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ORIGINAL ARTICLE

Association between availability of care providers and healthcare utilizations among adults with asthma

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ABSTRACT

Background: Limited accessibility to providers may delay appropriate control of asthma exacerbations. The objective of our study is to estimate the contributors to the hospital/emergency department (ED) visits among adults with asthma focusing on the availability of healthcare providers.

Methods: We conducted a pooled cross-sectional analysis using the 2011–2013 Asthma Call-Back Survey linked with 2012–2016 Area Health Resource Files. We employed multivariable logistic regression with dichotomous outcomes of hospitalization and ED visits. Key covariates were the availability of county-level healthcare provider variables per 100,000 persons such as the number of lung disease specialists (including pulmonary care specialists, and allergy and immunology specialists), the number of hospitals, the number of safety-net facilities including rural health centers (RHCs) and federally qualified health centers (FQHCs), and the number of primary care physicians (PCPs).

Results: Among 25,621 adults, proportions of hospital visits and ED visits were 3.3% and 13.2%, respectively. An additional RHC reduced by 3% the odds of having an ED visit (odds ratio [OR] = 0.97, $p = .004$). Patients with cost barriers to seeing a PCP were 60% (OR = 1.60, $p = .028$) more likely to have a hospital visit than those without. In addition, patients with cost barriers to seeing a specialist were 90% (OR = 1.90, $p = .007$) and 111% (OR = 2.11, $p = .001$) more likely to have a hospital visit and ED visit, respectively, than those without.

Conclusions: Hospital and ED visits among adults with asthma are partially related to the availability of providers, and more related to financial barriers. Therefore, financial support for the vulnerable asthma population might be a target for policy makers interested in reducing hospitalizations and ED visits.

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Introduction

The burden of asthma is considerable in the United States with an annual 2.1% increase of asthma prevalence from 2001 to 2010¹. The three main goals of asthma disease in Healthy People 2020 were to reduce asthma-caused deaths, hospitalizations and emergency department (ED) visits². Asthma-caused deaths have shown a decline of 5.6% annually from 2001 to 2009¹. However, asthma-caused hospitalizations and ED visits appear to have reached a plateau as they have been stable during the years 2001 to 2009³. Asthma-caused hospitalizations and ED visits per 100 persons with asthma were 2.2 and 8.3 on average during the years 2001 to 2009, respectively³. Although these numbers were much lower than the all-population hospitalizations and ED visits (11.6 and 42.1 per 100 population, respectively)^{4,5}, it is necessary to target the reduction of asthma-caused hospitalizations and ED visits since asthma is a chronic disease having potentially preventable hospitalizations and ED visits⁶.

The rates of potentially preventable asthma hospitalizations and ED visits changed over time. The rate of potentially preventable asthma hospitalizations decreased by 15.3%, but the rate of potentially preventable asthma ED visits increased by 8.6% during the years 2008 to 2012⁷. Reducing potentially preventable asthma hospitalizations and ED visits would be achievable through the control of asthma exacerbations⁸.

Previous studies investigated the determinants of hospitalizations and ED visits among individuals with asthma in order to determine vulnerable populations and to develop a policy tool for reducing hospitalizations and ED visits. Children, females, African Americans, and low income populations were regarded as being more likely to have asthma-caused hospitalizations or ED visits^{3,9–11}. Individuals with some comorbidities such as chronic obstructive pulmonary disease (COPD) were also considered to be vulnerable to having hospitalizations and ED visits¹². In addition, individuals with severe asthma exacerbations were regarded as being strongly vulnerable to having hospitalizations and ED visits^{9,13}.

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 Supplemental data for this article can be accessed [here](#).

Air pollution and having no-insurance status were also associated with ED visits^{14,15}.

The availability of healthcare providers may be an environmental factor to those individuals with asthma as it may influence their utilization of healthcare resources and limited accessibility to providers may delay appropriate control of asthma exacerbations¹⁶. Previous studies investigated the associations between healthcare utilizations and the availability of the following healthcare providers: primary care physicians (PCPs), lung disease specialists (including allergists and pulmonary specialists), safety-net facility (including rural health centers [RHCs] and federally qualified health centers [FQHCs]), and hospitals^{17–25}. Hospitals and PCPs may become barriers if there is limited access to them²⁶. RHCs and FQHCs focus primary care providers on financially disadvantaged populations in order to reduce ambulatory care sensitive (ACS) conditions^{24,25}.

