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Quality of Diabetes Mellitus Care by Rural Primary Care Physicians

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Abstract

Purpose—To explore the relationship between degree of rurality and glucose (hemoglobin A1c), blood pressure (BP), and lipid (LDL) control among patients with diabetes.

Methods—Descriptive study; 1,649 patients in 205 rural practices in the United States. Patients' residence ZIP codes defined degree of rurality (Rural-Urban Commuting Areas codes). Outcomes were measures of acceptable control (A1c $\leq$ 9%, BP $<$ 140/90 mmHg, LDL $<$ 130 mg/dL) and optimal control (A1c $<$ 7%, BP $<$ 130/80 mmHg, LDL $<$ 100 mg/dL). Statistical significance was set at $P < .008$ (Bonferroni's correction).

Findings—Although the proportion of patients with reasonable A1c control worsened by increasing degree of rurality, the differences were not statistically significant (urban 90%, large rural 88%, small rural 85%, isolated rural 83%; $P = .10$); mean A1c values also increased by degree of rurality, although not statistically significant (urban 7.2 [SD 1.6], large rural 7.3 [SD 1.7], small rural 7.5 [SD 1.8], isolated rural 7.5 [SD 1.9]; $P = .16$). We observed no differences between degree of rural and reasonable BP or LDL control ($P = .42$, $P = .23$, respectively) or optimal A1c or BP control ($P = .52$, $P = .65$, respectively). Optimal and mean LDL values worsened as rurality increased ($P = .08$, $P = .029$, respectively).

Conclusion—In patients with diabetes who seek care in the rural Southern US, we observed no relationship between degree of rurality of patients' residence and traditional measures of quality of care. Further examination of the trends and explanatory factors for relative worsening of metabolic control by increasing degree of rurality is warranted.

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Disclosures

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Keywords

family medicine; health disparities; internal medicine; medical care; quality

INTRODUCTION

Diabetes mellitus affects 23.5 million people in the United States,^{1, 2} and it is more common in the Southeast and Southwest regions.³ Evidence suggests that diabetes control in the South is worse than in other US regions.^{4, 5} For example, in the State of Alabama, fewer patients in rural practices achieve target goals for glucose (hemoglobin A1c), blood pressure (BP), and low-density lipoproteins (LDL); they also are less likely to receive preventive services like eye exams, foot exams, lipid profiles, and micro-albumin screening.⁵ Furthermore, the overall mortality rate among patients with diabetes living in smaller communities is higher than their urban counterparts.^{6, 7}

Rural residents face barriers to health care which may exacerbate health care disparities.^{8–13} Such barriers include distance to clinics and hospitals, lack of adequate transportation, the relative shortage of specialists and diabetes educators, cultural beliefs, and costs of care.³ The disparity in diabetes care may be a major contributor to the overall health disparity burden.¹⁴ Although studies have reported differences in diabetes quality of care between rural and urban populations,^{4, 5, 15} the impact of patient rurality has been less well studied.

The term “rurality” encompasses a multifaceted concept without universal agreement.¹⁶ Rural and urban taxonomies have been developed based on population size, density, proximity, adjacency and relationship to a metropolitan area and work commutes. The Rural-Urban Commuting Area (RUCA) taxonomy provides a sensible approach to differentiate rural areas according to their economic integration with nearby rural and urban areas.^{17, 18} Therefore, the flexibility and accuracy of the RUCA classification may allow for better delineation of disparities among patients with diabetes across the spectrum of rural environments.

The objective of this study was to explore the relationship between degree of rurality of patients’ residence and glucose, blood pressure, and lipid control among patients with diabetes mellitus. We hypothesize that patients with diabetes who live in more rural areas have worse glucose, blood pressure, and lipid control when compared to patients from less rural areas.

METHODS

Setting and Participants

We used data from the Rural Diabetes Online Care (R-DOC) study (ClinicalTrials.gov identifier: NCT00403091).¹⁹ The R-DOC study was a cluster-randomized clinical trial comparing a multi-component physician intervention with a control arm. Further details of the study design, methods, recruitment and retention processes, data collection, and patient characteristics have been published elsewhere.^{19–21} In the present study, we combined data from the control and intervention groups because earlier analyses did not reveal a significant effect attributable to the intervention for any of the primary outcomes (measures of acceptable and optimal control for A1c, BP, and LDL) or secondary outcomes (process measures). (See below for definitions.) We did observe an absolute increase in the rates of assessment of A1c and LDL¹⁹ in both study arms and in the intensification of medications (unpublished observation).

