Sleep Breath (2009) 13:317–323
DOI 10.1007/s11325-009-0266-2

ORIGINAL ARTICLE

Elevated economic burden in obstructive lung disease patients with concomitant sleep apnea syndrome

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Received: 18 December 2008 / Revised: 23 February 2009 / Accepted: 23 March 2009 / Published online: 30 May 2009

Abstract
Purpose The purpose of this study is to examine the incremental economic burden of sleep apnea syndrome (SAS) among individuals with concomitant asthma, chronic obstructive pulmonary disease (COPD), or both (i.e., asthma/COPD).
Methods Maryland Medicaid claims data were used to identify beneficiaries with asthma (n=3,072), COPD (n=3,455), or both (n=2,604). We compared patient's baseline characteristics by SAS and stratified the analyses by disease cohort to examine the effect of SAS on medical utilization and cost.
Results SAS was more prevalent among beneficiaries with asthma/COPD (6.72%) than beneficiaries with COPD alone (2.87%) or asthma alone (2.15%). Asthma/COPD and COPD beneficiaries with SAS had more medical service claims (p<0.001) and higher medical cost than beneficiaries without SAS: $5,773 and $4,155 in excess costs among asthma/COPD (p=0.037) and COPD patients (p=0.035), respectively. Medical utilization and cost did not differ by SAS in asthma patients (p=0.567).
Conclusions SAS may add additional economic burden on beneficiaries who already have COPD or asthma/COPD.

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Keywords Sleep apnea syndrome · Asthma · COPD · Medicaid · Utilization · Cost

Introduction

Sleep apnea syndrome (SAS) is characterized by episodes of partial or complete breathing cessation during sleep. Obstructive sleep apnea is the most common type of SAS [1] in which the airway is collapsed or blocked during sleep, causing recurrent episodes of upper airway obstruction, accompanied by drops in oxygen saturation, sleep fragmentation, and severe snoring. According to the National Heart, Lung, and Blood Institute, 12 million US adults have SAS, and more than half of the individuals with this condition are overweight or obese [2]. African Americans, Hispanics, and Pacific Islanders are more likely to develop SAS than Caucasians [2]. The prevalence of SAS has been estimated at 0.5–9% in women and 1–24% in men, depending on the methodology, the population, and the definition of SAS employed in the study [3, 4]. SAS is often underdiagnosed but may have serious adverse consequences and, as a result, place substantial economic burdens on the individuals and the health care system. Studies have shown that SAS is associated with increased health care utilization and cost across different populations, including children [5], young adults [6], and middle-age and older adults [7]. Health care cost data from 2 years prior to the diagnosis of obstructive sleep apnea showed that middle-age (40–64 years) and elderly (65–89 years) patients had more than 1.8 times as high health care costs compared to the matched controls without obstructive sleep apnea (p< 0.001) [7]. Using data on the prevalence of undiagnosed moderate to severe SAS in middle-age adults, Kapur and

colleagues estimated that untreated SAS may cause $3.4 billion additional medical costs in the USA [8].

Evidence implicates SAS as a risk factor for other respiratory conditions such as asthma [9] and chronic obstructive pulmonary disease (COPD) [10] (which is known as the "overlap syndrome", see reference 10 for review). SAS may share common inflammatory pathways with asthma and COPD, possibly explaining part of the association. For example, in individuals with asthma, recurrent asthma exacerbations are a major cause of morbidity and health care cost, and the risk of frequent exacerbations has been shown to increase with SAS (odds ratio [OR]=3.4; 95% confidence interval [CI], 1.2–10.4) [11]. Individuals with COPD may be more likely than non-COPD individuals to experience sleep-related symptoms [12], including frequent snoring (OR=1.34; 95% CI, 1.04–1.71), breathing pauses (OR=1.46; 95% CI, 1.01–2.10), and excessive daytime sleepiness (OR=2.04; 95% CI, 1.33–3.14), which also are cardinal symptoms of SAS.

