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Contextual, Ecological and Organizational Variations in Risk-Adjusted COPD and Asthma Hospitalization Rates of Rural Medicare Beneficiaries

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Abstract

The purpose of this study is to examine what factors contributing to the variability in chronic obstructive pulmonary disorder (COPD) and asthma hospitalization rates when the influence of patient characteristics is being simultaneously considered by applying a risk adjustment method. A longitudinal analysis of COPD and asthma hospitalization of rural Medicare beneficiaries in 427 rural health clinics (RHCs) was conducted utilizing administrative data and inpatient and outpatient claims from Region 4. The repeated measures of risk-adjusted COPD and asthma admission rate were analyzed by growth curve modeling. A generalized estimating equation (GEE) method was used to identify the relevance of selected predictors in accounting for the variability in risk-adjusted admission rates for COPD and asthma. Both adjusted and unadjusted rates of COPD admission showed a slight decline from 2010 to 2013. The growth curve modeling showed the annual rates of change were gradually accentuated through time. GEE revealed that a moderate amount of variance (marginal $R^2 = 0.66$) in the risk-adjusted hospital admission rates for COPD and asthma was accounted for by contextual, ecological, and organizational variables. The contextual, ecological, and organizational factors are those associated with RHCs, not hospitals. We cannot infer how the variability in hospital practices in RHC service areas may have contributed to the disparities in admissions. Identification of RHCs with substantially higher rates than an average rate can portray the need for further enhancement of needed ambulatory or primary care services for the specific groups of RHCs. Because the risk-adjusted rates of

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hospitalization do not very by classification of rural area, future research should address the variation in a specific COPD and asthma condition of RHC patients. Risk-adjusted admission rates for COPD and asthma are influenced by the synergism of multiple contextual, ecological, and organizational factors instead of a single factor.

Keywords

Rural health clinics; Affordable Care Act; COPD and asthma hospitalization; rurality

INTRODUCTION

Chronic obstructive pulmonary disorder (COPD) takes a heavy toll on costs of care, amounting to the projected annual cost for $49.9 billion in the United States (American Lung Association, 2013; Centers for Disease Control and Prevention, 2012; Kabir, Connolly, Koh, & Clancy, 2010). COPD is a major contributing factor to morbidity, disability and mortality in the older adult population. Hospitalizations associated with COPD and asthma are often cited as an ambulatory care sensitive condition or potentially avoidable hospitalization. Empirical research suggests that personal attributes (Kabir et al., 2010; Ong, Earnest, & Lu, 2005), socioeconomic status (Trachtenberg, Dik, Chateau, & Katz, 2014), health care system or provider factors (Casalino et al., 2014; O'Malley, Pham, Schrag, Wu, & Bach, 2015;), health education for self-care management (Gadoury et al., 2005), and access to primary care (Caminal, Starfield, Sanchez, Casanova, & Morales, 2005) are potential predictor variables for COPD hospitalizations. However, little is known about how these factors contribute to the variability in COPD hospitalization rates when the influence of patient characteristics is being simultaneously considered by applying a risk adjustment method.

The Centers for Medicare and Medicaid Services (CMS) has started monitoring the avoidable hospitalizations by implementing a financial sanction plan to eliminate this hospital quality problem. Beginning October 2012, Medicare payments decreased by 1- 2% in 2013 and 3% in 2014. Beginning in October 2014, the readmission rate for Medicare patients with chronic obstructive pulmonary conditions were included. Concomitantly, the enactment of the Patient Protection and Affordable Care Act (abbreviated as the ACA) in March 23, 2010, is expected to enhance patient-centered care, particularly related to an emphasis on the improved delivery of ambulatory care and prevention by expanding health insurance coverage for the uninsured (Wan, Ortiz, Berzon, & Lin, 2015).

Our construction of a unique database for Rural Health Clinics (RHCs) for a period of seven years from 2007 through 2013 (including the pre-ACA period and the post-ACA period) offers a unique opportunity to examine trends and patterns of rural disparities in COPD and asthma hospitalizations in eight states of Region 4 (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee).

