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Secondhand Smoke Exposure and Pediatric Healthcare Visits and Hospitalizations

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Abstract

Introduction—This study assessed the relationship between secondhand smoke exposure (SHSe) as measured by serum cotinine and healthcare utilization among children.

Methods—In 2016, the 2009–2012 National Health and Nutrition Examination Survey data were analyzed including 4,985 children aged 3–19 years. Associations between SHSe and having a routine place for health care, type of place, and hospital utilization were examined using logistic regression models. Poisson regression analyses assessed the relationship between SHSe and number of hospital admissions. Relationships between SHSe and acute care visits and hospital utilization were examined among asthmatic children.

Results—SHSe level did not differ by having a routine place for health care, although children with high SHSe indicative of active smoking (cotinine ≥ 3 ng/mL) were 3.49 times (95% CI=1.77, 6.89) more likely to use an emergency department. Children with high SHSe were 2.85 times (95% CI=1.87, 4.34) more likely to have had an overnight hospital stay. Children with high SHSe had 2.05 times (95% CI=1.46, 2.87) the risk of having a higher number of hospital admissions for overnight stays versus children with no SHSe (cotinine <0.05 ng/mL). Among asthmatic children, those with high SHSe and low SHSe (cotinine 0.05–2.99 ng/mL) were more likely to have an acute care visit, overnight hospital stay, and higher number of hospital admissions than asthmatic children with no SHSe.

Conclusions—High SHSe is associated with increased healthcare utilization. The emergency department and inpatient settings are important venues in which to routinely offer cessation and SHSe reduction interventions.

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INTRODUCTION

Despite a recent decline in secondhand smoke exposure (SHSe), more than 37% of children in the U.S. are regularly exposed.[1] Health effects of SHSe include respiratory symptoms, lower respiratory illnesses, ear infections, and sudden infant death syndrome.[2,3] SHSe is associated with asthma, and asthmatic children who are exposed to SHS have more frequent and severe exacerbations.[2,4] SHSe is a risk factor for these acute exacerbations that result in increased emergency department (ED) visits, intensive care unit admissions, hospitalizations, and readmissions.[5–9] Economic costs attributable to smoking and SHSe are more than $156 billion[3] and direct medical expenses for asthma exceed $50 billion in the U.S.[10]

Research linking SHSe to healthcare utilization in children has yielded discordant results. Prior investigations have found that SHS-exposed children are at increased risk for ED visits,[11] hospitalizations, bed days for respiratory conditions, and total annual expenditures to care for these respiratory conditions.[12] Another study found that SHS-exposed children who had Medicaid have significantly higher ED and prescription drug expenditures, potentially for respiratory illnesses.[13] Conversely, prior observational studies have found a negative association between self-reported SHSe and children's healthcare utilization, including fewer general practitioner visits for mild respiratory symptoms[14] and preventive care visits[15,16]; this may be because caregivers who smoke may not utilize their child's primary pediatric provider for ill or preventive care visits.[17] Other research revealed no associations between self-reported SHSe and primary care or ED visits and hospitalizations.[16] Similarly, mixed evidence for healthcare utilization among asthmatic children has been documented. In addition to studies that have shown a positive relationship between SHSe and healthcare visits and associated costs in children with asthma,[8,9,18,19] an inconsistent association using salivary cotinine to measure SHSe was found, such that children with high cotinine levels had an elevated general practitioner contact rate, whereas children with moderate cotinine levels had a reduced rate of consultations for asthma.[20]

Although there are clear evidence-based guidelines that exhort pediatric practitioners to routinely screen for and provide SHSe counseling at every healthcare visit, rates of assistance for helping caregivers reduce their child's SHSe remain low.[21] An understanding of the relationship between objectively measured SHSe and healthcare utilization is critical to prioritize limited healthcare resources and provide pertinent information to healthcare professionals and policymakers that may inform decisions about how SHSe reduction interventions may decrease healthcare visits and costs. This information may mobilize pediatric practitioners to intervene with and provide brief counseling to all caregivers who smoke. The primary objective of this study was to assess the relationship between SHSe and healthcare utilization among a national sample of children aged 3–19 years. Routine places for healthcare and hospitalization outcomes among children with serum cotinine levels indicative of high SHSe and low SHSe were compared with those with no SHSe. Children with detectable SHSe were hypothesized to be at increased risk for higher healthcare utilization than children with no SHSe. As research indicates that most asthmatic children are exposed to SHS,[22] the relationships between SHSe and acute care visits to the ED and urgent care centers for asthma-related complaints and hospitalizations were examined

among asthmatic children. Asthmatic children with detectable SHSe were posited to be at elevated risk for having higher healthcare utilization than asthmatic children with no SHSe.

METHODS

Data Sample

In 2016, a secondary data analysis of the 2009–2012 National Health and Nutrition Examination Survey (NHANES) was performed. NHANES is a series of nationally representative, cross-sectional surveys that assess the health and nutrition status of the civilian non-institutionalized population in the U.S.[23] Upon National Center for Health Statistics Research Ethics Review Board approval, written consent was obtained from participants who were selected using complex, stratified, multistage probability sampling procedures.[24] During each survey, data were collected via a household interview and a subsequent medical examination that included collection of various physical examination and laboratory measurements.[24] Children who were aged 3–19 years (N=4,985) were selected for the present study's analyses because serum cotinine was collected among those aged ≥ 3 years.

The two most recent NHANES cycles were combined to create a large aggregated data set. A university-based IRB determined this study was "not human subjects' research," and was exempt from review.

