Original Article

Depression and Asthma Outcomes in Older Adults: Results from the National Health and Nutrition Examination Survey

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What is already known about this topic? Depression is a prevalent comorbidity among older adults with asthma. There are no nationally representative studies describing the association of depression on key asthma outcomes such as emergency department (ED) visits among older adults.

What does this article add to our knowledge? Data from the National Health and Nutrition Examination Survey survey (2007-2012) were analyzed. This study shows that older adults with asthma and depression are twice as likely to have asthma-related ED/urgent care visits, sleep disturbances, and decreased health-related quality of life.

How does this study impact current management guidelines? The management of asthma in the context of depression is not well understood. Early diagnosis through routine screening for depression in older adults with asthma and proper treatment may improve asthma outcomes in this population.

BACKGROUND: Older adults have high rates of asthma morbidity and mortality, as well as increased rates of depression. There are no nationally representative studies describing the association of depression on key asthma outcomes such as emergency department (ED) visits among older adults.
OBJECTIVE: The objective of this study was to determine the association of depression with asthma outcomes in older adults (age ≥ 55) from the National Health and Nutrition Examination Survey (NHANES).
METHODS: Data from the NHANES survey (2007-2012) were analyzed. Bivariate analyses and multivariate Poisson regression models were used to examine associations between depression and asthma outcomes among adults above the age of 55.
RESULTS: Approximately 7.01% (n = 509) of the sample reported a physician diagnosis of asthma. Older adults with asthma and depression (n = 196) had increased asthma episodes (prevalence ratio [PR], 1.53; 95% confidence interval [CI], 1.00-2.35), ED/urgent care visits for asthma (PR, 2.24; 95% CI, 1.15-4.34), sleep disturbances due to asthma (PR 2.75; 95% CI, 1.54-4.92), and activity limitation (PR, 1.77; 95% CI, 1.00-3.18; $P = .05$) compared with older asthmatics without depression. They also reported worse health-related quality of life measures across 4 domains including days of poor general health, physical health, mental health, and inactivity ($P < .001$ for all). No significant differences in spirometric values were observed.
CONCLUSIONS: Older adults with asthma and depression are nearly twice as likely to have poor asthma outcomes across several indicators, including asthma-related ED/urgent care visits compared with those without depression. Screening for depression and providing supportive resources may decrease the burden of asthma among older adults. © 2017 American Academy of Allergy, Asthma & Immunology (J Allergy Clin Immunol Pract 2017;■:■-■)

Key words: *Asthma; Depression; Older adults; Asthma with depression; Spirometry; NHANES; Asthma outcomes; Emergency department visits; Health-related quality of life*

Asthma is commonly thought of as a disease of children and young adults, yet a significant percentage (4% to 13%) of the older adult population in the United States is affected.[1] Unfortunately, morbidity and mortality rates are often highest among elderly patients with asthma, with one study noting a 3-fold increase in the death rate among older patients in comparison with younger patients.[2-6]

Depression is a prevalent comorbidity among older adults with asthma.[7,8] Small cohort studies have observed that depression can have an adverse impact on self-management and subsequent asthma outcomes. Co-occurring depression with asthma among older adults results in lower rates of adherence to controller medications, and rescue inhalers, and decreased asthma control and quality-of-life measures.[9-11] However, these studies either had a small sample size[10] or studied inner city

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Abbreviations used
BMI- *Body mass index*
CI- *Confidence interval*
ED- *Emergency department*
FEV1- *Forced expiratory volume at 1 second*
FVC- *Forced vital capacity*
HrQOL- *Health-related quality of life*
NCHS- *National Center for Health Statistics*
NHANES- *National Health and Nutrition Examination Survey*
PHQ-9- *9-item Patient Health Questionnaire*

patient populations,[9] and therefore lacked definitive conclusions about generalizability to key affected populations such as older adults. Further, existing studies have not examined key outcomes such as asthma hospitalizations and emergency department (ED) visits that provide critical proxies for disease control.

Previous analyses of National Health and Nutrition Examination Survey (NHANES) data support associations between obstructive lung function and increased mental health problems.[12,13] However, there is a lack of data in older adults regarding the association of depression on asthma outcomes in a large nationally representative sample. A better understanding of the association of depression among older adults with asthma outcomes will provide important information for targeting prevention and self-management support to this commonly overlooked group.

