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Title page

Healthcare Costs Attributable to Secondhand Smoke Exposure at Home for U.S. Adults

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ABSTRACT

Objective: To estimate healthcare costs attributable to secondhand smoke (SHS) exposure at home among nonsmoking adults (18+) in the U.S.

Methods: We analyzed data on nonsmoking adults (N=67,735) from the 2000, 2005, and 2010 (the latest available data on SHS exposure at home) U.S. National Health Interview Surveys. This study was conducted from 2015-2017. We examined hospital nights, home care visits, doctor visits, and emergency room (ER) visits. For each, we analyzed the association of SHS exposure at home with healthcare utilization with a Zero-Inflated Poisson regression model controlling for socio-demographic and other risk characteristics. Excess healthcare utilization attributable to SHS exposure at home was determined and multiplied by unit costs derived from the 2014 Medical Expenditures Panel Survey to determine annual SHS-attributable healthcare costs.

Results: SHS exposure at home was positively associated with hospital nights and ER visits, but was not statistically associated with home care visits and doctor visits. Exposed adults had 1.28 times more hospital nights and 1.16 times more ER visits than non-exposed adults. Annual SHS-attributable healthcare costs totaled $4.6 billion (including $3.8 billion for hospital nights and $0.8 billion for ER visits, 2014 dollars) in 2000, $2.1 billion (including $1.8 billion for hospital nights and $0.3 billion for ER visits) in 2005, and $1.9 billion (including $1.6 billion for hospital nights and $0.4 billion for ER visits) in 2010.

Conclusions: SHS-attributable costs remain high, but have fallen over time. Tobacco control efforts are needed to further reduce SHS exposure at home and associated healthcare costs.

Keywords: Healthcare Costs, Secondhand Smoke Exposure at Home, Nonsmoking Adults, U.S.

INTRODUCTION

Secondhand smoke (SHS) exposure has been linked to numerous health conditions, including stroke, respiratory illness, lung cancer, and heart disease for adults;[1-3] and ear infections, asthma, respiratory symptoms, respiratory infections (bronchitis and pneumonia), sudden infant death syndrome (SIDS), and attention deficit hyperactivity disorder (ADHD) for children.[1,4,5] The harmful health effects of SHS exposure have resulted in excess economic costs. In the U.S., several state-level studies have been conducted to estimate the economic impact of SHS exposure. In Maryland, the economic costs of adult illness and premature death attributable to SHS exposure amounted to $523.8 million in 2005.[6] In Minnesota, the total annual cost of treatment for SHS-related diseases among children and adults was $228.7 million in 2008 dollars, which amounted to $44.58 per resident.[7] In North Carolina, the total annual cost of treatment for health conditions related to SHS exposure among children and adults was estimated to be $293.3 million in 2009 dollars.[8] In Indiana, the direct cost of health care and premature loss of life attributed to SHS among adults and children was estimated to be $1.3 billion in 2010, resulting in SHS-related costs of $201 per capita.[9] In California, the SHS-attributable healthcare costs among children and adults totaled over $241 million in 2009.[10] Internationally, one study estimated that the total healthcare costs of SHS exposure at home among nonsmoking adults (aged 19+) in rural China amounted to $1.2 billion in 2011, which represents 0.3% of China's national healthcare expenditures in 2011.[11] Another study estimated that direct and indirect costs of SHS exposure totaled $126 million among adults aged 35 and older in Taiwan in 2010, representing 0.03 % of Taiwan's gross domestic product.[12]

National-level studies on the economic impact of SHS exposure are limited in the U.S. One study estimated the total annual SHS-attributable medical cost in the U.S. at $6.9 billion in 2005.[13] Another study reported that SHS exposure resulted in more than 42,000 deaths, nearly 600,000 years of potential life lost, and $6.6 billion of lost productivity in 2006 in the U.S.[14] A study estimated that the costs incurred by society for illnesses and deaths due to SHS exposure among never-smoking adults who lived in U.S. public housing range from $87 - $135 million depending on how sensitive a biomarker was used to detect exposure in 2011.[15]