Briefly, participants were 205 family, general, and internal medicine physicians located in rural areas (population size < 25,000 habitants) of 11 Southeastern states (Alabama, Arkansas, Florida, Georgia, Kentucky, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, West Virginia).²⁰ Physicians were enrolled in the study between September 2006 and September 2008; the study was closed in July 2009. The institutional review boards at the University of Alabama at Birmingham and at the Tuscaloosa Campus of the University of Alabama approved the protocol.

Outcomes

The main outcomes were measures of reasonable or optimal hemoglobin A1c, BP, and LDL control. Reasonable control was defined as the overall proportion of patients with A1c $\leq$ 9%, BP < 140/90 mmHg, and LDL < 130 mg/dL. Optimal control was defined as the proportion of patients with A1c < 7%, BP < 130/80 mmHg and LDL < 100 mg/dL. These thresholds were consistent with guidelines at the time the study was conducted.^{22–24}

The secondary outcomes were process measures, the rate of assessment of A1c and LDL (over the previous 1 year and 2 years, respectively) and BP at the last visit. We also examined group mean values (A1c, systolic BP [SBP], diastolic BP [DBP], and LDL).

Rurality

We used the patients' residence Zip codes to define degree of rurality. We categorized each patients' residence by RUCA codes, a census tract-based taxonomy scheme that has been used widely for research and policy purposes.^{16–18, 25–29} The RUCA classification utilizes population density, geography, and patterns of commuter flow to assign the urban-rural continuum into 33 categories that can be aggregated to create fewer groups. Using the Zip code-level approximation,^{18, 30} we categorized patients into living in 4 groups: urban, large rural, small rural, or isolated small rural areas (see Table 1). We did not use the physicians' Zip codes to define rurality because all physicians enrolled in the study practiced in rural areas.²⁰

Statistical analysis

The primary unit of analysis in this study was the patient. First, we compared patient's characteristics by rurality category using analysis of variance (ANOVA) or the Chi square test as appropriate. Second, we compared the outcomes between rurality category by using the Chi square test (main outcomes [reasonable, optimal control], secondary outcome [rate of assessment of A1c, BP, and LDL]) or the ANOVA test (secondary outcome [mean values of A1c, SBP, DBP, and LDL]).

Finally, we examined reasonable A1c control adjusting for covariates. We used generalized linear latent and mixed models (GLLMM) and adjusted for group, period, interactions (group by time; intervention and control by before and after, respectively), age over 65, African American race, Medicaid insurance, insulin use, glucose self-monitoring, peripheral vascular disease, adherence to appointments, and clustering effects of patients within practices. The choice of covariates was grounded in results from our prior work.^{19, 31} We did not compare other main outcomes, as the results of the second step in the statistical analysis were not significant.

Comparisons with a $P < .008$ were considered statistically significant (Bonferroni's correction, 6 comparisons for the main outcomes [reasonable or optimal A1c, BP, and LDL control]). We used STATA 11.0 (StataCorp., College Station, Texas) for all analyses.

RESULTS

Patients' Zip code data were available for 1,649 patients of the 2,127 who comprised the study population (77.5%). The majority of patients lived in non-urban areas (87.6%, 1,445/1,649). Patient characteristics are shown in Table 2.

Patients' characteristics were similar across the 4 RUCA groups: urban, large rural, small rural, and isolated rural. However, the proportion of African Americans, the prevalence of Medicaid insurance, and the prevalence of peripheral vascular disease were higher in rural areas (all $P < .008$), Table 2.

Main Outcomes – A1C, Blood Pressure, Lipid Control

The rates of reasonable and optimal A1c, BP, and LDL control for each RUCA category are displayed in Figure 1 (reasonable, A1c $< 9\%$, BP $\leq 140/90$ mmHg, LDL ≤ 130 mg/dL; optimal, A1c $< 7\%$, BP $< 130/80$ mmHg, LDL < 100 mg/dL).