In addition, lung disease specialists were associated with a reduction of healthcare utilizations among adults with respiratory disease such as asthma or COPD^{17–23}. Receiving care from specialists was found to reduce ED visits among an asthma population^{17–19,22}. However, previous studies were targeting a severe asthma population such as those who were hospitalized at baseline²², or those who visited ED¹⁸. Also, they were targeting local area such as Carolina or California^{17,19}.

The objective of our study aims to estimate the contributors to the hospital/ED visits among adults with asthma based upon Andersen's behavioral model²⁷. A specific contributor to be estimated is the availability of healthcare providers based on nationally representative survey data. We hypothesized that the improved availability or accessibility of healthcare providers will reduce healthcare utilization since limited accessibility to healthcare providers may delay appropriate care of asthma. Since the survey data included a broader selection of individuals with asthma in the population, the results will

reveal a broader relationship between the availability of healthcare providers and utilization.

Patients and methods

Datasets

We analyzed the 2011–2013 Asthma Call-Back Survey (ACBS) dataset, which is a cross-sectional survey dataset among adults (18+ years old) conducted 2 weeks after the Behavioral Risk Factor Surveillance Survey (BRFSS)²⁸. The BRFSS is a state-based cross-sectional survey data among adults (18+ years old) in all 50 states, District of Columbia (DC), Puerto Rico, the US Virgin Islands, and Guam. Among BRFSS respondents, adult respondents with lifetime asthma were asked to participate in the follow-up telephone ACBS survey within 2 weeks of the BRFSS interview. The 2011 ACBS released landline survey data only, but 2012 and 2013 ACBSs released landline and cellphone survey data. Since 2011 ACBS landline data is comparable to 2012 and 2013 ACBS landline data, we included 2012 and 2013 ACBS landline data only for analysis²⁸. The ACBS median response rate for adult landline data was 48.4% in 2011, 47.2% in 2012, and 47.0% in 2013²⁹. The 2011, 2012 and 2013 landline data included 40 states, 37 states, and 38 states, respectively.

Based on state and county variables, the ACBS dataset was linked with the county-level 2012–2016 Area Health Resource Files (AHRF) dataset, which collected information on care providers at county level³⁰. Since 2012 ACBS data does not include a county variable, we obtained it from 2012 BRFSS data.

Study population

The final sample size for data analysis amounted to 25,621 observations (Figure 1). It was based upon 32,656

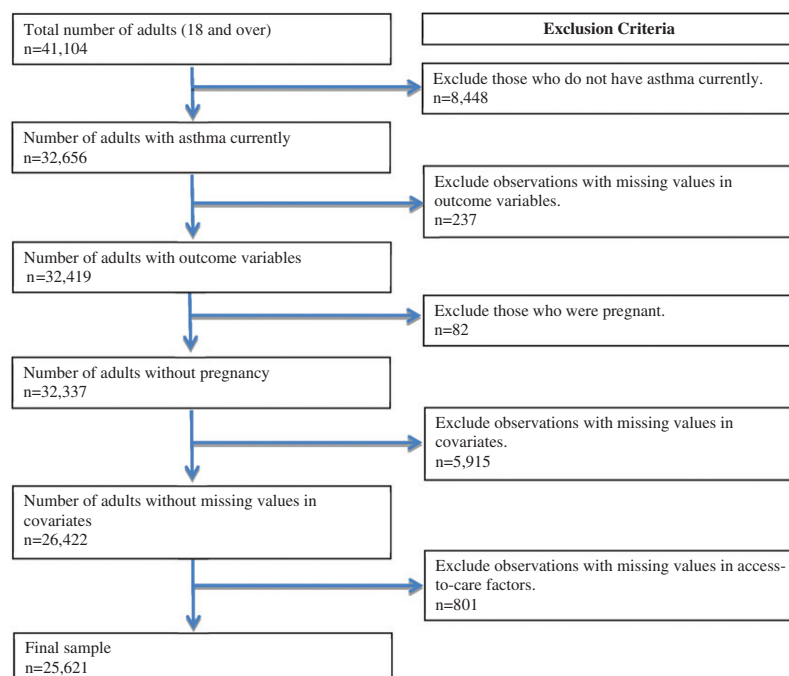


Figure 1. Sample extraction.

observations of adults with current asthma whereby the following observations were excluded: missing values in outcome variables (237 observations), women with pregnancy (82 observations), and missing in other covariates (5915 observations) and access-to-care factors (801 observations).

