



Original investigation

# Health Care Utilization and Expenditures Attributable to Smokeless Tobacco Use Among US Adults

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## Abstract

**Introduction:** This study estimated the health care utilization and expenditures attributable to the use of smokeless tobacco (ST) which includes chewing tobacco, snuff, dip, snus, and dissolvable tobacco among US adults aged 18 and older.

**Methods:** We used data from the 2012–2015 National Health Interview Surveys ( $n = 139451$  adults) to estimate a zero-inflated Poisson (ZIP) regression model on four health care utilization measures among US adults (hospital nights, emergency room [ER] visits, doctor visits, and home care visits) specified as a function of tobacco use status, and other covariates. Tobacco use status was classified into four categories: current ST users, former ST users, non-ST tobacco users, and never tobacco users. ST-attributable utilization was calculated based on the estimated ZIP model using an “excess utilization” approach. It was then multiplied by the unit cost estimated from the 2014 Medical Expenditures Panel Survey data to derive ST-attributable health care expenditures.

**Results:** During 2012–2015, 2.1% of adults were current ST users and 7.7% were former ST users. ST-attributable health care utilization amounted to 681 000 hospital nights, 624 000 ER visits, and 4.6 million doctor visits per year (home care visits results were not significant). This resulted in annual excess expenditures of \$1.8 billion for hospitalizations, \$0.7 billion for ER visits, and \$0.9 billion for doctor visits, totaling over \$3.4 billion (in 2014 dollars).

**Conclusion:** Comprehensive tobacco control policies and interventions are needed to reduce ST use and the associated health care burden.

**Implications:** This is the first study to assess the impact of ST use on health care burden in the United States. Findings indicate that excess annual health care expenditures attributable to ST use for US adults were \$3.4 billion in 2014 dollars.

## Introduction

Smokeless tobacco (ST) use and its accompanying health risks are a significant and growing public health problem in the United States. ST encompasses a range of tobacco products, including

chewing tobacco, dry snuff, snus, oral moist snuff, and dissolvable tobacco. From 2000 to 2015, total consumption of all types of ST increased by 23.1%.<sup>1</sup> Annual consumption of moist snuff increased especially rapidly during this period from 66.2 to 117.4

billion pounds,<sup>1</sup> and by 2014, accounted for 88% of all ST sales nationally.<sup>2</sup>

Over 8 million US adults now use ST,<sup>3</sup> and use is notably higher in certain subgroups, including rural dwellers,<sup>4</sup> young adult males,<sup>5</sup> and participants in certain sports and activities.<sup>6</sup> On average, 1315 adolescents aged 12–17 are first-time ST users every day.<sup>7</sup> According to the 2015 National Youth Risk Behavior Survey (YRBS), 10.8% of high school (HS) students reported smoking cigarettes and 7.3% reported having used ST in the past 30 days.<sup>8</sup> Among middle- and high-school students who were current tobacco users, daily tobacco use was more prevalent for ST users than for cigarette smokers, cigar smokers, and e-cigarette users.<sup>9</sup>

Although existing and potential ST users may perceive ST products as safe alternatives to cigarettes,<sup>10</sup> ST poses significant health risks to users. ST contains many of the same toxic and carcinogenic compounds as cigarette smoke. Research has found that ST use contributes to dental diseases,<sup>3,11</sup> and oral, esophageal, and pancreatic cancer.<sup>12,13</sup> In addition, 54.8% of chewing tobacco users and 42.5% of snuff users also use other tobacco products<sup>14</sup> and thus may be exposed to even greater health risks.

The harmful health effects of ST are likely to result in excess health care expenditures. However, to our knowledge, there has been no comprehensive national-level study of the impact of ST use on health care costs in the US. This study will estimate annual health care expenditures attributable to ST use among U.S adults during 2012–2015.