Research literature suggests that the severity of illness and other personal characteristics may explain differential rates in COPD and asthma hospitalizations (Quintana et al., 2015). However, high hospital admission rates have been attributable to the lack of transitional care

(Gold, Ortiz, & Wan, 2013; Jackson, Trygstad, DeWalt, & DuBard, 2013; Mor & Besdine, 2011), inadequate or poor access to primary care (Caminal et al., 2005; Joynt, Harris, Orav, & Jha, 2011; McCall, Brody, Mobley, & Subramenian, 2004), racial or socioeconomic inequalities (Biello, Rawlings, Carroll-Scott, Browne, & Ickovics, 2010; Chang, Mirvis, & Waters, 2008; Gottlieb, Beiser, & O'Connor, 1995; Laditka, Laditka, & Masanduno, 2003), and the provision of poor quality of hospital care (Jencks, Williams, & Coleman, 2009; The Official U.S. Government Site for Medicare, 2014).

The purpose of this investigation is to explore how contextual, ecological and organizational factors of RHCs may influence variations in COPD and asthma hospitalization rates after having risk-adjusted pertinent patient factors among Medicare beneficiaries who have access to RHCs in the eight states. More specifically, following research questions relevant to the patterns and trends of risk-adjusted COPD and asthma hospitalization rates of rural Medicare patients are addressed in this empirical study:

1. What are the risk-adjusted COPD and asthma hospitalization rates (per clinic) in varying categories of rural areas for 2007 through 2013?
2. Have the rates changed over the past seven years (2007 through 2013)? Can the change be reflected by the period effect attributable to the Affordable Care Act when other influencing factors are simultaneously considered?
3. Is there a difference in risk-adjusted COPD and asthma hospitalization rates between low- and high-socioeconomic status areas served by RHCs?

The present study uses time-series data aggregated into RHC years (472 RHCs observed for seven years) as the unit of analysis, using multivariate modeling analytics to identify statistically significant factors influencing the disparities in risk-adjusted COPD and asthma hospitalization rates. The identification of contributing factors to the high prevalence of COPD and asthma hospital admissions may shed some light on potential policy development or organizational interventions targeting the mutable contextual (e.g., policy, socioeconomic development, rurality, health and professional resources, etc.), ecological factors (e.g., aggregated indicators of population distribution, racial composition, patient mix, dual eligibility status, etc. in areas served by RHCs), and organizational factors (e.g., affiliation with accountable care organizations, years in operation, size, staffing mix, ownership, and other RHC characteristics).

RELATED RESEARCH

Avoidable hospitalizations are considered an important measure of sentinel health events and community health performance. Brennan (2014) reported findings from CMS research on Medicare and suggested that high avoidable hospitalization rates represent quality problems. Using 2003-2004 data Jencks et al. (2009) showed that hospitalization rates across Region 4 vary by state from 18.1% in South Carolina to 21.9% in Mississippi. In the United States, morbidity caused by COPD accounts for 4% - the fourth leading cause of mortality ranked after heart attacks, cancer and stroke (Hurd, 2000). Furthermore, air pollution and smoking may have contributed directly the increase of COPD hospitalization.

According to a recent report by the University of Washington Population Health Institute (2014) on county variations in health and health care in the U.S., the four contributing factors to the improvement of health care and health care outcomes by the percentage distribution include: 1) 10% attributed to physical environment and policy, 2) 20% to clinical care and technology, 3) 30% to personal behavioral factors, and 4) 40% to social and economic factors. This report points out strategic priorities for achieving population health by reducing health care disparities attributable to the contextual, ecological, and health delivery system factors. The potential avoidable COPD hospitalizations can be further identified if the determinants of risk-adjusted rates are made. The present study explores how the availability of RHCs, the ACA period effect, rurality, numbers of dual eligible, and many aggregated organizational characteristics at the RHC level, may influence the patterns and trends of risk-adjusted rates of COPD and asthma hospitalizations for the period of 2007 through 2013.