Statistical analysis

We conducted the pooled cross-sectional analysis using the multivariable logistic regression model where dichotomous outcome variables were asthma-related hospitalization and ED visit. ACBS collected asthma-related hospital/ED visits among adults with asthma based on the following survey questions. "During the past 12 months, have you had to stay overnight in a hospital because of your asthma?" "During the past 12 months, have you had to visit an emergency room or urgent care center because of your asthma?"

Covariates were classified into four categories according to Andersen's behavioral model²⁷: (1) predisposing characteristics, (2) need factors, (3) enabling resources, and (4) availability of healthcare system. For analysis, all potential covariates were included in the models. Key covariates were the availability of healthcare system indicating county-level care provider variables. The county-level variables included the number of lung disease specialists per 100,000 persons (including pulmonary care specialists, and allergy and immunology specialists), the number of hospitals per 100,000 persons, the number of safety-net facilities per 100,000 persons including FQHCs and RHCs, and the number of primary care physicians per 100,000 persons. The county-level variables were obtained with the calculation: county-level variables = (the number of per-county providers/county population) × 100,000. The county population has a mean value of 462,723 persons with a range of 473 persons (minimum)–10,000,000 persons (maximum).

We assumed the linear relationship between the availability of healthcare system and outcome variables since reasonable categorical classification of these variables were not available. This linearity assumption was tested in the sensitivity analyses. We combined pulmonary care specialists, and allergy and immunology specialists since we assumed that they have equal knowledge about care of asthma. Since RHCs were normally located in rural areas, we included the urban/rural variable in order to control the unobserved difference between urban and rural areas such as the quality difference in air. The survey did not include a question on whether the respondent had a usual source of care.

Predisposing characteristics included age group, gender, race, marital status, education level, smoking status, urban/rural residence, state and year. Perceived need factors included last medication period and comorbidities (heart attack, coronary heart problem, stroke, COPD, cancer, arthritis, depression, diabetes). The last medication period was obtained from the following question: "How long has it been since you last took asthma medication?" The last medication period was included as an indicator of severity of asthma. People with a shorter period since last medication (e.g. <1 day ago) were considered to have more severe asthma than those with a longer period since last medication (e.g. never or >1 year). Comorbidities were determined based on

the following self-reported questions: "Has a doctor, nurse, or other health professional ever told you that you had any of the following?"

- Heart attack, called a myocardial infarction
- Angina or coronary heart disease
- Stroke
- Any types of cancer including skin cancer
- COPD: chronic obstructive pulmonary disease, emphysema or chronic bronchitis
- Some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia
- Depressive disorder, including depression, or dysthymia
- Diabetes

The enabling resources included income level, cost barriers in seeing doctors, cost barriers in seeing specialists, and cost barriers for medication. A health insurance variable was not included because its effect was overlapping with cost barrier variables. The cost barrier variables were obtained from the following questions.

- Was there a time in the past 12 months when you needed to see your primary care doctor for your asthma but could not because of the cost?
- Was there a time in the past 12 months when you were referred to a specialist for asthma care but could not go because of the cost?
- Was there a time in the past 12 months when you needed to buy medication for your asthma but could not because of the cost?

Sensitivity analyses were conducted to examine whether any deviation from the model affects the results. The first and second sensitivity analyses checked the functional relationship between the availability of healthcare system and outcome variables. The first sensitivity analysis employed dichotomous healthcare system variables since the change from non-availability (zero) to availability (>zero) of healthcare system may have a different effect on outcomes compared to an incremental effect of availability. The second sensitivity analysis employed the quadratic form of healthcare system variables since the availability of healthcare system may have diminishing marginal effect on outcome variables. The third sensitivity analysis replaced the number of hospitals with the number of hospital beds since the number of hospital beds may be a more accurate measure of availability of hospital service.

All analyses in this study were conducted using Stata version 12 (StataCorp, College Station, TX, USA). The significance level was set to 5%. The survey command function for weighted regression was employed to reflect the complex sampling procedures.

Results

As reflected in Table 1, among 25,621 adults, 64.7% were female and 70.2% were Caucasian. The younger group

Table 1. Descriptive statistics: un-weighted/weighted $N = 25,621/16,326,325$.

