Access to Care and the Incidence of End-Stage Renal Disease Due to Diabetes

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OBJECTIVE — Low socioeconomic status (SES) is associated with an increased risk of end-stage renal disease (ESRD) due to diabetes. Because ESRD is a preventable complication of diabetes, the association with SES may be related to limited access to treatment.

RESEARCH DESIGN AND METHODS — In this population-based ecological study, I examined the association between the incidence of ESRD attributed to diabetes and the proportion of hospitalizations with no insurance, Medicaid, or managed care insurance; residence in a primary care provider shortage area or rural area; and rate of hospitalizations for hyperglycemic complications, by ZIP code in California in 2001–2004.

RESULTS — The incidence of ESRD attributed to diabetes was higher in ZIP codes with higher proportions of hospitalizations with no insurance ($r = 0.45$; $P < 0.0001$) or Medicaid ($r = 0.69$; $P < 0.0001$) and in ZIP codes with higher rates of hospitalizations for hyperglycemic complications ($r = 0.27$; $P < 0.0001$). The incidence was lower in ZIP codes with higher proportions of hospitalizations with managed care insurance ($r = -0.37$; $P < 0.0001$) and was lower in primary care provider shortage areas and rural locations. In contrast, there were only weak associations between measures of access to care and the incidence of ESRD attributed to polycystic kidney disease, a condition that is not treatable.

CONCLUSIONS — The incidence of ESRD attributed to diabetes is strongly associated with area-based measures of access to care, suggesting that access to treatment partly mediates the association between SES and the incidence of ESRD.

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End-stage renal disease (ESRD), representing renal disease severe enough to require treatment with dialysis or renal transplantation, is an increasingly common and costly chronic disease. In 2006, >110,000 patients began treatment for ESRD in the U.S., and ESRD treatment comprised 6.4% of the Medicare budget (1). Diabetes accounts for >40% of new cases, and the incidence of ESRD due to diabetes outpaces that of all other causes of ESRD (1). Identifying modifiable factors that contribute to ESRD due to diabetes could therefore have an important impact on the nation's health and resource utilization.

Individuals of low socioeconomic status (SES) have an increased risk of ESRD (2–4). Those living in the poorest 25% of neighborhoods in the U.S. have a risk of ESRD that is 1.2–2.7 times higher than that of those living in the wealthiest 25% of neighborhoods (4). However, the strength of association between SES and ESRD varies among primary renal diseases. Stronger SES gradients in risk have been reported for ESRD due to diabetes or hypertension than other causes. These were presumed to be due to limited availability of antidiabetic and antihypertensive treatment among persons of lower SES (3). We recently reported that although SES was strongly associated with the incidence of ESRD due to diabetes, there was a weaker association with ESRD due to lupus nephritis and no association with ESRD due to autosomal dominant polycystic kidney disease (ADPCKD) (4). The contrasting association between SES and ESRD due to diabetes, which is preventable (5,6), and SES and ESRD due to ADPCKD, which is less preventable (7), suggests that access to effective treatment may have an important role in mediating the association between SES and the risk of ESRD.

In this population-based study, we examined associations between measures of access to care and the incidence of ESRD attributed to diabetes or ADPCKD. We hypothesized that area-based markers of poor access to care would be directly correlated with the local incidence of ESRD attributed to diabetes but would not be related to the local incidence of ESRD attributed to ADPCKD.

RESEARCH DESIGN AND METHODS

This study used an ecological design in which areal measures of SES and access to medical care were associated with variations in the incidence of ESRD across small areas. This design was used because population-based areal measures of SES, access to care, and ESRD incidence were available, whereas patient-based measures of SES were not available. California was studied because it is the most populous state and because population-based data on hospitalizations in California were available. These hospitalization data provided information on medical insurance coverage and the frequency of admissions for hyperglycemic complications, which were used as measures of access to care. The data sources included information on county and ZIP code but not on census tract or block group. ZIP codes were used as the area because these were the smallest geographic units reported. The study was exempted from human subjects review by the National Institutes of Health Office of Human Subjects Research.

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Sources of data

Data were drawn from five sources: the U.S. Renal Data System (USRDS), the 2000 U.S. Census, the California Office of Statewide Health Planning and Development patient discharge data files, the U.S. Department of Health and Human Services Health Resources and Services Administration Health Professional Shortage Area database, and the U.S. Department of Agriculture Economic Research Service Rural-Urban Commuting Area database.