Given that SAS and other two respiratory conditions, asthma and COPD, are associated with increased health care utilization and cost [13], it is logical to assume that the presence of SAS may add incrementally to the health care burden. However, this relationship has not been demonstrated, and it remains possible that the enormous cost of asthma or COPD could "overwhelm" that of SAS, such that the incremental cost of concomitant existing disorders is not great. As the coexisting conditions are becoming increasingly important public health issues, it will be important to understand the economic impact associated with SAS. The current study employed data from the Maryland Medicaid managed care plans to examine the incremental economic burden of SAS among beneficiaries with concomitant COPD, asthma, or both. Using the Medicaid database enabled us to investigate the impact of SAS in a low-income population with a high proportion of minorities, who may be at higher risk of incurring above-average health care utilizations. We tested the hypothesis that concomitant SAS adds to the incremental health care burden and cost of patients with obstructive lung diseases (OLD, i.e., asthma, COPD, or both).

Materials and methods

Data source

Data were obtained from the Maryland Medicaid database for 2001 through 2003. These data contain all claims records for medical inpatient, outpatient, and pharmacy services submitted to the state. During the study period, there were more than 445,000 Medicaid beneficiaries, representing approximately 10% of the overall state population. The Medicaid beneficiaries were disproportionately African American (>50%) and females (>60%).

Sample

The eligible study population was comprised of Medicaid beneficiaries who were aged 40 to 64 years on the date of January 1, 2001, and were enrolled in one of seven contracted managed care organizations. We used the International Classification of Disease, 9th Revision Clinical Modification (ICD-9-CM) as the reference for coding the presence of the relevant diseases. Asthma was defined as the diagnosis code 493.xx,, COPD as diagnosis codes 491.xx, 492.xx, and 496.xx, and SAS as diagnosis codes 780.51 (insomnia with SAS, unspecified) and 780.53 (hypersomnia with SAS, unspecified) in the primary, secondary, or tertiary diagnosis field in their medical claims during the study period of January 1, 2001 to December 31, 2003. The index date was defined as the date of the first medical claim with an asthma and/or COPD diagnosis during the study timeframe. All sample beneficiaries were required to have at least 360 days of follow-up from the index date. As a result, 9,131 beneficiaries met the inclusion criteria. In our previous study, Medicaid beneficiaries with both asthma and COPD incurred substantially higher medical utilization and cost compared to beneficiaries with either condition alone [13]. Therefore, we assigned beneficiaries who had exclusively asthma or COPD in the first 30 months to the asthma (n=3,072) or COPD cohort (n=3,455). Beneficiaries who had both conditions during the first 30 months were assigned to the asthma/COPD cohort (n=2,604). Medical utilization data were collected from the index date through the end of the study (i.e., December 31, 2003) or the last date of service, whichever occurred first. Overall, the average follow-up time was 909 days.

Measures

In evaluating the economic burden, resource use was measured by overall medical utilization (defined as the total number of service claims) as well as the total medical cost for individual categories including physician visits, outpatient services, and inpatient services. Because Medicaid managed care claims data do not contain actual costs for each service claim, we estimated medical cost by using the average unit cost for each type of service and imputed the cost values based on the Medicaid fee schedule for services. The imputed medical costs in SAS therefore represent the relative, additional costs of the observed population. All utilization and cost data were annualized to adjust for varying follow-up days.

Demographic characteristics (i.e., age, gender, and race) were compared between beneficiaries with and without SAS by disease cohort. Comorbidity burden (exclusive of COPD, asthma, or SAS) was measured using the Charlson Comorbidity Index (CCI) with the Deyo modification [14, 15], which contains 17 categories of comorbid conditions with each assigned a weight from 1 to 6, resulting in a total maximum score of 33. The CCI scores were derived from the ICD-9-CM diagnosis codes in the claims data within the follow-up period of each beneficiary's index date. Because obesity has been shown to correlate with SAS and with higher health care cost [16], the proportion with an obesity diagnosis (ICD-9-CM diagnosis code 278.xx) in each disease cohort also was assessed.

Analysis

We assessed medical utilization among beneficiaries with asthma, COPD, and asthma/COPD according to the concomitant diagnosis of SAS. Chi-square tests and *t*-tests were performed to compare baseline characteristics by SAS in each disease cohort. We then stratified the analyses to examine the effect of SAS on economic burden by disease cohort. Specifically, medical utilization and cost data were regressed on patients' baseline characteristics. We tested three model specifications including ordinary least squares (OLS), OLS with log transformation, and generalized linear model (GLM). We chose GLM as our final model to account for non-normally distributed data and to models utilization and cost in their natural scale rather than in a transformed scale (e.g., log transformation). A modified Park test was performed to determine the type of GLM to be employed [17]. Based on results of the Park test, we used a Poisson-distributed GLM with a log-link function to detect statistical differences in medical utilization between beneficiaries with and without SAS, and a gamma-distributed GLM with a log-link function to detect statistical differences in medical cost. The independent variables included a SAS indicator (yes/no), demographic characteristics, obesity diagnosis (yes/no), the CCI score, and days in cohort.