Category	Variable	# of sample	Weighted mean (SD)/ proportion (%)	Hospital visit (=Yes) (χ^2 test)	ED visit (=Yes) (χ^2 test)
Outcome variables	Hospital visit				
	Yes	858	3.3		
	No	24,763	96.7		
	ED visit				
Predisposing characteristics	Yes	3387	13.2		
	No	22,234	86.8		
	Age group			$p < .001$	$p = .033$
	18–34	7283	28.4	1.3%	11.7%
	35–44	4568	17.8	2.9%	14.9%
	45–54	4989	19.5	4.6%	16.2%
	55–64	4614	18.0	4.7%	12.7%
	65+	4167	16.3	4.4%	11.1%
	Gender			$p = .002$	$p < .001$
	Male	9050	35.3	2.3%	9.6%
	Female	16,571	64.7	3.9%	15.2%
	Race			$p = .001$	$p < .001$
	Caucasian	17,976	70.2	2.8%	11.6%
	African American	3066	12.0	6.3%	20.2%
	Hispanic	2798	10.9	3.6%	13.7%
	Other races	1781	6.9	3.3%	16.8%
	Marital status			$p < .001$	$p < .001$
	Married	12,651	49.4	2.5%	11.2%
	Single	6422	25.1	2.5%	13.2%
	Divorced	3812	14.9	4.7%	18.7%
	Widowed	1919	7.5	6.3%	14.1%
	Separated	817	3.2	9.3%	17.2%
	Education			$p < .001$	$p < .001$
	Some high school	3610	14.1	7.1%	23.3%
	High school graduation	5853	22.8	3.9%	13.6%
	Some college	8987	35.1	2.8%	12.6%
	College graduation	7171	28.0	1.7%	8.6%
	Smoking status			$p = .005$	$p < .001$
	Non-smoker	20,100	78.5	3.0%	11.6%
	Current smoker	5521	21.5	4.6%	19.0%
	Urban/rural status			$p = .569$	$p = .226$
	Urban	21,059	82.2	3.3%	12.9%
	Rural	4562	17.8	3.6%	14.6%
	Year			$p = .884$	$p = .822$
	2011	8588	33.5	3.5%	13.5%
	2012	8613	33.6	3.3%	13.4%
	2013	8420	32.9	3.3%	12.7%
Availability of healthcare providers	# of lung disease specialists per 100,000 persons	25,621	4.8 (4.1)		
	# of hospitals per 100,000 persons	25,621	2.0 (2.0)		
	# of RHCs per 100,000 persons	25,621	1.4 (4.5)		
	# of FQHCs per 100,000 persons	25,621	1.9 (3.2)		
	# of PCPs per 100,000 persons	25,621	7.4 (3.0)		
Enabling resources	Cost barrier in seeing PCP			$p < .001$	$p < .001$
	Yes	3376	13.2	7.5%	25.2%
	No	22,245	86.8	2.7%	11.4%
	Cost barrier in seeing specialist			$p < .001$	$p < .001$
	Yes	1821	7.1	10.0%	32.5%
	No	23,800	92.9	2.8%	11.8%
	Cost barrier for medication			$p < .001$	$p < .001$
	Yes	4786	18.7	6.6%	23.2%
	No	20,835	81.3	2.6%	10.9%
	Annual income			$p < .001$	$p < .001$
	<\$15k	5206	20.3	6.1%	20.2%
	\$15k– <\$25k	5018	19.6	4.9%	16.6%
	\$25k– <\$35k	2641	10.3	3.6%	13.1%
	\$35k– <\$50k	2906	11.3	2.5%	11.9%
	\$50k– <\$70k	3389	13.2	1.8%	8.6%
	≥\$70k	6461	25.2	1.1%	8.1%
Needed factors	Last medication period			$p < .001$	$p < .001$
	Never or >1 year	4623	18.0	0.6%	2.7%
	<1 day ago	10,539	41.1	6.1%	20.0%
	1–6 days ago	3095	12.1	2.9%	14.3%
	1 week–3 months	4060	15.8	1.7%	11.4%

(continued)

Table 1. Continued

Category	Variable	# of sample	Weighted mean (SD)/ proportion (%)	Hospital visit (=Yes) (χ^2 test)	ED visit (=Yes) (χ^2 test)
	3 months–1 year	3304	12.9	0.9%	7.7%
	COPD			$p < .001$	$p < .001$
	Yes	9616	37.5	7.2%	22.2%
	No	16,005	62.5	1.0%	7.8%
	Myocardial infarction			$p < .001$	$p < .001$
	Yes	1800	7.0	10.2%	20.2%
	No	23,821	93.0	2.8%	12.7%
	Angina or coronary heart disease			$p < .001$	$p = .001$
	Yes	1951	7.6	9.6%	17.8%
	No	23,670	92.4	2.8%	12.8%
	Stroke			$p < .001$	$p < .001$
	Yes	1333	5.2	9.2%	22.0%
	No	24,288	94.8	3.0%	12.7%
	Arthritis			$p < .001$	$p < .001$
	Yes	10,979	42.9	5.4%	16.5%
	No	14,642	57.1	1.9%	10.8%
	Depression			$p < .001$	$p < .001$
	Yes	9168	35.8	5.4%	17.8%
	No	16,453	64.2	2.2%	10.7%
	Diabetes			$p < .001$	$p < .001$
	Yes	3924	15.3	7.1%	17.6%
	No	21,697	84.7	2.7%	12.4%
	Cancer			$p = .005$	$p = .745$
	Yes	3808	14.9	4.8%	13.6%
	No	21,813	85.1	3.1%	13.2%