## Methods

### Data Source

#### National Health Interview Survey

The National Health Interview Survey (NHIS) is a nationally representative cross-sectional survey of approximately 35,000 households in the US civilian noninstitutionalized population. It is conducted by the National Center for Health Statistics of the US Centers for Disease Control and Prevention, and is administered by the US Census Bureau. It collects information about individual's sociodemographics, health conditions, health care utilization, and health insurance coverage. Three components of the NHIS were used in the analysis: the Family Core, the Sample Adult Core, and Cancer Control Supplement. The Family Core collects information from a knowledgeable adult about household composition, health insurance coverage, and access to and use of health care services for all family members. The NHIS Sample Adult File collects information from a randomly selected adult from each family about cigarette smoking history and other risk behaviors. In 2012–2014, questions about the use of ST and other non-cigarette tobacco (cigar and pipe) were added to the Sample Adult File. Since 1987, a NHIS Cancer Control Supplement has been periodically collected the use of a range of tobacco products. The most recent NHIS Cancer Control Supplement was conducted in 2015 and asked questions about the use of tobacco products, such as ST, cigars, and pipes. We pooled data from the 2012–2015 surveys and included cigarettes, cigars, pipe, and ST in our models.

#### Medical Expenditures Panel Survey

The Medical Expenditures Panel Survey (MEPS) provides nationally representative estimates of health care use, expenditures, sources of payment, and health insurance coverage for the US civilian noninstitutionalized population. We used the 2014 MEPS to calculate the unit costs for health care utilization.

## Outcome Variables

Four types of health care utilization were included in this study.

**Hospital nights** were measured by the number of nights spent in a hospital receiving inpatient care in the last 12 months.

**Emergency room (ER) visits** were the number of visits to the ER for the respondents' own health in the past 12 months. The original value of the answer was categorical and top-coded at 16 visits. We transformed the categorical values into continuous values using the median value of each category except that we also used the value of 16 for the top-coded category.

**Doctor visits** were determined by the answers to the following two NHIS Family Core questions: "During the last 2 weeks, did {person} see a doctor or other health care professional at a doctor's office, a clinic, an emergency room, or some other place?", and "How many times did {person} visit a doctor or other health care professional during the last 2 weeks?"

**Home care visits** were the number of home care visits by a health care professional that the respondent received in the past 2 weeks.

## Covariates

**Tobacco use status** included four mutually exclusive tobacco user groups: (1) current ST users, (2) former ST users, (3) non-ST tobacco users, and (4) never tobacco users. Current ST users were those who now use ST every day or some days. Because the 2012–2015 NHIS questionnaires defined ST as tobacco products which are placed in the mouth or nose (including chewing tobacco, snuff, dip, snus, or dissolvable tobacco), our definition for ST included all these products. Former ST users were those who have used ST products at least once and now do not use ST at all. Therefore, respondents who ever used ST once in their lifetime, regardless of their non-ST tobacco use status, were defined as either current or former ST users. Non-ST tobacco users comprised respondents who have smoked 100 cigarettes (including current and former cigarette smokers) or have ever smoked cigars (regular cigars, little filtered cigars, or cigarillos) or pipes (regular pipes, water pipes, or hookah) at least once in their lifetime but have never used ST. Never tobacco users were respondents who have never used any tobacco products in their lifetime (never smoked 100 cigarettes, and never smoked or used ST, cigars, or pipes even once).

**Sociodemographic characteristics** included age (18–34, 35–64, and 65+), gender (male and female), race/ethnicity (non-Hispanic white, Hispanic, non-Hispanic black, non-Hispanic Asian, and non-Hispanic other), education (<HS, HS graduate (including general education development), some college, and college graduate or above), poverty status, marital status (married, separated/divorced/widowed, never married, and living with a partner), and region of residency (Northeast, Midwest, South, and West). Based on NHIS data for the ratio of family income to the poverty threshold taking into account family size,<sup>15,16</sup> we categorized poverty status as: poor (<100% of Federal Poverty Level [FPL]), low income (100%–199% of FPL), middle income (200%–399% of FPL), high income (≥400% of FPL), and unknown. We did not excluded "unknown" group, because 9.4% of adults fell in this category and we were concerned that income might not be missing at random.

**Binge drinking status** based on the NHIS question: "In the past year, on how many days did you have 5 or more drinks of any alcoholic beverage?", respondents who answered one or more days were classified as binge drinkers.

**Body mass index (BMI)** was categorized as: underweight (BMI <18.5 kg/m<sup>2</sup>), normal (BMI = 18.5–24.9 kg/m<sup>2</sup>), overweight (BMI = 25.0–29.9 kg/m<sup>2</sup>), and obese (BMI ≥30.0 kg/m<sup>2</sup>).