Using data from the 2007-2012 waves of NHANES data, the purpose of this study was to examine the prevalence of depression among older adults with asthma, and to assess differences in asthma outcomes among older adults with and without comorbid depression.

METHODS

Data source

The NHANES sample represents the US population of all ages, and examines a nationally representative sample of approximately 5000 civilian, noninstitutionalized persons each year. NHANES uses a 4-stage probability sampling design to select participants, which includes 15 primary stage strata with 2 primary sampling units (PSUs per strata, to total 30 PSU-equivalent units every 2-year data collection cycle). Details of the multistage sampling strategy are described elsewhere.[14] Individuals are chosen at random to participate in NHANES from a list of all persons residing in selected households, with average selection of 1.6 persons per household. African Americans, Hispanics, low-income whites, and older adults are oversampled to increase the reliability of their health status estimates. The likelihood of the same individual being interviewed twice is not explicitly stated by Centers for Disease Control and Prevention (CDC); however, it is thought to be extremely low (personal communication).

The NHANES survey collects data on demographic, socioeconomic, dietary, and health-related questions, and is conducted in the respondents' homes using computer-assisted personal interviewing. The survey was approved by the ethics review board of the National Center for Health Statistics (NCHS), and written informed consent for data collection was obtained from all adult participants.

Analytic sample

Six years (2007-2012) of NHANES survey data were pooled for the current analysis. The analytic sample includes adult men and women 55 years of age and older, which has previously been used as an age cutoff in NHANES studies for older adults.[15,16] An age cutoff of 55 years has also been used for studies of older adults with depression.[17,18] NHANES data sets from 2007-2012 were used as specific respiratory survey questions for spirometry measurement, asthma outcome measures, and Patient Health Questionnaire-9 (PHQ-9) for depression were available and consistent through those years.

Depression. Depression was assessed using the PHQ-9, a validated depression questionnaire. It is a 9-item screening instrument that asks about the frequency of symptoms of depression over the past 2 weeks. Depression severity is classified as no depression (PHQ-9 score <5), mild (PHQ-9 score 5-9), or moderate to severe (PHQ-9 score ≥ 10).[19] This is a known classification system generally used for PHQ-9.

Asthma. The presence of asthma was assessed based on positive response to the following questions: "Has a doctor or health professional ever told you that you have asthma?" and "Do you still have asthma?" Individuals with pulmonary conditions such as emphysema, chronic obstructive pulmonary disease, or chronic bronchitis were excluded from the analysis.

Asthma outcomes

Outcomes assessed included asthma symptom episodes, ED visits, sleep disturbance, activity limitation, spirometry, and health-related quality of life (HrQOL). Respiratory-specific NHANES survey questions can be accessed at: http://www.cdc.gov/asthma/survey/NHANES_2016_508.pdf.

Asthma symptom episodes. Asthma symptoms episodes were assessed by the number of wheezing episodes, through the following item: "In the past 12 months, how many attacks of wheezing or whistling have you had?" (1-12 episodes). Wheezing was defined to respondents as "breathing difficulty producing a hoarse or whistling sound" and attacks as "the occurrence of a symptom where there is an identifiable beginning and end point."

Emergency department. Health care use data were available related to ED visits through the question: "During the past 12 months, have you had a visit to the emergency room or urgent care center because of asthma?" (yes/no).

Sleep disturbance. The survey question asked: "In the past 12 months, how often, on average, has sleep been disturbed because of wheezing?" Response choices were never, less than 1 night per week, and 1 or more nights per week.

Activity limitation. The survey question asked: "During the past 12 months, how much did you limit your usual activities due to wheezing or whistling?" Responses were measured on a 5-point Likert scale ranging from "not at all" to "a lot." Based on the distribution of responses, activity limitation was collapsed into 3 categories: none, little, or frequent.

Spirometry. Data points used to assess spirometry included baseline forced expiratory volume at 1 second (FEV1) (mL), forced vital capacity (FVC) (mL), age (years), height (cm), gender, and ethnicity. The predicted spirometry values were determined using normative reference equations developed from NHANES III data by Hankinson et al.[20] Percent predicted values were calculated using baseline spirometry values and predicted spirometry values.