Measures

The independent variable, serum cotinine, the metabolite of nicotine, is an objective biomarker for SHSe that has widespread use as an accepted measure of SHSe in epidemiologic research.[25–27] NHANES measured serum cotinine by an isotope dilution high performance liquid chromatography system. Based on the recommendations for serum cotinine cut points to distinguish high SHSe from low SHSe of Avila Tang et al.[27] and Benowitz and colleagues,[28] the following categories were used: (1) no SHSe (cotinine < 0.05 ng/mL); (2) low SHSe (cotinine 0.05–2.99 ng/mL); and (3) high SHSe (cotinine ≥ 3 ng/mL). This study was unable to distinguish between nonsmokers (cotinine < 2.99 ng/mL) and active smokers (cotinine ≥ 3 ng/mL) given self-report smoking status was not collected in children aged <12 years.

Several healthcare utilization outcome variables were investigated. The relationship between SHSe and whether children had a routine place to go for health care (yes, no) was examined. If yes, then a follow-up question asked what type of place they most often go for health care. Routine places were: clinic or health center, doctor's office or HMO, ED, and hospital outpatient department (yes, no). Each type of place was also assessed based on SHSe.

The relationship between SHSe and hospitalization outcomes was assessed: (1) whether children were patients in a hospital overnight within 12 months (yes, no); and (2) how many overnight or longer hospital admissions had occurred within the past 12 months among those who were patients overnight. Number of hospital admissions was coded by NHANES as zero times, one time, two times, three times, four times, five times, and six times or more. SHSe and healthcare utilization related to children with asthma was examined including

whether a doctor or other health professional ever said that the child had asthma (yes, no). A follow-up question on if children had a visit to an ED or urgent care center because of asthma (yes, no) was asked only among those who currently had an asthma diagnosis. Hospitalization outcomes in asthmatic children were also examined.

Sociodemographic variables that were used to adjust for differences between groups included children's age, sex, race/ethnicity, and annual household income. Age was categorized as 3–11 years and 12–19 years. Race/ethnicity was categorized as white, black, Hispanic, and other race including multiracial. Income level included <$20,000/year, $20,000–$44,999/year, $45,000–74,999/year, and ≥ $75,000/year.

Statistical Analysis

Statistical analyses were performed using R, version 3.3.0. Examination weights provided by NHANES were used to account for the complex sampling design, differential probabilities of selection, and survey non-response, in addition to incorporating the complex design into the calculation of all variance estimates and statistical tests by using weighted statistical models to adjust for additional covariates using methods available in R.[29–31] Sociodemographic differences were examined based on the prevalence of SHSe in each group using chi-square tests. The associations between SHSe and healthcare utilization outcome variables were examined by testing a series of logistic regression models adjusting for the covariates. Follow-up Poisson regression analyses were performed to examine the relationship between SHSe and number of hospital admissions. All statistical analyses were two-sided and a p-value < 0.05 was considered statistically significant.

RESULTS

Of sampled children, 52.5% were aged 3–11 years and 47.5% were aged 12–19 years; 48.8% were female; and more than half were non-Hispanic white (55.3%), followed by 22.0% Hispanic, 14.4% black, and 8.3% other race including multiracial. Based on household income, 17.6% of children had an income of < $20,000/year, 27.6% had an income of $20,000–$44,999/year, 19.2% had an income of $45,000–74,999/year, and 35.6% had an income of ≥ $75,000/year. Children with no SHSe represented 56% of the sample, whereas 35% had low SHSe and 9% had high SHSe. For asthmatic children, 49% had no SHSe, 39% had low SHSe, and 12% had high SHSe.

Statistically significant differences in sociodemographic characteristics between serum cotinine levels were noted. Sex, age, race/ethnicity, and household income differed based on SHSe (Table 1). Approximately 93.5% of children had a routine place to go for health care; 73.9% reported a doctor's office or HMO as the most frequently accessed place, followed by a clinic or health center (23.6%), ED (1.3%), and hospital outpatient department (0.6%). Table 2 displays results from the adjusted logistic regression models of the associations between SHSe and routine place to go for health care. After adjustment, SHSe level was unrelated to whether children had a routine place to go for health care. Regarding type of routine place for health care, adjusted results showed that children with high SHSe (≥ 3 ng/mL) were 3.49 times more likely to report an ED as their routine place for health care compared with children with no SHSe (< 0.05 ng/mL, 95% CI=1.77, 6.89, p < 0.001); no

difference was observed between low SHSe (0.05–2.99 ng/mL) and no SHSe levels. No associations were found between SHSe levels and the following routine places to go for health care: doctor's office or HMO; clinic or health center; or hospital outpatient department.

Adjusted logistic regression model results indicated that there was a statistically significant association between SHSe and overnight hospital stays in the past 12 months (Table 3). Children with high SHSe (≥ 3 ng/mL) were 2.85 times more likely to have had an overnight hospital stay than children with no SHSe (> 0.05 ng/mL; 95% CI=1.87, 4.34, $p < 0.001$); no difference was found between low SHSe (0.05–2.99 ng/mL) and no SHSe. While controlling for covariates, there was a statistically significant difference between SHSe and number of hospital admissions (Table 4). Children with high SHSe had 2.05 times the risk of having a higher number of hospital admissions compared with children with no SHSe (95% CI=1.46, 2.87, $p < 0.001$); no difference was found between low SHSe and no SHSe.