**Proportion of months uninsured** was measured by the number of months during which the respondent did not have any health insurance coverage in the past year divided by 12.

### Statistical Analysis

We first estimated the prevalence of tobacco use among all US adults and subgroups stratified by each covariate. The bivariate analysis chi-square test was used to determine if there was any difference in the prevalence of tobacco use across all subgroups of each covariate. Then, for each group of tobacco user, we estimated the percentage of adults who used health care services and the average health care utilization among those who used health care services by tobacco use status.

The health care utilization measures are likely to have many zero values (i.e., excess zeros) and the distribution of the measure is generally skewed to the right. To deal with these distributional characteristics, we explored several estimation models including a two-part model, Poisson regression model, negative binomial regression model, zero-inflated Poisson (ZIP) regression model, and zero-inflated binomial regression model.<sup>17</sup> Based on goodness of fit and root-mean square error test criteria, we chose the ZIP regression model, a model which employs two processes. The first process is governed by a binary distribution that generates the “sure zeros” (those who would always choose not to use health care services regardless of any circumstances even if they were ill or injured). The second process uses a Poisson distribution to generate the count (0, 1, 2, 3, ...) of the measure. In our analysis, the zero value in the second process refers to those who did not use health care services because they are not ill or injured. For each health care utilization outcome variable, we used a separate ZIP regression model to estimate health care utilization as a function of tobacco use status (reference group = never tobacco users) and all other covariates. The first process of the ZIP regression was estimated using a logit model on the probability of falling in the “sure zero” group. The second process of the ZIP regression was estimated using a Poisson model on the natural log of the expected count of visits or nights. To facilitate interpretation of the results, we reversed the signs of the coefficients in the logit model so that the results reflect the probability of having non-zero health care utilization. For the Poisson model, the exponentiated coefficients are reported in this paper because they are easier to interpret.

**ST-attributable health care utilization** was estimated using an “excess utilization” approach. First, the estimated coefficients from the ZIP regression model were used to generate two sets of predicted health care utilization for both current and former ST users: one for a factual case and one for a counterfactual case. For the factual case, predicted utilization was derived by plugging the actual values of all independent variables into the estimated model. For the counterfactual case, the predicted utilization was derived for a hypothetical “never-tobacco-using ST user (current and former)” who was assumed to have the same characteristics as the ST users except that they were assumed to be a never tobacco user. The difference between the factual and counterfactual predictions is the health care utilization attributable to ST use. Finally, for doctor visits and home care visits, we multiplied the estimated attributable values by 26 to derive the annual values because these two health care utilization measures were based on a 2-week timeframe.

**ST-attributable health care expenditures** were determined by multiplying the ST-attributable health care utilization by the unit cost per utilization. For each health care service, the unit cost was derived

as the sum of total expenditures divided by total utilization in the 2014 MEPS. The average annual ST-attributable health care expenditure was derived by dividing the four-year total of ST-attributable health care expenditures during 2012–2015 by 4.

All analyses were estimated using the NHIS sampling weights that adjust for nonresponse and unequal probabilities of sample selection. Analyses were performed using SAS version 9.4 procedures—PROC SURVEYFREQ and PROC SURVEYMEANS, as well as Stata version 14.0 procedures—svy: zip and svy: total that correct for the complex survey design in the NHIS to produce accurate standard errors. A two-tailed  $p < 0.05$  was considered to be statistically significant.

### Sensitivity Analysis

Due to the fact that many ST users are using other non-ST tobacco at the same time, we conducted a sensitivity analysis by controlling poly-use among ST users. We disaggregated current ST users and former ST users into current ST sole users, current ST poly-users and former ST sole users and former ST poly-users. Current (former) ST sole users were current (former) ST users who have never used non-ST products (i.e., never smoked 100 cigarettes, and never smoked cigars and pipes even once) in their lifetime. Current (former) ST poly-users were current (former) ST users who have smoked 100 cigarettes or have used cigars or pipes at least once in their lifetime. Therefore, tobacco use status was classified into six categories here: current ST sole users, current ST poly-users, former ST sole users, former ST poly-users, non-ST tobacco users, and never tobacco users (the reference group). We re-estimated the ZIP model using these tobacco user groups and derived health care expenditures attributable to sole ST use.

