Published in final edited form as:

J Asthma. 2019 April ; 56(4): 369–379. doi:10.1080/02770903.2018.1463379.

Association of Secondhand Smoke Exposure with Asthma Symptoms, Medication Use, and Healthcare Utilization among Asthmatic Adolescents

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Abstract

Objective—The study objective was to investigate the association between secondhand smoke exposure (SHSe) and asthma symptoms, medication use, and emergency department (ED)/urgent care (UC) utilization among adolescents.

Methods—We performed a secondary cross-sectional analysis of Population Assessment of Tobacco and Health Study wave 2 (2014-2015) including asthmatic adolescents ($N=2,198$). Logistic regression models were built to assess the association between SHSe and categorical outcomes. Poisson regression models were built to examine the associations between SHSe and number of asthma attacks that required steroid medication use and number of ED/UC visits.

Results—Participants with SHSe 1 hour in the past seven days were at increased risk of reporting shortness of breath and harder to exercise (aOR, 1.22; 95% CI, 1.04-1.43), wheezing (aOR, 1.26; 95% CI, 1.01-1.56), wheezing disturbing sleep (aOR, 1.88; 95% CI, 1.35-2.63), wheezing during/after exercise (aOR, 1.41; 95% CI, 1.19-1.66), wheezing limited speech (aOR, 2.11; 95% CI, 1.55-2.86), dry cough at night (aOR, 1.86; 95% CI, 1.54-2.24), and asthma symptoms disturbing sleep (aOR, 2.25; 95% CI, 1.81-2.79). Participants with SHSe 1 hour were more likely to regularly take asthma medications (aOR, 1.25; 95% CI, 1.03-1.52), including steroid medications (aOR, 1.86; 95% CI, 1.19-2.91), oxygen therapy (aOR, 2.88; 95% CI, 1.82-4.54) and controlling medications (aOR, 1.50; 95% CI, 1.24-1.82). Asthma symptoms and medication use varied by living with a smoker and home SHSe. Participants with SHSe were at increased risk of having a higher number of asthma attacks that required steroid use. Participants who lived with a smoker (aRR, 2.15; 95% CI, 1.80-2.57) and had home SHSe (aRR, 2.20, 95% CI, 1.81-2.67) were at increased risk of having higher ED/UC visits for asthma.

Conclusions—SHSe reduction efforts are critically needed for asthmatic adolescents, and EDs/UCs are promising venues.

Keywords

Secondhand smoke; environmental tobacco smoke exposure; urgent care; asthma symptoms; adolescence; tobacco abuse; epidemiology

INTRODUCTION

A total of 17.3% U.S. adolescents have had asthma in their lifetime, and 10% currently have asthma [1]. Asthma is characterized by airway obstruction (i.e., asthma attacks), bronchial hyperresponsiveness, and recurring symptoms (e.g., coughing, wheezing) in response to exposures including tobacco smoke [2]. Secondhand smoke exposure (SHSe) negatively impacts adolescents' respiratory health and is associated with asthma exacerbations [3]. Despite this, up to half of asthmatic adolescents remain exposed nationwide [4–6].

SHSe has been identified as a preventable risk factor of increased illness severity and healthcare utilization in asthmatic children [7–11], but little is known about the influence SHSe has on asthmatic adolescents' health and healthcare utilization. To highlight the need to focus research on asthmatic adolescents, a recent meta-analysis did not include any studies that focused solely on adolescents [12]. One study included in this review focused on both children and adolescents, and found parental smoking was associated with increased risk of wheeze and severe asthma symptoms among 13–14 year olds [13]. Similarly, other research including both children and adolescents indicated SHS-exposed youth have greater asthma severity [14]. Conversely, other work that stratified outcomes by age reported no relationship between SHSe and asthma symptoms such as wheezing among 12–16 year olds [15]. Concerning asthma medication use, prior studies that used a wide age range of pediatric patients found that independent of age, patients were more likely to receive steroids intravenously (IV) [16] or orally, and IV magnesium sulfate [17]. However, these two studies on asthma medication use also found no difference between SHSe and receipt of oxygen, IV magnesium sulfate [16], albuterol, and epinephrine [17]. Thus, research on the association of SHSe with asthma symptoms and medication use among adolescents exclusively is critically needed to address the gaps in the literature.

Asthma is a leading diagnosis in emergency department (ED) patients, accounting for 1.63 million visits each year [18]. U.S. trends show that ED visits and hospitalizations for asthma among 0–17 year olds have remained stable over the past decade, with rates of 11 per 100 asthmatic children having ED visits and two per 100 being hospitalized [19]. Prior research found that 76% of pediatric ED patients with asthma from 2–18 years old are exposed to secondhand smoke (SHS) [17]. Adolescents utilize emergency departments as a usual source for non-urgent medical care instead of seeking this type of care at primary care or clinic based settings [20–22]. Thus, it is important to assess the relationship between SHSe and acute healthcare utilization among adolescents. Most existing literature has examined this relationship in younger children [23,24] or wide age ranges from 0–19 years old [5,17,25,26]. The prior evidence base reports a complex relationship between SHSe and healthcare utilization. Focusing exclusively on adolescents who may frequent acute

healthcare settings would provide insight into this relationship to better inform targeted SHSe prevention efforts which may assist in decreasing unnecessary ED visits.