Approximately 17.4% of children were told by a doctor or other health professional that they had asthma. Statistically significant differences were found between all SHSe levels and ever having an asthma diagnosis (Table 3). Children with high SHSe (≥ 3 ng/mL, OR=1.34, 95% CI=1.05, 1.71, $p < 0.001$) and low SHSe (0.05–2.99 ng/mL, OR=1.28, 95% CI=1.09, 1.51, $p < 0.001$) were significantly more likely to have ever had asthma than children with no SHSe (< 0.05 ng/mL). Among asthmatic children, there were statistically significant associations between all SHSe levels and having an acute care visit for asthma (Table 3). Asthmatic children with high SHSe (OR=4.74, 95% CI=1.93, 11.68, $p < 0.001$) and low SHSe (OR=2.17, 95% CI=1.24, 3.80, $p < 0.01$) were significantly more likely to have had a visit to an ED or urgent care center because of asthma than those with no SHSe. Asthmatic children with high SHSe (OR=4.44, 95% CI=3.14, 6.28, $p < 0.001$) and low SHSe (OR=1.40, 95% CI=1.05, 1.88, $p < 0.01$) were more likely to have had an overnight hospital stay than asthmatic children with no SHSe (Table 3). Asthmatic children with high SHSe were also at 3.87 times the risk of having a higher number of hospital admissions than asthmatic children with no SHSe (95% CI=3.06, 4.89, $p < 0.001$); no difference was found between low SHSe and no SHSe (Table 4).

DISCUSSION

In the present study, the association between biochemically validated SHSe and healthcare utilization among children using a nationally representative sample was assessed. Previous studies evaluating SHSe related to healthcare utilization have yielded mixed results, which may be due to lack of biochemical validation of caregiver reported SHSe in most studies, and therefore this study was undertaken to address the current gap in the literature. As hypothesized, children with high SHSe were at elevated risk for higher healthcare utilization. Although differences were not observed between those with low SHSe and no SHSe based on healthcare utilization, it is important to note that 44% of children had detectable SHSe (> 0.05 ng/mL). This is consistent with national research, which found that 24.2 million children (37.3%) had detectable SHSe as measured by serum cotinine.[1] These findings provide further impetus to comply with the American Academy of Pediatrics[32,33]

recommendation to screen for and provide SHSe reduction counseling to caregivers who smoke during all healthcare visits.

The finding that EDs are a common place for health care among children with high, biochemically validated SHSe confirms results of a prior study conducted by Merianos et al.[17] using self-reported SHSe. The present study found that children with high SHSe are 3.5 times more likely to routinely seek ill care or health advice at an ED than children with no SHSe. Higher ORs were found in the present study compared with the previous study that relied on self-report. The prior study indicated that children with home SHSe were at increased risk to seek care at the ED (i.e., OR=1.40) than unexposed children, potentially due to caregivers under-reporting their child's SHSe level.[27,34] These results underscore the importance of screening and intervening with caregivers in the ED about their child's SHSe to mobilize them to reduce their child's exposure by quitting smoking. Prior research has revealed that smoking-cessation efforts targeting caregivers in the ED are accepted by both pediatric ED staff and caregivers,[35] and increase caregiver quit attempts.[35,36] However, a significant proportion of children with SHSe are not being identified in the ED as screening rates are low and counseling rates are even lower.[37,38] Promising research suggests that the use of clinical decision support systems within the electronic health record may help to facilitate the systematic screening and counseling of all caregivers who smoke by healthcare providers in the ED and other settings.[39–43] As healthcare providers find clinical decision support system use both feasible and acceptable, further research is needed to determine how the routine use of these tools impacts future SHSe-related morbidity, visits, and costs in pediatric patients.

The present study found significant associations between SHSe and both hospital utilization outcome variables, indicating that children with high SHSe were more likely to have stayed in a hospital overnight and have a higher number of hospital admissions than children with no SHSe. Even though the study was unable to assess illness severity in children who were hospitalized given the nature of the NHANES data, prior studies have found that SHSe in children is associated with elevated risk of illness severity among children who are hospitalized, including those with asthma.[44,45] Furthermore, as evidenced by prior research,[43,46,47] hospitalization is an opportune time to routinely screen for SHSe and use as a "teachable moment" to educate caregivers about the dangers of exposing their child to tobacco smoke. Though routine screening in the inpatient setting is feasible[46,47] and caregivers are willing to receive smoking-cessation counseling while their child is hospitalized,[48] few hospitals currently have standardized system supports (e.g., a mandatory child SHSe question during admission) for healthcare professionals to screen and intervene with caregivers about their smoking behaviors. Strengthening policies and procedures of healthcare system supports, such as clinical decision support system use and implementation of evidence based-guidelines,[49,50] may increase practitioners' rates of engaging caregivers in meaningful SHSe reduction discussions to reduce their child's SHSe.[43]

The present study's findings indicated that 39% of children with asthma had high SHSe and 12% had low SHSe; thus, more than half (51%) of asthmatic children are exposed to SHS, which parallels prior findings.[22] Results also revealed that children with high SHSe and low SHSe were at increased risk to have ever had asthma. Consistent with the hypothesis, the

present study found statistically significant associations between all SHSe levels and having an acute care visit to the ED or an urgent care center for asthma and hospital utilization among asthmatic children. Asthmatic children with high SHSe and low SHSe were significantly more likely to have had an acute care visit to the ED or urgent care center or an overnight hospital stay. Similar to findings including the whole sample, results indicated that asthmatic children with high SHSe were at increased risk of having a higher number of hospital admissions. The prevalence of childhood asthma continues to rise in the U.S., especially among those who are non-Hispanic black and come from low socioeconomic backgrounds.[51] Thus, asthma-related healthcare encounters among children have remained stable over the past decade for ED visits and hospitalizations.[52] This is not surprising, especially among SHS-exposed children, given SHSe increases the risk of asthma severity and related ED visits, hospitalizations, and even length of hospital stays.[5–9,45,53] Initiatives to eliminate SHSe among children with asthma are greatly needed.