### Study Sample

The pooled 2012–2015 NHIS data contained 139451 adults aged 18+. Excluding the 3416 (2.6%) respondents with missing values for tobacco use status resulted in a sample size of 136035 for the analysis of tobacco use prevalence. For the ZIP regression model analyses, we further excluded those respondents with missing values for the health care utilization outcome variables, education, marital status, binge drinking, BMI, and proportion of uninsured months, resulting in final study samples of 129156 adults for hospital night analysis, 128722 adults for ER visit analysis, 129210 adults for doctor visit analysis, and 129287 adults for home care visit analysis.

### Results

Among the 136035 sampled adults (Table 1), more than half the respondents were female, 51.3% were between ages 34 and 64, 66.4% were non-Hispanic white, 13.4% had less than a HS education, 29.6% reported being poor or having low income, 53.0% were married, and 36.9% lived in the South. By risk behavior characteristics, 23.0% were binge drinkers, more than 60% were overweight or obese, and 14.1% did not have any health insurance during the entire past 12 months.

### Prevalence of Tobacco Use

Table 1 also shows the prevalence of current ST use, former ST use, non-ST tobacco use, and never tobacco use stratified by covariates. During 2012–2015, 2.1% of adults were current ST users, 7.9% were former ST users, 39.8% were non-ST tobacco users, and

**Table 1.** Sample Distribution of the Study Sample Adults and Prevalence of Tobacco Use, 2012–2015 NHIS

Variables	All adults		Current ST users		Former ST users		Non-ST tobacco users		Never tobacco users		p
	N	%	N	%	N	%	N	%	N	%	
Total	136035	100.0	2771	2.1	10338	7.9	55320	39.8	67606	50.2	
Year											
2012	34026	24.9	667	2.1	2541	8.2	13925	40.3	16893	49.4	0.18
2013	34120	25.2	637	2.0	2504	7.8	13867	40.0	17112	50.2	
2014	36233	25.5	792	2.2	2875	7.8	14513	39.2	18053	50.7	
2015	31656	24.4	675	2.3	2418	7.7	13015	39.7	15548	50.3	
Gender											
Male	60332	47.9	2532	4.2	8507	14.0	26696	42.8	22597	39.1	<.001
Female	75703	52.1	239	0.3	1831	2.3	28624	37.1	45009	60.4	
Age											
18–34	36513	30.1	965	2.8	3002	8.1	12793	33.8	19753	55.2	<.001
35–64	68063	51.3	1476	2.1	5778	8.8	27784	40.3	33025	48.8	
65+	31459	18.6	330	1.1	1558	5.1	14743	48.2	14828	45.7	
Race/ethnicity											
NH white	83625	66.4	2372	2.9	8440	10.2	37325	43.5	35488	43.4	<.001
Hispanic	22964	15.3	101	0.4	732	3.3	7148	30.5	14983	65.9	
NH black	19719	12.0	205	0.9	769	3.7	7900	37.5	10845	58.0	
NH Asian	8155	5.6	24	0.3	219	2.4	2263	26.1	5649	71.3	
NH other	1572	0.9	69	4.8	178	9.8	684	41.0	641	44.3	
Education											
Less than high school	20483	13.4	484	2.7	1134	6.1	8388	40.1	10477	51.1	<.001
High school	34784	25.6	942	2.9	2730	8.3	15237	43.4	15875	45.4	
Some college	41627	30.9	932	2.2	3633	8.6	17572	41.1	19490	48.1	
College +	38562	29.7	407	1.1	2825	7.6	13933	35.4	21397	55.9	
Missing	579	0.5	6	2.3	16	4.0	190	34.8	367	58.9	
Poverty status											
Poor	22482	12.6	406	2.0	1351	6.2	9561	41.9	11164	49.9	<.001
Low income	25915	17.0	482	2.0	1762	7.0	10785	40.6	12886	50.4	
Middle income	35395	26.5	875	2.6	2995	8.8	14559	40.0	16966	48.7	
High income	40489	34.8	855	2.1	3615	8.8	16080	39.3	19939	49.8	
Unknown	11754	9.2	153	1.3	615	5.9	4335	36.9	6651	55.9	
Marital status											
Married	59302	53.0	1175	2.1	4698	8.2	22524	38.7	30905	51.0	<.001
S/D/W	36130	17.4	663	1.8	2328	6.7	16829	47.2	16310	44.3	
Never married	32022	22.2	674	2.2	2491	7.4	11957	34.3	16900	56.2	
Living with partner	8274	7.2	259	3.4	800	9.8	3892	47.2	3323	39.6	
Missing	307	0.2	0	0.0	21	6.6	118	41.5	168	51.9	
Region											
Northeast	22393	17.7	207	1.0	1156	5.4	9851	41.7	11179	51.9	<.001
Midwest	28406	22.6	769	2.7	2793	10.2	11911	41.9	12933	45.2	
South	48592	36.9	1118	2.7	3398	7.8	19473	38.9	24603	50.6	
West	36644	22.8	677	1.6	2991	7.7	14085	37.8	18891	53.0	