Due to the success in implementing smoke-free policies beginning in the early 2000s,[16] the prevalence of SHS exposure in the United States has been declining substantially since 2000.[17] Using data from the National Health and Nutrition Examination Surveys (NHANES), a recent Centers for Disease

Control and Prevention (CDC) report found that the percentage of the U.S. nonsmoking population (aged ≥3 years) with cotinine-measured SHS exposure declined from 52.5% in 1999–2000 to 25.3% in 2011–2012.[17] Although progress has been made to implement comprehensive smoke-free laws in indoor workplace and public places in the past two decades,[17] it is more challenging to restrict smoking at home. As of 2011, 17% of U.S. households did not have 100% smoke-free rules at home.[18] Thus, the home setting is still the primary source of SHS exposure for many people.[18] Not only do smokers expose people that they live with, but they may also expose people in neighboring units in multi-unit housing, making home smoking an even greater public health issue.[19]

To get the attention of the policymakers who may influence the adoption of home smoking rules, it is helpful to quantify the burden of SHS home exposure by estimating the economic cost associated with this exposure. However, none of the national-level cost of SHS studies cited above examined the cost of SHS exposure in the home environment.[13-15]To fill this gap in the literature, this study estimated annual healthcare costs attributable to SHS exposure at home among nonsmoking adults in the U.S. in 2000, 2005 and 2010.

METHODS

Data source

This study used two data sources.

National Health Interview Surveys (NHIS). The NHIS is an annual, nationally representative, in-person survey of households in the civilian, non-institutionalized population in the U.S. In each sampled household, one adult and one child are randomly selected to provide detailed health information. The NHIS Sample Adult and Person files contain information on healthcare utilization and the number of months without any health insurance coverage. In addition, the same randomly selected core NHIS adult participants are asked to participate in a Cancer Control Supplement, which contains detailed questions about tobacco use and SHS exposure at home. The SHS question was asked in this Cancer Control Supplement in 2000, 2005, and 2010 (though not in the latest 2015 NHIS Cancer Control Supplement). We pooled the Sample Adult files, Person files, and Cancer Control Supplement data from 2000, 2005, and 2010 to obtain a large enough sample to analyze the association between SHS exposure and healthcare utilization.

Medical Expenditures Panel Survey (MEPS). The MEPS is a nationally representative, face-to-face, household interview survey of the U.S. civilian non-institutionalized population conducted annually since 1996. It contains detailed information on each individual's healthcare utilization, expenditures, and the associated ICD-9 diagnostic codes for healthcare services used. It also includes the sources of payment for each medical event, insurance coverage, health status, medical conditions, and sociodemographic characteristics. The most recent MEPS data available when this study was conducted, the 2014 wave, was used to obtain unit costs for healthcare utilizations.

Study sample

This study was limited to nonsmokers because it is difficult to separate the impact of active and passive smoking for smokers. Nonsmokers were defined as those who had not smoked 100 cigarettes in their lifetime or those who had smoked 100 cigarettes in their lifetime but do not currently smoke.

Measures

Dependent variables. Four healthcare utilization outcome variables were included in our analysis as dependent variables: the number of nights in the hospital in the past 12 months (hospital nights), the number of home care visits in the past 2 weeks (home care visits), the number of doctor visits in the past 2 weeks (doctor visits), and the number of emergency room visits in the past 12 months (ER visits). These four variables are those that the NHIS includes to query about health utilization.

The primary independent variable was self-reported SHS exposure at home. Nonsmoking adults were defined as being exposed to SHS at home if they answered "yes" to the NHIS question: "In a usual week, does anyone who lives here, including yourself, smoke cigarettes anywhere inside this home?", and answered one or more days to the following question: "Usually, about how many days per week do people who live here smoke anywhere inside this home?".

Other covariates. Socio-demographic characteristics included age (18-34, 35-64, and 65+), gender (male and female), race and ethnicity (Non-Hispanic (NH) White, NH African American, NH Asian, NH Other, and Hispanic), education (<high school degree, high school graduate/general educational development (GED), some college, and ≥college degree), and poverty status based on the federal poverty level (FPL) guideline (poor (<100% FPL), low income (100%-199% FPL), middle income

(200%-399% FPL), high income (≥400% FPL), and unknown). Because 18.7% of respondents had unknown income status, we included "unknown" as a separate category. The number of months without health insurance was determined by two questions in the NHIS Person file. If the respondent answered "yes" to the question "In the past 12 months, was there any time when you did not have any health insurance or coverage?", then he/she was asked "In the past 12 months, about how many months were you without coverage?" We also include the survey year as a covariate in the model.