Given that asthmatic adolescents have disproportionately high rates of SHSe [1,6] and ED utilization for non-urgent care [20–22], our study aim was to investigate the association between SHSe and asthma symptoms, medication use, and ED/urgent care (UC) utilization among asthmatic adolescents nationwide. Based on prior work [5,17], we hypothesized that asthmatic adolescents with SHSe would be at increased risk of reporting asthma symptoms and medication use which may reflect more severe illness and higher ED/UC utilization than unexposed asthmatic adolescents.

METHODS

We performed a secondary cross-sectional analysis of Population Assessment of Tobacco and Health (PATH) Study wave 2 data collected from 10/23/2014–10/30/2015 including non-smoking adolescents from 12–17 years old who have been told by a health professional they have asthma ($N=2,198$). We excluded adolescents who did not have asthma ($n=7,740$) and who were current cigarette smokers ($n=481$). The PATH Study is a longitudinal cohort study conducted by the National Institutes of Health and Food and Drug Administration to continuously observe tobacco use and related health effects in U.S. adolescents and adults [27]. This study was exempt from IRB review due to the “not human subjects’ research” determination.

Wave 1 used a four-stage stratified area probability sample design to recruit participants who were 9 years old in all U.S. states and the District of Columbia [27]. The PATH design involved selecting 156 primary sampling units (i.e., counties or groups of counties), 6,049 second-stage sampling segments, and 166,088 mailing addresses, resulting in 76,539 sampled individuals who resided at the selected mailing addresses. A measure of size approach was used to select primary sampling units with higher probabilities of having key subgroups including young adults, black adults, and tobacco users, and to improve the probability of having sufficient subgroup sample sizes. Using measure of size, 35 primary sampling units were selected and the remaining 121 units were grouped into 57 different strata determined by urban or rural area, census region and division, Core Based Statistical Area status and size, proportion of adults over the age of 25 years who had a bachelor’s degree or higher, proportion of the population with family income below the poverty level by 200 percent, and the proportion of the population who were black or Hispanic origin. Sociodemographic data from the 2010 U.S. census were used to group sampling segments, and then a systematic sample of household addresses were selected from each segment to achieve the desired sampling rate.

Up to two adolescents were sampled from each residence. Wave 1’s response rate for the youth interview was 78.2%. Wave 2 did not do additional sampling and all wave 1 respondents were eligible for wave 2 if they still lived in the U.S. and were not incarcerated. Wave 2’s retention rate for continuing youth was 88.5%, and aged-up adolescents who were selected during Wave 1 as shadow youth (9–11 years old) to be interviewed during later waves when they turned 12 years old had a recruitment rate of 82.0%. Parents gave

permission for their child to complete the youth interview portion using audio-assisted self-interviewing.

SHSe was measured by asking adolescents whether: they live with anyone who smokes tobacco; smoking tobacco is allowed inside their home; and they were in close contact with others when they were smoking at home, in a car, at school, or outdoors for 1 hour in the past seven days (no, yes). Cohen's kappa coefficients were calculated between the SHSe measures. The agreement between living with a smoker and home TSE was equal to 0.33; the agreement between living with a smoker and TSE 1 hour was equal to 0.36; and the agreement between home TSE and TSE 1 hour was equal to 0.22. The overall kappa coefficient between all three variables was 0.31, which is interpreted as having a fair strength of agreement [28].

We assessed several asthma symptom outcome variables: overall health status (poor/fair/good, very good/excellent); shortness of breath and harder to exercise compared to peers; wheezing or whistling in the chest in the past 12 months; wheezing disturbing sleep in the past 12 months; wheezing limited speech to only 1-2 words between breaths in the past 12 months; chest sounded wheezy during or after exercise in the past 12 months; dry cough at night not associated with a cold or chest infection in the past 12 months; asthma symptoms (i.e., coughing, wheezing, shortness of breath, chest tightness or pain) disturbing sleep in the past 30 days (no, yes); and asthma control in the past 30 days (not at all/poorly/somewhat controlled, well/completely controlled).

We examined several medication use outcomes indicative of severity: took medications regularly for asthma in the past 12 months, including a: quick-relief inhaler (e.g., albuterol, ipratropium), controller/long-acting inhaler including steroid inhaler (e.g., beclomethasone, fluticasone, salmeterol, tiotropium), other controlling medication (e.g., montelukast, zafirlukast, theophylline, roflumilast), oral or injected steroid medication (e.g., prednisone, prednisolone, dexamethasone), oxygen therapy, or other asthma medication; used a rescue inhaler, nebulizer treatment, or other controlling medication such as albuterol in the past 30 days; had an asthma attack that required the use of an oral or injected steroid medication in the past 12 months (no, yes); and number of asthma attacks that required use of an oral or injected steroid medication in the past 12 months (continuous).

For ED/UC utilization, we assessed whether asthmatic adolescents: visited an ED or UC center for asthma in the past 12 months (no, yes); and number of times they visited an ED or UC center for asthma in the past 12 months (continuous).

Covariates were adolescent age, sex, race, and ethnicity, and parent education level. Age was categorized by PATH: 12-14 years and 15-17 years. Race included: white, black, or other race; ethnicity included non-Hispanic or Hispanic. Parent education level included: less than high school, high school graduate or equivalent, some college (no degree), bachelor's degree, or advanced degree.

