

Racial Disparities in Diabetes Hospitalization of Rural Medicare Beneficiaries in 8 Southeastern States

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Abstract

This study examined racial variability in diabetes hospitalizations attributable to contextual, organizational, and ecological factors controlling for patient variabilities treated at rural health clinics (RHCs). The pooled cross-sectional data for 2007 through 2013 for RHCs were aggregated from Medicare claim files of patients served by RHCs. Descriptive statistics were presented to illustrate the general characteristics of the RHCs in 8 southeastern states. Regression of the dependent variable on selected predictors was conducted using a generalized estimating equation method. The risk-adjusted diabetes mellitus (DM) hospitalization rates slightly declined in 7 years from 3.55% to 2.40%. The gap between the crude and adjusted rates became wider in the African American patient group but not in the non-Hispanic white patient group. The average DM disparity ratio increased 17.7% from the pre-Affordable Care Act (ACA; 1.47) to the post-ACA period (1.73) for the African American patient group. The results showed that DM disparity ratios did not vary significantly by contextual, organizational, and individual factors for African Americans. Non-Hispanic white patients residing in large and small rural areas had higher DM disparity ratios than other rural areas. The results of this study confirm racial disparities in DM hospitalizations. Future research is needed to identify the underlying reasons for such racial disparities to guide the formulation of effective and efficient changes in DM care management practices coupled with the emphasis of culturally competent, primary and preventive care.

Keywords

community health, managerial epidemiology, rural health, disease management, impact evaluation

Introduction

Hospitalization for diabetes mellitus (DM) has been identified as one of the major ambulatory care-sensitive conditions (ACSCs) in the effort of monitoring and improving chronic care to prevent hospitalization. The DM hospitalization rates have not been decreasing over the past decade, with higher rates in the African American population than in the non-Hispanic white population.¹⁻³

The Centers for Medicare and Medicaid Services (CMS) has started monitoring avoidable hospitalizations and readmissions by implementing the Hospital Readmissions Reduction Program (HRRP) through section 3025 of the Patient Protection and Affordable Care Act (ACA) to eliminate the hospital quality problem. This program penalizes hospital with high readmission rates for Medicare patients treated for ACSCs. Beginning October 2012, Medicare payments were to decrease by 1% to 2% in 2013 and by 3% in 2014.⁴ Concomitantly, the enactment of the ACA on March 23, 2010, has been expected to enhance patient-centered care and improve the delivery of

ambulatory care and preventive services through the expansion of health insurance coverage for the uninsured. Also, the ACA is expected to narrow racial disparities in health coverage, access to care, and preventive service use.⁵ The HRRP solidifies the importance of reduction efforts for ACSCs. Higher levels of care continuity for patients can reduce inpatient hospitalization for chronic disease.^{6,7} The improved health insurance coverage and population health management via the ACA could have a direct impact on the reduction of DM hospitalization rates, particularly for the uninsured minority population.

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According to the results of Rural Healthy People 2020 national survey, diabetes is top 2 priority in rural areas.⁸ For the elderly individuals, the presence of rural health clinics (RHCs) may help to reduce county's rate of hospitalization for ACSCs.⁹ The RHC database for ACSCs, which was compiled from rural Medicare beneficiaries for the period of 7 years from 2007 through 2013 (including the pre-ACA period for 2007 through 2009 and the post-ACA period for 2010 through 2013), offers a distinct opportunity to examine trends and patterns of racial disparities in DM hospitalizations in the 8 states of region 4, which include Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee.

Related Research

The DM hospitalization is avoidable and commonly considered as a measure of the lack of access to primary care in the community.¹⁰⁻¹³ Racial differences in potentially preventable hospitalizations for DM were found in a Hawaii study.¹⁴ This disparity cannot be adequately explained by race alone.¹⁵⁻¹⁹ Also, the factors influencing health disparities, particularly those between the non-Hispanic white and African American population residing in different sizes of rural areas, are not well understood. A systematic review and analysis of racial disparities in the use of health services and outcomes of diabetes care and control are needed to identify the determinants of DM hospitalization at both facility- and ecological-level analysis. The identification of contributing factors to the high prevalence of hospitalization for DM by race may offer guidance for potential policy developments or interventions targeting the mutable county characteristics (eg, state, rurality classification, poverty, demographic characteristics, health, and professional resources distribution), clinic characteristics (eg, provider status/ownership, staff size, and health system affiliation), and aggregated RHC patient characteristics (eg, dual eligibility status and ambulatory care service utilization). The determinants of racial disparities in DM hospitalization can be grouped into 3 categories: the contextual, organizational, and ecological, whereas patient variations, such as comorbidity, age, gender, and other related risk factors, are properly adjusted.