Final sample size

The pooled 2000, 2005, and 2010 NHIS data contained 68,659 nonsmoking adults. The final study sample contained 67,735 nonsmoking adults after excluding 924 (1.3%) respondents with missing information on education, number of months without insurance, or any of the four healthcare utilization variables.

Statistical analysis

For each type of healthcare utilization (hospital nights, home care visits, doctor visits, and ER visits), three measures were estimated for all nonsmoking adults and by SHS exposure status during the study period: the mean healthcare utilization per person regardless of having positive utilization or not, the mean healthcare utilization per person among those with positive utilization, and the proportion having positive utilization. For the two mean healthcare utilization rates, the difference in utilization rates between exposed and unexposed adults was tested using a bivariate linear regression model. To test the difference in the proportion having positive utilization between exposed and unexposed adults, a Chi-square test was used.

For each healthcare utilization outcome, an econometric model was developed to analyze the association of SHS exposure at home (independent variable) and the particular healthcare utilization variable (dependent variable) among nonsmoking adults. The dependent variable in each case is a count variable containing many zero values (approximately 90.5% for hospital nights, 99.1% for home health care visits, 81.4% for doctor visits, and 80.7% for ER visits). We tested several modeling strategies to address the zero values and compared them in terms of goodness of fit and root-mean square error, and selected the zero-inflated Poisson (ZIP) regression model for this study. The ZIP model also included socio-demographic characteristics and number of months without health insurance. The ZIP model employs two components which correspond to two zero generating

processes. The first process generates the "sure zero" cases for people who would not be expected to have healthcare utilization regardless of their health). The second process uses a Poisson distribution to generates counts. The counts in the second process includes people who had reason to have healthcare utilization but chose not to, and people who had one or more episodes of utilization. We estimated the first process with a logit model to predict whether or not an individual would be in the “sure zero” group, and estimated the second process with the Poisson model to predict the natural log of the expected count of visits or nights for those adults who are not in the sure zero group. The signs of the coefficients in the logit model in the first process were reversed so that they indicate the probability of having non-zero healthcare utilization. We reported exponentiated coefficients for the Poisson model in the second process.

SHS-attributable healthcare utilization

For each healthcare service, if the estimated ZIP model did not show a statistically significant coefficient for the SHS exposure variable, SHS-attributable healthcare costs were assumed to be zero. If the estimated ZIP model showed a statistically significant coefficient for the SHS exposure variable, the SHS-attributable healthcare utilization was determined by an “excess utilization” methodology.[37] Two sets of predicted healthcare utilization values were generated for each exposed person: one for a factual scenario and one for a counterfactual scenario. Under the factual scenario, the actual value of each independent variable was plugged into the estimated model to derive the prediction. Under the counterfactual scenario, the exposed persons were assumed to have the actual values for socio-demographic, risk characteristics, and number of months without health insurance coverage but were assumed to be not exposed to SHS at home. The difference between the factual and the counterfactual predictions among all nonsmoking adults exposed to SHS at home is the SHS-attributable excess healthcare utilization.

SHS-attributable healthcare costs

The SHS-attributable healthcare cost was determined by multiplying the SHS-attributable healthcare utilization by the mean costs per hospital night, per home care visit, per doctor visit, or per ER visit, obtained from the 2014 MEPS data. All costs are estimated in 2014 dollars. We estimated SHS-attributable healthcare costs for 2000, 2005, and 2010 using year-specific SHS exposure.

All analyses incorporated the appropriate sampling weights to adjust for selection probabilities from the sampling design and survey nonresponse. We also took into account sample weights and the effects of the complex sampling design of the NHIS. Standard errors and 95% confidence intervals were computed. All analyses were carried out using SAS version 9.4 (SAS Institute, Cary, NC) and STATA version 14.0 (Stata Corp LLC, TX). A two-tailed p-value <0.05 was considered to be statistically significant.