Limitations

This study is not without limitations. The NHANES design is cross-sectional in nature, and inferences are not causal. Random cotinine measurements may have a limited capacity to identify SHSe after 1–2 days.[25] Because self-report smoking data were not used to measure the child's smoking status, active smoking may have confounded the present study's results among older children. The study was limited to the measures provided by NHANES, including the wording and formatting of self-reported healthcare utilization questions where participants may not have understood the differences between types of healthcare places and social desirability bias may have occurred. Although potential sociodemographic confounding variables were adjusted for in analyses, residual confounding by factors unaccounted for in the models may have occurred and unexpectedly biased results. Longitudinal research would provide insight into the effect SHSe has on the child's illness and healthcare utilization rates over time.

CONCLUSIONS

The current study found that objective measurements of SHSe were associated with increased utilization of EDs and hospitalizations among SHS-exposed children with high serum cotinine levels. The study also found that high SHSe and low SHSe had a prominent impact on acute care visits for asthma and overnight hospital stays among asthmatic children. Healthcare settings that care for a high volume of SHS-exposed children, including the ED and inpatient settings, should be considered important venues to routinely incorporate SHSe screening, smoking-cessation, and SHSe reduction interventions—especially among children with SHSe-related illnesses such as asthma.[32,38] These efforts may increase quit attempts, reduce smoking among caregivers, and decrease potentially preventable and costly ED visits and hospitalizations.[36,48] Future research should assess illness severity and healthcare costs related to these visits. Assessing the cost–benefits of providing cessation interventions to caregivers of SHS-exposed children may help to drive the implementation of standardized SHSe screening and counseling in all pediatric settings.

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References

1. Homa DM, Neff LJ, King BA, et al. Vital signs: disparities in nonsmokers' exposure to secondhand smoke–United States, 1999–2012. MMWR Morb Mortal Wkly Rep. 2015; 64(4):103–108. [PubMed: 25654612]
2. U.S. DHHS. The health consequences of involuntary exposure to tobacco smoke: a report of the Surgeon General U.S DHHS. CDC, National Center for Chronic Disease Prevention and Health Promotion Office on Smoking and Health; 2006.
3. U.S. DHHS. The health consequences of smoking - 50 years of progress: a report of the Surgeon General. Rockville, MD: U.S. DHHS, Office of the Surgeon General; 2014.
4. Burke H, Leonardi-Bee J, Hashim A, et al. Prenatal and passive smoke exposure and incidence of asthma and wheeze: systematic review and meta-analysis. Pediatrics. 2012; 129(4):735–744. https://doi.org/10.1542/peds.2011–2196. [PubMed: 22430451]
5. Rodríguez-Martínez CE, Sossa-Briceño MP, Castro-Rodriguez JA. Predictors of hospitalization for asthma in children: results of a 1-year prospective study: predictors of hospitalization for asthma. Pediatr Pulmonol. 2014; 49(11):1058–1064. https://doi.org/10.1002/ppul.22936. [PubMed: 24376022]
6. van den Bosch GE, Merkus PJFM, Buysse CMP, et al. Risk factors for pediatric intensive care admission in children with acute asthma. Respir Care. 2012; 57(9):1391–1397. https://doi.org/10.4187/respcare.01325. [PubMed: 22348677]
7. Howrylak JA, Spanier AJ, Huang B, et al. Cotinine in children admitted for asthma and readmission. Pediatrics. 2014; 133(2):e355–e362. https://doi.org/10.1542/peds.2013-2422. [PubMed: 24446438]
8. Wang Z, May SM, Charoenlap S, et al. Effects of secondhand smoke exposure on asthma morbidity and health care utilization in children: a systematic review and meta-analysis. Ann Allergy Asthma Immunol. 2015; 115(5):396–401. https://doi.Org/10.1016/j.anai.2015.08.005. [PubMed: 26411971]
9. Jin Y, Seiber EE, Ferketich AK. Secondhand smoke and asthma: what are the effects on healthcare utilization among children? Prev Med. 2013; 57(2):125–128. https://doi.org/10.1016/j.ypmed.2013.05.003. [PubMed: 23701846]
10. CDC. Asthma in the U.S. www.cdc.gov/VitalSigns/Asthma/index.html. Updated 2011
11. Mahabee-Gittens EM, Gordon JS. Missed opportunities to intervene with caregivers of young children highly exposed to secondhand tobacco smoke. Prev Med. 2014; 69:304–305. https://doi.org/10.1016/j.ypmed.2014.10.031. [PubMed: 25449690]
12. Hill SC, Liang L. Smoking in the home and children's health. Tob Control. 2008; 17(1):32–37. https://doi.org/10.1136/tc.2007.020990. [PubMed: 18218804]
13. Levy DE, Rigotti NA, Winickoff JP. Medicaid expenditures for children living with smokers. BMC Health Serv Res. 2011; 11(1):125. https://doi.org/10.1186/1472-6963-11-125. [PubMed: 21612635]
14. Jacobs-van der Bruggen MAM, Wijga AH, Brunekreef B, et al. Do parents who smoke underutilize health care services for their children? A cross sectional study within the longitudinal PIAMA study. BMC Health Serv Res. 2007; 7(1):83. https://doi.org/10.1186/1472-6963-7-83. [PubMed: 17565678]
15. Florence CS, Adams EK, Ayadi MF. Pediatric health care costs attributable to exposure to second-hand smoke: an exploratory analysis. J Health Care Finance. 2007; 34(1):36–43. [PubMed: 18972984]
16. McBride CM, Lozano P, Curry SJ, Rosner D, Grothaus LC. Use of health services by children of smokers and nonsmokers in a health maintenance organization. Am J Public Health. 1998; 88(6):897–902. https://doi.org/10.2105/AJPH.88.6.897. [PubMed: 9618616]