Table 1. Continued

Variables	All adults		Current ST users		Former ST users		Non-ST tobacco users		Never tobacco users		p
	N	%	N	%	N	%	N	%	N	%	
Binge drinking											
No	103 787	75.2	1300	1.3	5357	5.3	38897	36.4	58233	57.0	<.001
Yes	29763	23.0	1388	4.7	4787	16.3	15234	50.3	8354	28.6	
Missing	2485	1.8	83	3.2	194	8.2	1189	47.1	1019	41.5	
BMI											
Underweight	2422	1.8	23	1.1	105	4.3	1057	38.7	1237	55.9	<.001
Normal	45108	33.6	643	1.4	2898	6.4	17978	38.5	23589	53.7	
Overweight	45194	33.2	1096	2.5	3943	9.2	18674	40.8	21481	47.5	
Obese	39120	28.2	978	2.8	3298	9.0	16126	40.8	18718	47.5	
Missing	4191	3.1	31	0.8	94	2.4	1485	35.7	2581	61.1	
Health insurance coverage status											
No	19977	14.1	467	2.5	1562	7.7	8126	40.9	9822	49.0	0.00
Yes	115540	85.4	2289	2.1	8743	7.9	47020	39.7	57488	50.4	
Missing	518	0.5	15	3.1	33	8.1	174	35.8	296	53.0	

% = weighted percentage; BMI = body mass index; NH = non-Hispanic; NHIS = National Health Interview Survey; ST = smokeless tobacco; S/D/W = separated/divorced/widowed.

50.2% were never tobacco users. The prevalence of tobacco use varied by all covariates except survey year.

**Average Health Care Utilization**

Average health care utilization for each type of health care service among adults stratified by tobacco use status is shown in Table 2. The corresponding utilization rates of hospitalization, ER visits in the past 12 months, doctor and home care visits in the past 2 weeks were 8.0%, 22.9%, 16.5%, and 0.7% for current ST users and 8.0%, 20.2%, 18.7%, and 1.0%, for former ST users. In the past 12 months, among those who were hospitalized or had ER visits, current ST users had average 9.4 hospital nights and 2.2 ER visits, while former ST users had average 6.7 hospital nights and 2.0 ER visits. In the past 2 weeks, among those who had doctor visits or used home care services, current ST users had average 1.4 doctor visits and 6.7 home care visits, while former ST users had average 1.5 doctor visits and 5.5 home care visits.

**Association Between ST Use and Health Care Utilization**

Table 3 presents the estimated results from the ZIP regression models, which includes a logit and a Poisson regression, for each health care utilization measure. Both current and former ST users were more likely than never tobacco users to have hospital nights and ER visits in the past 12 months, but they were not statistically different from never tobacco users in the probability of having doctor visits or home care visits in the past 2 weeks. The Poisson regression results indicate that current ST users had 1.2 times as many ER visits in the past 12 months as never tobacco users, but did not significantly differ from never tobacco users in the number of hospital nights, doctor visits, and home care visits. Former ST users had 1.2 times as many doctor visits in the past 2 weeks as never tobacco users but did not significantly differ from never tobacco users in the number of hospital nights, ER visits, and home care visits.