METHODS

Design and Data Sources

We conducted a longitudinal analysis of COPD and asthma hospitalization of rural Medicare beneficiaries based on administrative and claims data gathered from a variety of data sources compiled for CMS. The presence of hospital billing codes for admissions was coded as a hospitalized case (coded 1) or not-hospitalized case (coded 0). The detailed calculation for COPD and asthma hospitalization is described as follows.

Denominator—Patients should have at least one international classification of disease (ICD-9) diagnosis code for COPD or asthma in the Medicare Outpatient claims during the calendar year. These codes are as follows: 4910, 4911, 49120, 49121, 4918, 4919, 4920, 4928, 494, 4940, 4941, 496, 49300, 49301, 49302, 49310, 49311, 49312, 49320, 49321, 49322, 49381, 49382, 49390, 49391, and 49392. The exceptions and exclusions in the denominator were patterned after the measure ACO #9 version 9 (Centers for Medicare & Medicaid Services, 2012). In other words, the end-stage-renal disorder (ESRD) patients and patients transferring from a hospital, skilled nursing facility or intermediate care facility, or another health care facility were excluded from the analysis.

Numerator—Patients should have one principal ICD-9 diagnosis of COPD or asthma in Medicare Inpatient claims. The details of codes are as follows:

1) A diagnosis code indicating COPD or asthma 4910, 4911, 49120, 49121, 4918, 4919, 4920, 4928, 494, 4940, 4941, 496, 49300, 49301, 49302, 49310, 49311, 49312, 49320, 49321, 49322, 49381, 49382, 49390, 49391, 49392; or (2) a principal diagnosis code of 4660 or 490 and a secondary diagnosis of one or more of the codes 4910, 4911, 49120, 49121, 4918, 4919, 4920, 4928, 494, 4940, 4941, or 496.

The COPD and asthma hospitalization rate is computed as the total number of Medicare inpatient claims for hospital admissions divided by the total number of outpatient claims of COPD and asthma patients served by each RHC per year. The formula used was as follows:

$$\text{Crude hospital admission rate} = \frac{\text{number of COPD and asthma hospitalizations}}{\text{number of patients diagnosed with COPD or asthma from the outpatient file}};$$

Using logistic regression analysis of the Medicare claims file, we created a Charlson Index (Deyo, Cherkin, & Ciol, 1992), age, gender, race, and other personal factors as risk adjusters, to arrive at an expected number of COPD and asthma admissions for each RHC per year. The risk-adjusted COPD and asthma admission rate, a dependent variable in this analysis, was then calculated using the expected number of COPD and asthma admissions (numerator) divided by the total COPD and asthma outpatients treated by each RHC (denominator). The formula is as follows:

$$\text{Risk- adjusted admission rate} = \frac{\text{number of adjusted COPD and asthma hospitalizations}}{\text{number of COPD and asthma patients treated by the RHC and identified from the outpatient file}}$$

Our analysis of variation in the adjusted COPD and asthma hospitalization rate may be accounted for by the contextual, ecological, and organizational factors. Analyses present major characteristics of RHCs serving Medicare beneficiaries in varying degrees of rural areas: RHCs located in an urbanized area, large rural area, small rural area, and isolated rural area. The total rural older adults studied, ranged from 202,707 patients in 2007 to 225,344 patients in 2013. Excluding missing cases for not having the total number of patients documented in the Medicare claims file, we retained only 472 RHCs for this research.

Measurements

The contextual variables, derived from the Health Resources and Services Administration (HRSA) Area Health Resource File (AHRF), include: the percentage of poverty population, rurality (in four levels), racial composition, state, etc. In addition, a dichotomized predictor variable showing the potential period effect of the ACA on RHC performance was created: before 2010 (2007 through 2009) coded as 0 and after 2010 (2010 through 2013) coded as 1. Personal attributes of Medicare beneficiaries such as size of patient population served, average age, % female patients, % Hispanic users, % White patients, % dually eligible, and diagnostic mix indicators are considered as aggregated indicators or ecological factors in this analysis. The organizational factors include years of RHC operation, staff mix (a ratio of primary care provider visits by the total number of health clinic visits), staff size, provider-based practice, ownership, etc.