Reasonable control across RUCA categories ranged between 83% to 90% for A1c, 59% to 64% for BP, and 83% to 88% for LDL. In the unadjusted analysis, the prevalence of reasonable control was the same for A1c, BP, and LDL across the 4 RUCA categories ($P = .10$, $P = .42$, $P = .23$, respectively), Figure 1 (top panel).

Optimal control across RUCA categories ranged between 48% to 55% for A1c, 27% to 32% for BP, and 53% to 66% for LDL. In the unadjusted analysis, the prevalence of optimal control was the same for A1c, BP, and LDL across the 4 RUCA groups ($P = .52$, $P = .65$, $P = .08$, respectively), Figure 1 (bottom panel).

Compared to patients residing in an urban setting, we observed no differences across the RUCA categories for reasonable A1c control (large rural, $P = .59$; small rural, $P = .25$; isolated rural, $P = .22$) in the adjusted analysis (data not shown).

Secondary Outcomes - Process Measures and Mean Values

Process measures—A1c, BP, and LDL assessment—across RUCA categories are shown in Table 3. We observed no statistical differences for the proportion of A1c, BP, or LDL assessed for patients across the 4 RUCA categories ($P = .06$, $P = .04$, $P = .53$, respectively).

The mean values of A1c, BP, and LDL for each RUCA category are displayed in Figure 2. The mean A1c values increased by degree of rurality, although it was not statistically significant (urban 7.2 [SD 1.6], large rural 7.3 [SD 1.7], small rural 7.5 [SD 1.8], isolated rural 7.5 [SD 1.9]; $P = .16$), Figure 2. Also, the mean values were not statistically different for SBP, DBP, and LDL across the 4 RUCA categories ($P = .16$, $P = .68$, $P = .90$, and $P = .029$, respectively), Figure 2.

DISCUSSION

In this study of patients with diabetes cared for by primary care physicians in the rural Southern US, we observed no relationship between degree of rurality of patients' residence and traditional measures of quality of care. We observed no statistical differences in care by rurality residence regardless of the A1c, BP, and LDL measure we used—rates of reasonable or optimal control, rates of assessment, or mean values.

Although our hypothesis that patients with diabetes who live in more rural areas would have worse control when compared to patients from less rural areas was not confirmed, we cannot ignore the relative worsening of metabolic control by increasing degree of rurality for A1c

(reasonable control, Figure 1) or mean A1c and LDL levels (Figure 2). We can entertain tentative explanations for our findings. First, no differences truly exist.

Second, although we had a sample size of over 1,500 patients, it may not have been sufficient to detect such differences. None of the comparisons reached the threshold for statistical significance of $P < .008$. Multiple comparisons may yield seemingly statistical differences when none truly exist—a type II error. We acknowledge that others may view the Bonferroni's correction as too rigid for our study.

Third, patient complexity may explain a portion of the variability of diabetes control. We have previously found that glucose control (A1c $\geq 7\%$) was lower in the worst quartile of practices as compared to the best quartile of practices (19%–23% vs. 75%–76%).^{31, 32} Practices in the worst quartile of control had higher proportions of younger patients, African Americans, and patients on insulin. Furthermore, practices in the worst quartile of control had a higher proportion of patients experiencing difficulty with self-testing and keeping appointments.³¹ Other studies have found that African Americans have higher A1c as compared to their Caucasian counterparts³³ and less self-monitoring.³⁴ Regardless of the explanatory factors, for each patient, management to control metabolic derangements represents good quality of care.

Fourth, the population may not be representative of all rural areas in the Southern US. We specifically selected patients who sought care at rural practices of primary care physicians (the physicians themselves were enrolled in a clinical trial¹⁹). Generally, patients enrolled in clinical trials are healthier than non-enrolled patients; however, in our study we had a large number of patients with multiple co-morbidities, as documented by the Charlson's comorbidity index³⁵ and a large number of practices with patients with uncontrolled diabetes.³¹

Last, other patient and physician factors, not examined in our study, may also have played a role in the results we observed. For example, factors such as access to care,¹¹ distance and transportation,^{27, 36} access to specialists, diabetes education,¹⁵ cultural, educational, socio-economic, social support, and community factors were not studied.³⁷ Physician factors such as education, continuing medical education, quality improvement initiatives,³⁸ experience, workload, attitudes and other factors were beyond the study design. We also did not explore other measures of diabetes care attributable to the physician, such as medication intensification.^{21, 39}

Nevertheless, our study has important implications. In spite of multiple studies reporting differences in quality of care for patients with diabetes between rural and urban populations,^{4,5, 15, 40, 41} it seems that exploring further disparities *across the spectrum of rural environments* has not been well studied.

