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Geography Matters: Relationships among Urban Residential Segregation, Dialysis Facilities, and Patient Outcomes

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Background: End-stage renal disease disproportionately affects black Americans. However, the impact of residential segregation by race—a prominent feature of many U.S. cities—on outcomes of patients receiving dialysis and on facility performance has not been evaluated.

Objective: To examine the relationship among racial composition of ZIP codes in metropolitan areas, outcomes of patients receiving dialysis, and characteristics of dialysis facilities.

Design: Retrospective cohort study of patients receiving dialysis and cross-sectional study of dialysis facilities.

Setting: U.S. metropolitan ZIP codes with differing percentages of black residents.

Patients: Black and non-Hispanic white patients who initiated long-term dialysis between 1 January 1995 and 31 December 2002 (n = 399 424) and dialysis facilities in operation in December 2004 (n = 3244).

Measurements: Mortality and time to transplantation among patients receiving dialysis, and performance of dialysis facilities on the basis of quality indicators (anemia management, dialysis adequacy, and facility-level mortality rates).

Results: Most black patients (50.3%) but few white patients (5%) lived in the 3% (n = 769) of ZIP codes in which most residents were black. In analyses adjusted for patient and ZIP code characteristics, mortality rates were higher among white patients but not among black patients living in areas with a higher percentage of black residents (adjusted hazard ratio for ZIP codes with ≥75% black residents vs. <10% black residents, 1.14 [95% CI, 1.07 to 1.21] for white patients and 1.02 [CI, 0.99 to 1.06] for black patients). Time to transplantation was longer among both black and white patients (adjusted hazard ratio for ZIP codes with ≥75% black residents vs. <10% black residents, 0.84 [CI, 0.78 to 0.92] and 0.63 [CI, 0.57 to 0.71] for black patients and white patients, respectively). Dialysis facilities located in areas with a higher percentage of black residents were more likely to have higher-than-expected mortality rates and were less likely to meet performance targets.

Limitations: Patient-level analyses were restricted to black and non-Hispanic white patients. Patient-level and facility-level analyses focused only on the percentage of black residents in each ZIP code.

Conclusions: The racial composition of urban residential areas is associated with time to transplantation and dialysis facility performance on standard quality measures. Closer scrutiny of care provided to patients receiving dialysis who live in predominantly black residential areas and to dialysis facilities operating in these areas may be warranted.

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In the United States, end-stage renal disease (ESRD) disproportionately affects black persons (1). For reasons that are poorly understood, black patients receiving dialysis have lower mortality rates than do white patients (2–9). Nevertheless, they are less likely to have kidney transplantation (10, 11), to achieve dialysis treatment targets (12–14) (for example, for anemia management, dialysis adequacy, and fistula placement), and to adhere to dialysis treatments (15). Furthermore, many racial disparities in dialysis outcomes persist despite guideline-based quality improvement efforts (16).

Although several studies have addressed the importance of regional location as a determinant of outcomes of patients receiving dialysis and of dialysis practice patterns (13, 17–19), few studies have examined differences in patient outcomes and facility performance across smaller geographic areas (20). Residential segregation by race is a prominent feature of many U.S. cities that may contribute to differences in health status between black and white persons but may not be captured in large-scale regional comparisons (21). Poor health outcomes in segregated neighborhoods may occur because of various mechanisms, including poor-quality housing; lack of community resources to support healthy behaviors; exposure to stressors, such as crime and environmental toxins; and limited access to high-quality medical care (21–24). We therefore evaluated the hypothesis that patients receiving dialysis and facilities located in ZIP codes with a large percentage of black residents would have worse outcomes than those in ZIP codes with a small percentage of black residents.

METHODS

Data Sources

We conducted separate analyses to compare dialysis patient–level and dialysis facility–level characteristics in metropolitan areas according to the percentage of black

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Context

Differences in outcomes for patients receiving dialysis have been documented according to race and region but not according to neighborhood.

Contribution

The researchers compared outcomes for patients receiving dialysis according to race and racial composition of their residential neighborhoods. Mortality was associated more with an individual's race than with neighborhood racial composition. Time to transplantation was associated more with racial composition than with race.

Caution

Neighborhood data from 2000 may have been inaccurate for some patients who began dialysis earlier.

Implications

Individual race mattered more than neighborhood racial composition for mortality. The opposite was true for time to transplantation. A neighborhood-based approach might be useful for addressing disparities in kidney transplantation.

—The Editors

residents in each patient's or each facility's ZIP code. We used data from the 2000 U.S. Census to define the proportion of black residents in each ZIP code area and to ascertain ZIP code–level socioeconomic characteristics. We used patient-level data from the United States Renal Data System (USRDS), a comprehensive registry of all patients with ESRD, to ascertain date of onset of ESRD; demographic, insurance, and employment status; and information on comorbid conditions at the initiation of dialysis. The USRDS also collects information on residence ZIP code and dialysis modality over time and records the date of first renal transplantation and the date of death.