Disparity in Adjusted COPD and Asthma Admission Rates between a Given Year and a Reference Year for Medicare Beneficiaries Accessing each RHC— The formula for computing the disparity ratio is as follows: (the deviation of an annual rate from the reference average rate in 2009 divided by this reference average rate) × 100. The deviation from an average rate or a norm is used to compare the changes in adjusted COPD and asthma admission rates of RHCs. For the purpose of this research, an average rate in 2009 of all study RHCs was used as a reference value so that the percentage deviation from an average rate of admissions per year refers to the disparity: a positive value refers to poorer performance (higher COPD and asthma hospitalization rate) than an average RHC rate in 2009 and a negative value (lower rate) indicates better performance.

Because of the problematic issue of missing values in the claims file, longitudinal data from 2007 to 2013 were pooled together in the analysis. Thus, the unit of analysis for a dependent variable is referred to as “RHC-year,” and the risk-adjusted COPD and asthma admission rate deviation from that of the 2009 rate was determined for all 472 RHCs.

Analytical methods—Three statistical methods were used to analyze the data pooled from 2007 to 2013, similar to a time-series without using a panel group of RHCs in the longitudinal analysis. Descriptive statistics are presented to illustrate the general characteristics of the RHCs in Region 4. Significance tests, at the alpha level of 0.05, were performed when the analysis of variance for eight states for a given attribute or variable was appropriate. The repeated measures of risk-adjusted COPD and asthma admission rate were analyzed by growth curve modeling for 2007 through 2013. This enabled us to ascertain if any autocorrelations of the variables exist (Wan, 2002). Regression of the dependent variable on selected predictors clustered into contextual, organizational, and ecological variables was analyzed by a generalized estimating equation (GEE) method, using the pooled data for the 472 RHCs with complete information for COPD and asthma admissions (N= 2,910 RHC years) and analyzed by the SAS Institute’s GENMOD procedure.

Both time constant and time-varying predictors were included. The reasons for performing GEE to identify the relevance of selected predictors in accounting for the variability in adjusted admission rates for COPD and asthma are: 1) a repeated measure of the risk-adjusted hospitalization rate of RHCs in seven years as the dependent variable; 2) some missing values found for the predictor variables; 3) robust standard estimates available for performing more consistent and accurate tests of statistical significance; and 4) the availability of the Quasi-likelihood Information Criterion [QIC] to reflect the relative quality of the proposed model in fitting the data.

RESULTS

Descriptive Statistical Analysis

Comparing Crude and Risk-Adjusted COPD and Asthma Hospitalization Rates of RHCs by State—For the crude hospitalization rates for COPD and asthma at the RHC level, all eight states located in Region 4 tend to have varying levels of admissions (Table 1). Lower average rates were found in Mississippi and South Carolina as compared to the other states. Kentucky had the highest rate (13.11%) for all seven years. Statistically significant yearly variations by state were further identified, using analysis of variance of average rates: only Kentucky and Georgia showed a statistically significant yearly variation. For the risk-adjusted hospitalization rates of COPD and asthma, lower averages were found for Mississippi and South Carolina than for other states. Kentucky had the highest average adjusted rate (10.29%) as compared to other states. Yearly fluctuations in the adjusted rate were observed for each state. However, the rates for 2013 appeared to decline in the seven states, except for North Carolina (where there was no change).

Graphic Trend in Risk-Adjusted Rates of Hospitalization in Rural Medicare Beneficiaries with COPD and Asthma—A steady increase in risk-adjusted rates for hospitalization for COPD and asthma patients has been observed from 2007 through 2009 (Fig. 1). The rates in 2010 through 2013 showed a slight decline. A similar pattern was observed for both crude and risk-adjusted rates for COPD and asthma hospitalization although risk-adjusted rates were slightly lower than crude rates.

Graphic Trend in Disparity Ratio of COPD and Asthma Hospital Admissions—The risk-adjusted admission rates of each RHC were compared to an average rate of 2009 in the pre-ACA period. The percentage deviations from this mean were calculated: the higher the positive value, the poorer the care of COPD and asthma patients in the ambulatory care setting is observed. The disparity trend is shown in Fig. 2: the average rate of 2013 is 5 percentage points lower than that of 2009.