17. Merianos, AL., Odar Stough, C., Nabors, LA., Mahabee-Gittens, EM. Tobacco smoke exposure and health care utilization among children in the United States. Am J Health Promot. In press. Online January 30, 2017. https://doi.org/10.1177/0890117116686885
18. Kamble S, Bharmal M. Incremental direct expenditure of treating asthma in the United States. J Asthma. 2009; 46(1):73–80. https://doi.org/10.1080/02770900802503107. [PubMed: 19191142]
19. Mannino DM, Homa DM, Redd SC. Involuntary smoking and asthma severity in children: data from the third National Health and Nutrition Examination Survey. Chest. 2002; 122(2):409–415. https://doi.org/10.1378/chest.122.2.409. [PubMed: 12171810]
20. Crombie IK, Wright A, Irvine L, Clark RA, Slane PW. Does passive smoking increase the frequency of health service contacts in children with asthma? Thorax. 2001; 56(1):9–12. https://doi.org/10.1136/thorax.56.L9. [PubMed: 11120897]
21. McMillen, R., O'Connor, KG., Groner, J., Tanski, S., Park, ER., Klein, JD. Changes and factors associated with tobacco counseling: results from the AAP periodic survey. Acad Pediatr. In press. Online January 16, 2017. https://doi.org/10.1016/j.acap.2017.01.002
22. Kit BK, Simon AE, Brody DJ, Akinbami LJ. U.S. prevalence and trends in tobacco smoke exposure among children and adolescents with asthma. Pediatrics. 2013; 131(3):407. https://doi.org/10.1542/peds.2012-2328. [PubMed: 23400612]
23. Johnson CL, Paulose-Ram R, Ogden CL, et al. National Health and Nutrition Examination Survey: analytic guidelines, 1999–2010. National Center for hHalth Statistics. Vital Health Stat. 2013; 2(161)
24. Zipf G, Chiappa M, Porter KS, Ostchega Y, Lewis BG, Dostal J. National Health and Nutrition Examination Survey: Plan and operations, 1999–2010. National Center for Health Statistics. Vital Health Stat. 2013; 1(56):1–37.
25. Benowitz NL. Cotinine as a biomarker of environmental tobacco smoke exposure. Epidemiol Rev. 1996; 18(2):188–204. https://doi.org/10.1093/oxfordjournals.epirev.a017925. [PubMed: 9021312]
26. Bernert JT Jr, Gunter EW, Miller BB, et al. Development and validation of sensitive method for determination of serum cotinine in smokers and nonsmokers by liquid chromatography/atmospheric pressure ionization tandem mass spectrometry. Clin Chem. 1997; 43(12):2281–2291. [PubMed: 9439445]
27. Avila-Tang E, Elf JL, Cummings KM, et al. Assessing secondhand smoke exposure with reported measures. Tob Control. 2013; 22(3):156–163. https://doi.org/10.1136/tobaccocontrol-2011-050296. [PubMed: 22949496]
28. Benowitz NL, Bernert JT, Caraballo RS, Holiday DB, Wang J. Optimal serum cotinine levels for distinguishing cigarette smokers and nonsmokers within different racial/ethnic groups in the United States between 1999 and 2004. Am J Epidemiol. 2009; 169(2):236–248. https://doi.org/10.1093/aje/kwn301. [PubMed: 19019851]
29. Gatz DF, Smith L. The standard error of a weighted mean concentration—I. bootstrapping vs other methods. Atmos Environ. 1995; 29(11):1185–1193. https://doi.org/10.1016/1352-2310(94)00210-C.
30. Gatz DF, Smith L. The standard error of a weighted mean concentration—II. estimating confidence intervals. Atmos Environ. 1995; 29(11):1195–1200. https://doi.org/10.1016/1352-2310(94)00209-4.
31. Research Triangle Institute. SUDAAN user's manual. release 6.40. 8-16-8-17.
32. American Academy of Pediatrics. Policy statement - tobacco use: a pediatric disease. Pediatrics. 2009; 124(5):1474–1487. https://doi.org/10.1542/peds.2009-2114. [PubMed: 19841108]
33. Farber HJ, Groner J, Walley S, Nelson K, Section on Tobacco Control. Protecting children from tobacco, nicotine, and tobacco smoke. Pediatrics. 2015; 136(5):e1439–e1467. https://doi.org/10.1542/peds.2015-3110. [PubMed: 26504135]
34. Prochaska JJ, Grossman W, Young-Wolff KC, Benowitz NL. Validity of self-reported adult secondhand smoke exposure. Tob Control. 2015; 24(1):48–53. https://doi.org/10.1136/tobaccocontrol-2013-051174. [PubMed: 23997071]
35. Mahabee-Gittens EM, Gordon JS, Krugh ME, Henry B, Leonard AC. A smoking cessation intervention plus proactive quitline referral in the pediatric emergency department: a pilot study.