RESULTS

Sample distribution

Among the nonsmoking adults in final study sample, 6.8% reported being exposed to SHS at home, slightly more than half were aged 35-64 and were female, 70.0% were NH White, more than half had a middle income or above, and 29.5% had a college degree or above education (Table 1). On average, 17.0% of all nonsmoking adults were uninsured in at least one of the past 12 months. The mean number of months without insurance in the past 12 months was 1.81 months.

Table 1. Sample size distribution by SHS exposure at home, sociodemographic characteristics, survey year, and health insurance coverage among nonsmoking adults (2000, 2005, and 2010 NHIS)*

Variables	N	%
Total	67,735	100.0
SHS exposure at home		
No	63,648	93.2
Yes	4,087	6.8
Age		
18–34	19,030	30.1
35–64	33,755	51.2
≥65	14,950	18.7
Gender		
Male	28,360	46.5
Female	39,375	53.5
Race and ethnicity		
Non-Hispanic White	41,800	70.0
Non-Hispanic African American	9,502	11.0
Non-Hispanic Asian	3,076	4.6
Non-Hispanic Other	667	1.0
Hispanic	12,690	13.3
Poverty status (% of federal poverty level)		
Poor (0.00-0.99)	8,037	8.7

Low income (1.00- 1.99)	10,792	13.7
Middle income (2.00-3.99)	16,243	24.6
High income (≥4.00)	19,890	34.4
Unknown	12,773	18.7
Education		
Less than high school	12,312	14.9
High school graduate/GED	17,789	26.5
Some college	19,077	29.1
College degree or above	18,557	29.5
Year		
2000	24,205	31.2
2005	23,160	33.3
2010	20,370	35.6
Number of Months without health insurance, past 12m (mean=1.81)		
0 months	55,356	83.0
1-12 months	12,379	17.0

* All estimates are weighted.

Healthcare utilization

Table 2 shows that the mean number of hospital nights, ER visits, home care visits, and doctor visits among all nonsmoking adults was 0.6, 0.4, 0.1, and 0.3 per person annually, respectively. Nonsmoking adults who had at least one hospital night had an average of 6.7 hospital nights per year. Similarly, among those with utilization, the mean number of ER visits, home health care visits, and doctor visits were 1.9, 5.4, and 1.5 per person annually, respectively. The bivariate linear regression results show that the mean hospital nights and mean ER visits were significantly higher among exposed nonsmokers than non-exposed nonsmokers regardless whether the mean value was calculated among all nonsmoking adults or only among those with positive utilization. The percent of people having positive hospital nights, ER visits, home health care visits, and doctor visits among all nonsmoking adults was 9.5%, 19.3%, 0.9%, and 18.6%, respectively. The Chi-square test showed that the percentage having positive utilization was significantly higher among exposed nonsmokers compared to unexposed nonsmokers for hospital nights and for ER visits.

Table 2. Mean healthcare utilization and percent of people having positive utilization among nonsmoking adults by SHS exposure at home (2000, 2005, and 2010 NHIS data)*

		SHS exposure at home			
	N	**Total**	**Exposed**	**Non-**	**P****

				exposed	
Hospital nights* **					
Mean (among all)	67,735	0.6	1.0	0.6	0.000
Mean (among those with at least one night)	6,945	6.7	8.8	6.5	0.005
% of those with at least one night (among all)	67,735	9.5	11.0	9.3	0.002
ER visits* **					
Mean (among all)	67,735	0.4	0.6	0.4	<.0001
Mean (among those with at least one visit)	13,549	1.9	2.2	1.9	0.000
% of those with at least one visit (among all)	67,735	19.3	26.5	18.8	<.0001
Home care visits* **					
Mean (among all)	67,735	0.1	0.1	0.1	0.755
Mean (among those with at least one visit)	846	5.4	5.3	5.4	0.876
% of those with at least one visit (among all)	67,735	0.9	1.0	0.9	0.565
Doctor visits* **					
Mean (among all)	67,735	0.3	0.3	0.3	0.543
Mean (among those with at least one visit)	13,215	1.5	1.5	1.5	0.147
% of those with at least one visit (among all)	67,735	18.6	17.3	18.7	0.064

* All estimates are weighted.
**For the two mean healthcare utilization rates, the bivariate linear regression model was used to test the difference in utilization rates between exposed and unexposed adults. The Chi-square test was used to test the difference in the proportion having positive utilization between exposed and unexposed adults.
***Hospital nights: the number of nights in the hospital in the past 12 months; ER visits: the number of emergency room visits in the past 12 months; Home care visits: the number of home care visits in the past 2 weeks; Doctor visits: the number of doctor visits in the past 2 weeks.