Health-related quality of life. HrQOL was assessed over the last 30 days. Questions included "number of days physical health was not good," "number of days mental health was not good," and "inactive days due to physical or mental health" through open-ended responses options. Total unhealthy days were calculated by adding the number of days physical and mental health was not good. The CDC HrQOL questions have undergone cognitive and validity testing and have been used in previous studies.[21]

Demographic data

Key demographic data were collected, including age, sex, marital status, race/ethnicity, educational attainment, socioeconomic status, body mass index (BMI), age of asthma diagnosis, and smoking history. Socioeconomic status was assessed through a ratio of family income and a corresponding poverty threshold, known as the income-to-needs ratio. The income-to-needs ratio was collapsed into 2 categories: poverty (income to needs ratio <2) and above poverty level (income to needs ratio ≥ 2).[22] BMI was assessed based on body weight and standing height. Smoking history was assessed via pack of cigarettes smoked per year. Chronic conditions were assessed via the self-reported history available across each cycle of data.

Statistical analysis

Analyses were computed in SAS v.9.4 (SAS Institute Inc., Cary, NC) and SUDAAN 11.1 (Research Triangle Institute, Research Triangle Park, NC). To make population inferences, all sample data were weighted before analysis as is typically done with NHANES data. When a sample is weighted in NHANES, this means that a sample weight is assigned to each sample person as a measure of the number of people in the population represented by that sample person.[14] A weighted sample is then representative of the US Census civilian noninstitutionalized population. To adjust for the NHANES complex sample design, SAS SURVEY and SUDAAN procedures were used. The data were weighted using the full sample 2-year health interview weight for NHANES. Based on recommendations from NCHS when pooling multiple years of data,[14] because 3 cycles (6 years of data) were combined for this analysis, each cycle-specific case weight was divided by 3, which produced a scaled weight across all 6 years that summed to the US population at the midpoint of the 6-year time period. Missing data were ignored given that less than 10% of missing data were observed on variables in the analysis. Statistical significance was assigned based on alpha = 0.05 or 95% confidence intervals (CIs) for estimates of population statistics.

The weighted prevalence of demographic and clinical characteristics, comorbidities (see Tables E1 and E2 in this article's Online Repository at www.jaci-inpractice.org), and adverse asthma outcomes (asthma symptoms, sleep disturbances, activity limitation, ED/urgent office visits, HrQOL, spirometry) in the US population with asthma without depression (PHQ-9 <5), and asthma with depression (PHQ-9 ≥ 5) were estimated using SAS V9.4 Survey procedures. The weighted prevalence of asthma outcomes was also examined across depression severity classification (asthma without depression [PHQ-9 <5], asthma with mild depression [PHQ-9 5-9], and asthma with moderate-to-severe depression [PHQ-9 ≥ 10]; see Tables E1 and E2). Estimates for older adult with asthma with and without comorbid depression were compared using a Student's *t*-test or chi-square tests of independence with the Rao-Scott complex sample design adjustment.

Multivariate Poisson regression (log link, Poisson pseudo likelihood) with the SUDAAN ProcLoglink procedure was used to estimate the prevalence ratio (relative risk) of the presence of depression (PHQ-9 ≥ 5) on adverse asthma outcomes (asthma symptoms, sleep disturbances, activity limitation, ED visits, urgent office visits, HrQOL, and spirometry). The Taylor series linearization method was used to compute robust estimates of standard errors for the Poisson regression coefficients and CIs for the corresponding prevalence ratio estimates. All models were estimated using the NHANES analysis weight and were adjusted for age, sex, marital status, educational attainment, socioeconomic status, years living with asthma, number of chronic conditions, race, and body mass index.

RESULTS

Sample

The overall unweighted interview response rate was 75.4% (n = 9,762) in 2007-2008, 77.3% (n = 10,253) in 2009-2010, and 69.5% (n = 9,338) in 2011-2012. The final unweighted sample interviewed between 2007 and 2012 comprised 29,353 individuals, of whom 7,256 individuals were older than 55 years. Of this group, approximately 7.01% (n = 509) of individuals 55 years and older reported current asthma; of these individuals, 38.5% (n = 196) also reported depressive symptoms. Of those with depression, 57.7% (n = 113) reported mild depressive symptoms and 42.3% (n = 83) reported moderate-to-severe depressive symptoms.