Nicotine Tob Res. 2008; 10(12):1745–1751. https://doi.org/10.1080/14622200802443494. [PubMed: 19023825]

36. Mahabee-Gittens EM, Khoury JC, Ho M, Stone L, Gordon JS. A smoking cessation intervention for low-income smokers in the ED. Am J Emerg Med. 2015; 33(8):1056–1061. https://doi.org/10.1016/j.ajem.2015.04.058. [PubMed: 25976268]
37. Wilson KM, Wesgate SC, Best D, Blumkin AK, Klein JD. Admission screening for secondhand tobacco smoke exposure. Hosp Pediatr. 2012; 2(1):26–33. https://doi.org/10.1542/hpeds.2011-0005. [PubMed: 24319810]
38. Lustre BL, Dixon CA, Merianos AL, Gordon JS, Zhang B, Mahabee-Gittens EM. Assessment of tobacco smoke exposure in the pediatric emergency department. Prev Med. 2016; 85:42–46. https://doi.org/10.1016/j.ypmed.2016.01.003. [PubMed: 26794047]
39. Jenssen BP, Shelov ED, Bonafide CP, Bernstein SL, Fiks AG, Bryant-Stephens T. Clinical decision support tool for parental tobacco treatment in hospitalized children. Appl Clin Inform. 2016; 7(2):399–411. https://doi.org/10.4338/ACI-2015-12-RA-0169. [PubMed: 27437049]
40. Jenssen BP, Bryant-Stephens T, Leone FT, Grundmeier RW, Fiks AG. Clinical decision support tool for parental tobacco treatment in primary care. Pediatrics. 2016; 137(5):1. https://doi.org/10.1542/peds.2015-4185.
41. Mahabee-Gittens EM, Dexheimer JW, Gordon JS. Development of a tobacco cessation clinical decision support system for pediatric emergency nurses. Comput Inform Nurs. 2016; 34(12):613–614. https://doi.org/10.1097/CIN.0000000000000267. [PubMed: 27926592]
42. Sharifi M, Adams WG, Winickoff JP, Guo J, Reid M, Boynton-Jarrett R. Enhancing the electronic health record to increase counseling and quit-line referral for parents who smoke. Acad Pediatr. 2014; 14(5):478–484. https://doi.org/10.1016/j.acap.2014.03.017. [PubMed: 25169159]
43. Blaine K, Rogers J, Winickoff JP, et al. Engaging in secondhand smoke reduction discussions with parents of hospitalized pediatric patients: a national survey of pediatric nurses in the United States. Prev Med. 2014; 62:83–88. https://doi.org/10.1016/j.ypmed.2014.01.021. [PubMed: 24502846]
44. Wilson KM, Pier JC, Wesgate SC, Cohen JM, Blumkin AK. Secondhand tobacco smoke exposure and severity of influenza in hospitalized children. J Pediatr. 2013; 162(1):16–21. https://doi.org/10.1016/j.jpeds.2012.06.043. [PubMed: 22863259]
45. Andrews AL, Shirley N, Ojukwu E, Robinson M, Torok M, Wilson KM. Is secondhand smoke exposure associated with increased exacerbation severity among children hospitalized for asthma? Hosp Pediatr. 2015; 5(5):249–255. https://doi.org/10.1542/hpeds.2014-0128. [PubMed: 25934808]
46. Kruse GR, Rigotti NA. Routine screening of hospital patients for secondhand tobacco smoke exposure: a feasibility study. Prev Med. 2014; 69:141–145. https://doi.org/10.1016/j.ypmed.2014.09.017. [PubMed: 25284258]
47. Winickoff JP, Hillis VJ, Palfrey JS, Perrin JM, Rigotti NA. A smoking cessation intervention for parents of children who are hospitalized for respiratory illness: the stop tobacco outreach program. Pediatrics. 2003; 111(1):140–145. https://doi.org/10.1542/peds.111.1.140. [PubMed: 12509567]
48. Ralston S, Grohman C, Word D, Williams J. A randomized trial of a brief intervention to promote smoking cessation for parents during child hospitalization. Pediatr Pulmonol. 2013; 48(6):608–613. https://doi.org/10.1002/ppul.22614. [PubMed: 22782737]
49. Jenssen, BP., Wilson, KM. Tobacco control and treatment for the pediatric clinician: practice, policy, and research updates. Acad Pediatr. In press. Online January 6, 2017. https://doi.org/10.1016/j.acap.2016.12.010
50. Pbert L, Klein JD, Farber H, et al. State-of-the-art office-based interventions to eliminate youth tobacco use: the past decade. Pediatrics. 2015; 135(4):734–747. https://doi.org/10.1542/peds.2014-2037. [PubMed: 25780075]
51. Zahran HS, Bailey C, Garbe P. Vital signs: Asthma prevalence, disease characteristics, and self-management education–United States, 2001–2009. MMWR Morb Mortal Wkly Rep. 2011; 60(17):547–552. [PubMed: 21544044]
52. Akinbami, LJ., U.S. National Center for Health Statistics. Trends in asthma prevalence, health care use, and mortality in the United States, 2001–2010. Hyattsville, MD: U.S. DHHS, CDC, National Center for Health Statistics; 2012.

53. Merianos AL, Dixon CA, Mahabee-Gittens EM. Secondhand smoke exposure, illness severity and resource utilization in pediatric emergency department patients with respiratory illnesses. J Asthma. In press. Online December 8, 2016.