Although the USRDS collects facility-level data, facility location is not provided. We therefore examined the characteristics of dialysis facilities by using an alternate data source, the Center for Medicare & Medicaid Services' (CMS) Dialysis Facility Compare database (25). This is a publicly available source of current information on all Medicare-certified dialysis facilities. Dialysis Facility Compare grew out of the Balanced Budget Act of 1997, which directed CMS to implement a system to measure and report the quality of dialysis services under Medicare. The database includes information on ZIP code location, ownership, organization, services, and selected quality measures for all Medicare-certified dialysis facilities.

Study Sample

Patient-level analyses were based on data supplied by USRDS, but analyses were conducted by the study investigators. We identified all patients 18 to 100 years of age who began long-term dialysis between 1 January 1995 and 31 December 2002 (n = 701 815). We excluded patients who died (n = 60 894) or had kidney transplantation (n = 16 136) within 90 days after onset of ESRD. This approach is recommended by the USRDS to allow time for stabilization of dialysis modality (for example, in-center hemodialysis, home hemodialysis, or peritoneal dialysis). Among the remaining 624 785 patients, we identified 517 759 who were black or non-Hispanic white. Among these patients, 110 255 were excluded because they did not live in a metropolitan area. A total of 8080 additional patients were excluded because their ZIP code of residence could not be linked to a ZIP code tabulation area in the U.S. Census. The sample for analysis consisted of the remaining 399 424 patients. Compared with patients in the study, persons excluded because their ZIP code could not be linked to a ZIP code tabulation area in the U.S. Census were slightly younger (61.1 years [95% CI, 60.8 to 61.4] vs. 62.3 years [CI, 62.3 to 62.4]) and included a higher percentage of black persons (45.4% [CI, 44.3% to 46.5%] vs. 38.5% [CI, 38.3% to 38.6%]) and men (58.9% [CI, 57.8% to 60.0%] vs. 53.6% [CI, 53.4% to 53.7%]).

We included all facilities listed in Dialysis Facility Compare with a ZIP code in a metropolitan area that could be linked to a ZIP code tabulation area in the 2000 U.S. Census. There were 4440 facilities listed in Dialysis Facility Compare on 29 December 2004, of which 3330 were located in a metropolitan area and 3244 could be linked to a ZIP code tabulation area in the 2000 census.

Outcome Variable

For patient-level analyses, we examined time from day 90 of ESRD to death from any cause and time to first kidney transplantation. Follow-up data on death and transplantation were available through 31 December 2003.

Predictor Variable

The primary predictor variable was the percentage of black residents (according to the 2000 U.S. Census) in the ZIP code where each patient was residing 90 days after initiation of dialysis. This variable was categorized a priori as fewer than 10% (referent), 10% to 24%, 25% to 49%, 50% to 74%, or 75% or more of the residential population.

Covariates for Patient-Level Analyses

The following characteristics were included in race-stratified patient-level multivariable analyses: age, sex, and insurance status at initiation of dialysis (Medicare, Medicaid, employer group coverage, uninsured, Department of Veterans Affairs, or other); employment at the time of dialysis initiation (full-time, part-time, retired because of age, retired because of disability, homemaker, student, or unemployed), and comorbid conditions at initiation of dialysis that were ascertained from the Medical Evidence Form (diabetes, peripheral arterial disease, history of stroke, cardiac disease, and current smoking). Patients were classified as having diabetes if it was listed as the cause of ESRD or if they were identified as using insulin on the Medical

Evidence Form. Cardiac disease included a history of congestive heart failure or ischemic heart disease. Analyses were also adjusted for whether patients were receiving in-center hemodialysis versus peritoneal dialysis or home hemodialysis at day 90. We adjusted for the census division corresponding with each patient's residential ZIP code and aggregate socioeconomic characteristics at the ZIP code level from the 2000 U.S. Census.

Covariates for Facility-Level Analysis

Facility characteristics that we examined in descriptive analysis were ownership (major chain, minor chain, or independent), profit status (profit or nonprofit), number of dialysis chairs, presence of a late shift (shifts starting after 5 p.m. that are usually instituted to expand the capacity of the facility or accommodate patients who work), whether the facility offered peritoneal dialysis or home hemodialysis training, the percentage of patients in each facility achieving selected facility-level performance measures (target hematocrit ≥33% and urea reduction ratio ≥65%), and facility-specific mortality rates. The standard mortality ratio for each facility was calculated based on the observed mortality rate in a given facility compared with what would be expected on the basis of national mortality rates for patients of the same age, sex, race, and diabetes status as patients in the facility. Patient survival for each facility is reported in Dialysis Facility Compare as "better than expected" if the upper 95% CI for the standard mortality ratio is less than 0.8 and "worse than expected" if the lower 95% CI for the standard mortality ratio is greater than 1.2.