Results

Of the 9,131 beneficiaries classified as asthma, COPD, or both, 340 beneficiaries had a diagnosis of SAS in their Medicaid claims (Fig. 1). The proportion with diagnosed SAS was highest in the asthma/COPD cohort (6.72%), followed by the COPD cohort (2.87%) and the asthma cohort (2.15%). Beneficiaries with COPD were older (mean age=52.4 years) than beneficiaries with asthma/COPD (mean age=51.3 years, $p<0.001$) and beneficiaries with asthma (mean age=48.1 years, $p<0.001$). The study sample was predominantly female and African American (Table 1). Age, gender, and race did not differ by SAS diagnosis in each disease cohort, whereas beneficiaries with SAS were more likely to have the concomitant diagnosis of obesity ($p<0.001$). Comorbidity burden measured by the CCI was slightly higher in beneficiaries with SAS but this trend was not statistically significant. In the asthma/COPD cohort, beneficiaries with SAS had longer follow-up time than those without SAS ($p=0.028$), whereas follow-up time did not differ by SAS diagnosis in other two disease cohorts.

Figure 2 illustrates average annualized medical utilization by SAS in each cohort, adjusted for age, gender, race, obesity, CCI scores, and days in cohort. As previously reported [13], the asthma/COPD cohort had a much higher number of medical service claims compared to the asthma and the COPD cohorts. Beneficiaries in the asthma/COPD cohort who had the concomitant diagnosis of SAS had a significantly higher number of medical service claims than beneficiaries without SAS ($p<0.001$); physician office visits accounted for the largest share of medical utilization, followed by inpatient care and outpatient visits. Similar patterns were observed for the COPD cohort ($p<0.001$) and the asthma cohort although, in the latter, the effect of SAS was not statistically significant ($p=0.338$).

Adjusted average medical costs by SAS in each disease cohort are displayed in Fig. 3. As previously reported [13], the asthma/COPD cohort incurred much higher medical costs compared to the asthma and the COPD cohorts. Beneficiaries in the asthma/COPD and COPD cohorts who had the concomitant diagnosis of SAS had significantly higher medical cost than those without SAS. For asthma/COPD, average annual medical costs were $5,773 higher among beneficiaries with SAS ($p<0.037$), with inpatient care accounting for more than 80% of medical cost. In the COPD cohort, beneficiaries with SAS on average incurred $4,155 higher medical cost compared to beneficiaries without SAS ($p=0.035$). Annualized medical cost did not differ by SAS in the asthma cohort ($866 in excess cost, $p=0.567$).

Discussion

Asthma and COPD are two common respiratory conditions that may coexist with SAS. We have demonstrated that among Medicaid beneficiaries with COPD or concomitant diagnoses of asthma and COPD, SAS was a predictor of higher medical utilization and greater economic burden. Interestingly, while all three categories of utilization (inpatient, outpatient, and physician office) were affected by the presence of SAS, the category of outpatient care accounted for the greatest differential in utilization and