State variable was included for analysis but not displayed in the table.

ED: emergency department; RHC: rural health clinic; FQHC: federally qualified health center; COPD: chronic obstructive pulmonary disease; PCP: primary care physician.

(aged <55) was representative of 65.7% of the population studied. Adults with cost barriers in seeing PCPs, in seeing specialists and for medication were 13.2%, 7.1% and 18.7%, respectively. The proportions of hospital visits and ED visits were 3.3% and 13.2%, respectively. The risk of hospitalization and ED visits generally went up with age, but the oldest people surveyed were not at as great a risk as the slightly younger age groups.

The availability of healthcare providers partially affected healthcare utilization as shown in Table 2. An additional RHC per 100,000 persons reduced by 3% the odds of having an ED visit (odds ratio [OR] = 0.97, $p = .004$), which corresponds to a reduction of 0.34 percentage point (pp) in the probability of having an ED visit. The availabilities of other healthcare providers were not associated with hospital or ED visits. On the other hand, the cost barriers in enabling resources were closely associated with hospital and ED visits. For instance, patients with cost barriers in seeing a PCP were 60% (OR = 1.60, $p = .028$) more likely to have a hospital visit than those without. In addition, patients with cost barriers in seeing a specialist were 90% (OR = 1.90, $p = .007$) and 111% (OR = 2.11, $p = .001$) more likely to have hospital visits and ED visits, respectively, than those without.

The perceived need factors were strongly associated with hospital and ED visits. People with severe asthma were more likely to have hospital and ED visits than those with mild asthma. For instance, people taking medication <1 day ago were 724% and 796% more likely to have hospital and ED visits than the reference group (never or >1 year period), respectively (all $p < .001$). This effect decreased as the period

since taking medication increased as an increased period indicates decreased severity of asthma. Some comorbidities were associated with hospital and ED visits. Patients with COPD, myocardial infarction and depression were 252%, 57%, and 41% more likely to have hospitalization than those without (all $p < .05$). In addition, patients with COPD were 166% ($p < .001$) more likely to have ED visit than those without.

On the other hand, disparities were found in hospital and ED visits among predisposing characteristics. Patients who were 55+ years old were 41–49% less likely to have an ED visit than those who were 18–34 years old ($p < .05$). Males were 37% less likely to have an ED visit than females ($p < .001$). In addition, African Americans were 112% and 68% more likely to have hospitalizations and ED visits, respectively, than Caucasians (all $p < .05$).

The results of the sensitivity analyses in Table 3 were consistent with those of Table 2. For the first sensitivity analysis with dichotomous healthcare system variables, people with RHCs in their county were 22% (OR = 0.78, $p = .045$) less likely to get ED visits than those without RHCs. In addition, people with hospitals in their county were 50% (OR = 0.50, $p = .44$) less likely to get hospital visits than those without hospitals. Other factors related to healthcare providers were not associated with hospital and ED visits.

For the second sensitivity analysis with quadratic forms of healthcare system variables in Table 3, the RHC variable and its square term were statistically significant (all $p < .05$) indicating the diminishing marginal effect of RHCs on ED visits. As shown in Table 4, an additional RHC at RHC = 1.4 (mean

Table 2. Results of adjusted logistic regression (un-weighted/weighted $N = 25,621/16,326,325$).