Contextual Determinants

The trends of racial disparities in adult diabetes are higher in African Americans than in non-Hispanic whites.¹ Environmental and socioeconomic factors are the contextual variables that influence racial disparities in diabetes prevalence.^{18,20} An analysis of preventable hospitalizations for DM, using the National Health Insurance data from Taiwan, shows that socioeconomic status (SES) disparities coupled with geographical variables were associated with preventable DM hospitalizations, particularly those observed in the low-income individuals residing in low SES neighborhoods.¹³

Health-care access to effective primary care is a key contributing factor to avoidable hospitalization.^{11,21,22} It is worthy

of noting that rurality may have an impact on hospitalizations of ACSCs and that isolated rural or frontier communities may be at greater risk for preventable hospitalizations. However, age-specific hospitalization rates show different effects of provider availability on ACSC hospitalizations. Furthermore, the regional or state variation in access to primary care services also exists because health resources are inequitably distributed in the United States. Under the impact of health-care reforms from a policy intervention perspective, it is reasonable to investigate a variety of federally initiated policies, such as the quality improvement effort,²³ the CMS HRRP to penalize acute care hospitals with a higher readmission rate for older adult patients, and the ACA to improve insurance coverage for the uninsured and to emphasize primary and preventive care services for the elderly individuals.^{24,25}

Organizational Determinants

The presence of primary care providers, such as RHCs and community health centers, in counties may help to reduce hospitalization rates for ACSCs, such as DM, heart failure, chronic obstructive pulmonary disease, and hypertension, particularly among older adults.^{16,26,9} The physician supply was associated with the primary care system's performance in urban areas but not in rural areas.²⁷ Although an overall pattern of primary care availability is relatively comparable, the effect of primary care providers in varying size of rural areas has not been studied, particularly in the context of racial disparities.

Adequate physician supply and equitable distribution of medical staff, such as nurse practitioners or physician assistants, throughout all regions in all levels of health-care facilities are germane to ensure the quality and accessibility of needed health services. Thus, the structure of health-care organizations, irrespective of ambulatory care clinics and acute care hospitals, may yield different effects on their performance. In a series of publications generated by the Rural Health Research Group at the University of Central Florida, investigators have consistently reported that provider-based RHCs outperformed their counterparts of independent RHCs in a variety of areas including productivity, cost efficiency, and quality as measured by readmissions.^{24,28,29} Furthermore, Kuo et al³⁰ reported that the performance of medical staff (nurse practitioners vs primary care physicians serving Medicare beneficiaries with DM) showed comparable patient care outcomes.

Ecological Determinants

The aggregation of individual characteristics at the facility-level constitutes ecological variables. For instance, prior research discovered that the type of patients' diagnoses treated,³¹ the dually eligible status,^{23,24,32} insurance coverage,³³ race,^{17,26,34} SES,^{35,36} and medical care needs^{37,38} accounted for the variability in health services use. The presence or absence of these characteristics measured at the aggregate level or facility level may either facilitate or impede the

use of health services, as the predisposing factors to hospital utilization.^{31,38}

In summary, cited literature highlights the need to identify the relative influences of each component of the determinants in explaining racial disparities between crude and adjusted ratios in the period of implementing health policy reforms such as ACA, CMS Hospital Readmission Reduction Program, and community-based care for chronic conditions. Furthermore, race-specific strategies should be developed and implemented once the underlying causes of racial disparities in health care are identified.

The 3-fold purpose of this investigation of rural clinics' variation in hospitalizations of diabetes includes the following: (1) to examine rural trends and patterns of crude- and race-specific risk-adjusted hospitalization rates for DM by state and year (before and after the ACA enactment); (2) to compare the rates between African American and non-Hispanic white Medicare beneficiaries residing in various rural communities; and (3) to investigate how contextual, organizational, and ecological factors combined may account for racial differences in DM hospitalizations.

Research Methods

The present study explores how the availability of RHCs, the ACA period effect, rurality, dual eligibility, and many aggregated patient and organizational characteristics at the RHC level may also influence the patterns and trends of risk-adjusted DM admission rates for the period of 2007 through 2013 while racial disparities are being examined.