We used the USRDS, a national population-based registry, to obtain information on patients with treated incident ESRD (1). Patients are enrolled in the USRDS after being certified as needing ongoing renal replacement therapy by their attending nephrologist. The registry includes information on patient demographic characteristics, the primary renal disease causing ESRD, renal replacement therapy, and outcomes. We abstracted data on all patients with incident ESRD attributed to diabetes or ADPCKD from 1 January 2001 to 30 June 2004 who resided in California. This information included patient age, sex, race, and ZIP code of residence. We limited the analysis to those aged 20 or older, so that the group with ESRD attributed to ADPCKD would not be likely to include patients with other forms of cystic renal disease. Of 18,843 patients, we excluded 466 (2.5%) because of missing or invalid ZIP codes, leaving 18,377 for analysis (17,605 with diabetes and 772 with ADPCKD).

We used data from the 2000 U.S. Census to compute an area-based measure of SES, based on seven characteristics of the residents of each ZIP code (log of median household income, proportion with income <200% of the federal poverty level, log of median house value, log of median monthly rent, mean education level, proportion of individuals aged ≥25 years who were college graduates, and proportion of employed persons with a professional occupation) (4). We computed the mean ± SD of each measure among all ZIP codes and corresponding z scores for each ZIP code. The z score represents the number of SDs above or below the mean at which data for each particular ZIP code lie. The composite SES score was computed as the unweighted sum of the z scores for all seven measures. The composite SES score correlated well with individual-level educational attainment (4). Residents of ZIP codes with an SES score of −1.11 (20th percentile of the distribution of ZIP codes in California) had a median household income of $34,315, 35% had incomes <200% of the federal poverty level, 12.9% were college graduates, and 25% had a professional occupation. Residents of ZIP codes with an SES score of 6.43 (80th percentile of the distribution of ZIP codes in California) had a median household income of $66,873, 12% had incomes <200% of the federal poverty level, 42.8% were college graduates, and 48.4% had a professional occupation.

The California Office of Statewide Health Planning and Development patient discharge data files include discharge abstracts for each hospitalization at all acute-care, nonfederal hospitals in the state. The abstracts include information on patient demographic characteristics, ZIP code of residence, the principal diagnosis (defined as the condition chiefly responsible for the hospitalization, by ICD-9-CM codes), up to 24 additional diagnoses, major procedures, and disposition. The discharge abstracts are prepared from medical and billing records by trained abstractors. Data are subjected to extensive reliability and consistency checks, and data fields with error rates of 0.1% or higher are returned to hospitals for correction (8). Reabstraction studies that compared these discharge abstracts with original medical records have found specificities for diagnoses of 0.98–1.00 and sensitivities of 0.88–1.00 (9). The average number of hospitalizations in the data files was 3.9 million annually.

We used hospitalization data from January 2001 to June 2004 to derive three measures of medical insurance coverage. For each ZIP code, we computed the proportion of hospitalizations among residents aged ≥20 years for which there was no insurance, Medicaid coverage, or managed care insurance. We also computed the rate of hospitalizations among residents aged ≥20 for which a hyperglycemic complication (ketoacidosis or hyperosmolar coma, by ICD-9-CM codes) was the reason for admission and used this as a measure of access to care that was specific to diabetes (10,11). In addition, we computed the rate of lower-extremity amputations in patients with diabetes among residents aged ≥20 years by ZIP code, as a comparison condition for ESRD caused by diabetes.

We used the Health Resources and Services Administration Health Professional Shortage Area database to identify census tracts in California that had been designated as primary care shortage areas at any time from January 2001 to June 2004 (12). Among the criteria for this designation is a population–to–primary care physician ratio of ≥3,500:1 and barriers to accessing care in neighboring areas. We mapped these census tracts to ZIP codes and classified each ZIP code either as having ever or never been a primary care shortage area. Lastly, we used the U.S. Department of Agriculture Rural-Urban Commuting Area database to classify each ZIP code as rural (code 9 or 10) or urban (codes 1–8) (13).

Statistical analysis

The unit of analysis was the ZIP code. The dependent variables were the incidences of ESRD caused by either diabetes or ADPCKD. Incidences were standardized to the age (10-year groups), sex, and race distribution of the California population in 2000 using direct standardization. We used Pearson correlations to examine associations between the incidences and the SES score, the insurance measures, and rates of hospitalizations for hyperglycemic complications. These analyses were weighted by the population in each ZIP code so that more populous ZIP codes contributed more to the associations than sparsely populated ZIP codes. We used unweighted t tests to compare incidences between ZIP codes that were in primary care shortage areas and those that were not and between rural and urban ZIP codes. We repeated the analyses using rates of hospitalizations for lower-extremity amputation in patients with diabetes as the dependent variable.

