.2	3.8	4.0	4.4	4.0	4.1	4.2	3.7	4.3	4.2	3.0	4.3	3.4	2.4	3.6	2.5	
Non-dialysis related	8.8	8.7	14.6	11.0	8.8	15.3	11.1	8.8	11.9	10.0	8.4	9.8	8.9	8.0	9.4	9.4	7.8	9.6	9.2	7.8	9.7	9.5	
Malignancy	4.1	2.4	0.7	1.6	2.3	1.6	1.7	3.9	2.6	2.4	4.7	4.0	2.8	5.2	4.6	3.2	4.5	4.5	3.2	3.3	3.4	2.8	
Miscellaneous	16.1	16.4	14.3	16.6	15.8	11.7	14.3	15.6	11.5	13.2	15.6	11.6	13.5	16.7	11.7	14.4	18.8	13.1	15.2	21.1	14.3	16.5	
Behavior related	5.5	4.1	2.4	3.8	3.7	2.6	3.3	4.2	2.3	3.1	4.8	2.7	3.7	5.6	2.9	4.4	7.2	3.7	5.1	9.5	4.8	6.7	
Non-behavior related	10.6	12.3	11.9	12.8	12.1	9.1	11.0	11.4	9.2	10.2	10.8	8.9	9.8	11.1	8.8	10.0	11.7	9.4	10.1	11.6	9.5	9.8	
Unknown/Missing	19.5	22.0	23.7	22.9	20.6	23.8	21.7	19.5	22.7	19.8	18.6	21.6	18.6	18.0	20.4	17.8	18.1	21.1	19.4	19.6	22.8	21.6	

Abbreviations: W, white race; B, black race; H, Hispanic ethnicity; CVD, cardiovascular disease; AMI, acute myocardial infarction; SCA, sudden cardiac arrest; VASC+CBV, vascular/cerebrovascular.

Table 3

Cause-specific death rates by race/ethnicity in seven age groups

Race/ethnicity	All-cause	Five major causes				
		Cardiovascular	Infection	Malignancy	Miscellaneous	Unknown/missing
		Deaths per 1000 patient-years				
Overall	233.5	112.1	28.8	9.5	37.6	45.5
Age 18-30 yr						
White	67.3	31.9	8.0	1.6	11.1	14.8
Black	70.1	30.5	12.4	0.5	10.0	16.6
Hispanic	30.6	13.6	4.4	0.5	5.1	7.0
Age 31-40 yr						
White	112.4	54.7	14.2	2.6	17.8	23.2
Black	91.2	40.6	16.8	1.4	10.7	21.7
Hispanic	63.6	29.9	9.7	1.1	9.1	13.8
Age 41-50 yr						
White	151.5	73.4	19.1	5.9	23.6	29.5
Black	116.3	55.0	18.5	3.1	13.4	26.4
Hispanic	95.0	47.6	13.7	2.3	12.6	18.8
Age 51-60 yr						
White	207.0	101.0	25.5	9.6	32.3	38.5
Black	149.6	73.2	20.9	6.0	17.3	32.3
Hispanic	133.4	69.4	17.5	3.8	18.0	24.8
Age 61-70 yr						
White	287.2	139.0	33.7	14.9	47.9	51.7
Black	206.2	102.0	28.3	9.5	24.2	42.1
Hispanic	193.0	98.4	26.3	6.1	27.8	34.4
Age 71-80 yr						
White	392.3	187.2	42.4	17.8	73.8	71.0
Black	305.0	144.5	42.3	13.7	40.1	64.4
Hispanic	291.9	144.5	36.9	9.4	44.4	56.6
Age >80 yr						
White	556.4	255.6	56.4	18.1	117.3	109.0
Black	475.5	219.2	63.5	16.3	67.9	108.6
Hispanic	468.5	220.6	56.3	12.9	77.3	101.4