Outcomes Covariates (reference group)	Hospital visit				ED visit			
	OR	$p > t $	95% CI		OR	$p > t $	95% CI	
Availability of healthcare providers								
Lung disease specialists per 100,000 persons	0.99	0.735	0.94	1.04	1.03	0.135	0.99	1.06
Hospitals per 100,000 persons	1.02	0.561	0.96	1.08	1.02	0.301	0.98	1.07
RHCs per 100,000 persons	0.99	0.356	0.97	1.01	0.97	0.004*	0.94	0.99
FQHCs per 100,000 persons	0.99	0.711	0.97	1.02	0.99	0.605	0.97	1.02
PCPs per 100,000 persons	1.01	0.745	0.94	1.09	0.96	0.082	0.91	1.01
Predisposing characteristics								
Age group (18–34)								
35–44	1.41	0.388	0.65	3.07	1.00	0.987	0.68	1.46
45–54	1.50	0.299	0.70	3.23	0.81	0.262	0.57	1.17
55–64	1.43	0.369	0.65	3.14	0.59	0.006*	0.41	0.86
65+	1.29	0.533	0.58	2.84	0.51	0.001*	0.35	0.75
Male	0.70	0.056	0.48	1.01	0.63	<0.001*	0.49	0.80
Race (Caucasian)								
African American	2.12	0.001*	1.37	3.29	1.68	0.006*	1.16	2.44
Hispanic	1.61	0.139	0.86	3.02	1.07	0.737	0.71	1.63
Other races	1.05	0.857	0.61	1.82	1.57	0.024*	1.06	2.33
Marital status (married)								
Single	1.10	0.725	0.65	1.87	1.11	0.573	0.78	1.57
Divorced	0.89	0.584	0.59	1.35	1.11	0.479	0.83	1.49
Widowed	1.17	0.450	0.77	1.78	0.91	0.503	0.68	1.21
Separated	1.95	0.036*	1.04	3.63	0.85	0.456	0.55	1.31
Education (some high school)								
High school graduation	0.84	0.406	0.56	1.27	0.68	0.017*	0.49	0.93
Some college	0.73	0.169	0.47	1.14	0.65	0.010*	0.47	0.90
College graduation	0.76	0.290	0.46	1.26	0.62	0.008*	0.43	0.88
Smoker	0.76	0.153	0.52	1.11	1.02	0.883	0.80	1.30
Urban	1.30	0.174	0.89	1.91	1.01	0.924	0.75	1.37
Year (2011)								
2012	0.90	0.543	0.65	1.26	0.92	0.513	0.73	1.17
2013	0.87	0.445	0.62	1.24	0.94	0.624	0.75	1.19
Enabling resources								
Cost barriers in seeing PCP	1.60	0.028*	1.05	2.44	1.28	0.161	0.91	1.81
Cost barriers in seeing specialist	1.90	0.007*	1.19	3.03	2.11	0.001*	1.34	3.33
Cost barriers for medication	1.09	0.645	0.75	1.58	1.13	0.362	0.87	1.47
Annual income (\$35k– <\$50k)								
<\$15k	1.20	0.531	0.68	2.13	1.02	0.916	0.70	1.49
\$15k– <\$25k	1.15	0.595	0.68	1.95	1.00	0.984	0.72	1.41
\$25k– <\$35k	1.21	0.528	0.67	2.16	0.96	0.835	0.66	1.39
\$50k– <\$70k	0.99	0.971	0.53	1.85	0.85	0.385	0.60	1.22
≥\$70k	0.85	0.679	0.40	1.80	0.91	0.633	0.63	1.32
Needed factors								
Last medication period (never or >1 year)								
<1 day ago	8.24	<0.001*	4.49	15.13	8.96	<0.001*	4.92	16.31
1–6 days ago	3.80	0.001*	1.69	8.51	5.49	<0.001*	2.85	10.58
1 week–3 months	3.02	0.002*	1.51	6.05	4.84	<0.001*	2.64	8.89
3 month–1 year	1.99	0.081	0.92	4.31	3.58	<0.001*	1.86	6.91
Comorbidities								
COPD	3.52	<0.001*	2.40	5.16	2.66	<0.001*	2.04	3.45
Myocardial infarction	1.57	0.005*	1.15	2.13	1.22	0.243	0.87	1.72
Angina or coronary heart disease	1.41	0.035*	1.02	1.94	0.94	0.670	0.69	1.27
Stroke	1.08	0.672	0.76	1.52	1.10	0.539	0.81	1.48
Arthritis	1.26	0.205	0.88	1.79	1.12	0.324	0.90	1.39
Depression	1.57	0.002*	1.17	2.11	1.21	0.080	0.98	1.50
Diabetes	1.27	0.147	0.92	1.74	0.97	0.795	0.76	1.23
Cancer	1.02	0.909	0.74	1.39	0.87	0.293	0.68	1.12
Constant	1.8E-03	<0.001*	5.5E-04	0.01	0.04	<0.001*	0.01	0.10

State variable was included for analysis but not displayed in the table.