Statistical Analysis

We generated Kaplan–Meier curves for death and for transplantation after stratification by race and percentage of ZIP code residents who were black. Among patients of the same race, we used the log-rank test to compare death and transplantation rates in areas with fewer than 10% black residents versus those with 75% or more black residents. We used Cox proportional hazard models to measure the association between the primary predictor and time from day 90 of ESRD to death from any cause and to first kidney transplantation. For time to transplantation, patients were censored at the time of death. Clustering by ZIP code of residence was accommodated by using the "sandwich estimate" of Lin and Wei (26). We used the likelihood ratio test to test for interaction between patient race and the percentage of black residents in each patient's ZIP code. Because race interactions were present for time

Table 1. **Patient Characteristics, by Racial Composition of ZIP Code**

Characteristic	Proportion of Black Residents in ZIP Code*				
	<10% (*n* = 194 289†)	10%–24% (*n* = 66 532†)	25%–49% (*n* = 52 141†)	50%–74% (*n* = 39 910†)	≥75% (*n* = 46 552†)
Black patients, *n*	17 386	24 888	33 952	33 231	44 170
White patients, *n*	176 903	41 644	18 189	6679	2382
Black patients, %	9.0 (8.8–9.1)	37.4 (37.0–37.8)	65.1 (64.7–65.5)	83.3 (82.9–83.6)	94.9 (94.7–95.1)
Mean age, *y*	64.9 (64.8–64.9)	61.5 (61.4–61.7)	59.7 (59.6–59.9)	59.0 (58.8–59.1)	58.6 (58.5–58.8)
Women, %	43.2 (43.0–43.4)	46.6 (46.2–47.0)	50.0 (49.5–50.3)	51.2 (50.7–51.7)	51.7 (51.2–52.1)
Health coverage at onset of end-stage renal disease, %					
Medicare	59.0 (58.8–59.2)	51.3 (51.0–51.7)	47.9 (47.4–48.3)	46.5 (46.0–47.0)	45.0 (44.5–45.4)
Medicaid	13.6 (13.4–13.8)	21.2 (20.9–21.5)	27.6 (27.3–28.0)	30.8 (30.3–31.2)	31.0 (30.6–31.5)
Employer group coverage	27.3 (27.1–27.5)	25.8 (25.5–26.1)	23.7 (23.3–24.0)	22.2 (21.8–22.6)	23.0 (22.6–23.3)
Veterans Affairs	1.33 (1.28–1.38)	1.41 (1.32–1.50)	1.43 (1.33–1.53)	1.55 (1.42–1.67)	1.46 (1.35–1.57)
Other	42.4 (42.2–42.7)	31.5 (31.1–31.8)	25.2 (24.9–25.6)	20.6 (20.2–21.0)	19.1 (18.7–19.4)
No coverage	4.3 (4.2–4.4)	7.6 (7.4–7.8)	9.5 (9.2–9.7)	11.3 (11.0–11.6)	12.0 (11.7–12.3)
Employment status, %					
Full-time	9.9 (9.7–10.0)	10.0 (9.7–10.2)	9.9 (9.6–10.2)	9.1 (8.8–9.4)	9.0 (8.7–9.2)
Part-time	2.3 (2.2–2.4)	1.9 (1.8–2.0)	1.9 (1.7–2.0)	1.7 (1.6–1.8)	1.5 (1.4–1.6)
Retired because of age	49.0 (48.8–49.2)	39.2 (38.8–39.6)	33.5 (33.1–33.9)	30.2 (29.7–30.7)	30.2 (29.7–30.6)
Retired because of disability	16.3 (16.2–16.5)	19.9 (19.6–20.2)	20.9 (20.5–21.3)	22.3 (21.8–22.7)	20.3 (19.9–20.7)
Homemaker	5.9 (5.8–6.1)	4.8 (4.6–5.0)	4.0 (3.8–4.2)	3.4 (3.2–3.6)	3.2 (3.0–3.4)
Student	0.3 (0.27–0.33)	0.3 (0.27–0.36)	0.3 (0.28–0.39)	0.4 (0.31–0.43)	0.3 (0.25–0.35)
Medical leave of absence	3.0 (2.9–3.1)	3.4 (3.3–3.6)	3.6 (3.4–3.7)	3.8 (3.6–4.0)	3.9 (3.7–4.1)
Unemployed	13.3 (13.1–13.5)	20.5 (20.2–20.8)	26.0 (25.6–26.4)	29.3 (28.8–29.7)	31.7 (31.2–32.1)
Receiving in-center hemodialysis, %	86.5 (86.4–86.7)	88.7 (88.4–88.9)	90.1 (89.8–90.4)	91.7 (91.5–92.0)	93.0 (92.7–93.2)
Comorbid conditions, %					
Diabetes	44.5 (44.3–44.8)	46.6 (46.2–47.0)	46.0 (45.6–46.7)	46.8 (46.3–47.3)	45.2 (44.8–45.7)
Cardiac disease	48.2 (48.0–48.5)	43.6 (43.3–44.0)	38.9 (38.5–39.4)	36.4 (35.9–36.8)	32.1 (31.7–32.6)
Peripheral arterial disease	16.9 (16.7–17.1)	14.4 (14.2–14.7)	11.8 (11.5–12.1)	10.2 (9.9–10.5)	8.3 (8.0–8.5)
Stroke	9.4 (9.3–9.6)	9.3 (9.0–9.5)	8.8 (8.6–9.1)	9.0 (8.7–9.3)	8.1 (7.8–8.3)
Current smoker	5.3 (5.2–5.4)	6.2 (6.0–6.4)	5.8 (5.6–6.0)	5.9 (5.7–6.2)	5.4 (5.2–5.6)

* Values in parentheses are 95% CIs. Health coverage may sum to greater than 100% in patients with multiple sources of coverage. Four percent of patients were missing data on comorbid conditions and insurance status, 10% were missing data on employment status, fewer than 1% were missing data on dialysis method, and fewer than 0.01% were missing data on age and sex.
† Number of patients.