**Health Care Expenditures Attributable to ST Use**

ST use resulted in an excess health care utilization of 681 000 hospital nights, 624 000 ER visits, and 4.6 million doctor visits per year during the period of 2012–2015 (Table 4). Because neither current ST use nor former ST use was significant in the ZIP regression for home care visits, the excess home care visits attributable to ST use were zero. The unit cost in 2014 was \$2682 per hospital night, \$1071 per ER visit, and \$196 per doctor visit. Annual expenditures attributable to ST use for adults was \$1.8 billion for hospitalizations, \$0.7 billion for ER visits, and \$0.9 billion for doctor visits, totaling \$3.4 billion.

The ZIP model results from the sensitivity analysis indicate that neither current ST sole users nor former ST sole users were significantly different from never tobacco users in the probability of having utilization and number of visits doctor visits and home care visits (table not shown). In terms of hospital nights and ER visits in the past 12 months, the Poisson regression results from the ZIP model indicated that current ST sole users had 4.0 times as many hospital nights and 1.7 times as many ER visits as never tobacco users, and former ST sole users did not differ significantly from never tobacco users in the number of hospital nights but had 0.74 times as many ER visits as never tobacco users. The logit regression results from the ZIP model indicated that neither current nor former ST sole users were statistically different from never tobacco users in the

**Table 2.** Health Care Utilization by Types of Health Care Service and Tobacco Use Status Among US Adults, 2012–2015

	Current ST users	Former ST users	Non-ST tobacco users	Never tobacco users
Sample size	2771	10 338	55 320	67 606
Hospital nights (in the past 12 months)				
% With ≥1 night	8.0	8.0	10.3	7.9
Mean number of nights (sd)	9.4 (2.8)	6.8 (0.6)	6.9 (0.2)	6.0 (0.2)
ER visits (in the past 12 months)				
% With ≥1 visit	22.9	20.2	21.9	16.1
Mean number of visits (sd)	2.2 (0.1)	2.0 (0.1)	2.0 (0.0)	1.9 (0.0)
Doctor visits (in the past 2 weeks)				
% With ≥1 visit	16.5	18.7	22.1	18.0
Mean number of visits (sd)	1.4 (0.1)	1.5 (0.0)	1.5 (0.0)	1.4 (0.0)
Home care visits (in the past 2 weeks)				
% With ≥1 visit	0.7	1.0	1.4	1.2
Mean number of visits (sd)	6.7 (2.0)	5.5 (0.6)	5.7 (0.2)	5.9 (0.3)

ER = emergency room; sd = standard deviation; ST = smokeless tobacco.

probability of using hospital or ER care. Based on these ZIP model results, we estimated that ST sole use attributed to an average of 331 000 excess hospital nights and 13 000 excess ER visits per year during the period of 2012–2015, which resulted in \$0.9 billion loss in total excess health care expenditures including \$887 million for hospitalizations and \$13 million for ER visits. These results suggest that even if we only consider sole ST users, there were significant excess health care expenditures compared to never tobacco users.

## Discussion

This is the first study to assess the health care expenditures attributable to ST use in the United States. We estimated ST-attributable health care expenditures for four types of services alone to be \$3.4 billion per year. While this is far less than the health care expenditures attributable to cigarette smoking, which was estimated to be \$170 billion in 2010,<sup>18</sup> the costs are nonetheless substantial. Furthermore, these costs are likely to be disproportionately borne by rural, young adult, and athlete groups who have the highest rates of ST use.<sup>4–6</sup> Given the increasing popularity of ST use,<sup>1</sup> these costs are likely to increase in the future. ST use is associated with multiple health consequences that could result in health care expenditures, including increased risk of oral, pharyngeal, and pancreatic cancer.<sup>2,13</sup> Biomarkers of exposure to the known carcinogen nicotine-derived nitrosamine ketone (NNK) can be found at similar or greater levels among adult ST users as among cigarette smokers.<sup>19,20</sup> ST use leads to dental diseases, such as periodontal disease and tooth decay,<sup>11,21</sup> and these dental-related problems sometimes result in ER visits.<sup>22</sup> Additionally, some studies have reported an association between ST use and hypertension or other cardiovascular conditions, although the published evidence is inconsistent.<sup>23</sup> Our study documents that these health outcomes result in excess health care expenditures attributable to ST use.