Design and Data Sources

We conducted a longitudinal analysis of hospital admissions based on administrative and claims data gathered from a variety of data sources compiled for CMS. The DM hospital admissions of rural Medicare patients between 2007 and 2013 were captured in the CMS's inpatient claims files of the Chronic Conditions Warehouse. The presence of hospital billing codes for admissions enabled a hospitalized case to be coded as 1 and a not hospitalized case to be coded as 0.

The *International Classification of Diseases, Ninth Revision, Clinical Modification* codes used to identify Medicare beneficiaries with DM were based on 4 categories: (1) short-term complications with diabetes; (2) long-term complications with diabetes; (3) uncontrolled diabetes; and (4) lower extremity amputation with diabetes. The hospital admission rate for patients with DM was computed by the total number of Medicare claims for DM admissions divided by the total number of hospital claims of patients with DM served by each RHC per year. The formulas used are as follows:

$$\begin{aligned} &\text{Crude DM hospital admission rate} \\ &= \frac{\text{Number of actual DM admissions}}{\text{Number of RHC patients with DM}} \end{aligned}$$

$$\begin{aligned} &\text{Risk-adjusted DM hospital admission rate} \\ &= \frac{\text{Number of adjusted DM admissions}}{\text{Number of RHC patients with DM}} \end{aligned}$$

$$\begin{aligned} &\text{DM disparity ratio} \\ &= \frac{\text{Number of actual DM admissions}}{\text{Number of adjusted DM admissions}} \end{aligned}$$

Using logistic regression analysis of the Medicare claims files with the Charlson Comorbidity Index and other factors as risk adjusters,²⁴ including age, gender, and other personal factors, an expected number of admissions was calculated for each RHC per year by racial groups. The race-specific risk-adjusted admission rate was then calculated using the expected number of DM admissions as the numerator divided by the total number of patients with DM in each RHC as the denominator. Furthermore, a disparity ratio between the crude rate and the adjusted/expected rate for DM hospitalization for each racial group was calculated. This ratio could be interpreted as the relative risk, for example: (1) a ratio of 1 refers to no difference between the crude rate and the adjusted rate; (2) a ratio under 1 refers to a lower than adjusted/expected rate observed; and (3) a ratio greater than 1 refers to a higher than expected rate found.

Our analysis focused on rural disparities in RHCs to account for variations in the adjusted rate of admissions by the contextual, organizational, and ecological factors. The analyses presented major characteristics of RHCs serving Medicare beneficiaries in several categories of rural areas as defined by Rural Urban Community Area codes. The rurality was classified into the urban, large rural, small rural, and isolated rural areas. The total rural elderly individuals studied ranged from 216 141 patients in 2007 to 232 677 patients in 2013. Excluding the missing cases for not having the total number of patients documented in the Medicare claims files, 621 RHCs were included in the final analysis.

Measurements

The contextual variables were derived from the Health Resources and Services Administration Area Resource File and include the percentage of the population in poverty, classification of rurality, and state. In addition, a dichotomized predictor variable showing the potential period effect of the ACA on RHC performance was created. The years before 2010 (2007 through 2009) were coded as 0, and the years after 2009 (2010 through 2013) were coded as 1.

The organizational factors included years of RHC operation, staff mix calculated as a total number of physician, physician assistant, and nurse practitioner full-time equivalent, provider-based or independent clinic practice, and ownership. The ecological factors of RHCs were the aggregate personal attributes of Medicare beneficiaries, such as the size of Medicare patient served and the percentage of dually eligible patients.

To identify the trend of risk-adjusted admission rates for each racial group, the risk-adjusted rates of RHCs between the

African American patient group and non-Hispanic white patient group were compared. The patient groups composed of Hispanic patients and individuals who identified themselves as another race category were too small to be useful for comparing the RHC variations. Due to the problematic issue of missing values in the claims files, longitudinal data from 2007 to 2013 were pooled together in the analysis. Thus, the unit of analysis for the dependent variable is referred to as “RHC-year” with all 8 states combined in 7 years. The number of RHCs varied by year and by state, with the largest number of RHCs located in Mississippi and the smallest number in Tennessee. The total observations for RHC years were 3957. However, when we performed multivariate analysis of risk-adjusted DM hospitalization rates, the number of total observations decreased to 1482 and 2377 RHC years for African Americans and non-Hispanic whites, respectively, after deleting missing cases for selected predictor variables.