Weighted estimates of demographic characteristics of the sample stratified by individuals with asthma only and asthma with depression are presented in Table I. No significant mean age or gender differences were evident among those with asthma and asthma with depression. More Mexican/Hispanic (9.2% vs 4.8%, $P = .004$) and black (11.7% vs 9.2%, $P = .004$) older adults reported asthma and depression compared with those with asthma without depression. Individuals with asthma and depression included a higher proportion with lower education level, obesity (mean BMI of 32.3 vs 30.1, $P = .01$), and who were unmarried (53.1% married vs 68.5%, $P = .002$), and met federal guidelines for poverty (57.6% vs 29.7%, $P \leq .001$) compared with individuals with asthma without depression. They also had a greater mean number of other chronic conditions (2.5 vs 1.9, $P = .001$) (see Table E1 in this article's Online Repository at www.jaci-inpractice.org for the prevalence of specific chronic conditions among those with asthma with and without depression).

Prevalence of asthma outcomes among older adults with asthma with and without depression

The weighted prevalence of asthma outcomes in older adults with asthma with and without depression is reported in Table II. Those with depression reported a higher mean number of asthma symptom episodes in the last 12 months (6.6 vs 5.08; $P = .05$) and nocturnal awakening with more than 1 night per week (49.3% vs 19.3%; $P \leq .001$) (Figure 1). They were also far more likely to have required a visit to the ED/urgent care for asthma in the last 12 months, with 28.1% of those with asthma and depression reporting such an event compared with 11.5% of those without depression ($P \leq .001$) (Figure 1).

HrQOL measures were significantly impaired in all 4 domains (see Table II) in individuals with asthma and depression. No significant difference was noted in spirometry findings of percent predicted FEV1, FVC, and FEV1/FVC between groups.

Regression analysis for asthma outcomes

Table III shows the results of weighted Poisson regression models of the likelihood of adverse asthma outcomes among

TABLE I. Weighted demographic and clinical characteristics of the US population 55+ years in age with asthma (n = 509) with and without depression

Factor	Asthma without depression (n = 313)	Asthma with depression (n = 196)	*P* value
Age, mean [95% CI]	65.23 [63.97 to 66.49]	65.23 [63.79 to 66.66]	.99
Male	42.91 [34.59 to 51.23]	32.72 [25.23 to 40.23]	.062
Married	68.47 [63.36 to 73.59]	53.10 [41.78 to 64.43]	**.002**
Race/ethnicity			**.004**
Mexican/other Hispanic white	4.82 [2.83 to 6.82]	9.28 [5.32 to 13.24]	
White	83.06 [77.26 to 88.56]	71.78 [62.22 to 81.34]	
Black	9.26 [5.41 to 13.11]	11.71 [6.13 to 17.30]	
Other	2.86 [0.62 to 5.08]	7.22 [2.82 to 11.62]	
Education			**≤.001**
<High school	17.30 [11.15 to 23.46]	31.26 [21.24 to 41.28]	
High school or GED	20.38 [13.32 to 27.46]	32.23 [22.03 to 42.43]	
Some college or associates degree	27.84 [21.97 to 33.72]	24.27 [17.62 to 30.92]	
College or above	34.47 [25.78 to 43.16]	12.24 [4.91 to 19.56]	
Income-to-needs ratio, mean [95% CI]	3.33 [2.89 to 3.76]	2.31 [1.89 to 2.73]	**.001**
Poverty	29.67 [19.46 to 39.87]	57.56 [46.41 to 68.71]	**≤.001**
Above poverty level	70.33 [60.13 to 80.54]	42.44 [31.29 to 53.59]	**≤.001**
BMI, mean [95% CI]	30.10 [29.32 to 30.89]	32.29 [30.66 to 33.93]	**.01**
Number of other chronic conditions, mean [95% CI]	1.92 [1.68 to 2.15]	2.53 [2.29 to 2.77]	**.001**
Age of asthma diagnosis, mean [95% CI]	35.95 [32.15 to 39.75]	41.47 [37.99 to 44.95]	**.04**
Cigarette smoking (packs per year)	50.49 [37.89 to 63.09]	54.16 [36.76 to 71.56]	.73

BMI, Body mass index; *CI*, confidence interval; *GED*, general educational development.
Data is presented as % [95% CI], unless otherwise indicated. Bold indicates statistical significance ($P \leq .05$).