The ZIP model results are shown in Table 3. SHS exposure at home was significantly associated with hospital nights and ER visits, but was not statistically associated with home care visits and doctor visits. Exposed adults were more likely to have hospital nights and ER visits than non-exposed adults and had 1.28 times more hospital nights and 1.16 times more ER visits. Survey year was not associated with hospital nights and ER visits.

Table 3. Zero-inflated Poisson models on healthcare utilization among nonsmoking adults (2000, 2005, and 2010 NHIS, N=67,735)*

	Number of nights of hospital overnight, past 12 months				**Number of ER visits, past 12 months**				**Number of home care visits, past 2 weeks**				**Number of doctor visits, past 2 weeks**			
	ZIP				**ZIP**				**ZIP**				**ZIP**			
	logit		**Poisson**		**logit**		**Poisson**		**logit**		**Poisson**		**logit**		**Poisson**	
Variables	**Coef.**	**p**	**exp**	**p**	**Coef.**	**p**	**exp**	**p**	**Coef.**	**p**	**exp**	**p**	**Coef.**	**p**	**exp**	**p**
SHS exposure at home																
No (ref)																
Yes	**0.19**	0.00	**1.28**	0.01	**0.32**	0.00	**1.16**	0.01	0.27	0.12	0.94	0.60	-0.04	0.67	1.10	0.23
Age																
18–34 (ref)																
35–64	0.01	0.90	**1.52**	0.00	**-0.21**	0.00	1.08	0.08	**1.43**	0.00	1.44	0.14	**0.25**	0.00	**1.26**	0.00

≥65	**0.78**	0.00	**1.98**	0.00	**0.12**	0.02	1.09	0.14	**2.91**	0.00	**1.65**	0.04	**1.11**	0.00	**1.14**	0.04
Gender																
Male (ref)																
Female	**0.44**	0.00	**0.89**	0.03	**0.11**	0.00	**1.17**	0.00	**0.48**	0.00	0.88	0.18	**0.55**	0.00	0.95	0.20
Race and ethnicity																
NH White (ref)																
NH African American	-0.02	0.65	1.16	0.05	**0.20**	0.00	**1.20**	0.00	**0.43**	0.00	1.02	0.80	**-0.26**	0.00	**1.17**	0.01
NH Asian	**-0.49**	0.00	0.87	0.24	**-0.22**	0.03	0.91	0.40	-0.19	0.48	1.06	0.83	**-0.42**	0.00	0.93	0.51
NH Other	0.20	0.18	1.20	0.42	0.19	0.15	**1.37**	0.02	0.59	0.19	0.71	0.50	0.02	0.94	1.12	0.50
Hispanic	**-0.12**	0.02	0.89	0.09	**-0.15**	0.00	0.97	0.59	0.05	0.69	**0.70**	0.01	**-0.47**	0.00	**1.18**	0.01
Poverty status (% of federal poverty level)																
Poor (0.00-0.99)																
Low income (1.00-1.99)	**-0.23**	0.00	1.02	0.79	**-0.19**	0.00	0.90	0.05	**-0.53**	0.00	0.90	0.35	-0.10	0.31	0.93	0.37
Middle income (2.00-3.99)	**-0.44**	0.00	**0.84**	0.05	**-0.28**	0.00	**0.70**	0.00	**-1.12**	0.00	0.84	0.20	**-0.19**	0.03	0.89	0.11
High income (≥4.00)	**-0.52**	0.00	**0.68**	0.00	**-0.30**	0.00	**0.62**	0.00	**-1.60**	0.00	0.81	0.19	0.04	0.64	**0.77**	0.00
Unknown	**-0.43**	0.00	**0.84**	0.04	**-0.46**	0.00	**0.76**	0.00	**-0.81**	0.00	0.92	0.46	-0.12	0.23	**0.82**	0.01
Education																
Less than high school																
High school graduate/GED	**-0.16**	0.00	0.95	0.44	**-0.11**	0.02	**0.90**	0.02	**-0.44**	0.00	1.15	0.16	-0.13	0.12	1.07	0.30
Some college	**-0.13**	0.01	0.94	0.38	-0.02	0.75	**0.87**	0.00	**-0.53**	0.00	1.19	0.13	0.05	0.57	1.12	0.06
College degree or above	**-0.33**	0.00	0.95	0.56	**-0.28**	0.00	**0.76**	0.00	**-0.38**	0.01	0.97	0.84	0.00	0.97	1.05	0.47
Year																
2000 (ref)																
2005	-0.01	0.88	0.95	0.40	0.03	0.44	0.99	0.88	0.10	0.32	1.17	0.08	0.09	0.15	1.00	0.93
2010	0.01	0.73	0.95	0.45	0.09	0.05	1.01	0.84	**0.37**	0.00	0.95	0.60	**0.19**	0.00	1.01	0.90
# of months no insurance																
0-12 months	**-0.04**	0.00	0.99	0.34	**-0.02**	0.00	**1.00**	0.59	**-0.14**	0.00	1.01	0.56	**-0.05**	0.00	**0.98**	0.00