Multivariate Analysis

Correlations of Annual Risk-Adjusted Admission Rates for COPD and Asthma (2007 through 2013)—Serial-correlations are considered to be an important methodological problem that has to be addressed in longitudinal analysis of RHC data. The correlation analysis shows that the rates for risk adjusted COPD and asthma admissions among the seven years studied were strongly and positively associated. The potential threat of auto-regression of the rates in longitudinal analysis was further examined using latent growth curve modeling to detect the change trajectories of COPD and asthma rates.

Latent Growth Curve Modeling of Risk-Adjusted COPD and Asthma Hospitalization Rates (2007 through 2013)—Fig. 3 shows that a latent growth curve model of seven waves the observations for 472 RHCs formulated to examine the relationship between the two latent growth components, the intercept reflecting the initial status and the slope of yearly rates showing the trajectories of rate change. This latent growth curve model fits the data very well (with a Chi-square value of 4.921, 12 degrees of freedom; NFI= 0.991, TLI = 0.983, CFI = 0.993, and RMSEA = 0.075). A negative and statistically insignificant association between the two growth factors (intercept and slope) was found (−0.030) as autoregressions of the rates were simultaneously considered in the model. The relationship between each annual rate and the intercept is 0.928, 0.763, 0.705, 0.751, 0.705, 0.701, and 0.733 from 2007 through 2013, respectively. The *relationship* between each annual rate and the slope is 0.00, 0.062, 0.115, 0.184, 0.230, 0.286 and 0.359 for the respective years. This suggests that the rates of change were gradually accentuated through time.

GEE analysis of predictors—GEE offers a unique perspective in the examination of repeated measures such as risk-adjusted hospital admission rates for COPD and asthma for the 2,910 RHC years. The analysis follows a two-step hierarchical regression: 1) the average adjusted rate of 2009 as a continuous dependent variable was regressed on each group of predictors such as the contextual, organizational and aggregated patient attributes independently; and 2) statistically significant predictors from each group of predictors, using a backward selection method, were combined in the second step of regression analysis.

Rurality was categorized into three dummy variables (large rural, small rural, and isolated rural areas with RHC located in an urbanized area as a reference group) in the final regression equation. The results of substantively meaningful and statistically significant predictors for the risk-adjusted hospitalization rate for COPD and asthma are presented in Table 2. For the purpose of illustrating the relative importance of each predictor included in the analysis, we present standardized regression coefficients (parameter estimates) and relevant statistics in the table. A positive regression coefficient indicates that a higher risk-adjusted hospital admission rate of RHC years is observed. Similarly, a negative coefficient suggests that a lower average adjusted admission rate for COPD and asthma is observed for a given predictor variable. A marginal R^2 for the estimating equation is also computed to show the total variance in the dependent variable explained by all predictors included.

Table 2 reveals several interesting findings as follows: 1) the variable “ACA period” had a positive relationship to COPD and asthma admissions; 2) no apparent differences by rurality were found; 3) Alabama, Georgia, Kentucky, North Carolina, South Carolina and Tennessee had a higher rates than Florida and Mississippi; 4) RHCs that treated more patients had a higher admission rate; and 5) the percentage of the dually eligible and White patients treated at RHCs was positively related to the rates. Lower rates were more likely to be related to the percentage of African Americans, females, poverty population where RHCs were located, years of operation, and the percentage of female patients treated at RHCs. The total variance explained by the 21 predictors shown by the marginal R-squared value is 66.3%.

DISCUSSION

The analysis of RHC-related data with multiple years of observation enables us to shed some light on the variability in both crude and risk-adjusted admission rates for COPD and asthma. The findings of this empirical study offer specific answers to the research questions noted earlier. First, there was little variation in admission rates for COPD and asthma by rurality or rural classification. This finding is confirmed by multivariate analysis, holding other predictor variables constant. Second, there was a positive relationship between the average number of RHC patients treated and the COPD and asthma admission rate. Thus, increasing the total number of RHC patients may lead to the increase in COPD and asthma admissions to hospitals.