TABLE II. Weighted prevalence of asthma outcomes in older adults with asthma (n = 509) with and without depression

Variables	Asthma without depression (n = 313)	Asthma with depression (n = 196)	*P* value
Asthma symptom episodes, mean [95% CI]	5.08 [4.13 to 6.02]	6.60 [5.23 to 7.97]	**.05**
Emergency department visit in the last 12 mo, % [95% CI]	11.48 [6.97 to 15.98]	28.10 [19.61 to 36.57]	**≤.001**
Sleep disturbance, % [95% CI]			**≤.001**
Never	53.71 [40.64 to 66.79]	33.62 [25.40 to 41.84]	
One or more nights per week	19.32 [12.26 to 26.39]	49.33 [38.95 to 59.70]	
Less than one night per week	26.96 [13.65 to 40.27]	17.05 [9.88 to 24.21]	
Activity limitation, % [95% CI]			.09
None	49.37 [37.57 to 61.18]	39.70 [27.07 to 52.33]	
A little	23.97 [14.64 to 33.29]	15.82 [7.75 to 23.88]	
Frequent	26.66 [15.98 to 37.34]	44.48 [32.88 to 56.08]	
Health-related quality of life, mean [95% CI]			
Unhealthy days	6.34 [4.79 to 7.96]	18.45 [15.73 to 21.18]	**.001**
Days physical health was not good	5.14 [3.63 to 6.65]	13.78 [11.00 to 16.56]	**.001**
Days mental health was not good	1.42 [0.96 to 1.88]	10.60 [8.52 to 12.67]	**.001**
Inactive days due to health	2.14 [1.09 to 3.18]	10.15 [7.68 to 12.63]	**.001**
Spirometry			
FEV1% predicted	83.71 [78.54 to 88.88]	78.95 [73.31 to 84.60]	.266
FVC% predicted	91.34 [87.62 to 95.05]	86.96 [81.63 to 92.30]	.218
FEV1/FVC% predicted	90.86 [87.99 to 93.73]	90.07 [86.09 to 94.04]	.739

CI, Confidence interval; *FEV1*, forced expiratory volume at 1 s; *FVC*, forced vital capacity.
Data is presented as % [95% CI], unless otherwise indicated. Bold indicates statistical significance ($P \leq .05$).

older adults with asthma with increasing depressive symptoms. Individuals with depressive symptoms were associated with a greater likelihood of asthma symptom episodes (PR, 1.53; 95% CI, 1.0-2.35), ED/urgent care visits for asthma (PR, 2.24; 95% CI, 1.15-4.34), sleep disturbances (PR, 2.75; 95% CI, 1.54-4.92), and activity limitation (PR, 1.77; 95% CI, 1.00-3.18). Depressive symptoms were also associated with worse HrQOL through multiple measures. This included the number of unhealthy days (PR, 2.34; 95% CI, 1.67-3.29), days physical health was not good (PR, 2.11; 95% CI, 1.44-3.09),

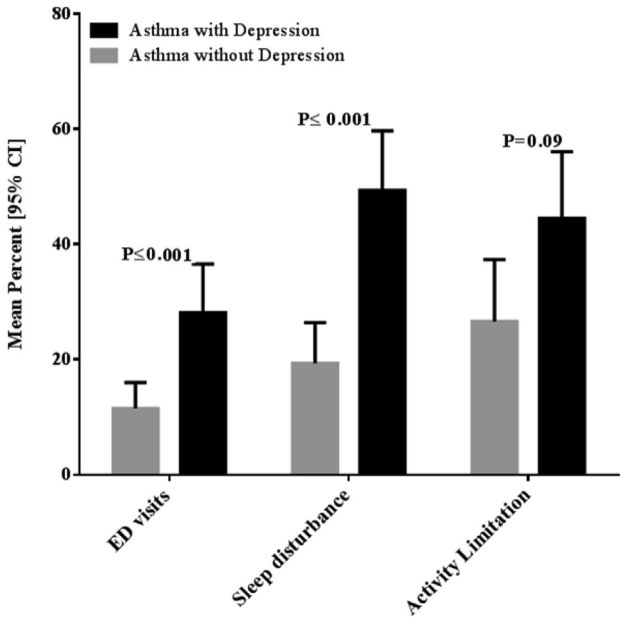

FIGURE 1. Weighted prevalence of ED visits, any sleep disturbance (1 or more night per week), and frequent activity limitation in older adults with asthma in the last 12 months. *CI*, Confidence interval; *ED*, emergency department.