Table 2. **Socioeconomic Characteristics, by Racial Composition of ZIP Code***

Characteristic	Proportion of Black Residents in ZIP Code†				
	<10% (*n* = 9998‡)	10%–24% (*n* = 1875‡)	25%–49% (*n* = 980‡)	50%–74% (*n* = 446‡)	≥75% (*n* = 323‡)
Median per capita income, $	23 883 (23 671–24 094)	20 461 (20 122–20 800)	17 838 (17 478–18 198)	15 222 (14 805–15 641)	13 824 (13 332–14 315)
Median families living below the poverty line, %	6.4 (6.3–6.6)	10.3 (9.9–10.6)	14.5 (13.9–15.0)	20.3 (19.3–21.3)	25.2 (23.7–26.7)
Persons employed in managerial or professional positions, %	33.6 (33.4–33.9)	31.5 (31.0–32.1)	28.5 (27.8–29.2)	25.7 (24.8–26.6)	23.4 (22.5–24.3)
Housing units occupied by owner, %	58.1 (57.8–58.5)	49.5 (48.6–50.4)	44.2 (42.9–45.5)	43.1 (41.1–45.0)	42.8 (40.7–44.9)
Median value of owner-occupied housing units, $	152 008 (149 777–154 239)	120 082 (116 271–123 895)	103 420 (99 462–107 377)	83 525 (79 131–87 919)	80 489 (74 116–86 863)
Persons age ≥25 y with a high school diploma, %	83.4 (83.2–83.6)	78.5 (78.0–79.0)	74.1 (73.4–74.9)	69.8 (68.8–70.8)	68.7 (67.6–69.8)
Persons age ≥25 y with a college degree, %	25.0 (24.7–25.3)	22.6 (21.9–23.2)	19.1 (18.3–19.8)	15.2 (14.3–16.0)	12.9 (12.0–13.9)

* Only ZIP codes in which at least 1 cohort patient resided at day 90 of end-stage renal disease are described. Data on each covariate listed in the table were missing for fewer than 1% of ZIP codes that were included in the analysis.
† Values in parentheses are 95% CIs.
‡ Number of ZIP codes.

to death and time to transplantation, analyses were stratified by race and were adjusted for all other patient and ZIP code characteristics that were examined.

To avoid bias caused by excluding patients with missing data (**Tables 1** and **2**), we used a hot-deck multiple imputation procedure (27, 28). Estimates were based on 20 completed data sets; imputed values were obtained by sampling with replacement from available data in the same ZIP code, except for 970 patients for whom we sampled from all ZIP codes with a similar percentage of black residents. The proportional hazard assumption was checked using estimated log (−log [survivor function]) versus time curves. We also estimated the probability of having transplantation in the next year as conditional on being alive at the beginning of the year. In this analysis, the probability of transplantation was calculated by using mixed-effects logistic regression with a random effect for ZIP code. All analyses were done using Stata statistical software, version 8.1 (Stata Corp., College Station, Texas).

Role of the Funding Sources

The institutional review board at the University of California, San Francisco, and the Research Committee at the Department of Veterans Affairs Medical Center, San Francisco, approved the study. The funding sources had no role in the design, conduct, or analysis of this study or in the decision to submit the manuscript for publication.

RESULTS

Patient-Level Analyses

Seven hundred sixty-nine (3%) ZIP codes had 50% or more black residents. Most black patients (50.3%) but few white patients (5%) lived in one of these areas (**Table 1**). Conversely, 72% of white patients began dialysis in areas in which fewer than 10% of residents were black. Compared with patients receiving dialysis who were living in areas in which fewer than 10% of residents were black, those living in areas with 75% or more black residents were younger, more likely to be female, and more likely to have Medicaid or be uninsured at the time of ESRD onset (**Table 1**). They were also less likely to be employed full-time and more likely to be retired because of disability or unemployed at ESRD onset. Finally, patients living in areas with 75% or more black residents had a lower prevalence of cardiac disease, peripheral arterial disease, and stroke and were more likely to receive in-center hemodialysis (**Table 1**).

The patient cohort was distributed across 13 622 metropolitan ZIP codes (**Table 2**). Compared with ZIP codes having fewer than 10% black residents, those with 75% or more black residents had a lower median per capita income, higher percentage of families living below the poverty level, lower percentage of the employed population in managerial or professional occupations, lower percentage of owner-occupied housing units, lower median value of owner-occupied housing units, and lower percentage of high school graduates and college graduates (**Table 2**).