ED: emergency department; RHC: rural health clinic; FQHC: federally qualified health center; COPD: chronic obstructive pulmonary disease; NA: not applicable; OR: odds ratio.

Marginal effect of RHC for ED visit outcome: -0.34 percentage point ($p = .004$).

* $p < .05$.

reduced the probability of having an ED visit by 0.43 pp, but its effect on the probability of having an ED visit diminished as the number of RHCs increased.

For the third sensitivity analysis by replacing the number of hospitals with the number of hospital beds in Table 3, hospital beds did not show any association with hospitalization and ED visits. This result was consistent with Table 2

showing that the number of hospitals was not associated with outcome variables.

Discussion

This study investigated factors associated with hospital and ED visits among adults with asthma. The results showed that

Table 3. Sensitivity analyses of adjusted logistic regression (un-weighted/weighted $N = 25,621/16,326,325$).

Outcomes	Hospital visit				ED visit			
Covariates (reference group)	OR	$p > t $	95% CI		OR	$p > t $	95% CI	
First sensitivity analysis: dichotomous healthcare system variables								
Availability of healthcare providers								
Existence of lung disease specialists per 100,000 persons	1.11	0.677	0.68	1.83	1.07	0.718	0.75	1.51
Existence of hospitals per 100,000 persons	0.50	0.044*	0.26	0.98	1.15	0.578	0.70	1.88
Existence of RHCs per 100,000 persons	1.19	0.337	0.84	1.68	0.78	0.045*	0.60	0.99
Existence of FQHCs per 100,000 persons	1.24	0.227	0.87	1.77	1.10	0.527	0.81	1.50
Existence of PCPs per 100,000 persons	1.10	0.622	0.74	1.64	0.85	0.255	0.65	1.12
Second sensitivity analysis: quadratic forms of healthcare system variables								
Availability of healthcare providers								
Lung disease specialists per 100,000 persons	1.02	0.776	0.91	1.13	1.04	0.285	0.97	1.12
Square term	1.00	0.570	0.99	1.00	1.00	0.607	1.00	1.00
Hospitals per 100,000 persons	1.01	0.769	0.93	1.10	1.05	0.261	0.97	1.13
Square term	1.00	0.681	1.00	1.00	1.00	0.424	1.00	1.00
RHCs per 100,000 persons	0.99	0.613	0.96	1.03	0.95	0.002*	0.93	0.98
Square term	1.00	0.975	1.00	1.00	1.00	0.003*	1.00	1.00
FQHCs per 100,000 persons	1.03	0.351	0.96	1.11	1.00	0.929	0.96	1.04
Square term	1.00	0.211	1.00	1.00	1.00	0.732	1.00	1.00
PCPs per 100,000 persons	1.04	0.689	0.86	1.26	0.91	0.179	0.80	1.04
Square term	1.00	0.716	0.99	1.01	1.00	0.420	1.00	1.01
Third sensitivity analysis: use the number of hospital beds instead of the number of hospitals								
Availability of healthcare providers								
Lung disease specialists per 100,000 persons	0.99	0.706	0.94	1.04	1.03	0.146	0.99	1.06
Hospital beds per 100,000 persons	1.00	0.885	1.00	1.00	1.00	0.822	1.00	1.00
RHCs per 100,000 persons	0.99	0.425	0.97	1.01	0.97	0.006*	0.95	0.99
FQHCs per 100,000 persons	1.00	0.741	0.97	1.02	0.99	0.670	0.97	1.02
PCPs per 100,000 persons	1.01	0.713	0.94	1.09	0.96	0.097	0.91	1.01

ED: emergency department; RHC: rural health clinic; FQHC: federally qualified health center; COPD: chronic obstructive pulmonary disease; PCP: primary care physician; OR: odds ratio.

* $p < .05$.

Table 4. Marginal effects of RHCs on ED visits (from second sensitivity analysis: quadratic form of RHC variable in Table 3).