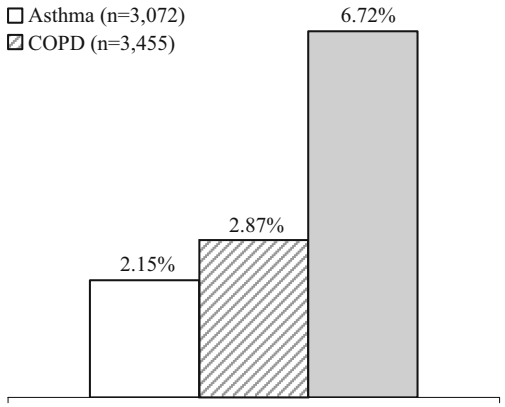


Fig. 1 Proportion with diagnosed sleep apnea syndrome by disease cohort

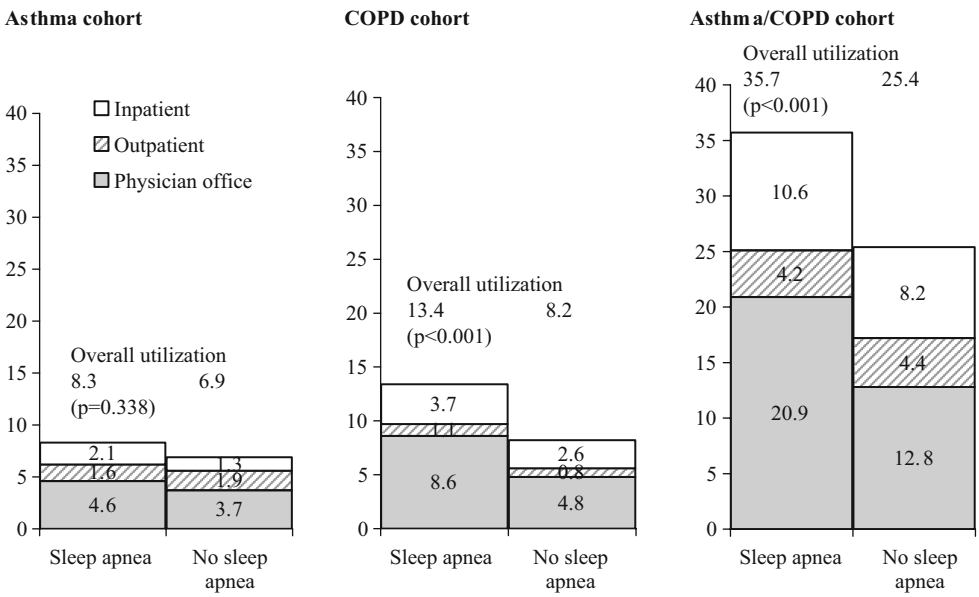
inpatient care accounted for the greatest differential in costs. Since the common factor in those cohorts in which SAS adds incremental costs was COPD (COPD and asthma/COPD), it is logical that SAS adds incremental utilization and cost primarily in patients with COPD, and not those with asthma. In the ensuing discussion we consider the findings in the light of the currently available literature.

We found that SAS was more prevalent among beneficiaries with concomitant diagnoses of asthma and COPD and least prevalent among beneficiaries with asthma alone. It is known that the prevalence of SAS increases with age, and, in our sample, beneficiaries with COPD (including both the COPD and asthma/COPD cohorts) were older than beneficiaries with asthma. It is possible that COPD is a greater risk for the presence of SAS because most COPD is