Analytical Methods

Three statistical methods were used to analyze the pooled data for the years 2007 to 2013; each method was similar to a time series without using a panel group of RHCs in the longitudinal analysis. First, descriptive statistics were calculated to illustrate the general characteristics of the RHCs in the 8 states of region 4. Significance tests, at the α level of 0.05, were performed when the analysis of variance (ANOVA) for the 8 states for a given attribute or variable was appropriate. Second, correlation analysis of repeated measures of DM hospital admissions was performed for 2007 through 2013. The results showed that no serial correlations of risk-adjusted rates existed for the 7-year study period. Since no linear trends were found, growth curve modeling was not performed for the trend analysis. Finally, regression of the dependent variable on selected predictors clustered into contextual, organizational, and ecological variables was conducted using a generalized estimating equation (GEE) method in the SPSS (Version 22.0. Armonk, NY: IBM Corp) software with the pooled data for all RHCs with complete information for the total numbers of patients served and admissions (1482 and 2377 RHC years for African Americans and non-Hispanic whites, respectively).

Both time-constant and time-varying predictors were included in the analysis. The reasons for performing GEE to identify the relevance of selected predictors in accounting for the variability in adjusted DM admission rates are as follows: (1) a repeated measure of the risk-adjusted rate of each RHC for the 7 years was used as a dependent variable; (2) the predictor variables had many missing variables; (3) robust standard estimates were available for performing more consistent and accurate tests of statistical significance; and (4) quasi-likelihood information criterion was available to reflect the relative quality of the proposed model in fitting the data. A detailed statistical description of GEE used for this analysis can be obtained from the authors.

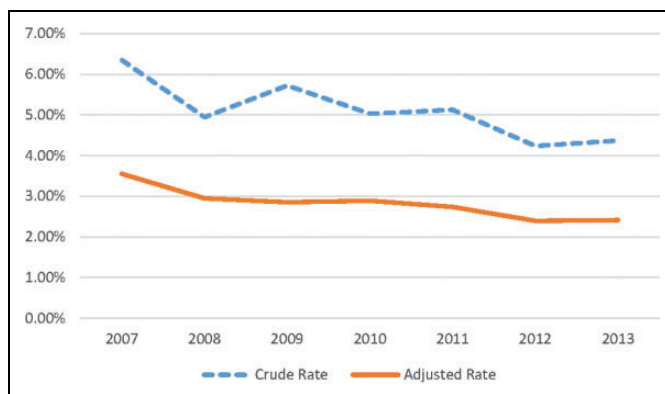


Figure 1. Overall rural health clinic (RHC) crude and risk-adjusted rates for diabetes mellitus (DM) hospitalization.

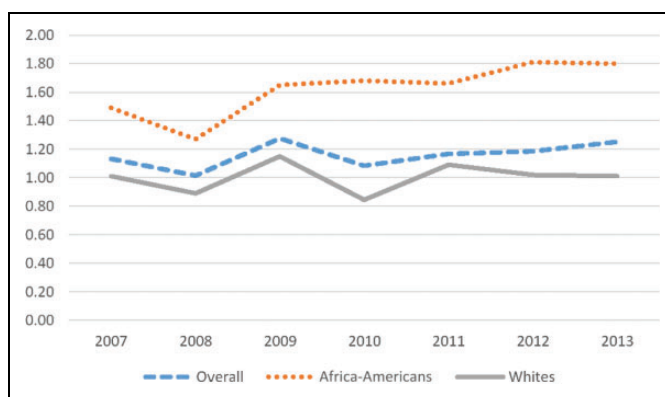


Figure 2. Ratio between the crude and risk-adjusted rates by racial group.

Results

Overall RHC Rates for DM Hospitalization

According to the descriptive analysis of the data, there were 705 RHCs studied over a period of 7 years in 8 states of region 4. The crude DM hospital admission rates declined from 6.35% in 2007 to 4.37% in 2013 for Medicare patients served by RHCs (see Figure 1). The risk-adjusted DM hospitalization rates showed a similar decline over 7 years from 3.55% to 2.40% for the respective year.

Variations in the Ratio Between the Crude and Risk-Adjusted Rates (Disparity Ratio in DM Hospitalizations) by Racial Group

The crude and adjusted ratios by year and race are shown in Figure 2. The ratios, which reflect the disparity or gap between the actual (crude) and adjusted (expected) rates, for both of the racial groups consistently showed that African American diabetic patients had higher hospitalization rates than white patients throughout the 7 years. For instance, the crude rate of African Americans was 49% higher than expected in 2007, and the crude rate steadily increased to 80% higher than expected in 2013. Thus, the gap between the crude and adjusted

Table 1. Race-Specific Ratio (Observed vs Expected Number) for Diabetes Mellitus (DM) Hospitalizations by State and Year in Region 4 Rural Health Clinics.