Third, both adjusted and unadjusted rates of COPD and asthma admission showed a slight decline from 2010 to 2013 although the speed of change was relatively small. The latent growth curve model offered more substantive explanations in regard to the nature of hospital admission rates for COPD and asthma. Because of the interdependence of the yearly rates, the change trajectories of admissions had to be considered in a thorough analysis of the contextual, ecological, and organizational predictors of the COPD and asthma admission rates. Careful analysis of the 21 predictor variables with a GEE method revealed that a moderate amount of variance (marginal $R^2 = 0.66$) in the risk-adjusted hospital admission rates for COPD and asthma was accounted for by contextual, ecological, and organizational variables.

Fourth, the percentage of dually eligible beneficiaries reflects the relative socioeconomic and health status of Medicare patients served by RHCs. This variable was positively and statistically significantly associated with the COPD and asthma hospitalization rates: the higher percentage of the dually eligible served by RHCs, the higher the rate of admissions. Similarly, the greater the number of impoverished and White population in a county where RHCs were located, the higher the hospitalization rate for COPD and asthma. It is interesting to note that other aggregated demographic characteristics such as the percentage of female patients treated at RHCs were negatively associated with the COPD and asthma admission rate.

These empirical findings are relatively robust since our analyses are based on GEE analysis of longitudinal data with a risk adjustment method to remove patient differences. However, this study may subject to a few methodological limitations. First, the unit of analysis based on RHC year was measured by hospital admission claims for COPD and asthma of Medicare patients. 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 admissions. Second, the contextual, ecological, and organizational factors are those associated with RHCs, not hospitals. Our interest is to determine how the RHC and community area characteristics, reflecting the contextual, ecological, and organizational attributes, may account for the variability in COPD and asthma admissions in RHC years. Third, because the purpose of this investigation was to focus on the variability in the COPD admission rates, identification of RHCs with substantially higher rates than an average rate can portray the need for further enhancement of needed ambulatory or primary care services for the specific groups of RHCs. Lastly, we were unable to explore the full picture of regional variation in hospital admissions for COPD and asthma among RHCs in the United States because our data were restricted to eight southeastern states in Region 4.

Notwithstanding the limitations just described, this investigation has enlightened us about the lack of variability in hospital admission rates for COPD and asthma by rurality; the risk-adjusted rates of hospitalization do not vary by classification of rural area. Future studies should address the variation in a specific COPD and asthma condition of RHC patients. In addition, the effectiveness in detecting the underlying causes or mechanisms, such as the severity of COPD or chronicity of the illness, for the variations in hospital admissions for COPD and asthma and in implementing feasible organizational or community interventions, should be explored in future rural health research.

CONCLUSIONS

Our study offers new evidence showing the relevance of contextual, ecological, and organizational factors in influencing the disparities in hospital admission rates for COPD and asthma. The admission rates of rural Medicare beneficiaries were much lower in Region 4 than the U.S. average. No apparent ACA effect on hospital admissions for COPD and asthma was observed. The CMS Hospital Readmissions Reduction Program and other quality improvement initiatives may account for the rate decline in 2013, however. In order to disentangle the co-variations or synergistic effects of both ACA and Readmissions

Reduction Program, researchers have to design and conduct thorough studies to investigate hospital practice variations in rural areas for multiple years.

This study contributes to the literature in social epidemiological research from the contextual, ecological, and organizational perspectives in the analysis of longitudinal data. The results reveal that it is not a single operative factor alone that influences risk-adjusted admission rates for COPD and asthma. The disparities, portrayed by race coupled with socioeconomic status, are influenced by access to primary care and practice patterns (Pappa, Hadden, & Fisher, 1997; Roos, Walld, Vhanova, & Bond, 2005). It is the synergism of multiple contextual, ecological, and organizational factors, as shown in this study, that should be considered in the design and implementation of intervention studies such as using proper incentive plans or penalties to address the problem of potentially avoidable hospital admissions for COPD and asthma through prevention and enhancement of disease management of rural Medicare beneficiaries. Furthermore, an evidence-based approach to guiding effective and efficient changes in admission practices coupled with the use of community-based care modalities, such as transitional care, mobile health care management technologies and a comprehensive care program for COPD (Fan, et al., 2012) should be formulated.