Statistical Analysis

Statistical analyses were conducted using R version 3.3.0 [29]. Appropriate sampling weights were used to obtain nationally representative estimates while accounting for the study design, post-stratification, and survey non-response. We assessed the associations between the covariates (i.e., age, sex, race, ethnicity, and parent education level) and self-reported SHSe by performing chi-square tests. We also examined whether the age adolescents were diagnosed with asthma differed based on SHSe. Multivariable logistic regression models were built to assess the association between each SHSe variable and all categorical asthma symptom, medication use, and ED/UC utilization outcome variables separately, while controlling for the selected covariates. We report adjusted odds ratios (aORs) and 95% confidence intervals (CIs) for these models. Poisson regression models were built to examine the associations between SHSe and number of asthma attacks that required steroid medication use and number of ED/UC visits for asthma since these data were skewed. Poisson models for count data allow for skewed data. We report adjusted relative risk (aRR) and 95% CIs for these models. Analyses were two-sided with a *p*-value < .05 to indicate statistical significance. Incomplete cases were removed prior to analyses.

RESULTS

A total of 41.0% (*n*=914) asthmatic adolescents were 12-14 years old and 59.0% (*n*=1,284) were 15-17 years old; 57.3% (*n*=1,264) were male; the majority of participants were white (64.4%, *n*=1,304) followed by 19.3% (*n*=415) black, and 16.3% (*n*=382) were other race; 77.2% (*n*=1,535) were non-Hispanic. Parent education level varied with 13.0% (*n*=318) completing less than high school, 21.5% (*n*=459) graduating high school or equivalent, 34.2% (*n*=720) completing some college, 18.5% (*n*=337) completing a bachelor's degree, and 12.8% (*n*=222) completing an advanced degree. Concerning SHSe, 28.9% (*n*=657) lived with a smoker, 20.2% (*n*=449) had home SHSe, and 36.0% (*n*=770) were in close contact with others when smoking for 1 hour in the past seven days.

SHSe and Demographic Differences

Table 1 displays demographic characteristics based on SHSe measures. Adolescent race, ethnicity, and parent education level differed based on living with a smoker and home SHSe. Adolescent age, sex, ethnicity, asthma diagnosis age, and parent education level differed based on SHSe for 1 hour in the past seven days.

SHSe and Asthma Symptom Outcomes

Table 2 presents the associations between SHSe and asthma symptom outcome variables. Participants who lived with a smoker were at lower odds to report good/excellent overall health status (aOR, 0.73; 95% CI, 0.61-0.88) or well/completely controlled asthma (aOR, 0.62; 95% CI, 0.46-0.84) than those who did not live with a smoker. Participants who lived with a smoker were more likely to report shortness of breath and harder to exercise compared to peers (aOR, 1.21; 95% CI, 1.02-1.44), wheezing in the chest (aOR, 1.32; 95% CI, 1.05-1.67), wheezing limited speech (aOR, 1.47; 95% CI, 1.07-2.01), wheezing during or after exercise (aOR, 1.44; 95% CI, 1.21-1.72), and were 2.08 times (95% CI, 1.66-2.59) more likely to report asthma symptoms disturbing sleep.

Participants with home SHSe were at reduced odds for reporting good/excellent overall health status (aOR,0.79; 95%CI,0.65-0.97), but at increased odds of reporting wheezing disturbing sleep (aOR,1.56; 95%CI,1.06-2.27), dry cough at night (aOR,1.37; 95%CI,1.11-1.71), and asthma symptoms disturbing sleep (aOR,1.58; 95%CI,1.23-2.02).

Participants with SHSe 1 hour in the past seven days were at decreased odds of having very good/excellent overall health status (aOR,0.81; 95%CI,0.69-0.97) and well/completely controlled asthma (aOR,0.51; 95%CI,0.38-0.69). Participants with SHSe 1 hour in the past seven days were at increased risk of reporting shortness of breath and harder to exercise (aOR,1.22; 95%CI,1.04-1.43), wheezing in the chest (aOR,1.26; 95%CI,1.01-1.56), wheezing disturbing sleep (aOR,1.88; 95%CI,1.35-2.63), wheezing during or after exercise (aOR,1.41; 95%CI,1.19-1.66), and dry cough at night (aOR,1.86; 95%CI,1.54-2.24).

Participants with SHSe 1 hour in the past seven days were over two times more likely to report that wheezing limited speech (aOR,2.11; 95%CI,1.55-2.86) or asthma symptoms disturbing sleep (aOR,2.25; 95%CI,1.81-2.79).

SHSe and Asthma Medication Use

Living with a smoker was unrelated to regularly taking asthma medications (Table 3). Regarding medication types, participants who lived with a smoker were more likely to report they regularly used a quick-relief inhaler (aOR,1.33; 95%CI,1.07-1.64) or controller/long-acting inhaler (aOR,1.36; 95%CI,1.06-1.76), but less likely to take “other” asthma medications (aOR,0.64; 95%CI,0.43-0.96). Participants who lived with a smoker were 3.58 times (95%CI,1.09-11.78) more likely to have had an asthma attack that required use of an oral or injected steroid medication. Additionally, participants who lived with a smoker (mean [*M*]=6.13, standard error [*SE*]=2.56) were at increased risk of having a higher number of asthma attacks that required steroid use (aRR,0.17; 95%CI,0.07-0.41) than participants who did not live with a smoker (*M*=4.64, *SE*=1.05).