		Alabama		Florida		Georgia		Kentucky		Mississippi		North Carolina		South Carolina		Tennessee		P-Value
Race		n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	
Overall	Whites	276	1.25	478	0.77	291	1.18	615	1.02	550	1.21	345	0.72	325	0.96	201	0.92	.001
	African Americans	162	1.49	266	1.47	207	2.17	88	1.16	520	1.91	257	1.14	335	1.56	72	1.22	.001
2007	Whites	39	0.95	72	1.14	39	1.08	75	0.79	79	1.57	50	0.61	40	0.77	29	0.74	.163
	African Americans	21	0.66	29	1.91	35	2.23	9	2.26	74	1.36	36	0.78	46	1.57	13	1.82	.182
2008	Whites	44	1.23	69	0.66	47	0.58	92	0.94	85	1.09	55	0.53	44	1.13	32	1.00	.284
	African Americans	26	1.59	43	0.95	34	2.25	13	0.60	76	1.20	45	0.87	54	1.19	11	1.93	.188
2009	Whites	43	1.04	70	0.75	42	1.99	92	1.02	85	1.63	51	0.86	48	0.74	31	1.29	.033
	African Americans	27	2.33	42	1.47	33	1.84	18	0.92	77	1.93	42	1.05	45	1.86	11	0.87	.499
2010	Whites	41	1.37	65	0.91	43	0.80	98	0.74	79	0.85	51	0.64	47	0.85	31	.71	.650
	African Americans	25	1.80	47	1.17	29	2.96	9	1.74	78	1.64	35	1.42	51	1.53	10	1.92	.395
2011	Whites	40	1.32	69	0.63	47	1.50	89	1.26	78	1.29	52	1.18	49	0.90	27	0.21	.179
	African Americans	18	2.03	42	1.50	24	1.54	12	0.79	76	2.44	38	1.22	50	1.29	11	0.85	.195
2012	Whites	34	1.46	67	0.46	38	1.42	87	1.13	76	0.98	46	0.60	47	1.27	30	1.30	.161
	African Americans	23	0.49	36	1.44	25	2.40	17	0.99	72	2.69	32	1.07	46	2.03	7	0.72	.082
2013	Whites	35	1.48	66	0.82	35	0.86	82	1.25	68	0.97	40	0.57	50	1.03	21	1.16	.609
	African Americans	22	1.41	27	2.30	27	1.92	10	1.50	67	2.15	29	1.75	43	1.52	9	0.00	.607

Table 2. Race-Specific Ratios (Observed vs Expected Number) for DM Hospitalizations by the ACA Effect and by Rurality.

Race	Period	RHCs (n)	Mean Ratio	SD	P Value
African Americans	Pre-ACA	860	1.47	2.63	.043
	Post-ACA	1047	1.73	3.09	
Whites	Pre-ACA	1353	1.02	2.02	.715
	Post-ACA	1728	0.99	2.08	

Race	Rurality	RHCs (n)	Mean Ratio	SD	P Value
African Americans	Urban	336	1.47	3.10	.121
	Large rural	396	1.51	2.78	
	Small rural	759	1.57	2.76	
	Isolated	416	1.91	3.07	
Whites	Urban	538	0.77	1.94	.014
	Large rural	679	0.95	1.80	
	Small rural	1066	1.07	1.92	
	Isolated	798	1.12	2.45	

Abbreviation: ACA, Affordable Care Act; DM, diabetes mellitus; RHC, rural health clinic; SD, standard deviation.

rates became wider in the African American patient group but not in the non-Hispanic white patient group.

One-way ANOVA for the ratios by state was performed for all 7 years combined, as well as for each year and racial group. Table 1 shows that state variations in the disparities were statistically significant in both racial groups. For non-Hispanic whites, the overall average ratio was 1.25 for Alabama (25% higher rate for the crude than the adjusted rate) and 0.72 for North Carolina (28% lower rate). The gap between non-Hispanic whites (a ratio of 1.18) and African American (2.17) patient groups showed the largest in Georgia compared to other states. For African Americans, the highest disparity ratio was found in Georgia (2.17), whereas lower ratios were found for North Carolina (1.14), Kentucky (1.16), and Tennessee (1.22). Relatively higher rates were found in the African American patient group compared to the non-Hispanic white patient group. However,

yearly fluctuations for the ratios were also found by state. For instance, in both Alabama and Tennessee, African Americans had lower ratios than whites in 2012 and 2013.