days mental health was not good (PR, 6.3; 95% CI, 4.10-9.64), and inactive days due to health (PR, 3.36; 95% CI, 1.95-5.81). No significant differences in spirometric values were observed.

Prevalence of asthma outcomes by depression severity

Poor asthma outcomes were noted with worsening depression severity stratification (Table E2, available in this article's Online Repository at www.jaci-inpractice.org). Frequent activity limitation progressively increased as the severity of depression increased. ED visits were also noted to be higher for mild (PR, 28.05; 95% CI, 15.50-40.61) and moderate-to-severe depression (PR, 28.13; 95% CI, 14.25-42.0). Sleep disturbance of 1 of more nights per week was significantly higher with mild depression (PR, 46.51; 95% CI, 31.47-61.55).

Older adults with asthma and moderate-to-severe depression also had slightly higher FEV1/FVC% predicted (96.69%, $P < .01$) and poor HrQOL compared with those with milder forms of depression.

DISCUSSION

This study is the first to describe the role of depression on poor asthma outcomes among a large, nationally representative sample of older adults. We found that more than one third of older adults with asthma had depression. Older adults with asthma and depression reported a lower socioeconomic position across several indicators and worse overall health and asthma-related control compared with those with asthma only. Most concerning, older adults with asthma and depression are twice as likely to have ED/urgent care visits for asthma compared with those without depression. These findings were noted despite being controlled for age, gender, marital status, educational attainment, socioeconomic status, years living with asthma, BMI, race, and number of comorbidities.

TABLE III. Weighted adjusted multivariate regression models of depressive symptoms predicting asthma outcomes among older adults with asthma (n = 509)

Adverse asthma outcomes in the last 12 mo	Adjusted prevalence ratio of increasing depressive symptoms with asthma* Estimate [95% CI]	*P* value
Asthma symptom episodes	1.53 [1.00 to 2.35]	**.04**
Emergency department visits for asthma	2.24 [1.15 to 4.34]	**.01**
Sleep disturbances	2.75 [1.54 to 4.92]	**.001**
Frequent activity limitation	1.77 [1.00 to 3.18]	**.05**
Health-related quality of life		
Unhealthy days	2.34 [1.67 to 3.29]	**.001**
Days physical health was not good	2.11 [1.44 to 3.09]	**.001**
Days mental health was not good	6.29 [4.10 to 9.64]	**.001**
Inactive days due to health	3.36 [1.95 to 5.81]	**.001**
Spirometry		
FEV1% predicted	1.00 [0.91 to 1.10]	.99
FVC% predicted	1.02 [0.96 to 1.09]	.51
FEV1/FVC% predicted	0.98 [0.92 to 1.04]	.42

CI, Confidence interval; *FEV1*, forced expiratory volume at 1 s; *FVC*, forced vital capacity; *PHQ-9*, 9-item Patient Health Questionnaire.
Models adjusted for age, sex, marital status, educational attainment, socioeconomic status, years living with asthma, number of other chronic conditions, race, and body mass index. Bold indicates statistical significance ($P \leq .05$).
*Depression was modeled as a dichotomous variable: asthma without depression (PHQ-9 score <5), and asthma with depression (PHQ-9 score ≥5).