No differences were found between home SHSe and asthma medication use (see Table 3). However, participants with home SHSe (*M*=9.46, *SE*=4.10) were at 2.40 times (95%CI,1.62-3.57) the risk of having a higher number of asthma attacks that required steroid medication use than unexposed participants (*M*=3.82, *SE*=0.82). Participants with SHSe 1 hour in the past seven days were more likely to regularly take asthma medications (aOR,1.25; 95%CI,1.03-1.52) than those who were not in close contact with others when they were smoking. Participants were 1.86 times (95%CI,1.19-2.91) more likely to regularly take oral or injected steroid medication, 2.88 times (95%CI,1.82-4.54) more likely to take oxygen therapy, and 1.50 times (95%CI,1.24-1.82) more likely to use a rescue inhaler, nebulizer treatment, or other controlling medication. Participants with SHSe 1 hour in the past seven days (*M*=6.01, *SE*=2.15) were at 2.58 times (95%CI,1.76,3.80) the risk of having a higher number of asthma attacks that required steroid medication use than unexposed participants (*M*=4.00, *SE*=1.03).

SHSe and ED/UC Utilization

No relationships between SHSe and having an ED/UC visit for asthma were found (Table 4). However, participants who lived with a smoker (aRR,2.15; 95%CI,1.80-2.57) and had home

SHSe (aRR,2.20, 95% CI,1.81-2.67) were at increased risk of having a higher number of ED/UC visits for asthma than unexposed participants. Participants who lived with a smoker had an average of 4.02 (SE=1.11) ED/UC visits compared to an average of 2.06 (SE=0.30) visits among unexposed participants. Participants with home SHSe had an average of 4.22 (SE=1.35) visits compared to an average of 2.17 (SE=0.28) visits among unexposed participants.

DISCUSSION

We found that 28.9% of asthmatic adolescents lived with a smoker and 20.2% had home SHSe. Rates of living with a smoker and home SHSe were highest among black and non-Hispanic asthmatic adolescents. As parent education level increased, SHSe decreased. Research indicates asthma prevalence is increasing over time, with rates highest among children 0-17 years old who are non-Hispanic black (17%) and come from low socioeconomic households (13.5%) [30]. Although most non-smoking adolescents have detectable biochemical levels of SHSe [6] and the home is the most commonly reported place of exposure [3], our findings indicated that over one-third (36%) of asthmatic adolescents were around SHSe 1 hour in the past seven days regardless of the source and setting of exposure. It is important to note that no exposure to SHS is the only safe status for adolescents [3], and comprehensive smoke-free policies should be increased in both private and public settings [31]. Further, SHSe reduction efforts are critically needed for asthmatic adolescents, especially since those who are around smoking, regardless of the setting, are at increased risk to initiate smoking themselves [32,33].

We found significant relationships between SHSe and asthma symptom outcomes among asthmatic adolescents, consistent with our hypothesis. Overall, we found that SHSe predicted lower likelihood of reporting very good/excellent overall health status. Of note, asthmatic adolescents who had SHSe 1 hour in the past seven days were at increased risk of reporting all wheeze symptoms and asthma symptoms than unexposed adolescents. Participants who lived with a smoker were at risk of reporting complaints that suggest increased asthma symptoms indicative of severity, with the exception of wheezing disturbing sleep and dry cough at night. Additionally, participants with home SHSe were at increased risk of having a dry cough at night, and wheezing or asthma symptoms disturbing sleep. Similar to our findings, prior research found that younger adolescents from 13-14 years old had higher odds of reporting wheeze and severe asthma symptoms, which was defined as having at least one of the following symptoms in the past 12 months: 4 wheezing attacks; sleep disturbances due to wheezing 1 night per seven days; and wheezing limiting speech [13]. Our research expands on these findings by examining these symptoms individually and within a larger adolescent age range. The U.S. Surgeon General's Report [3] revealed that there is sufficient evidence of a causal relationship between SHSe and wheeze illnesses. Further, participants who lived with a smoker or had SHSe 1 hour were more likely to report shortness of breath and harder to exercise compared to peers, but less likely to report well/completely controlled asthma. Thus, we found that SHSe is related to moderate and severe asthma symptoms (e.g., cough, wheeze). Similar research indicates SHS-exposed youth are at greater risk of asthma severity and frequency of symptoms [14]. The different SHSe measures may have influenced these outcomes differentially, given the agreement

between these measures was fair. Thus, our study demonstrates that different types of SHSe are important risk factors for asthma symptoms among adolescents.

Approximately one-third of asthmatic adolescents regularly took asthma medications, which is slightly lower than rates (38.2%) presented in other research [34]. The present study found that asthmatic adolescents with SHSe ≥ 1 hour in the past seven days were more likely to regularly take asthma medication, with nearly a two-fold risk of regularly taking steroid medication. Results also revealed that asthmatic adolescents with SHSe ≥ 1 hour in the past seven days were at nearly a three-fold risk of receiving oxygen therapy. These participants were also 1.5 times more likely to use a rescue inhaler, nebulizer treatment, or other controlling medication. Further, asthmatic adolescents who lived with a smoker were at increased risk of using a quick-relief inhaler or controller or long-acting inhaler, and over 3.5 times more likely to have had an asthma attack that required use of an oral or injected steroid. Interestingly, those living with a smoker, had home SHSe, and had SHSe ≥ 1 hour in the past seven days were at increased risk of having a higher number of asthma attacks that required steroid medication use. Our findings on medication use varied from the prior literature. Specifically, prior work on ED patients 2-18 years old that only focused on SHSe documented in medical charts found that SHS-exposed patients were at increased risk of receiving IV or oral steroids, but no differences were found based on supplemental oxygen given and controlling medications including albuterol and epinephrine [17]. Our findings may have differed from this study since we focused solely on adolescents nationwide versus a specific pediatric ED population, and used three different measures of SHSe. The study's findings suggest potentially more frequent and severe exacerbation among asthmatic adolescents exposed to SHS nationwide.