Race-Specific DM Hospitalization Disparity Ratios by the ACA Effect and Rurality

In the Student *t* test, the average ratio had an increase of 26% from the pre-ACA period (1.47) to the post-ACA period (1.73) for the African American patient group (Table 2). Overall, the average ratios increased about 17.8% between the pre- and post-ACA period in the African American patient group, but the ratios did not change between the 2 periods in the non-Hispanic white patient group.

The variation in the DM hospitalization disparity ratios by rurality or rural classification was examined by the Student *t*

Table 3. Analysis of GEE Standardized Parameter Estimates of the African Americans Ratio (Observed vs Expected Number) for DM Hospitalizations (N = 1482 RHC Years; 371 RHCs).

Variables	Beta	Standard Error	95% Wald Confidence Interval		P-Value
			Lower	Upper	
Intercept	0.444	0.525	−0.585	1.473	.398
Contextual factors					
Percentage poverty population	−0.004	0.0129	−0.029	0.021	.762
State					
North Carolina (ref)					
Florida	0.543	0.3396	−0.123	1.208	.110
Tennessee	0.077	0.4878	−0.879	1.033	.875
Kentucky	0.016	0.4916	−0.947	0.980	.973
South Carolina	0.303	0.2560	−0.198	0.805	.236
Mississippi	0.566	0.2670	0.043	1.089	.034
Alabama	0.426	0.3682	−0.296	1.147	.248
Georgia	1.008	0.3554	0.311	1.704	.005
Rurality level					
Urban (ref)					
Large rural	0.261	0.2655	−0.260	0.781	.326
Small rural	0.186	0.2537	−0.311	0.683	.464
Isolated	0.533	0.3058	−0.066	1.132	.081
ACA period effect					
Pre-ACA (2007-2009) (ref)					
Post-ACA (2010-2013)	0.137	0.1539	−0.165	0.438	.374
Organizational factors					
The years of RHC operation	0.012	0.0171	−0.022	0.045	.484
Staff mix and size	−0.044	0.0259	−0.094	0.007	.092
RHC type					
Independent (ref)					
Provider based	−0.073	0.1950	−0.455	0.309	.707
Ownership type					
Government (ref)					
Profit	0.207	0.2626	−0.307	0.722	.430
Nonprofit	0.097	0.2422	−0.378	0.572	.689
Individual factors					
Size of Medicare beneficiary population served	0.000	0.0002	0.000	0.001	.202
Percentage of patient dually eligible	0.837	0.7292	−0.592	2.267	.251

Abbreviations: ACA, Affordable Care Act; DM, diabetes mellitus; GEE, generalized estimating equation; ref., reference; RHC, rural health clinic.

^aGEE fit criteria: quasi-likelihood information criterion (QIC) = 11 250.473. Information criteria are in smaller-is-better form.

test for 7 years. Table 2 shows that statistically significant differences in the ratios were found in the non-Hispanic white but not in the African American patient group. The average ratios for the non-Hispanic white patient group were higher in small and isolated rural areas than other 2 areas.

Generalized Estimating Equation Analysis of Risk-Adjusted DM Hospitalization Rates for Non-Hispanic White and African American Medicare Patients

The GEE analysis offers a unique perspective in the examination of repeated measures, such as race-specific risk-adjusted DM hospitalization rates of African American patients served by 371 RHCs with 1482 RHC years and of non-Hispanic whites served by 488 RHCs and 2377 RHC years. The risk-adjusted rate for DM hospitalization, which was a continuous dependent variable, was regressed on selected predictors such as patient's age, gender, Charlson comorbidity, and Medicare claims year.

Rurality was categorized into the 3 dummy variables of large rural, small rural, and isolated rural areas, whereas RHCs located in an urbanized area served as a reference group in the regression equation. A pre-ACA year was coded as 0, and a post-ACA year was coded as 1. This dummy variable is treated as the ACA effect on the DM hospitalization rates. The results of substantively meaningful and statistically significant predictors for the dependent variable are presented in Tables 3 and 4 for the African American and non-Hispanic white patient groups, respectively. For the purpose of illustrating the relative importance of each predictor included in the analysis, only statistically significant results on standardized regression coefficients (parameter estimates) and relevant statistics are presented in the table. A positive regression coefficient indicates that an increasing average DM disparity ratio is observed for a given predictor variable. Similarly, a negative coefficient suggests a declining average DM disparity ratio for a given predictor variable.