Next, we used weighted multiple regression models to examine the extent to which measures of access to care decreased the association between the SES score and the incidence of ESRD. In these models, incidence was the dependent variable, and the SES score, insurance variables, hospitalizations for hyperglycemic complications, and rural location were the independent variables. Residual analysis showed no deviations from normality, and there was no evidence of multicollinearity in the models. One influential observation was present in the model predicting ESRD attributed to diabetes; excluding this observation changed the standardized β coefficients by <0.03 and did not alter the significance tests. Analyses were performed using SAS programs (version 9.1, SAS, Cary, NC). All hypothesis tests were two-tailed, and $P < 0.05$ was considered statistically significant.

Table 1—*Correlations between ZIP code–based measures of access to care and the incidence of ESRD attributed to diabetes or ADPKD and the rate of hospitalizations for lower-extremity amputations in patients with diabetes, across ZIP codes in California, 2001–2004*

	ESRD attributed to diabetes		ESRD attributed to ADPCKD		Hospitalizations for lower-extremity amputation	
	r	*P*	*r*	*P*	*r*	*P*
SES score*	−0.55	<0.0001	−0.04	0.09	−0.51	<0.0001
Proportion of hospitalizations with no insurance	0.45	<0.0001	0.06	0.02	0.33	<0.0001
Proportion of hospitalizations with Medicaid	0.69	<0.0001	0.05	0.03	0.45	<0.0001
Proportion of hospitalizations with managed care insurance	−0.37	<0.0001	−0.01	0.77	−0.36	<0.0001
Rate of hospitalizations for hyperglycemic complications	0.27	<0.0001	—	—	0.46	<0.0001

Correlations were weighted by the population of each ZIP code. *Higher scores indicate wealthier areas.

RESULTS

Measures of access to care

Among 1,681 ZIP codes, the population aged ≥20 years ranged from 3 to 64,517, with a mean of 13,515. The SES scores ranged from −17.1 to 18.0 among ZIP codes, compared with the national average SES score of 0, indicating representation of both very poor and very wealthy neighborhoods. The proportion of acute-care hospitalizations for which there was no insurance ranged from 0 to 50% among ZIP codes (mean 2%), the proportion with Medicaid ranged from 0 to 100% (mean 17%), and the proportion with managed care insurance ranged from 0 to 83% (mean 24%). Of the ZIP codes, 117 (7%) were in federally designated primary care Health Professional Shortage Areas and 242 (14%) were rural. Over the 3.5-year study period, there were 16,553 hospitalizations for hyperglycemic complications in patients aged ≥20 years, with annual rates that ranged from 0 to 9,260 hospitalizations per million across ZIP codes.

Associations with ESRD attributed to diabetes

The average annual incidence of ESRD attributed to diabetes was 236 per million persons, with a range from 0 to 3,258 per million among ZIP codes. Incidences were inversely related with the composite SES score, with higher incidences in ZIP codes with lower SES (Table 1). Incidences were highly correlated with all three insurance measures, being higher in ZIP codes with a greater proportion of hospitalizations with Medicaid or no insurance coverage and lower in ZIP codes with a greater proportion of hospitalizations with managed care coverage. Incidences were also higher in ZIP codes with higher rates of hospitalizations for hyperglycemic complications. However, incidences were lower in ZIP codes in primary care Health Professional Shortage Areas (mean 162 per million) than in ZIP codes not in these areas (mean 241 per 100,000) (t = 2.07; P = 0.04). Incidences were also lower in rural (mean 123 per million) than in urban ZIP codes (mean 258 per million) (t = 4.85; $P < 0.0001$).

In a multivariate analysis that included the SES score, the insurance measures, rate of hospitalizations for hyperglycemic complications, and rural location, the variation in incidence of ESRD attributed to diabetes was significantly associated with the SES score and the proportion of hospitalizations with Medicaid coverage in the ZIP code (Table 2). The model R^2 was 0.48. Compared with a model that included the SES score as the only independent variable, the addition of the measures of access to care reduced the association of the SES score with the incidence of ESRD caused by diabetes by 86% (standardized β for SES score in the univariate model = −0.55; standardized β for SES score in the multivariate model = −0.074).