SHSe was unrelated to having an ED/UC visit for asthma, which differed from prior studies among asthmatic children of all ages that found SHSe increased the risk of having an ED visit [5,12]. This difference may be potentially due to adolescents being high utilizers of ED services for non-urgent healthcare [20–22], regardless of their SHSe status. Additionally, there has been stable asthma healthcare encounters in EDs for youth over the past decade [35], with asthma exacerbation being the top pediatric ED-treated SHSe-related illness among 6-18 year olds [36], irrespective of SHSe status.

Notably, and consistent with our hypothesis, asthmatic adolescents who lived with a smoker or had home SHSe had over two times the risk of having a higher number of ED/UC visits for asthma than unexposed adolescents. Contrarily, an older study that was conducted among children 2-12 years old and used self-report measures and cotinine, an optimal TSE biomarker [37], found a U-shaped relationship between cotinine and healthcare contacts for asthma suggesting asthmatic children with low TSE had reduced healthcare utilization, whereas those with high TSE had increased healthcare utilization [24]. This study also reported a negative association between self-reported parental smoking and healthcare contacts for asthma, suggesting an unclear relationship. Other research on asthmatic children 1-17 years old reported no statistical difference in the association between TSE and ED-based treatment management in children with moderate or severe asthma exacerbations, but recommended further investigation [26]. Our findings contribute to the growing body of literature suggesting EDs/UCs are promising venues for SHSe reduction and smoking

cessation interventions [38,39], especially for adolescents and their families. Prior research indicates that parents who smoke and pediatric ED professionals approve of tobacco cessation interventions in the pediatric ED settings [40]. ED-based efforts may reduce SHSe and related preventable ED visits by decreasing caregiver smoking [38]. Standardized SHSe efforts offered in these healthcare settings would strongly benefit asthmatic adolescents. Despite this, rates of regular screening for SHSe during ED visits remains low among children and adolescents [41]; such visits are missed opportunities to screen and intervene with parents who smoke and their asthmatic adolescents in these high volume settings.

Limitations

PATH's sampling design may have potentially biased adolescent SHSe rates in the present study as one of the key subgroups that had a high probability of selection was tobacco users. We were limited to variables provided by the PATH Study. For example, the survey only asked about ED/UC visits for asthma, and thus, we were unable to assess other healthcare settings and hospitalizations. PATH did not ask questions about characteristics of the home environment. Although we adjusted for possible confounders, potential confounding may have occurred and unexpectedly biased the present study's results. The PATH study only has self-reported SHSe measures and did not collect any biospecimens from adolescents; thus SHSe may have been underreported [42]. However, prior work among asthmatics found a strong association between interview data on SHSe and cotinine levels [43]. Similarly, participants may have not answered the question on current smoking accurately and were included in the present study, although prior research indicates that self-report smoking measures are the most commonly used method to assess tobacco, with rates that are similar with prevalence estimates and cotinine values among adolescents [44]. Additionally, clinician-determined asthma symptoms and medication use was not ascertained. Future studies should examine these relationships by using objective measures. Some of the statistically significant effect sizes for asthma symptom related outcomes were relatively small (e.g., aOR=1.21), and caution should be used when considering the associations since the clinical significance is unknown. The temporal or causal relationship between SHSe and asthma symptoms, medication use, and ED/UC utilization cannot be determined from using one wave of cross-sectional data to answer our study aims, and future waves will allow for longitudinal association between SHSe and asthma symptoms, medication use, and ED/UC utilization.

Conclusions/Key Findings

The present study found that SHSe was related to greater risk of asthma symptoms, medication use, and number of ED/UC visits among asthmatic adolescents. Peers, families, and communities should be included in SHSe reduction programming to educate them that there is no safe level of SHSe and thus, quitting and implementing smoking bans is crucial to potentially reducing asthma symptoms and medication use among adolescents. In the ED/UC settings, the National Heart, Lung, and Blood Institute Expert Panel [2] recommends the establishment of a patient-clinician partnership to facilitate teaching patients and their families asthma self-management skills including advising to avoid SHSe which can exacerbate the patient's asthma. Therefore, ED/UC professionals may want to consider

routinely offering SHSe screening and counseling especially among asthmatic adolescents and their families.