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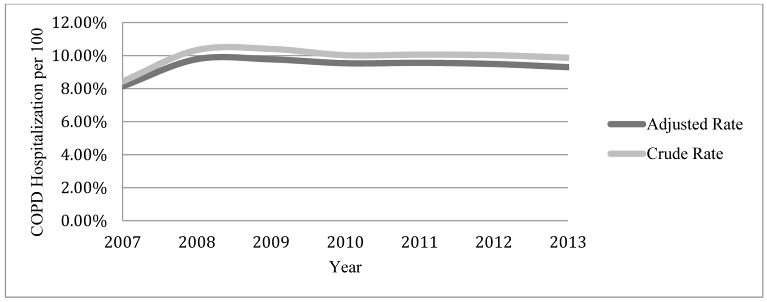

Fig. 1.

Crude and Risk Adjusted COPD and Asthma Hospitalization Rates in 472 RHCs by Year 2007 through 2013

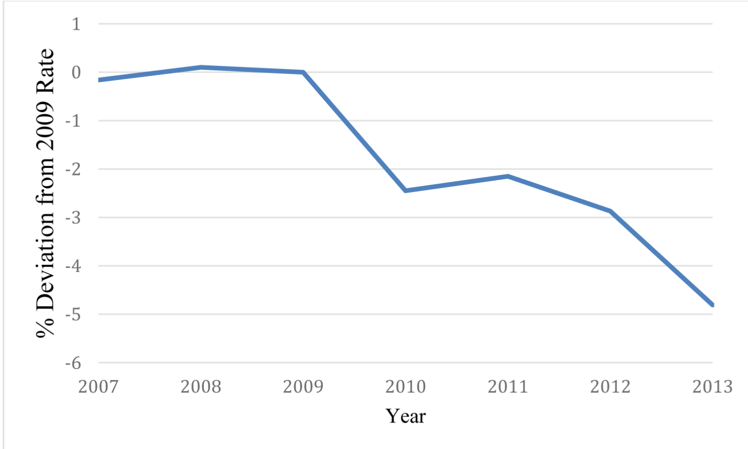

Fig. 2.

Trend for Disparities in Risk Adjusted COPD and Asthma Hospitalization Rates Compared to 2009 in 472 RHCs by Year 2007 through 2013

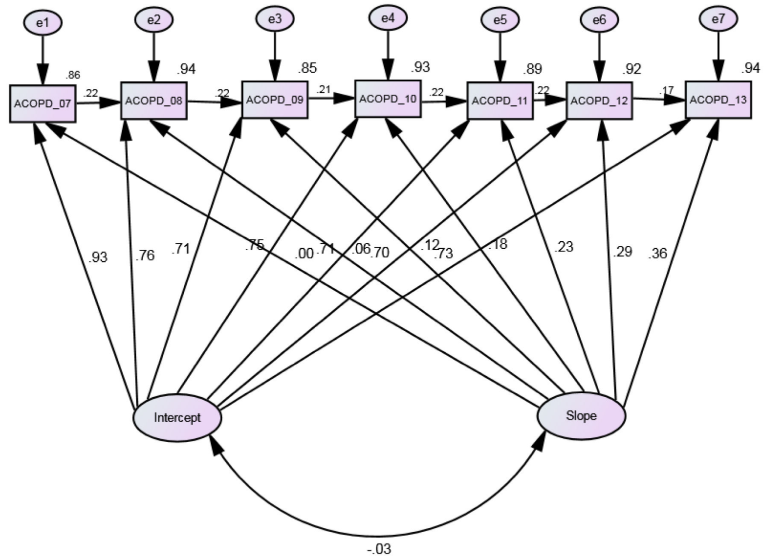

Fig. 3.
An Autoregressive Latent Growth Curve Model of Risk-Adjusted COPD and Asthma Admission (ACOPD) Rates: 2007 through 2013.