Associations with ESRD attributed to ADPCKD

The average annual incidence of ESRD attributed to ADPCKD was 10 per million persons, with a range from 0 to 1,340 per million among ZIP codes. In contrast to ESRD attributed to diabetes, there was no association between the incidence of ESRD attributed to ADPCKD and SES score, and only weak associations with the proportion of hospitalizations with no insurance or Medicaid (Table 1). There was also no difference in incidence between ZIP codes in primary care Health Professional Shortage Areas (mean 8.7 per million) and ZIP codes not in these areas (mean 10.3 per million) (t = 0.32; P = 0.76) or between rural (mean 9.9 per million) and urban (mean 10.3 per million) ZIP codes (t = 0.11; P = 0.92). No measures of access to care were associated

Table 2—*Association of measures of access to care and the incidence of ESRD attributed to diabetes or ADPKD by multiple regression analysis*

	ESRD attributed to diabetes			ESRD attributed to ADPKD		
	Standardized β	*t*	*P*	Standardized β	*t*	*P*
SES score*	−0.074	−2.47	0.02	−0.018	−0.44	0.67
Proportion of hospitalizations with no insurance	0.018	0.79	0.44	0.047	1.46	0.15
Proportion of hospitalizations with Medicaid	0.641	20.1	<0.0001	0.042	0.96	0.34
Proportion of hospitalizations with managed care insurance	0.014	0.66	0.52	0.035	1.16	0.25
Rate of hospitalizations for hyperglycemic complications	−0.025	−1.25	0.22	−0.03	−1.04	0.30
Rural location	−0.035	−1.96	0.06	0.009	0.38	0.71

*Higher scores indicate wealthier areas.

with variations in the incidence of ESRD attributed to ADPCKD in a multivariate model (Table 2).

Associations with rates of lower-extremity amputation in patients with diabetes

Over the 3.5-year study period, there were 9,892 hospitalizations among patients with diabetes in which a lower-extremity amputation was performed as the primary procedure of the hospitalization. The annual rate ranged from 0 to 1,078 hospitalizations per million persons among ZIP codes. Rates were highly correlated with the SES score, the insurance measures, and the rate of hospitalization for hyperglycemic complications (Table 1). Rates of lower-extremity amputations were somewhat less strongly associated with the proportion of hospitalizations with Medicaid or no insurance coverage and somewhat more strongly associated with hospitalizations for hyperglycemic complications than was the incidence of ESRD attributed to diabetes. The incidence of ESRD attributed to diabetes was correlated with the rate of hospitalizations for lower-extremity amputations among ZIP codes (weighted $r = 0.41$; $P < 0.0001$).

CONCLUSIONS — Diabetes is the most common cause of ESRD in the U.S. (1). Understanding and remedying the factors that contribute to the risk of ESRD due to diabetes can therefore have an important impact on the overall morbidity and costs of ESRD. SES is probably one of these factors. If persons living in poorer neighborhoods had the same risk as those living in the wealthiest 25% of neighborhoods, there would be >10,000 fewer new cases of ESRD due to diabetes in the U.S. annually (8). However, association does not necessarily indicate causation, and possible mechanisms by which SES or its correlates may act to influence the risk of ESRD remain undefined.

One potentially important mechanism is access to effective treatment. In this study, we found strong correlations between the incidence of ESRD attributed to diabetes and measures of insurance status. At the group level, the incidence of ESRD was higher in areas with poorer financial access to care. The incidence was also higher in areas with more hospitalizations for hyperglycemic complications, indicating that poorer diabetes-specific care was associated with higher rates of ESRD caused by diabetes. Adjusting for these measures of access to care greatly decreased the association between the incidence of ESRD and the area-based measure of SES, suggesting that financial access to care mediates this association in part. In contrast, there was comparably little association between measures of access to care and the incidence of ESRD attributed to ADPCKD. This finding was predicted based on the absence of association between SES and the risk of ESRD due to ADPCKD (4) and current treatment options for this condition. The parallel associations between SES and measures of access to care in these two conditions also suggest that access to care is an important mechanism by which SES is related to the incidence of ESRD.