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Table 1
 Characteristics of Asthmatic Adolescents by Secondhand Smoke Exposure Measures in the U.S., 2014-2015

Sociodemographic Variable	Lives with Smoker			Home SHSe			SHSe 1 Hour in Past 7 Days		
	No n (%) ^a	Yes n (%)	P Value	No n (%) ^a	Yes n (%)	P Value	No n (%) ^a	Yes n (%)	P Value
Adolescent Age									
12-14 years old	611 (69.7)	283 (30.3)	.24	688 (77.9)	199 (22.1)	.07	599 (67.5)	277 (32.5)	.005
15-17 years old	902 (72.0)	374 (28.0)		1,019 (81.0)	250 (19.0)		753 (61.8)	493 (38.4)	
Adolescent Sex									
Male	878 (71.7)	369 (28.3)	.48	981 (79.2)	261 (20.8)	.48	808 (67.0)	413 (33.0)	.001
Female	632 (70.3)	287 (29.7)		722 (80.4)	188 (19.6)		539 (59.8)	357 (40.2)	
Adolescent Race									
White	905 (70.9)	383 (29.1)	.02	1,043 (81.1)	245 (18.9)	.001	817 (64.5)	447 (35.5)	.29
Black	265 (65.3)	144 (34.7)		289 (72.3)	112 (27.7)		244 (60.1)	153 (39.9)	
Other Race	259 (74.8)	118 (25.2)		288 (81.0)	84 (19.0)		215 (63.2)	152 (36.8)	
Adolescent Ethnicity									
Non-Hispanic	1024 (69.8)	494 (30.2)	.02	1,166 (78.7)	341 (21.3)	.01	901 (62.0)	584 (38.0)	.001
Hispanic	457 (75.2)	150 (24.8)		512 (83.9)	96 (16.1)		425 (70.6)	170 (29.4)	
Parent Education Level									
Less than high school	190 (59.2)	122 (40.8)	<.001	219 (69.6)	89 (30.4)	<.001	183 (57.7)	123 (42.3)	<.001
High school or equivalent	284 (63.8)	167 (36.2)		333 (73.7)	116 (26.3)		252 (57.7)	181 (42.3)	
Some college	463 (65.5)	248 (34.5)		541 (76.3)	164 (23.7)		413 (59.6)	280 (40.4)	
Bachelor's degree	275 (83.3)	60 (16.7)		298 (89.9)	37 (10.1)		233 (69.8)	100 (30.2)	
Advanced degree	191 (88.1)	30 (11.9)		202 (92.6)	19 (7.4)		168 (78.3)	49 (21.7)	
Asthma Diagnosis Age									
>12 years old	779 (69.5)	372 (30.5)	.08	903 (79.3)	238 (20.7)	.09	717 (64.3)	409 (35.7)	.04
12-14 years old	113 (70.0)	54 (30.0)		127 (77.2)	38 (22.8)		96 (60.6)	67 (39.4)	
15-17 years old	33 (86.4)	6 (13.6)		36 (93.1)	3 (6.9)		19 (45.1)	20 (54.9)	

SHSe, secondhand smoke exposure.

^an refers to raw scores and percentages are weighted.

Asthma Symptom Outcomes by Secondhand Smoke Exposure Measures in Asthmatic Adolescents in the U.S., 2014-2015

Table 2

Lives with Smoker				Home SHSe				SHSe 1 Hour in Past 7 Days				
Outcome Variable		Multivariable Regression ^b		Outcome Variable		Multivariable Regression ^b		Outcome Variable		Multivariable Regression ^b		
No n (%) ^a	Yes n (%)	aOR (95%CI)	P Value	No n (%) ^a	Yes n (%)	aOR (95%CI)	P Value	No n (%) ^a	Yes n (%)	aOR (95%CI)	P Value	
Overall Health Status												
No	474 (29.7)	1,036 (70.3)	Ref	538 (30.3)	1,167 (69.7)	Ref		407 (28.9)	943 (71.1)	Ref		
Yes	251 (37.6)	405 (62.4)	0.73 (0.61, 0.88)	<.001	178 (37.9)	270 (62.1)	0.79 (0.65, 0.97)	.02	297 (37.0)	472 (63.0)	0.81 (0.69, 0.97)	.02
Shortness of Breath/Hard to Exercise												
No	860 (57.1)	648 (42.9)	Ref	934 (55.1)	769 (44.9)	Ref		777 (57.8)	569 (42.2)	Ref		
Yes	326 (50.7)	330 (49.3)	1.21 (1.02, 1.44)	.03	246 (55.7)	203 (44.3)	0.93 (0.77, 1.13)	.46	388 (51.2)	381 (48.8)	1.22 (1.04, 1.43)	.02
Wheezing or Whistling in Chest												
No	304 (37.3)	506 (62.7)	Ref	341 (36.4)	591 (63.6)	Ref		264 (36.9)	444 (63.1)	Ref		
Yes	122 (32.0)	263 (68.0)	1.32 (1.05, 1.67)	.02	83 (33.8)	170 (66.2)	1.09 (.84, 1.42)	.51	151 (33.0)	309 (67.0)	1.26 (1.01, 1.56)	.04
Wheezing Disturbing Sleep												
No	57 (24.0)	183 (76.0)	Ref	44 (29.9)	110 (70.1)	Ref		74 (27.0)	206 (73.0)	Ref		
Yes	89 (19.1)	382 (80.9)	1.15 (0.81, 1.61)	.43	101 (18.1)	450 (81.9)	1.56 (1.06, 2.27)	.02	70 (16.5)	347 (83.5)	1.88 (1.35, 2.63)	<.001
Wheezing Limited Speech												
No	395 (77.7)	109 (22.3)	Ref	454 (76.8)	137 (23.2)	Ref		358 (80.8)	85 (19.2)	Ref		
Yes	182 (69.4)	81 (30.6)	1.47 (1.07, 2.01)	.02	117 (68.3)	52 (31.7)	1.24 (0.86, 1.77)	.25	210 (67.5)	99 (32.5)	2.11 (1.55, 2.86)	<.001
Wheezing During/After Exercise												
No	1,033 (68.0)	466 (32.0)	Ref	1,149 (66.9)	541 (33.1)	Ref		933 (68.8)	405 (31.2)	Ref		
Yes	406 (62.1)	247 (37.9)	1.44 (1.21, 1.72)	<.001	282 (64.2)	164 (35.8)	1.10 (0.89, 1.34)	.37	475 (61.7)	291 (38.3)	1.41 (1.19, 1.66)	<.001
Dry Cough at Night												