For black patients, mortality rates were lowest in ZIP codes with 10% to 24% black residents and highest in areas with 75% or more black residents (**Table 3**). For white patients, mortality rates were lowest in areas with 10% or fewer black residents and highest in areas with 75% or more black residents (**Table 3**). Among both races, mortality rates were higher in ZIP codes with 75% or more black residents than in those with fewer than 10% black residents. However, differences in mortality by race were much greater than differences in mortality by ZIP code (**Figure 1**).

Among both races, unadjusted mortality risk increased as the percentage of black residents increased (**Table 3**). This pattern was most pronounced among white patients (interaction for race, $P < 0.001$). After adjustment for potential confounders, mortality risk was still slightly higher for white patients living in areas with a higher percentage of black residents but not for black patients living in these areas (adjusted hazard ratio for patients living in ZIP codes with ≥75% black residents vs. <10% black residents, 1.14

[CI, 1.07 to 1.21] for white patients and 1.02 [CI, 0.99 to 1.06] for black patients).

For both black and white patients, transplantation rates were lowest in areas with 75% or more black residents and highest in areas with fewer than 10% black residents (**Table 4**). Transplantation rates among black patients living in ZIP codes with fewer than 10% black residents were closer to rates among white patients living in these areas than to rates among black patients living in areas with 75% or more black residents (**Figure 2**). Similarly, transplantation rates among white patients living ZIP codes in which 75% or more of residents were black were closer to rates among black patients living in these areas than to rates among patients of either race living in areas with fewer than 10% black residents (**Figure 2**).

In unadjusted and adjusted analyses among both black and white patients, time to transplantation was longest in areas with a higher percentage of black residents (**Table 4**). This association was most pronounced for white patients living in these areas (interaction for race, $P < 0.001$), but the association persisted for both races after adjustment for potential confounders (adjusted hazard ratios for ZIP codes with ≥75% black residents vs. <10% black residents, 0.84 [CI, 0.78 to 0.92] and 0.63 [CI, 0.57 to 0.71] for black and white patients, respectively). These analyses were confirmed by using mixed-effects logistic regression analysis.

Facility-Level Analysis

Dialysis facilities in areas with a high proportion of black residents were on average larger (more stations) and less likely to be owned by a small chain (**Table 5**). Facility-level quality indicators for anemia management and dialysis adequacy were least favorable in areas with the highest percentage of black residents. A disproportionate percentage of facilities in predominantly black ZIP codes had higher-than-expected mortality rates on the basis of the age, sex, race, and diabetes status of their patients. For example, 12.7% (CI, 7.8% to 17.6%) of facilities in areas with 75% or more black residents had higher than expected mortality rates. In contrast, mortality rates were higher than expected in only 3.4% (CI, 2.5% to 4.3%) of facilities in ZIP codes with fewer than 10% black residents.

DISCUSSION

Published studies have emphasized the importance of patient, provider, and facility characteristics in understanding differences in mortality and transplantation rates among patients receiving dialysis (10, 11, 14, 29–32). Our findings suggest that the residential location of patients receiving dialysis is associated with time to transplantation and that the location of dialysis facilities is associated with achievement of performance targets.

In a large cohort of urban patients receiving dialysis, black and white patients lived, for the most part, in different ZIP codes. Time to transplantation was longest among patients living in areas with a high percentage of black residents, even after adjustment for patient race and ZIP code–level socioeconomic indicators. However, mortality rates were more a function of race than of residence: Differences in mortality rates among patients living in areas with differing percentages of black residents were far less pronounced than differences in mortality rates between black and white patients living in comparable residential areas. Dialysis facilities located in predominantly black residential areas were less likely to be owned by a small chain; were larger; and were less likely to meet performance measures for anemia management, dialysis adequacy, and expected patient mortality rates.

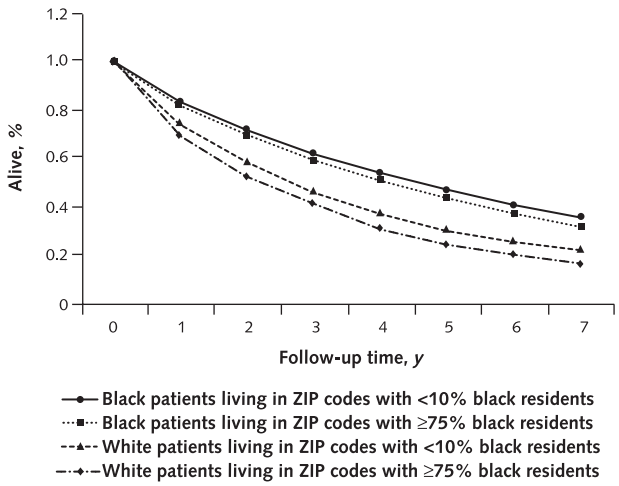
These findings suggest a need for more attention to the care of patients living in and to the performance of dialysis facilities operating in these resource-poor areas. A better understanding of barriers to transplantation and to achievement of facility performance targets in these areas could help guide future quality-improvement efforts. At