Note: Bold results indicate statistically significant results at the p<0.05 level
* All estimates are weighted.

SHS-attributable healthcare cost

SHS exposure at home was associated with an excess of 1.42 million hospital nights in 2000, 657,000 hospital nights in 2005, and 582,000 hospital nights in 2010. SHS exposure at home was associated with an excess of 768,000 ER visits in 2000, 325,000 ER visits in 2005, and 358,000 ER visits in 2010 (Table 4). Results of home health care visits and doctor visits were not significant. The mean cost per hospital night and per ER visit was $2,682 and $1,071 according to the 2014 MEPS data. Therefore, annual SHS-attributable costs in 2014 dollar for hospital nights was $3.8 billion in 2000, $1.8 billion in 2005, and $1.6 billion in 2010. Annual SHS-attributable costs for ER visits were $0.8 billion in 2000,

$0.3 billion in 2005, and $0.4 billion in 2010. Total annual SHS-attributable costs were $4.6 billion in 2000, $2.1 billion in 2005, and $1.9 billion in 2010.

Table 4. SHS attributable healthcare utilization and cost at home among nonsmoking adults (2000, 2005, and 2010 NHIS, 2014 MEPS) (in 2014 dollars)

	Total SHS-attributable healthcare utilization (1,000)				**Total SHS-attributable costs ($ million)**		
	2000	**2005**	**2010**		**2000**	**2005**	**2010**
Hospital nights	1,418.2	657.1	581.6		3.8	1.8	1.6
ER visits	768.4	324.7	357.5		0.8	0.3	0.4
Total					4.6	2.1	1.9

Note: Hospital nights: the number of nights in the hospital in the past 12 months; ER visits: the number of emergency room visits in the past 12 months.

DISCUSSION

This study found that SHS exposure at home was associated with excess hospital nights and ER visits. Our findings indicate that SHS exposure imposes a large economic burden in the U.S., totaling $4.6 billion in 2000, $2.1 billion in 2005, and $1.9 billion in 2010. Given the total adult population of 201.7 million in 2000, 217.8 million in 2005, and 229.5 million in 2010,[20] this amounts to $22.8 per adult in 2000, $9.6 per adult in 2005, and $8.3 per adult in 2010. The large reduction in SHS-attributable healthcare costs per adult over time is consistent with the large reduction in SHS exposure at home reported for adults between 2000 and 2010.[21]

Our estimates of SHS-attributable healthcare costs at home are lower than those reported in the other U.S. national study, conducted by Behan, Eriksen, and Lin, which estimated SHS-attributable medical costs for the U.S. as $6.9 billion in 2008.[13] The difference in estimates in the two studies is likely a result of the use of different measures of SHS exposure. Behan and colleagues used serum cotinine to determine SHS exposure, and biomarker-measured SHS exposure has been shown to lead to greater estimates of SHS exposure than self-reported SHS exposure.[22] Biomarker-measured exposure includes exposure in all settings, including workplaces and public spaces, and thus is a broader exposure measure. Our study included only reported exposure at home. Another reason could be their study included both children and nonsmoking adults, which leaded to a higher estimate than ours.