Table 1

Sociodemographic Characteristics of Children Aged 3–19 Years by SHSe Level, NHANES 2009–2012

Sociodemographic characteristics	Overall		No SHSe < 0.05 ng/mL		Low SHSe 0.05–2.99 ng/mL		High SHSe > 3ng/mL	
	n	% (95% CI)	n	% (95% Cl)	n	% (95% Cl)	n	% (95% Cl)
Child sex								
Female	2,391	48.8 (46.8, 50.8)	1,330	58 (55.3, 60.7)	908	35 (31.9, 38.1)	153	7 (2.9, 11.1)
Male	2,594	51.2 (49.2, 53.2)	1,377	55 (52.5, 57.6)	969	34 (31.1, 36.9)	248	11 (7.1, 14.9)
Child age								
3–11 years	2,707	52.5 (50.5, 54.5)	1,482	59 (56.5, 61.6)	1,134	38 (35.3, 40.7)	91	3 (0.0, 6.5)
12–19 years	2,278	47.5 (45.5, 49.5)	1,225	55 (52.3, 57.7)	743	32 (28.7, 35.3)	310	14 (10.1, 17.9)
Child race/ethnicity								
White	1,347	55.3 (52.6, 58.0)	650	56 (52.3, 59.7)	524	33 (28.9, 37.1)	173	11 (6.3, 15.7)
Black	1,241	14.4 (12.4, 16.4)	419	34 (29.5, 38.5)	699	55 (51.3, 58.7)	123	11 (5.5, 16.5)
Hispanic	1,823	22.0 (20.0, 24.0)	1,268	69 (66.5, 71.6)	482	26 (22.1, 29.9)	73	4 (0.0, 8.5)
Other races/multiracial	574	8.3 (6.0, 10.7)	370	60 (55.1, 64.9)	172	32 (24.9, 39.1)	32	8 (0.0, 17.4)
Household income level								
<$20,000/year	1,138	17.6 (15.4, 19.76)	376	32 (27.3, 36.7)	611	52 (48.1, 55.9)	151	16 (10.1, 21.9)
$20,000–$44,999/year	1,614	27.6 (25.4, 29.8)	810	48 (44.5, 51.5)	674	42 (38.3, 45.7)	130	10 (4.9, 15.1)
$45,000–$74,999/year	789	19.2 (16.5, 21.9)	468	59 (54.5, 63.5)	275	35 (29.3, 40.7)	46	7 (0.0, 14.5)
>$75,000/year	1,087	35.6 (32.7, 38.5)	841	75 (72.1, 77.9)	195	19 (13.5, 24.5)	51	6 (0.0, 12.5)

Notes: Boldface indicates statistical significance ($p < 0.001$).

N=4,985. n refers to raw scores; percentages are weighted and exclude missing data.

SHSe, secondhand smoke exposure; NHANES, National Health and Nutrition Examination Survey

Table 2

Adjusted Prevalence of Routine Place to go for Health Care Stratified by SHSe Level in Children

	Healthcare visits				Multivariable regression[b]
	No		Yes		
Cotinine level	**n**	**% (95% CI)[a]**	**n**	**% (95% CI)**	**OR (95% CI)**
Routine place to go for health care (n=4,984)					
No SHSe (< 0.05 ng/mL)	195	6 (2.7, 9.3)	2,512	94 (93.0, 95.0)	Ref
Low SHSe (0.05–2.99 ng/mL)	116	7 (2.3, 11.7)	1,760	93 (91.8, 94.2)	0.98 (0.76, 1.27)
High SHSe (> 3 ng/mL)	59	14 (5.2, 22.8)	342	86 (82.3, 89.7)	1.01 (0.71, 1.43)
Doctor's office or HMO as most often place for health care (n=4,614)					
No SHSe (< 0.05 ng/mL)	823	26 (23.1, 28.9)	1,689	74 (71.8, 76.2)	Ref
Low SHSe (0.05–2.99 ng/mL)	577	29 (25.3, 32.7)	1,183	71 (68.5, 73.6)	1.02 (0.87, 1.19)
High SHSe (> 3 ng/mL)	119	31 (22.8, 39.2)	223	69 (62.9, 75.1)	0.84 (0.66, 1.08)
Clinic or health center as most often place for health care (n=4,614)					
No SHSe (< 0.05 ng/mL)	1,748	77 (75.0, 79.0)	764	23 (20.1, 25.9)	Ref
Low SHSe (0.05–2.99 ng/mL)	1,245	74 (71.7, 76.4)	515	26 (22.3, 29.7)	1.04 (0.89, 1.22)
High SHSe (> 3 ng/mL)	251	75 (69.7, 80.3)	91	25 (16.2, 33.8)	1.08 (0.83, 1.41)
Emergency department as most often place for health care (n=4,614)					
No SHSe (< 0.05 ng/mL)	2,485	99 (98.6, 99.4)	27	1 (0.0, 4.7)	Ref
Low SHSe (0.05–2.99 ng/mL)	1,729	99 (98.6, 99.4)	31	1 (0.0, 4.5)	0.73 (0.38, 1.41)
High SHSe (> 3 ng/mL)	321	95 (92.7, 97.4)	21	5 (0.0, 14.4)	3.49 (1.77, 6.89)
Hospital outpatient department as most often place for health care (n=4,614)					
No SHSe (< 0.05 ng/mL)	2,495	99 (98.6, 99.4)	17	1 (0.0, 5.7)	Ref
Low SHSe (0.05–2.99 ng/mL)	339	99 (98.0, 100.0)	25	1 (0.0, 4.9)	1.54 (0.70, 3.37)
High SHSe (> 3 ng/mL)	1,735	100 (100.0, 100.0)	3	0 (0.0, 0.0)	0.64 (0.14, 3.02)

Notes: Boldface indicates statistical significance ($p < 0.001$). n refers to raw scores and percentages are weighted. Missing values excluded.

[a]Adjusted prevalence estimates and CIs.

[b]Regression controlling for child's sex, child age, child race/ethnicity, and household income level.