Table 3. **Cox Models for Time to Death, by Racial Composition of ZIP Code**

Subgroup	Proportion of Black Residents in ZIP Code	Patients, *n*	Person-Years	Deaths, *n*	Mortality Rate per 100 Person-Years (95% CI)	Unadjusted Hazard Ratio (95% CI)	Adjusted Hazard Ratio (95% CI)*
White patients	<10%	176 903	431 309	108 735	25.21 (25.05–25.37)	1.00 (referent)	1.00 (referent)
	10%–24%	41 644	101 048	25 926	25.66 (25.32–25.99)	1.02 (1.00–1.03)	1.02 (1.01–1.04)
	25%–49%	18 189	43 884	11 743	26.76 (26.24–27.28)	1.06 (1.04–1.08)	1.04 (1.02–1.07)
	50%–74%	6679	15 659	4475	28.58 (27.68–29.50)	1.13 (1.10–1.17)	1.08 (1.04–1.13)
	≥75%	2382	5575	1667	29.90 (28.39–31.49)	1.19 (1.13–1.24)	1.14 (1.07–1.21)
Black patients	<10%	17 386	51 802	8203	15.84 (15.49–16.19)	1.00 (referent)	1.00 (referent)
	10%–24%	24 888	74 887	11 597	15.49 (15.20–15.78)	0.97 (0.95–1.01)	0.97 (0.94–1.00)
	25%–49%	33 952	100 712	16 658	16.54 (16.29–16.80)	1.04 (1.02–1.07)	1.00 (0.97–1.03)
	50%–74%	33 231	98 128	16 487	16.80 (16.54–17.07)	1.06 (1.03–1.09)	0.99 (0.96–1.03)
	≥75%	44 170	130 397	22 506	17.26 (17.03–17.49)	1.09 (1.06–1.12)	1.02 (0.99–1.06)

* Adjusted for patient age, sex, employment status, insurance coverage, diabetes, cardiac disease, peripheral vascular disease, stroke, current smoking, receipt of in-center hemodialysis, census division, and the following census variables by ZIP code: median per capita income, percentage of families living below the poverty line, percentage of the population employed in managerial or professional occupations, percentage of owner-occupied housing units, median value of owner-occupied housing units, percentage of high school graduates, and percentage of college graduates among persons older than 25 years of age.

Figure 1. **Kaplan–Meier curve for death, by percentage of black residents in each patient's ZIP code and the race of the patient.**



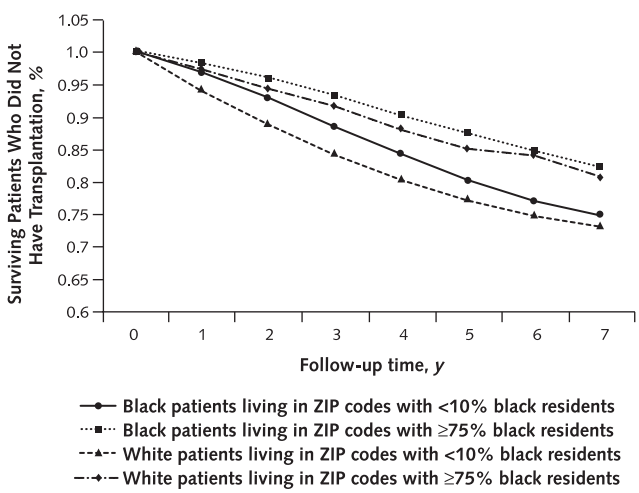
$P < 0.001$ by log-rank test for both black and white patients living in ZIP codes with fewer than 10% black residents versus those with 75% or more black residents.

the same time, the possibility remains that worse patient and facility outcomes in black residential areas reflect structural differences in health care resources and delivery of health care in these areas that are beyond the control of the individual dialysis facility. Evidence from outside the dialysis literature supports this possibility. For example, closure of urban hospitals is more common in black communities (21, 33). The availability of specialized procedures (such as cardiac revascularization) that are relevant to patients receiving dialysis can vary greatly, even among disadvantaged neighborhoods (34). The availability of well-qualified providers may also be an issue. Among a large sample of Medicare recipients, black and white patients were generally treated by different physicians, which primarily reflected the place in which black patients sought care (35). In this study, physicians treating black patients seemed to be less well-trained clinically and reported having less access to important clinical resources than did those treating white patients.

Regardless of the underlying reasons for differences in patient and facility outcomes in predominantly black residential areas, our findings have clear policy implications. First, low transplantation rates among both black and white patients living in these areas raise the question of whether an area-based or community-based approach to reducing racial disparities in transplantation may be an effective adjunct to existing patient-level, provider-level, and facility-level interventions. The National Kidney Foundation's Kidney Early Evaluation Program has already adopted such an approach in an attempt to improve detection of chronic kidney disease among high-risk groups (36, 37). Perhaps a program that is targeted at black residential areas and community organizations, or at providers and facilities operating in these areas, may help to increase transplantation rates among black patients receiving dialysis.