Table 4. Analysis of GEE Standardized Parameter Estimates of the Whites Ratio (Observed vs Expected Number) for DM Hospitalizations (N = 2 377 RHC Years; 488 RHCs).

Variables	β	Standard Error	95% Wald Confidence Interval		P Value
			Lower	Upper	
Intercept	.593	.2556	.092	1.094	.020
Contextual factors					
Percentage poverty population	-.011	.0085	-.028	.005	.183
State					
North Carolina (ref)					
Florida	-.049	.1440	-.331	.233	.732
Tennessee	-.090	.1693	-.422	.242	.596
Kentucky	.154	.1461	-.132	.440	.292
South Carolina	.154	.1537	-.147	.455	.315
Mississippi	.314	.1816	-.042	.669	.084
Alabama	.301	.2001	-.091	.693	.132
Georgia	.532	.2279	.085	.978	.020
Rurality level					
Urban (ref)					
Large rural	.325	.1304	.069	.580	.013
Small rural	.386	.1171	.156	.615	.001
Isolated	.279	.1613	-.038	.595	.084
ACA period effect					
Pre-ACA (2007-2009) (ref)					
Post-ACA (2010-2013)	-.088	.0821	-.249	.073	.285
Organizational factors					
The years of RHC operation	-.008	.0076	-.023	.007	.316
Staff mix and size	-.009	.0099	-.028	.010	.365
RHC type					
Independent (ref)					
Provider-based	-.016	.1188	-.249	.216	.891
Ownership type					
Government (ref)					
Profit	.162	.1676	-.166	.491	.333
Nonprofit	.144	.1594	-.169	.456	.367
Individual factors					
Size of Medicare beneficiary population served	7.786E ⁻⁵	6.5809E ⁻⁵	-5.112E ⁻⁵	.000	.237
Percentage of patient dually eligible	.507	.3693	-.217	1.231	.170

Abbreviations: ACA, Affordable Care Act; DM, diabetes mellitus; E, Exponent; GEE, generalized estimating equation; ref., reference; RHC, rural health clinic.

^aGEE fit criteria: quasi-likelihood information criterion (QIC) = 8832.996. Information criteria are in smaller-is-better form.

For the African American patients, there were a total of 1482 RHC years with complete information for predictor variables. Table 3 reveals several findings as follows: (1) Georgia and Mississippi had a higher ratio than other southeastern states; (2) the DM hospitalization disparity ratios did not vary by the rurality classification; (3) the variable “ACA period” had no effect; and (4) no statistically significant variability in the disparity ratios was explained by other predictor variables.

For non-Hispanic white patients served by RHCs, there were a total of 2377 RHC years with complete information for predictor variables. The statistically significant results are summarized in Table 4 as follows: (1) higher rates were founded in Georgia than other southeastern states and (2) large and small rural classifications had higher disparity ratios for DM hospitalization than other rural areas. The variable “ACA period” had no statistically significant relationship to the disparities between the crude and adjusted DM hospitalization rates in the non-Hispanic white group.

Discussion

The analysis of RHC data of 2007 through 2013 enables us to further the understanding about racial disparities in risk-adjusted rates and actual-expected ratios for DM hospitalization in region 4 of the United States. The findings of this empirical study offer specific answers to each of the 3 research questions.

First, the crude and risk-adjusted DM hospitalization rates decreased slightly over the past years, particularly in 2012 and 2013. The average DM hospitalization disparity ratios for both the non-Hispanic white patient group and African American patient group showed the variability by year. The average gap between the crude and adjusted rates for the African American group was 80% higher than expected in 2012 and 2013, but small gaps existed in other years. A careful analysis of the predictor variables with the GEE method revealed that only a limited number of predictors were statistically significant in accounting for the variability.

Second, the ACA period effect on the DM hospitalization disparity ratios was shown in both racial groups with a larger ratio or gap in the post-ACA period (1.73) than in the pre-ACA period (1.47) in the African American patient group. On the contrary, a slightly declined ratio for the post-ACA years was seen in the non-Hispanic white patient group. The reasons for racial differences in the gap between the actual and adjusted rates for African Americans could not be easily identified. Perhaps, the RHCs serving more African American Medicare beneficiaries with DM were more likely to admit their patients into hospitals because primary care physician practice patterns are associated with preventable admissions.³⁹ Therefore, health-care providers' practice patterns should be considered as an adjusted factor in a multiple regression model in the future research.