Table 1 Baseline characteristics of study sample

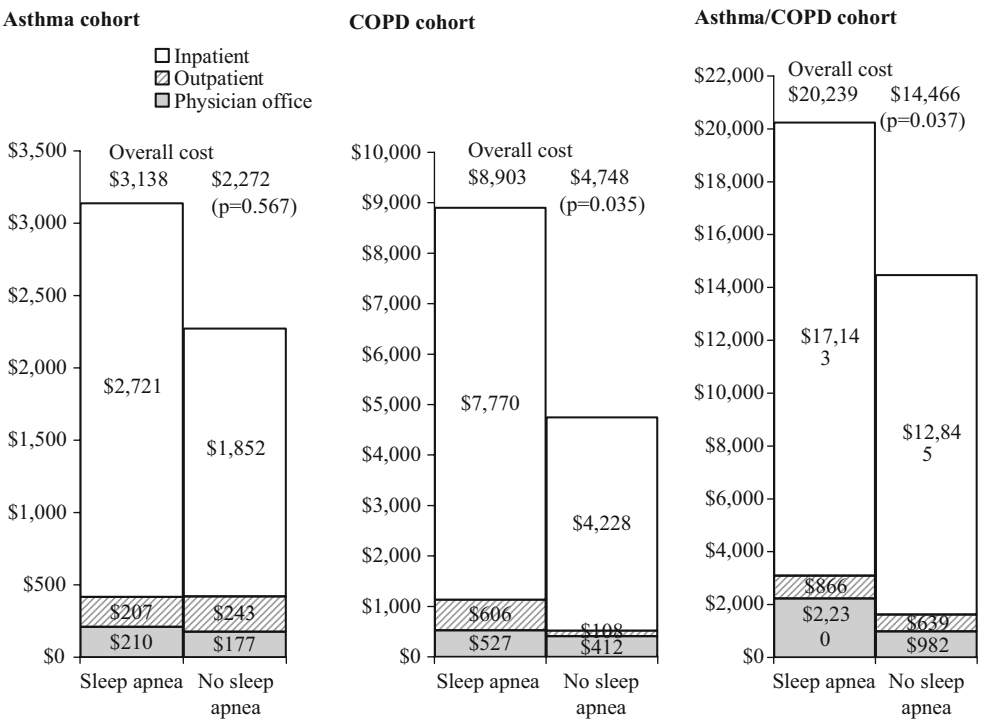
	Asthma (*n*=3,072)		
	SAS (*n*=66)	Non-SAS (*n*=3,006)	*P* value
Age in years, mean (SD)	47.0 (5.9)	48.2 (6.4)	0.129
Female, %	78.8	83.3	0.328
Race, %			0.706
White	28.8	31.3	
African American	63.6	63.3	
Other	7.6	5.4	
Obesity, %	47.0	15.4	<0.001
CCI, mean (SD)	3.2 (2.1)	2.8 (2.5)	0.193
Days in cohort, mean (SD)	909.9 (215.0)	860.9 (219.1)	0.072
	COPD (*n*=3,455)		
	SAS (*n*=99)	Non-SAS (*n*=3,356)	*P* value
Age in years, mean (SD)	51.7 (6.0)	52.5 (6.7)	0.243
Female, %	53.5	54.1	0.914
Race, %			0.685
White	54.6	50.5	
African American	41.4	45.8	
Other	4.0	3.7	
Obesity, %	45.5	8.5	<0.001
CCI, mean (SD)	4.1 (2.6)	3.6 (3.0)	0.064
Days in cohort, mean (SD)	881.4 (228.4)	836.6 (227.9)	0.054
	Asthma/COPD (*n*=2,604)		
	SAS (*n*=175)	Non-SAS (*n*=2,429)	*P* value
Age in years, mean (SD)	50.8 (6.3)	51.3 (6.8)	0.306
Female, %	73.1	76.0	0.401
Race, %			0.209
White	52.6	50.3	
African American	46.3	46.0	
Other	1.1	3.7	
Obesity, %	50.3	15.6	<0.001
CCI, mean (SD)	3.5 (2.3)	3.4 (2.7)	0.438
Days in cohort, mean (SD)	925.9 (213.2)	889.0 (216.0)	0.028

CCI Charlson Comorbidity Index, *COPD* chronic obstructive pulmonary disease, *SAS* sleep apnea syndrome, *SD* standard deviation



Note: Medical utilization was defined as the total number of service claims. Predictions were adjusted for age, gender, race, obesity, Charlson Comorbidity Index, and days in cohort.

smoking related and smoking is also a risk for SAS [18]. Thus, the presence of a common risk factor, smoking, could explain the association between SAS and COPD (in the COPD and asthma/COPD groups) but not the asthma group. Unfortunately the database did not include any reference to smoking habits. Unlike the other two cohorts, whose common factor is the presence of COPD diagnosis, beneficiaries with asthma who also had SAS did not appear to incur significantly higher utilization or medical cost compared with those without SAS. While an association



Note: Predictions adjusted for age, gender, race, obesity, Charlson Comorbidity Index, and days in cohort.

between SAS and asthma has been suggested by some [9, 19], in children, Ramagopal et al. [20] found that asthma was actually a negative predictor of SAS. In our sample of middle-aged adults, there are three other possible explanations for the low prevalence of SAS among beneficiaries with asthma. First, earlier studies found no evidence that individuals with asthma suffer from SAS more frequently than individuals without asthma, indicating that the prevalence of SAS is expected to be low [21, 22]. Second, asthma patients may not have been as likely to be screened for SAS, as compared to COPD patients. Asthma patients in our study were younger and more likely to be women, making them less likely to present the conventional risk factors to consider SAS. Third, we may not have sufficient sample size to detect differences in medical utilization and cost given a low prevalence of SAS among beneficiaries with asthma.