Lives with Smoker					Home SHSe					SHSe 1 Hour in Past 7 Days				
Outcome Variable		Multivariable Regression ^b			Outcome Variable		Multivariable Regression ^b			Outcome Variable		Multivariable Regression ^b		
TSE	No n (%) ^a	Yes n (%)	aOR (95%CI)	P Value	No n (%) ^a	Yes n (%)	aOR (95%CI)	P Value	No n (%) ^a	Yes n (%)	aOR (95%CI)	P Value		
No	1,202 (79.5)	303 (20.5)	Ref		1,356 (79.8)	344 (20.2)	Ref		1,105 (82.2)	241 (17.8)	Ref			
Yes	494 (75.8)	160 (24.2)	1.16 (0.95, 1.42)	.14	331 (73.4)	117 (26.6)	1.37 (1.11, 1.71)	.004	560 (72.5)	208 (27.5)	1.86 (1.54, 2.24)	<.001		
Asthma Symptoms Disturbing Sleep														
No	974 (83.2)	201 (16.8)	Ref		1,081 (81.5)	255 (18.5)	Ref		867 (84.4)	168 (15.6)	Ref			
Yes	350 (68.7)	160 (31.3)	2.08 (1.66, 2.59)	<.001	237 (70.7)	98 (29.3)	1.58 (1.23, 2.02)	<.001	425 (69.5)	187 (30.5)	2.25 (1.81, 2.79)	<.001		
Asthma Control														
No	105 (8.3)	1,069 (91.7)	Ref		128 (9.0)	1,208 (91.0)	Ref		79 (7.4)	958 (92.6)	Ref			
Yes	70 (14.1)	442 (85.9)	0.62 (0.46, 0.84)	.002	44 (13.6)	292 (86.4)	0.80 (0.57, 1.13)	.20	89 (14.1)	518 (85.9)	0.51 (0.38, 0.69)	<.001		

Table 3
Asthma Medications by Secondhand Smoke Exposure Measures in Asthmatic Adolescents in the U.S., 2014-2015

Lives with Smoker						Home SHSe						SHSe 1 Hour in Past 7 Days					
Outcome Variable			Regression ^b			Outcome Variable			Regression ^b			Outcome Variable			Regression ^b		
TSF	No n (%) ^a	Yes n (%)	aOR (95%CI)	P Value		No n (%) ^d	Yes n (%)		aOR (95%CI)	P Value		No n (%) ^d	Yes n (%)		aOR (95%CI)	P Value	
Regularly Takes Asthma Medications																	
No	802 (69.1)	372 (30.9)	Ref			906 (68.7)	432 (31.3)		Ref			718 (70.2)	320 (29.8)		Ref		
Yes	342 (67.2)	170 (32.8)	1.18 (0.96, 1.45)	.11		231 (68.9)	103 (31.1)		0.98 (0.78, 1.24)	.85		405 (66.1)	204 (33.9)		1.25 (1.03, 1.52)	.02	
Quick-Relief Inhaler Regularly Taken																	
No	859 (74.1)	309 (25.9)	Ref			964 (73.1)	370 (26.9)		Ref			758 (74.1)	275 (25.9)		Ref		
Yes	354 (69.6)	157 (30.4)	1.33 (1.07, 1.64)	.009		242 (72.2)	90 (27.8)		1.02 (0.80, 1.30)	.86		431 (70.5)	177 (29.5)		1.18 (0.97, 1.44)	.11	
Long-Acting Inhaler Regularly Taken																	
No	1,001 (85.6)	169 (14.4)	Ref			1125 (84.5)	210 (15.5)		Ref			887 (85.9)	148 (14.1)		Ref		
Yes	422 (82.6)	88 (17.4)	1.36 (1.06, 1.76)	.02		290 (86.6)	42 (13.4)		0.86 (0.63, 1.17)	.33		505 (82.8)	102 (17.2)		1.26 (0.99, 1.61)	.07	
Other Controlling Medication Regularly Taken																	
No	1,064 (90.9)	105 (9.1)	Ref			1205 (90.3)	129 (9.7)		Ref			941 (91.2)	93 (8.8)		Ref		
Yes	458 (89.4)	53 (10.6)	1.25 (0.92, 1.71)	.16		306 (91.6)	27 (8.4)		0.75 (0.51, 1.10)	.14		547 (89.2)	61 (10.8)		1.25 (0.93, 1.68)	.14	
Steroid Medication Regularly Taken																	
No	1,128 (96.2)	43 (3.8)	Ref			1292 (96.7)	43 (3.3)		Ref			1,005 (97.1)	31 (2.9)		Ref		
Yes	491 (96.4)	19 (3.6)	0.99 (0.61, 1.59)	.95		316 (94.8)	17 (5.2)		1.30 (0.78, 2.17)	.32		577 (94.7)	30 (5.3)		1.86 (1.19, 2.91)	.006	
Oxygen Therapy Regularly Taken																	
No	1,125 (96.1)	46 (3.9)	Ref			1285 (96.1)	51 (3.9)		Ref			1,006 (97.5)	29 (2.5)		Ref		
Yes	487 (95.7)	23 (4.3)	1.04 (0.65, 1.66)	.87		314 (95.1)	18 (4.9)		0.94 (0.56, 1.59)	.82		569 (93.2)	39 (6.8)		2.88 (1.82, 4.54)	<.001	
Other Asthma Medication Regularly Taken																	