Second, our results provide support for emerging concerns regarding pay-for-performance and its potential to further disadvantage vulnerable populations and the providers who care for them (38, 39). Several major dialysis chains already provide bonuses to dialysis facilities and providers who reach treatment targets (40), and Medicare will probably adopt a pay-for-performance policy for dialysis in the near future. The Medicare Payment Advisory Commission's 2006 report to Congress (41, 42) recommended pay-for-performance for facilities and physicians who treat patients receiving dialysis. The CMS is planning a 3-year demonstration (the ESRD Disease Management Demonstration) that will test a fully case-mix–adjusted payment system for an expanded bundle of services for patients with ESRD. A portion of the payment will be linked to ESRD-related quality measures. In our study, a disproportionate number of the 152 facilities with higher-than-expected mortality rates were located in areas with a high percentage of black residents. For example, 13% ($n = 358$) of all dialysis facilities, 28% ($n = 43$) of facilities with worse-than-expected survival rates, and only 7% ($n = 5$) of those with better-than-expected survival rates were located in ZIP codes with 50% or more black residents. Thus, policies that link patient and facility outcomes to facility or provider reimbursement may differentially impact facilities and providers operating in these resource-poor predomi-

Figure 2. **Kaplan–Meier curve for transplantation, by percentage of black residents in each patient's ZIP code and the race of the patient.**



$P < 0.001$ by log-rank test for both black and white patients living in ZIP codes with fewer than 10% black residents versus those with 75% or more black residents.

Table 4. **Cox Models of Time to Transplantation, by Racial Composition of ZIP Code**

Subgroup	Proportion of Black Residents in ZIP Code	Patients, *n*	Person-Years	Patients Who Received a Transplant, *n*	Transplantation Rate per 100 Person-Years (95% CI)	Unadjusted Hazard Ratio (95% CI)	Adjusted Hazard Ratio (95% CI)*
White patients	<10%	176 903	362 908	20 004	5.51 (5.43–5.59)	1.00 (referent)	1.00 (referent)
	10%–24%	41 644	86 639	4184	4.83 (4.68–4.98)	0.88 (0.85–0.91)	0.88 (0.85–0.91)
	25%–49%	18 189	38 093	1683	4.42 (4.21–4.64)	0.81 (0.77–0.85)	0.85 (0.81–0.89)
	50%–74%	6679	13 892	490	3.53 (3.22–3.86)	0.64 (0.59–0.70)	0.74 (0.68–0.80)
	≥75%	2382	5090	149	2.93 (2.50–3.45)	0.54 (0.46–0.63)	0.63 (0.57–0.71)
Black patients	<10%	17 386	46 201	1840	3.98 (3.81–4.17)	1.00 (referent)	1.00 (referent)
	10%–24%	24 888	68 495	2131	3.11 (2.98–3.25)	0.78 (0.72–0.83)	0.89 (0.83–0.95)
	25%–49%	33 952	38 093	2486	2.67 (2.57–2.77)	0.67 (0.63–0.71)	0.84 (0.78–0.90)
	50%–74%	33 231	91 308	2274	2.49 (2.39–2.60)	0.62 (0.58–0.66)	0.84 (0.78–0.90)
	≥75%	44 170	121 668	2945	2.42 (2.34–2.51)	0.60 (0.57–0.64)	0.84 (0.78–0.92)

* Adjusted for patient age, sex, employment status, insurance coverage, diabetes, cardiac disease, peripheral vascular disease, stroke, current smoking, receipt of in-center hemodialysis, census division, and the following census variables by ZIP code: median per capita income, percentage of families living below the poverty line, percentage of the population employed in managerial or professional occupations, percentage of owner-occupied housing units, median value of owner-occupied housing units, percentage of high school graduates, and percentage of college graduates among persons older than 25 years of age.

nantly black areas. Furthermore, because most patients living in these areas are themselves black and a large proportion of black patients receiving dialysis in the United States live in these areas, such policies may have the unintended consequence of amplifying racial disparities in access to quality dialysis care and to kidney transplantation (43, 44).

Our analyses have several limitations. First, the percentages of black residents in each ZIP code were ascertained from the 2000 U.S. Census. However, because cohort patients received initial dialysis anywhere from 1 January 1995 to 31 December 2002, our estimates of the percentage of black residents in each patient's ZIP code of residence at the time of dialysis initiation may be inaccurate, particularly in areas in which the population composition changed rapidly during the study period. In addition, geographic analyses of socioeconomic data at the census block or census tract levels may differ from those at the ZIP code level. However, to protect patient identity, USRDS standard analytic files do not provide patient addresses or census tract location, which would have allowed us to conduct analyses at finer levels of geographic resolution.

Second, patient-level and facility-level analyses of mortality rates are not strictly comparable. The patient-level mortality analysis reflects mortality risk among patients who started long-term dialysis between 1995 and 2002 (some of whom eventually received a kidney transplant), and mortality risk was adjusted for a wide variety of patient-level and ZIP code–level covariates. Facility standard mortality ratios were based on survival among patients receiving dialysis in each facility in December 2004. This ratio reflects actual mortality rates among patients in a given facility compared with what would be expected based on the age, race, sex, and diabetes status of those patients. The facility standard mortality ratio is not adjusted for the wide variety of covariates that we were able to include in patient-level analyses. In addition, other facility performance measures are not adjusted for patient race, and thus the findings and interpretation of facility-level analyses must be considered preliminary insofar as patient race may be important in explaining facility-level findings.