SHSe, secondhand smoke exposure; Ref, reference group

Table 3

Adjusted Prevalence of Overnight Hospital Stays, Asthma, and Acute Care Visits Stratified by SHSe Level

	Overall				
	No		Yes		Multivariable regression[b]
Cotinine level	**n**	**% (95% CI)[a]**	**n**	**% (95% CI)**	**OR (95% CI)**
Overnight hospital stays in past year for all children (n=4,985)					
No SHSe (< 0.05 ng/mL)	2,621	97 (96.4, 97.6)	86	3 (0.0, 6.5)	Ref
Low SHSe (0.05–2.99 ng/mL)	1,793	96 (95.0, 97.0)	84	4 (0.0, 8.1)	1.30 (0.92, 1.82)
High SHSe (> 3 ng/mL)	368	90 (86.9, 93.1)	33	10 (0.0, 20.2)	2.85 (1.87, 4.34) ***
Ever had asthma (n=4,985)					
No SHSe (< 0.05 ng/mL)	2,309	84 (82.4, 85.6)	398	16 (12.5, 19.5)	Ref
Low SHSe (0.05–2.99 ng/mL)	1,481	79 (76.8, 81.2)	396	21 (17.1, 24.9)	1.28 (1.09–1.51) ***
High SHSe (> 3 ng/mL)	298	75 (70.1, 79.9)	103	25 (16.6, 33.4)	1.34 (1.05–1.71) ***
Children with asthma					
Had an acute care visit for asthma in past year (n = 418)[c]					
No SHSe (< 0.05 ng/mL)	143	85 (79.1, 90.9)	32	15 (2.7, 27.4)	Ref
Low SHSe (0.05–2.99 ng/mL)	139	73 (65.6, 80.5)	68	27 (16.4, 37.6)	2.17 (1.24–3.80) **
High SHSe (> 3 ng/mL)	27	66 (48.2, 83.8)	9	34 (3.0, 65.0)	4.74 (1.93–11.68) ***
Overnight hospital stays in past year for children with asthma (n = 897)					
No SHSe (< 0.05 ng/mL)	378	96 (94.0, 98.0)	20	4 (0.0, 12.6)	Ref
Low SHSe (0.05–2.99 ng/mL)	368	94 (91.7, 96.4)	28	6 (0.0, 14.8)	1.40 (1.05–1.88) **
High SHSe (> 3 ng/mL)	93	88 (81.3, 94.7)	10	12 (0.0, 32.2)	4.44 (3.14–6.28) ***

Notes: Boldface indicates statistical significance

** p < 0.01;

*** p < 0.001).

N=4,985. n refers to raw scores and percentages are weighted.

[a] Adjusted prevalence estimates and CIs.

[b] Regression controlling for child's sex, child age, child race/ethnicity, and household income level.

[c] Question was only asked among those who still have asthma.

SHSe, secondhand smoke exposure; Ref, reference group

Table 4

Adjusted Prevalence of Number of Hospital Admissions for Overnight Stays Stratified by SHSe Level in Children

Cotinine level	Number of hospital admissions for overnight stays in past year														Poisson regression[b] RR (95% CI)
	0 times		1 time		2 times		3 times		4 times		5 times		>6 times		
	n	%(95% CI)[a]	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	
Overall (N=4,985)															
No SHSe (< 0.05 ng/mL)	2,724	96.7 (96.1 97.3)	72	2.6 (0.0, 6.3)	7	0.2 (0.0, 3.5)	8	0.3 (0, 4.0)	1	0.1 (0.0, 6.4)	0	0.0 (0.0, 0.0)	4	0.1 (0.0, 3.2)	Ref
Low SHSe (0.05–2.99 ng/mL)	404	90.4 (87.5, 93.3)	35	7.8 (0.0, 16.6)	2	0.5 (0.0, 10.3)	5	1.1 (0.0, 10.3)	0	0.0 (0.0, 0.0)	0	0.0 (0.0, 0.0)	1	0.2 (0.0, 9.0)	1.06 (0.81, 1.40)
High SHSe (> 3 ng/mL)	1,657	96.2 (95.2, 97.2)	48	2.8 (0.0, 7.5)	10	0.5 (0.0, 4.8)	4	0.2 (0.0, 4.5)	1	0.1 (0.0, 6.4)	1	0.1 (0.0, 6.4)	1	0.1 (0.0,6.4)	2.05 (1.46, 2.87)
Children with asthma (N=846)															
No SHSe (< 0.05 ng/mL)	421	95.9 (93.9, 97.9)	11	2.5 (0.0, 11.7)	3	0.7 (0.0, 9.9)	2	0.5 (0.0, 9.9)	1	0.2 (0.0, 9.6)	0	0.0 (0.0, 0.0)	1	0.2 (0.0, 9.6)	Ref
Low SHSe (0.05–2.99 ng/mL)	95	88 (81.5, 94.4)	7	6.5 (0.0, 24.7)	1	0.9 (0.0, 19.7)	4	3.7 (0.0, 22.1)	0	0 (0.0, 0.0)	0	0.0 (0.0, 0.0)	1	0.9 (0.0, 19.7)	1.10 (0.89, 1.37)
High SHSe (> 3 ng/mL)	330	94.6 (92.2, 96.9)	15	4.3 (0.0, 14.5)	2	0.6 (0.0, 11.0)	0	0 (0.0, 0.0)	1	0.3 (0.0, 10.9)	0	0.1 (0.0, 0.0)	1	0.3 (0.0, 10.9)	3.87 (3.06, 4.89)

Notes: Boldface indicates statistical significance ($p < 0.001$). n refers to raw scores and percentages are weighted. Missing values excluded.

[a] Adjusted prevalence estimates and CIs.

[b] Regression controlling for child's sex, child age, child race/ethnicity, and household income level.

SHSe, secondhand smoke exposure; RR, relative risk; Ref, reference group