SHSe 1 Hour in Past 7 Days									
Home SHSe									
Lives with Smoker									
TSE	Outcome Variable			Regression ^b			Outcome Variable		
	No <i>n</i> (%) ^a	Yes <i>n</i> (%)	aOR (95%CI)	<i>P</i> Value	No <i>n</i> (%) ^a	Yes <i>n</i> (%)	aOR (95%CI)	<i>P</i> Value	aOR (95%CI)
No	1,082 (92.4)	86 (7.6)	Ref		1243 (93.2)	90 (6.8)	Ref		Ref
Yes	481 (94.8)	29 (5.2)	0.64 (0.43, 0.96)	.03	307 (92.5)	25 (7.5)	0.98 (0.65, 1.49)	.93	1.38 (0.98, 1.95)
Rescue Inhaler, Nebulizer, or Other Controlling Medication Taken									
No	827 (69.8)	342 (30.2)	Ref		935 (69.2)	398 (30.8)	Ref		Ref
Yes	338 (65.5)	173 (34.5)	1.15 (0.94, 1.40)	.19	221 (66.2)	112 (33.8)	1.14 (0.91, 1.43)	.26	1.50 (1.24, 1.82)
Asthma Attack Required Steroid Medication									
No	26 (61.4)	17 (38.6)	Ref		22 (50.4)	21 (49.6)	Ref		Ref
Yes	5 (25.1)	14 (74.9)	3.58 (1.09, 11.78)	.04	8 (52.9)	9 (47.0)	1.33 (0.42, 4.25)	.63	1.69 (0.61, 4.69)
TSE	Outcome Variable			Poisson Regression ^b			Outcome Variable		
	<i>M</i> (SE)	aRR (95%CI)	<i>P</i> Value	<i>M</i> (SE)	aRR (95%CI)	<i>P</i> Value	<i>M</i> (SE)	aRR (95%CI)	<i>P</i> Value
Number of Asthma Attacks Required Steroid Medication									
No	4.64 (1.05)	Ref		3.82 (0.82)	Ref		4.00 (1.03)	Ref	
Yes	6.13 (2.56)	0.17 (0.07, 0.41)	<.001	9.46 (4.10)	2.40 (1.62, 3.57)	<.001	6.01 (2.15)	2.58 (1.76, 3.80)	<.001

SHSe, secondhand smoke exposure; aOR, adjusted odds ratio; CI, confidence interval; Ref, reference group; *M*, mean; SE, standard error; aRR, adjusted relative risk.

^a *n* refers to raw scores and percentages are weighted.

^b Regression controlling for adolescent age, sex, race, ethnicity, and parent education level.

Table 4

Emergency Department/Urgent Care Utilization by Secondhand Smoke Exposure Measures in Asthmatic Adolescents in the U.S., 2014–2015

Lives with Smoker				Home SHSe				SHSe 1 Hour in Past 7 Days			
Outcome Variable		Multivariable Regression ^b		Outcome Variable		Multivariable Regression ^b		Outcome Variable		Multivariable Regression ^b	
No n (%) ^a	Yes n (%)	OR (95%CI)	P Value	No n (%) ^a	Yes n (%)	OR (95%CI)	P Value	No n (%) ^a	Yes n (%)	OR (95%CI)	P Value
ED/UC Visit For Asthma											
No	1,093 (92.6)	86 (7.4)	Ref	1,251 (93.0)	91 (7.0)	Ref		969 (93.0)	71 (7.0)	Ref	
Yes	465 (89.8)	49 (10.2)	1.28 (0.91, 1.80)	295 (87.6)	41 (12.4)	1.44 (1.00, 2.07)	.06	553 (89.9)	60 (10.1)	1.35 (0.97, 1.86)	.07
Outcome Variable		Poisson Regression ^b		Outcome Variable		Poisson Regression ^b		Outcome Variable		Poisson Regression ^b	
M (SE)		aRR (95%CI)	P Value	M (SE)		aRR (95%CI)	P Value	M (SE)		aRR (95%CI)	P Value
Number of ED/UC Visits For Asthma											
No	2.06 (0.30)	Ref		2.17 (0.28)		Ref		2.85 (0.70)		Ref	
Yes	4.02 (1.11)	2.15 (1.80, 2.57)	<.001	4.22 (1.35)		2.20 (1.81, 2.67)	<.001	2.73 (0.57)		0.93 (0.78, 1.11)	.44

SHSe, secondhand smoke exposure; aOR, adjusted odds ratio; aRR, adjusted relative risk; CI, confidence interval; M, mean; SE, standard error; Ref, reference group; ED, emergency department; UC, urgent care.

^a n refers to raw scores and percentages are weighted.

^b Regression controlling for adolescent age, sex, race, ethnicity, and parent education level.