In our previous study [13], as in the present one, we found that the diagnosis of concomitant asthma/COPD was associated with greater medical cost and utilization than the diagnosis of either alone. The results are consistent with findings from a Medicare Advantage population, in which patients with both asthma and COPD incurred higher health care cost and used more health care services than those with COPD alone [23]. Our data also showed that SAS was associated with higher excess medical cost in patients with concomitant asthma/COPD than those with COPD only ($5,773 vs. $4,155 in excess cost). What is the reason that the presence of SAS predicted higher medical care utilization and cost? First, SAS is associated with poorer quality of life [24] and may exacerbate COPD symptoms [25]. Such possible exacerbations may render beneficiaries more likely to seek medical attention, leading to increased medical utilizations and consequently higher medical costs. Second, SAS is known to be a risk factor for cardiovascular disease [26]. Possibly, increased medical utilization is related to increased incidence of cardiovascular disease in this cohort of middle-age adults, which may account for the effect of SAS on inpatient utilization, that category accounting for the greatest share of annualized medical cost. Finally, it also is possible that the increased utilization and medical costs were attributed to current practice patterns. For instance, beneficiaries with concomitant asthma/COPD may demonstrate more severe respiratory symptoms, and be under greater medical scrutiny and referred to a sleep laboratory more frequently for follow-up examinations than beneficiaries with either asthma alone or COPD alone.

A recent review article reported that 80% of SAS cases were undiagnosed [27]. Several studies also have demonstrated that screening for SAS may be cost-effective; it would appear rational for providing effective clinical and perhaps laboratory screening for patients with COPD [28, 29]. However, it remains to be demonstrated whether and to what extent early treatment for sleep-related diagnoses of individuals with concurrent SAS and COPD, or COPD/asthma leads to changes in medical utilization or economic burden. In examining baseline characteristics, we did not find a higher SAS prevalent rate among African Americans in any of the disease cohorts. However, African Americans had lower medical utilization and cost compared to non-minority, even after controlling for age, gender, obesity, comorbidity, and days in cohort (data not shown). Future research is warranted to investigate possible racial/ethnic disparities in treating obstructive lung disease patients with concomitant SAS.

Several issues warrant caution in interpreting the results of this study. First, the Medicaid data employed in our study over-represent female, low-income populations, and minorities, especially African Americans. Since in the age range chosen the prevalence of SAS in males is greater than that of females, this could have led to an underestimate of the true prevalence of the SAS in beneficiaries with COPD or asthma/COPD. Given the characteristics of the Medicaid population, generalizing our results to other populations should be made with caution. Second, there are inherent limitations, such as coding bias, in using large claims databases. The diagnosis coded in patients' claims may be the most important condition or the condition that is most likely to result in payment. In our study, the cohort determination in our study was based on the ICD-9CM diagnosis codes recorded in claims files. Due to lacking clinical details (e.g., pathophysiologic data) in Medicaid claims data, we were unable to determine the extent to which the concomitant asthma/COPD diagnoses were accurate, nor did we have information on what the diagnoses were made based on pathophysiologic data or physician judgment as to which diagnosis codes to use. We also had no information on smoking and disease severity, which may lead to underestimate or overestimate the true economic burden of SAS in this population. Mapel and colleagues developed an algorithm based on medical and pharmacy claims records from a health maintenance organization to predict individuals at risk for having undiagnosed COPD [30]. Future research is needed to validate the algorithm to identify undiagnosed or uncoded COPD and asthma patients, especially in the Medicaid population in which obstructive lung disease is prevalent. Finally, our cost estimates were based on the Medicaid fee schedule for the medical service rendered rather than the actual costs for each type of service, which were not available in the Medicaid managed care claims data. Therefore, our cost estimation can only serve as proxies. This method is deemed reliable and valid since it draws cost information from the same Medicaid population.

To our knowledge, our study was the first to explore the economic impact of SAS among Medicaid beneficiaries with asthma, COPD, or both conditions. The diagnosis of concomitant asthma/COPD was associated with substantially higher medical utilization and cost than the diagnosis of either alone, and SAS may add additional economic burden on beneficiaries who already have COPD or concomitant asthma/COPD. Future research is warranted to evaluate the cost-effectiveness of early interventions and disease management programs for beneficiaries at high risk of developing SAS and other respiratory conditions.

Conflicts of interest The authors declare that they have no conflict of interest.

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