Outcome	ED visit		
	dy/dx	95% CI	
Marginal effect of RHCs at RHC =			
Mean (1.4)	−0.43 pp	−0.70 pp	−0.16 pp
0	−0.45 pp	−0.74 pp	−0.16 pp
1	−0.43 pp	−0.71 pp	−0.16 pp
2	−0.41 pp	−0.67 pp	−0.16 pp
3	−0.40 pp	−0.64 pp	−0.16 pp
4	−0.38 pp	−0.60 pp	−0.16 pp
5	−0.36 pp	−0.57 pp	−0.15 pp
6	−0.35 pp	−0.54 pp	−0.15 pp
7	−0.33 pp	−0.51 pp	−0.15 pp
8	−0.32 pp	−0.48 pp	−0.15 pp
9	−0.30 pp	−0.46 pp	−0.15 pp
10	−0.29 pp	−0.43 pp	−0.15 pp

RHC: rural health clinic; pp: percentage point; ED: emergency department.

the availability of healthcare providers was partially associated with ED visits. Only RHCs were negatively related with ED visits. This association was consistent in diverse functional relation models such as linear model, quadratic model and dichotomous model. However, other healthcare providers were not associated with healthcare utilizations among adults with asthma. A potential explanation on why the availability of most healthcare providers (except for RHCs) was not associated with hospital and ED visits is that it is due to small proportions of hospital and ED visits among the total observations as shown in Table 1. The small proportions suggest that asthma was well controlled among the broad asthma population.

Financial barriers were closely associated with hospital and ED visits. Among enabling resources, cost barriers to

specialists and PCPs were strongly influential on increasing hospital and ED visits.

The plausible reason for why financial barriers are influential on hospital and ED visits is because financial barriers may prevent good control of asthma, resulting in hospital and ED visits¹⁵. Our results demonstrating that a reduction of ED visits resulted from an additional RHC is supportive since RHCs are safety-net facilities solving financial barriers among a financially disadvantaged population.

As external validity, the availability of providers was not consistent with previous studies^{17–19,22}, showing that specialists were associated with reducing ED visits. The plausible reason for inconsistency with previous studies is due to the different target population. Our study targeted general adults with asthma, while the previous studies targeted asthma patients who already had hospitalizations. That is to say, the samples in previous studies contained a more risky population with more severe asthma disease than in our sample. However, comorbidity, age, gender and racial disparities were consistent with previous studies^{10,31,32}.

Our study showed the size of influence in the following order: (1) need factors, (2) enabling resources, (3) predisposing characteristics, and (4) availability of healthcare providers. Although need factors had strong associations with hospitalizations and ED visits, these factors indicate the asthma population to be vulnerable to hospital and ED visits.

Limitations

This study has several limitations. The first limitation is that the ACBS survey missed 11 states (Alaska, Arkansas,

Colorado, Delaware, Idaho, Minnesota, South Carolina, South Dakota, Tennessee, Virginia and Wyoming). However, from a population perspective, the above 11 states occupied only 12% of the 2015 US population³³; 88% of the US population in the included states will be sufficient to represent the US population. The second limitation is no direct measure on whether patients visited specialists. We assumed that the county-level population-weighted number of healthcare providers would be a good proxy to the availability of healthcare providers but not of utilization. The third limitation is that BRFSS ACBS coded counties with <50 respondents and with ≤10,000 population as “missing”, which restricted the examination of counties with the lowest level of healthcare resources²⁸. In the 2011–2013 ACBS data, 1207 observations (2.94% out of 41,104 observations) were coded as “missing”, which is a relatively small percentage. The fourth limitation is that all the participants of this study had landlines and agreed to participate in the survey. The study results may not be generalizable to the population who no longer had landlines or chose not to participate in the survey.

The fifth limitation is that around 20% of the sample was dropped due to missing values. As shown in Supplementary Online Appendix Table A, the excluded sample participants were more likely to have been younger, non-white, less educated, to have been interviewed in the later dates of this study, and clearly had less severe asthma because they were much more likely to have answered never or >1 year for the last medication period. The excluded population was also less likely to have had cost barriers in seeing their PCPs and for receiving medications. The excluded patients could have had fewer ED visits or hospitalizations (because they were healthy) yet still seemed to have some cost barriers.

Conclusion and policy implications

We found that hospital and ED visits among adults with asthma were partially related to the availability of providers, and more related to financial barriers. Only RHC availability was associated with reducing ED visits. The existence of financial barriers in seeing a PCP or specialist, and for medication was positively associated with hospital or ED visits. Therefore, financial support for the vulnerable asthma population might be a target for policy makers interested in reducing hospitalizations and ED visits.

Transparency

Declaration of funding

This study was not funded.

Declaration of financial/other relationships

M.K., W.T., and J.R. have disclosed that they have no significant relationships with or financial interests in any commercial companies related to this study or article. C.V.A. has disclosed that he is on CMRO's International Advisory Board and can freely use priority services, but he has no other relevant financial relationships to disclose.

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