Our results provide current rates of diabetes quality-of-care measures—diabetes control and process measures—across the spectrum of rural settings. We used trained abstractors, had a large sample size, and encompassed a wide range of geographic diversity in the rural Southern US. We also accounted for important patient factors including biological factors (age, African American race), diabetes severity (insulin use), co-morbidities, behavioral factors (glucose self-monitoring, adherence to appointments), and clustering effects of patients within practices.

The rates of control in our study are comparable or better than ones reported in other studies in rural areas. We observed rates of reasonable A1c ($< 9\%$), BP ($< 140/90$ mmHg), and LDL (≤ 130 mg/dL) control in 83% to 90%, 59% to 64%, and 83% to 88% of patients, respectively. The rates of optimal A1c ($< 7\%$), BP ($< 130/80$ mmHg), and LDL (< 100 mg/

dL) control were 48% to 55%, 27% to 32%, and 53% to 66% of patients, respectively. Compared to a large study of urban vs rural differences of metabolic control in the US (n = 11,755 patients),⁴⁰ the rate of uncontrolled A1c (> 8%) in African Americans living in rural areas was 61% as compared to 45% for their urban counterparts.

Diabetes control in rural patients has been examined in other smaller and less diverse rural areas. For example, in a before and after intervention study of 18 rural physicians in a Physician Health Organization in Pennsylvania caring for 1,172 patients,⁴² the A1c was < 7% in 51% to 56% of patients, the BP was < 140/90 mmHg in 68% to 79%, and the LDL was < 100 mg/dL in 44% to 49%. In a cross-sectional study of 142 patients attending 3 community health centers or 8 physician practices in rural North Carolina,⁴³ an A1c < 9.5% was observed in 59% to 65% of patients, the BP was < 140/90 mmHg in 46% to 58%, and the LDL was < 130 mg/dL in 35% to 43%. In another cross-sectional study of 78 rural patients in Alabama,⁵ the A1c was less than 7% in 33%, the BP was < 130/80 mmHg in 8%, and the LDL was < 100 mg/dL in 12% of patients.

The results from our study and others can be used to guide professional development. Physicians practicing in rural areas have specific needs for such professional development.⁴⁴ In fact, the web site developed for the current study was used to develop content for continuing medical education and has been widely disseminated to other rural practices after the study concluded.^{45–48}

Although a detailed discussion of health care policy is beyond the scope of this study, our findings may have important implications in the pay-for-performance era for physicians practicing in rural areas. If patients in more rural areas have worse glucose control, physicians may be penalized for factors that are beyond their control. Also, identifying promising interventions to improve care in patients living in more rural areas is needed.

In conclusion, in patients with diabetes cared for by primary care physicians in the rural Southern US, we observed no relationship between degree of rurality of patients' residence and traditional measures of quality of care. Further examinations of trends and explanatory factors of relative worsening of metabolic control by increasing degree of rurality are warranted.

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Figure 1.

Proportions of patients with reasonable and optimal hemoglobin A1c, blood pressure (BP, mmHg), and low-density lipoprotein cholesterol (LDL, mg/dL) for patients with diabetes in Southeastern United States by Rural-Urban Commuting Areas (RUCA) categories (n = 1,649 patients) (all $P > .05$).

Figure 2.

Mean hemoglobin A1c, systolic and diastolic blood pressure (SBP, DBP), and low-density lipoprotein cholesterol (LDL-C) for patients with diabetes in Southeastern United States by Rural-Urban Commuting Areas (RUCA) categories (n = 1,649 patients). Values are means and 95% confidence intervals.