Limited access to care may result in delayed diagnosis of diabetes, inadequate education in diet and self-care, inadequate access to medications or monitoring, and suboptimal treatment and follow-up. Previous studies of the association between access to care and health outcomes in patients with diabetes have focused on medical insurance status. Lack of medical insurance and, in some studies, lack of private medical insurance coverage have been associated with higher levels of A1C, higher prevalences of albuminuria, inconsistent use of antidiabetic medications, and lower frequencies of monitoring for diabetes complications (14–17). Not having a regular source of care has also been associated with higher levels of A1C (14,17). These limitations, if sustained, can increase the likelihood of ESRD. Conversely, areas with high proportions of managed care coverage in our study had lower rates of ESRD due to diabetes, suggesting that participation in systems emphasizing preventive care had beneficial effects on health outcomes. This finding is consistent with the observation that among enrollees in the Kaiser Permanente health maintenance organization, there was no association between SES and the incidence of ESRD due to diabetes, probably because SES-associated financial barriers to care were not present (18).

Previous studies have reported that areas with lower densities of physicians have higher rates of all-cause ESRD (19), but studies have not examined whether areas meeting the criterion of primary care provider shortage areas have rates of ESRD that differ from those of areas without provider shortages. Primary care provider shortages represent an organizational barrier to care and have been linked with both poorer quality of care and poorer health status among patients with diabetes (20). However, in this study, rates of ESRD attributed to diabetes were lower in areas designated as having shortages in primary care providers compared with areas not having shortages. Similarly, rates were lower in rural than in urban ZIP codes. Patients with a chronic condition such as diabetes may have been better able to secure providers despite living in a shortage area or rural area. The importance of education and self-care in the development of diabetes complications may have mitigated the influence of living in these areas. It is also possible that patients with severe diabetes moved out of shortage areas or into towns or cities in anticipation of the need for better access to care, thereby lowering rates of ESRD in these areas. Some misclassification may also have occurred because we classified ZIP codes as shortage areas if at any time during the 3.5-year study period they had been designated a shortage area. Rates of ESRD attributed to ADPCKD did not differ by shortage area or rural/urban location, suggesting that these geographic differences were due to factors specifically associated with diabetes.

The association between access to care and health outcomes in patients with diabetes was not unique to ESRD. Similar associations were found for rates of lower-extremity amputations. The risk of lower-extremity amputation in patients with diabetes has been associated with poor glycemic control and, although studied less extensively, poorer quality of care (21,22). These findings suggest that access to care may also have an important role in the risk of lower-extremity amputation. Together, these results provide convergent validity for the association of measures of access to care with the risk of ESRD attributed to diabetes.

Despite its importance, limited financial access to care is probably not the only mechanism by which SES is associated with increased rates of ESRD. Among patients treated in the Department of Veterans Affairs health care system or in managed care organizations, poorer and less well-educated patients had poorer glycemic control and lower adherence to self-care recommendations than wealthier or more well-educated patients (23,24). SES-related differences in diabetes-specific knowledge, motivation, health beliefs, social support, and competing priorities may account for some of these SES associations. However, medical insurance remains an important precondition enabling access to care.

The strengths of this study include the large population-based samples, the inclusion of several different measures of access to care, and the contrasts between two primary renal diseases that differ in their associations with SES. However, the study is ecological, and associations at the group level may not apply to individual patients. Cohort studies that assessed the association between barriers to care, SES, and the progression to ESRD among patients with different primary renal diseases would be needed to examine these associations at the individual level. Only one organizational barrier to care was studied, as area-level data on distances traveled to receive care, wait times, or other measures of access were not available. However, rural/urban location was used as a surrogate of distance traveled to obtain care. Although the incidences of ESRD were adjusted for race, we do not know whether the SES associations with ESRD varied by race or ethnicity. Seventy percent of patients with ESRD attributed to diabetes were white, as were 83% of patients with ESRD attributed to ADPCKD. There were too few patients of other racial groups to perform comparative analyses stratified by race or ethnicity. Cultural differences in health care utilization may interact with barriers to care to affect health outcomes and may either exaggerate or diminish the contrasts between ESRD attributed to diabetes and ESRD attributed to ADPCKD reported here. The study was limited to adults in California, and associations may differ in children or in other states.

Socioeconomic disparities are more pronounced for conditions that have effective treatments and for which there are socioeconomic barriers to accessing treatment (25). The results of this study indicate that access to care for treatable conditions is an important factor influencing rates of ESRD and mediating SES-associated differences in rates. Efforts to decrease rates of ESRD and to decrease socioeconomic disparities in ESRD incidence should include an emphasis on ensuring access to care before complications such as ESRD occur.

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