Our estimates most likely underestimate the true healthcare costs of SHS exposure at home for several reasons. First, our estimates only included SHS-attributable healthcare costs for adults. Children are also vulnerable to SHS exposure and the home setting is the primary source of SHS exposure for children.[4] Total costs would be greater if the costs of children's SHS exposure were included. Second, our study was limited to four types of healthcare costs only. It did not include the SHS-attributable healthcare costs for prescription medication and nursing home care, as well as SHS-attributable indirect morbidity and mortality costs. Third, this study only examined SHS exposure from cigarettes but did not include SHS exposure from cigars, pipes, hookah, or electronic cigarettes. Therefore, the true burden of SHS exposure at home might be higher.

This study is subject to some limitations. First, this study is based on self-report of SHS exposure that may result in recall bias and response bias. Second, our SHS exposure variable did not measure the degree of SHS exposure during a given day or the duration of SHS exposure during which the respondent has been exposed to SHS exposure at home. Third, we did not find a significant relationship between SHS exposure at home and home care visits or doctor visits. It is possible that differences could be detected with a larger sample. Another explanation could be that office visits and home care visits are more likely to be related to preventive care, whereas hospital stays and ER visits generally address immediate health issues. Those who are more concerned about future health might be more likely to use more preventive services and less likely to live in households where they are exposed to SHS. The good news and the bad news is that as fewer people are exposed to SHS, sample sizes become smaller and it is more difficult to detect differences between exposed and unexposed people. Fourth, the latest available data on SHS exposure at home from the NHIS is in 2010, so we were not be able to obtain the most recent prevalence of SHS exposure from NHIS. Fifth, although a disease-based approach which looked at healthcare utilization for specific SHS-attributable conditions might provide a more accurate estimate of SHS-attributable healthcare costs, this was not feasible with the NHIS data because the survey does not include questions on disease-specific healthcare utilization. Instead, we compared all utilization of each service for exposed and non-exposed individuals. Finally, our model did not adjust for the potential effects of SHS exposure in other environments such as the workplace or public places due to data limitations. Specifically, the NHIS did not ask questions about SHS exposure in public places, and only asked workplace exposure questions in 2000 and 2010 with different wording.

Our study found that total SHS-attributable cost in 2010 is still high. Tobacco control efforts are needed to further reduce SHS exposure at home. The U.S. Surgeon General Reports have concluded that the only way to fully protect nonsmokers is to eliminate smoking in all homes, worksites, and public places.[1,23,24] There are several approaches that have been shown to reduce SHS at home. We can implement smoke-free policies in multiunit housing, as the U.S. Department of Housing and Urban Development has recently done for all public housing.[25] Residents in MUH are particularly susceptible to involuntary SHS exposure because tobacco smoke can enter their living units from nearby units and shared areas where smoking occurs. It has been reported that adults who lived in MUH were less likely to have smoke-free home rules than those who lived in single-family housing, and that a third of MUH residents with smoke-free home rules still experienced SHS exposure in their homes.[26] Another way to reduce SHS exposure at home is to encourage the adoption of voluntary smoke-free home rules. Studies have shown that smoke-free policies in workplaces and public places result in decreased exposure at home[27] and clean indoor air laws are associated with an increased likelihood of having voluntary smoke-free home rules.[28] This underscores the need for comprehensive smoke-free laws that prohibit smoking in all public indoor areas. Another approach for reducing home SHS exposure is to promote health education programs to raise public awareness of the harms of SHS exposure.

CONCLUSION

SHS exposure-attributable healthcare costs fell between 2000 and 2010, but remain unacceptably high. Reducing SHS exposure at home will reduce the economic costs attributable to SHS. Our findings provide useful evidence for policymakers who are developing interventions to reduce SHS exposure at home in the U.S.

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