Table 1Rural-Urban Commuting Area (RUCA) taxonomy Group Definitions.^{18,30}

RUCA Aggregation Groups	RUCA Codes and Group Definition
Urban	1.0, 1.1, 2.0, 2.1, 3.0, 4.1, 5.1, 7.1, 8.1, 10.1 Metropolitan area or area with 30–50% secondary flow to urbanized area.
Large rural/town	4.0, 4.2, 5.0, 5.2, 6.0, 6.1 Micropolitan (10k-<50k urban cluster) with <30% secondary flow to urbanized area
Small rural/town	7.0, 7.2, 7.3, 7.4, 8.0, 8.2, 8.3, 8.4, 9.0, 9.1, 9.2 Small town (<10k urban cluster) with <30% secondary flow to urbanized area
Isolated small rural/town	10.0, 10.2, 10.3, 10.4, 10.5, 10.6 Rural (primary flow not to urban cluster / urbanized area) with secondary flow <50% urban cluster and <30% urbanized area

Table 2

Patients' Characteristics by Rural-Urban Commuting Area (RUCA) Categories.

Variable	Total	Urban	Large Rural	Small Rural	Isolated Rural	P value
	n=1,649 (100%)	n=204 (12.4%)	n=550 (33.4%)	n=500 (30.3%)	n=395 (24.0%)	
Age, years	60.2 (13.4)	61.1 (13.4)	60.1 (13.4)	59.4 (13.7)	60.1 (13.1)	.31
Gender, female	871/1,649 (53%)	107 (52%)	299 (54%)	251 (50%)	214 (54%)	.53
Race, African American	381/1,643 (23%)	30 (15%)	146 (27%)	101 (20%)	104 (26%)	.001
Obesity ^a	488/1,649 (30%)	50 (25%)	168 (31%)	157 (31%)	113 (29%)	.29
Smoker, current	202/1,597 (13%)	25 (13%)	74 (14%)	57 (12%)	46 (12%)	.73
No self-testing	588/1,492 (39%)	63 (37%)	196 (38%)	198 (44%)	131 (36%)	.11
Non-adherence to appointments	114/1,597 (7%)	20 (10%)	42 (8%)	32 (7%)	20 (5%)	.12
Insurance, Medicaid	216/1,649 (13%)	23 (11%)	79 (14%)	44 (9%)	70 (18%)	.001
Diabetes complications ^b	449/1,649 (27%)	64 (31%)	148 (27%)	142 (28%)	95 (24%)	.25
Insulin use	260/1,649 (16%)	31 (15%)	86 (16%)	84 (17%)	59 (15%)	.89
Hypertension	1,098/1,649 (67%)	136 (67%)	352 (64%)	355 (71%)	255 (65%)	.08
Hyperlipidemia	104/1,649 (6%)	17 (8%)	28 (5%)	28 (6%)	31 (8%)	.19
Peripheral vascular disease	121/1,649 (7%)	10 (5%)	27 (5%)	48 (10%)	36 (9%)	.007
Coronary artery disease ^c	350/1,649 (21%)	42 (21%)	110 (20%)	114 (23%)	84 (21%)	.73
Depression	242/1,649 (15%)	30 (15%)	88 (16%)	66 (13%)	58 (15%)	.65
Charlson's co-morbidity index	2.8 (2.0)	2.7 (2.0)	2.8 (2.0)	2.8 (2.1)	2.7 (2.0)	.90

Values are mean (SD) or %.

^aObesity: body mass index (BMI) ≥ 30 or clinical diagnosis.

^bDiabetes complications: retinopathy, neuropathy, nephropathy, or chronic kidney disease.

^cCoronary artery bypass grafting, stent, percutaneous coronary angioplasty.

Proportion of patients with diabetes assessed for hemoglobin A1c (past year), blood pressure (BP, last visit), and low-density lipoprotein (LDL, past 2 years) for patients with diabetes in Southeastern United States by Rural-Urban Commuting Areas (RUCA) categories (n = 1,649 patients).

Table 3

Variable	Total	Urban	Large Rural	Small Rural	Isolated Rural	P value
	n=1,649 (100%)	n=204 (12.4%)	n=550 (33.4%)	n=500 (30.3%)	n=395 (24.0%)	
Hemoglobin A1c	1,263/1,649 (77%)	141 (69%)	430 (78%)	386 (77%)	306 (77%)	.06
Blood pressure	1,548/1,649 (94%)	183 (90%)	519 (94%)	477 (95%)	369 (93%)	.04
LDL	1,145/1,649 (69%)	133 (65%)	389 (71%)	347 (69%)	276 (70%)	.53