A previous NHANES study reported the prevalence of depression in US adults (>18 years) of 21.6% (PHQ-9 ≥5).[13] Our study found that the prevalence of older adults with asthma and depression was 38.5%, which is nearly double. This is the first study to identify that older adults with asthma and depression were more likely to report asthma-related ED/urgent care use compared with those without depression in a large nationally representative sample, even after controlling for confounding factors in regression analysis. Previous studies that reported similar findings have had methodological limitations in showing an association between increased asthma-related ED/urgent care use among those with comorbid depression. For example, in one study (n = 317; of those 55 had depression), Krauskopf et al[9] reported an association between depressive symptoms and inpatient resource utilization (included ED visits) on an unadjusted analysis. However, in adjusted analysis, the association was lost. Similarly, in our previous study of 70 older adults with asthma, we were unable to find a statistically significant relationship between asthma-related ED visits and depression—again possibly due to the smaller sample size.[10]

We found that although older adults with asthma and depression had poor asthma outcomes and HrQOL measures, they did not have significantly different spirometry measurements. This differs from studies among all adult asthma subjects that have suggested an association of objective obstructive lung function findings with increased mental health problems.[12,13] A recent NHANES data analysis (2007-2012) suggests reduced bronchodilator response in adults aged 18 years and above with

asthma and major depression.[13] Our study focused on older adults, and we did not find an association between spirometric measurements and the general presence of depression with asthma. In fact, we found that those with moderate-to-severe depression had a slightly higher FEV1/FVC% predicted in the context of poor HrQOL and asthma outcomes. A previous prospective study among older adults with asthma showed similar results, where spirometry and exhaled nitric oxide results were not predictors for asthma quality of life or asthma control.[10] This suggests that for older adult patients with depression, factors other than optimization of lung function may play a more important role in management of asthma. The mechanistic reasons for a differing influence of lung function in younger versus older populations is not well understood, and further research is warranted.

Similarly, the pathophysiologic influences of depression on asthma are not fully understood. There have been different theories for how depression may affect asthma. Depression is known to precipitate an abnormal immune response, with increased production of proinflammatory cytokines IL1 and IL6, increased airway inflammation, and reduced response to short-acting β_2-agonist in individuals with asthma.[23-25] This may be related to dysregulation of the hypothalamic pituitary axis and the autonomic nervous system in patients with depression. Adherence to medications and the inhaler technique are poor in older adults with asthma and depression, and worse in those with low health literacy.[26] These factors may contribute to worsening asthma control in older adults with asthma and depression.

Multiple chronic conditions are common in older adults, where previous studies have reported asthma to be associated with the increased prevalence of chronic conditions including heart disease, hypertension, and obesity related risk factors.[27] Rates of depression are higher for older adults with comorbid illness, where the prevalence of depression in patients with stroke, myocardial infarction, or cancer is approximately 40%.[28,29] Our study revealed that older adults with asthma and depression do not have higher incidence of other comorbidities including liver disease, gout, arthritis, hypertension, kidney disease, or cancer. However, they were noted to have a higher prevalence of diabetes and coronary heart disease when compared with older adults with only asthma. The effect of depression on these conditions and its association with asthma outcomes in older adults is not well established, and our findings suggest that further investigation is warranted.

There are several limitations to this study. Although NHANES is considered a highly reliable measure of American's health status, it excludes institutionalized individuals and those in the military. Additionally, NHANES data set lacks information on the use of antidepressant medications, medication adherence, hospitalizations, asthma controller medication use, oral corticosteroid use, short-acting bronchodilator use, and physician diagnosis of depression. The direction and mechanisms of causality between adverse asthma outcomes in patients with asthma and depression cannot be determined in a cross-sectional study. As in all health surveys, errors in recall may have affected respondent reports. Despite these limitations, one of the major strengths of the study is that the sample for the survey was selected to represent the entire US population. Furthermore, NHANES analysis is performed via standardized procedures performed by uniformly trained personnel, which included spirometry measurements.

In conclusion, we have identified that older adults with asthma and depression have a 2-fold increase in ED or urgent care visits for asthma compared with those who did not have depression. They also have multiple additional adverse asthma outcomes including increased asthma symptoms, sleep disturbance, and poor HrQOL. Importantly, these poor outcomes were identified in the context of similar spirometric values between those with and without depression. Early diagnosis through routine screening for depression in older adults with asthma and proper treatment may improve asthma outcomes in this population. Further research regarding diagnosis, screening, and management of depression in older adults with asthma is warranted.