Table 1

Crude and Risk-Adjusted Rates of COPD and Asthma Hospitalization Per Hundred COPD and Asthma Outpatients Served by RHCs in Eight States by Year

State	Year	2007	2008	2009	2010	2011	2012	2013	Average
AL	Crude	9.27	10.19	10.09	9.83	9.40	9.64	9.35	9.7
	Adjusted	8.24	9.93	9.84	9.54	9.56	9.55	9.48	9.45
FL	Crude	9.75	11.91	12.25	11.42	11.58	11.40	12.04	11.46
	Adjusted	8.55	10.27	10.30	9.98	10.06	10.01	9.77	9.84
GA	Crude	7.8	10.34	10.64	10.33	10.44	10.58	10.05	10.01
	Adjusted	7.85	9.54	9.59	9.33	9.33	9.27	9.04	9.13
KY	Crude	10.99	14.21	13.74	12.33	13.27	13.44	13.91	13.11
	Adjusted	8.95	10.73	10.75	10.47	10.57	10.39	10.15	10.29
MS	Crude	6.25	7.57	7.65	7.51	7.11	7.15	6.92	7.18
	Adjusted	7.51	9.06	8.96	8.71	8.69	8.65	8.43	8.58
NC	Crude	7.61	8.88	9.00	8.96	8.71	8.44	8.08	8.54
	Adjusted	7.90	9.51	9.38	9.29	9.31	9.22	9.22	9.11
SC	Crude	6.53	7.50	7.55	8.14	7.42	7.16	7.15	7.36
	Adjusted	7.44	8.97	9.13	8.92	8.90	8.86	8.70	8.71
TN	Crude	9.34	12.05	12.66	12.37	12.87	12.34	9.73	11.65
	Adjusted	8.67	10.32	10.33	10.01	9.97	9.92	9.66	9.84

Table 2

Analysis of GEE Parameter Estimates for Predictors of Hospital Admission Rates for COPD and Asthma in RHCs (N = 2,910 RHC Years)

Variable	Estimate	Standard Error	95 % Confidence		Z	P- value
			Lower	Upper		
Contextual						
ACA Period Effect	0.096	0.008	0.081	0.111	12.76	<.0001
Rurality						
Remote and Isolated Rural Area	−0.028	0.020	−0.067	0.011	−1.42	0.1570
Small Rural Area	−0.016	0.020	−0.055	0.024	−0.77	0.4392
Large Rural Area	−0.028	0.019	−0.064	0.009	−1.49	0.1355
Ecological						
State						
Alabama	0.037	0.014	0.010	0.064	2.72	0.0066
Florida	0.039	0.024	−0.007	0.085	1.67	0.0940
Georgia	0.039	0.014	0.012	0.065	2.86	0.0043
Kentucky	0.080	0.021	0.038	0.122	3.74	0.0002
North Carolina	0.030	0.015	0.0004	0.059	1.99	0.0471
South Carolina	0.061	0.014	0.033	0.088	4.31	<.0001
Tennessee	0.045	0.014	0.018	0.072	3.32	0.0009
Females in A County	−0.034	0.014	−0.060	−0.008	−2.53	0.0116
African Americans in A County	−0.057	0.028	−0.111	−0.002	−2.03	0.0419
Older Adults in a County	0.034	0.019	−0.002	0.071	1.86	0.0628
Poverty Population in A County	0.103	0.020	0.064	0.142	5.16	<.0001
% Dually Eligible	0.115	0.023	0.070	0.160	4.99	<.0001
Organizational						
Years in operation	−0.028	0.013	−0.053	−0.003	−2.22	0.0267
Number of Patients Treated	0.086	0.022	0.042	0.130	3.83	0.0001
% White Patients	0.733	0.027	0.679	0.786	26.97	<.0001
% Female Patients	−0.148	0.020	−0.187	−0.109	−7.41	<.0001
%Other Users	0.119	0.015	0.090	0.148	8.15	<.0001

Notes: R-squared: 0.663.

QIC = 2943.05 and QICu = 2931.00.

* Z- statistics greater or equal to | 1.96 | are statistically significant at 0.05 level.