Third, the DM hospitalization ratios did not vary significantly by categories of rurality, irrespective of race. However, in the African American patient group, the ratio (1.91) of the DM hospitalization was higher in RHCs located in the isolated rural area.

Fourth, demographic and SES factors measured by the county-area characteristics, organizational characteristics, and aggregate patient factors of RHCs appear to be irrelevant in explaining the variability in the DM hospitalization disparity ratios in both racial groups. The RHCs located in Georgia had much higher rates than other states, irrespective of race. These findings were similar with a Germany's study results; organizational and population factors were weakly associated with ambulatory care-sensitive hospitalization rates.⁴⁰

The empirical findings presented are relatively robust since GEE analysis of longitudinal data of RHC years with a risk adjustment method removes patient differences in RHCs. However, this study may be subject to a few limitations. First, the unit of analysis of RHC year was measured by hospital admission claims of Medicare patients with DM. The measurement was based on episodes or events of the interest. We cannot infer how the variability in hospital practices in RHC service areas may have contributed to the disparities in DM admissions. Second, the contextual, organizational, and ecological factors are those associated with RHCs, not hospitals. Our interest is to determine how the RHC and community area characteristics, reflecting the county, and aggregated RHC patient attributes may account for the variability in admissions in multiple RHC years. Third, because the purpose of this investigation is to focus on the variability in the gap ratio between the crude and risk-adjusted DM admission rates, identification of RHCs with substantially higher ratio scan portrays the need for further enhancement of their ambulatory or primary care services needed for the specific groups of RHCs. It was not possible to explore the full picture of regional variation in DM hospital admissions among RHCs in the United States because our data were restricted to the 8 southeastern states in region 4. Finally, the supply-side variables such as hospital market competition, travel distance from RHC to a nearest hospital, and types of hospital in the model were not considered because RHC year was the unit of

analysis. Alternatively, a 3-level multivariate analysis could be performed to include the interaction terms among patient-, hospital-, and community-level predictor variables in the analysis of DM hospital admissions. Furthermore, other efforts such as community support for fostering transitional care or post-acute care for DM through disease management or coordinated care may also be relevant to the declined trend of DM hospitalization.

The DM hospitalizations are not well understood. The use of the disparity ratio or gap between the crude and risk-adjusted rates revealed no significant differences between non-Hispanic white patients and African American patients served by RHCs for most of the contextual, organizational, and ecological determinants. Future studies should address the variation in the stage of DM condition of RHC patients, using the American Diabetes Association's DM severity classification. In addition, the effectiveness in detecting the underlying causes or mechanisms for racial disparities of DM hospital admissions and in implementing feasible organizational or community interventions should be further explored in future rural health research on DM.

Conclusions

Our study examines the relevance of multifactors influencing racial disparities between the crude and risk-adjusted rates of DM hospitalizations. Although the DM admission rates of rural Medicare beneficiaries varied by state, there was a small decline in DM hospital admissions of Medicare patients in the 8 states of region 4 from 2010 through 2013. No statistically significant effect of ACA period on the disparity ratios for DM hospital admissions was shown in both non-Hispanic white patient group and African American patient group when other factors were simultaneously considered in multivariate analysis. The CMS HRRP and other quality improvement initiatives may have also accounted for the declining rates.

This study contributes to the literature in the disparities research from a system perspective through the analysis of longitudinal data for DM hospitalizations. The results reveal that very few predictors were influential to the disparity ratio between the crude and risk-adjusted DM admission rates. Race does play an important role since higher disparity ratios were found for African American than non-Hispanic white patients. The general RHC structural characteristics of facility age, ownership, and provider-based practice did not account for any statistically significant variability in the hospitalization ratios. Non-Hispanic white patients residing in small and large rural areas had more patients hospitalized than urbanized and remote rural areas. This suggests that DM management of rural Medicare beneficiaries should target those in small and large rural areas.

The results of this study confirm racial disparities in DM hospitalizations.^{17,26,41} Future research is needed to identify the underlying reasons for such racial disparities to guide the formulation of effective and efficient changes in DM care management practices coupled with the emphasis of culturally competent, primary and preventive care.⁴² Intervention

programs, such as using Telecare,⁴³ communication systems, transformation of diabetes care to primary care,⁴⁴ team care,⁴⁵ and DM disease management,⁴⁶ for reducing DM admissions are needed.

Authors' Note

The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

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