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TABLE E1. Weighted prevalence of comorbidities in older adults with asthma (n = 509) with and without depression

Factor	Asthma without depression PHQ < 5 (n = 313)	Asthma with depression PHQ ≥ 5 (n = 196)	*P* value
Coronary heart disease	8.87 [4.31 to 13.43]	11.54 [6.97 to 16.10]	**≤.001**
Congestive heart failure	7.60 [2.41 to 12.79]	11.05 [7.20 to 14.91]	.30
Liver disease	6.12 [1.59 to 10.66]	9.67 [5.05 to 14.30]	.29
Gout	9.51 [6.48 to 12.55]	7.63 [2.95 to 12.32]	.51
Diabetes mellitus	18.65 [11.87 to 25.42]	39.39 [29.29 to 49.51]	**≤.001**
Arthritis	55.46 [45.61 to 65.31]	64.15 [54.81 to 73.48]	.22
Hypertension	55.28 [46.46 to 64.10]	68.43 [58.34 to 78.52]	.07
Kidney disease	3.53 [1.49 to 5.7]	4.75 [0.81 to 8.67]	.54
Angina	7.24 [2.81 to 11.66]	10.76 [2.47 to 15.74]	.33
Cancer	19.37 [14.27 to 24.47]	26.59 [16.83 to 36.34]	.15

CI, Confidence interval; *PHQ*, Patient Health Questionnaire.
Data are presented as % [95% CI], unless otherwise indicated. Bold indicates statistical significance ($P \leq .05$).

TABLE E2. Weighted prevalence of asthma outcomes in older adults with asthma (n = 509) and depression severity stratification

Variables	Asthma without depression (PHQ < 5) (n = 313)	Asthma and mild depression (PHQ 5-9) (n = 113)	Asthma and moderate-to-severe depression (PHQ ≥ 10) (n = 83)	*P* value
Asthma symptom episodes, mean [95% CI]	5.07 [4.13 to 6.02]	6.53 [4.46 to 8.60]	6.68 [5.07 to 8.29]	.14
Emergency department visit in the last 12 mo	11.47 [6.69 to 15.98]	28.05 [15.50 to 40.61]	28.13 [14.25 to 42.00]	**<.001**
Sleep disturbance				**<.001**
Never	53.71 [40.64 to 66.78]	34.86 [21.54 to 48.19]	32.26 [19.87 to 44.65]	
Less than 1 night per week	26.96 [13.65 to 40.27]	18.61 [8.11 to 29.12]	52.40 [35.33 to 69.47]	
One or more nights per week	19.32 [12.26 to 26.38]	46.51 [31.47 to 61.55]	15.32 [5.65 to 25.04]	
Activity limitation				**<.001**
None	49.37 [37.56 to 61.17]	46.25 [27.80 to 64.69]	32.53 [20.37 to 44.69]	
A little	23.96 [14.63 to 33.29]	23.43 [9.26 to 37.59]	7.49 [1.43 to 13.54]	
Frequent	26.66 [15.97 to 37.34]	30.31 [16.16 to 44.47]	59.97 [45.40 to 74.55]	
Health-related quality of life, mean [95% CI]				
Unhealthy days	6.37 [4.79 to 7.95]	13.87 [10.54 to 17.20]	25.66 [23.65 to 27.66]	**<.001**
Days physical health was not good	5.13 [3.62 to 6.64]	10.09 [7.31 to 12.87]	19.58 [15.34 to 23.82]	**<.001**
Days mental health was not good	1.41 [0.96 to 1.87]	6.00 [3.93 to 8.08]	17.75 [14.55 to 20.94]	**<.001**
Inactive days due to health	2.13 [1.09 to 3.17]	5.13 [3.29 to 6.96]	18.14 [13.79 to 22.50]	**<.001**
Spirometry				
FEV1 % predicted	83.70 [78.53 to 88.87]	75.47 [67.91 to 83.03]	89.09 [80.18 to 98.00]	.09
FVC % predicted	91.33 [87.62 to 95.04]	85.51 [79.58 to 91.44]	91.20 [83.07 to 99.33]	.20
FEV1/FVC % predicted	90.85 [87.99 to 93.72]	87.63 [81.87 to 93.40]	96.69 [94.41 to 98.97]	**<.01**

CI, Confidence interval; *FEV1*, forced expiratory volume at 1 s; *FVC*, forced vital capacity; *PHQ*, Patient Health Questionnaire.
Data are presented as % [95% CI], unless otherwise indicated. Bold indicates statistical significance ($P \leq .05$).