Third, the insensitivity of information on comorbid conditions in USRDS may have limited our ability to adjust for the presence and severity of such conditions in our cohort (45). Furthermore, information on socioeconomic status was limited for individual patients. Differences in mortality rates among white patients living in ZIP codes with differing percentages of black residents are relatively modest and may reflect the impact of residual confounding by patient characteristics that were not captured in our analyses. However, the substantial differences in time to transplantation among both black and white patients living in ZIP codes with differing percentages of black residents seem unlikely to be due solely to residual confounding.

Finally, our study was restricted to non-Hispanic white and black patients living in metropolitan areas. Therefore, our results may not be generalizable to patients receiving dialysis and facilities located in rural areas or to patients receiving dialysis who belong to other racial and ethnic groups (for example, Hispanic and Asian patients).

In conclusion, ZIP code racial composition was strongly associated with time to transplantation but not with time to death among patients receiving dialysis. Differences in transplantation rates between patients living in ZIP codes with fewer than 10% black residents versus those with 75% or more black residents were at least as pronounced as differences between black and white patients living in ZIP codes with similar racial composition. However, differences in mortality rates across areas with differing percentages of black residents were far less pronounced than between-race differences in mortality rates. In a separate analysis, dialysis facilities in areas with a higher percentage of black residents were less likely than those in other areas to meet performance targets and were

Table 5. **Dialysis Facility Characteristics, by Racial Composition of ZIP Code**

Characteristic	Proportion of Black Residents in ZIP Code*				
	<10% (*n* = 1745†)	10–24% (*n* = 635†)	25%–49% (*n* = 406†)	50%–74% (*n* = 259†)	≥75% (*n* = 199†)
Mean stations, *n*	17.8 (17.4–18.1)	18.7 (18.0–19.3)	20.2 (19.3–21.1)	22.2 (20.8–23.6)	21.4 (20.1–22.7)
Provision of home-based therapies, %	51.9 (49.6–54.3)	51.2 (47.3–55.1)	47.5 (42.7–55.1)	50.2 (44.1–56.3)	44.7 (37.8–51.7)
Late shift, %	26.5 (24.4–28.6)	20.3 (17.2–23.5)	19.2 (15.4–23.1)	22.8 (17.6–27.9)	19.6 (14.0–25.2)
For-profit, %	78.9 (77.0–80.8)	81.0 (77.9–84.0)	84.5 (81.0–88.0)	78.8 (73.8–83.8)	82.4 (77.1–87.7)
Independent/government, %	24.6 (22.6–26.6)	23.3 (20.0–26.6)	21.7 (17.7–25.7)	24.3 (19.1–29.6)	29.7 (23.3–36.1)
Small chain, %	12.0 (10.5–13.6)	9.9 (7.6–12.3)	6.7 (4.2–9.1)	7.4 (4.1–10.5)	6.5 (3.1–10.0)
Large chain, %	63.4 (61.1–65.6)	66.8 (63.1–70.5)	71.7 (67.2–76.1)	68.3 (62.6–74.0)	63.8 (57.1–70.6)
Patients reaching target hematocrit ≥33%, %	88.9 (88.8–89.0)	88.8 (88.6–88.9)	88.6 (88.4–88.8)	88.3 (88.0–88.6)	88.3 (88.0–88.6)
Patients reaching target urea reduction ratio ≥65%, %	91.4 (91.3–91.5)	91.2 (91.1–91.4)	91.1 (90.9–91.3)	90.7 (90.5–91.0)	90.2 (89.9–90.4)
Survival category, %					
Better than expected	2.7 (2.0–3.6)	1.9 (0.8–3.0)	3.5 (1.6–5.4)	0.8 (0–1.9)	1.7 (0–3.5)
As expected	93.8 (92.6–95.0)	93.4 (91.3–95.4)	89.2 (86.1–92.4)	91.0 (87.3–94.6)	85.6 (80.5–90.8)
Worse than expected	3.4 (2.5–4.3)	4.7 (3.0–6.4)	7.3 (4.6–9.9)	8.2 (4.8–11.7)	12.7 (7.8–17.6)

* Values in parentheses are 95% CIs.
† Number of dialysis facilities.

more likely to have higher-than-expected patient mortality rates. These findings are particularly relevant to black patients receiving dialysis because most patients living in predominantly black residential areas are themselves black and more than half of all urban black patients receiving dialysis in the United States live in these areas.

Our findings call for closer scrutiny of the care provided to patients living, and by dialysis facilities operating, in predominantly black residential neighborhoods. Furthermore, low transplantation rates among patients receiving dialysis who live in these areas raise the question of whether an area-based approach to improving transplantation rates may be effective in reducing racial disparities in kidney transplantation.

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