Our estimated ZIP model can also be used to compare the health care utilization and expenditures attributable to non-ST tobacco use with those attributable to ST tobacco use. Based on the estimated coefficients for the “non-ST tobacco users” variable and the same “excess utilization” approach, we estimated that non-ST tobacco use was associated with 3.3 million excess hospital nights, 2.8 million excess ER visits, and 42.0 million excess doctor visit per year, which resulted in \$20.2 billion excess health care expenditures (\$9.0 billion hospitalizations, \$2.9 billion ER visits, and \$8.2 billion doctor

visits). These results indicate that while the prevalence of non-ST tobacco use (39.8%) was four times as large as the prevalence of current and former ST use (2.1% + 7.9%), the health care expenditures attributable to non-ST tobacco use (\$20.2) were six times as large as those attributable to ST tobacco use (\$3.4). Note that non-ST tobacco use lumps together current and former user of cigarettes, cigars, and pipes. The excess expenditures for each of those products could be estimated more accurately using a more detailed breakdown of product use (e.g., current vs. former use, specific tobacco products rather than an aggregate measure); however, that was not the purpose of this paper.

Our estimates are subject to several limitations. First, this study was based on self-reported health care utilization from the NHIS. Self-reported health care use may be subject to recall bias or underreporting.<sup>24</sup> Second, we were not able to include adolescents because the NHIS does not ask them about tobacco use, though the prevalence of ST use among youth is not negligible.<sup>6,8,9</sup> Third, several types of health care utilization were not included because the NHIS does not collect those data, including nursing home care, prescription drugs, and dental care. Fourth, due to the wording of the NHIS question about doctor visits in the past 2 weeks, there is a possibility that ER visits were included in the doctor visits as well. Fifth, due to data limitations, we were unable to include e-cigarettes or newer emerging tobacco products in the analysis. Sixth, due to the lack of lifetime use information for cigars and pipes, non-ST users included those experimental users who used cigars less than 50 times and pipes less than 20 times. Lastly, our analysis did not distinguish between different types of ST products, and due to different use prevalence and different levels of toxic constituents in different types of ST, excess health care expenditures could differ by ST type as well. For example, the pasteurized snus products that are popular in Scandinavian countries typically contain much lower levels of cancer-causing tobacco-specific nitrosamines (TSNAs) than cigarettes or conventional moist snuff. However, in the United States, snus products account for a small portion of total ST sales.<sup>2</sup> Furthermore, some US snus products manufactured differently from Scandinavian snus, can contain nitrosamine levels comparable to those in conventional moist snuff.<sup>25</sup> In early 2017, the US Food and Drug Administration proposed regulation that would set an upper limit on the carcinogen TSNA N-nitrosornicotine in all finished SLT products,<sup>26</sup> but that regulation is yet to be implemented. Thus, our results cannot apportion excess health care expenditures among

**Table 3.** Estimated Results From Zero-Inflated Poisson (ZIP) Regression Models on Health Care Utilization by Types of Health Care Services, 2012–2015

	Hospital nights (N = 129 156)			Emergency room visits (N = 128 722)			Doctor visits (N = 129 210)			Home care visits (N = 129 287)						
	Logit <sup>a</sup>		Poisson <sup>b</sup>	Logit <sup>a</sup>		Poisson <sup>b</sup>	Logit <sup>a</sup>		Poisson <sup>b</sup>	Logit <sup>a</sup>		Poisson <sup>b</sup>				
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p				
<b>Tobacco use status</b>																
Current ST users	0.28	.010	1.34	.336	0.41	.001	1.25	.043	0.34	.057	0.94	.580	-0.27	.465	1.10	.704
Former ST users	0.30	.000	0.93	.490	0.39	.000	1.11	.057	0.14	.105	1.19	.008	0.13	.359	0.98	.884
Non-ST tobacco users	0.29	.000	1.04	.535	0.32	.000	1.10	.003	0.15	.004	1.17	.000	0.07	.305	0.99	.905
Never tobacco users			Ref			Ref				Ref				Ref		
<b>Gender</b>																
Male	-0.34	.000	1.32	.000	-0.25	.000	0.90	.004	-0.44	.000	0.92	.013	0.02	.830	1.05	.545
Female			Ref			Ref				Ref				Ref		
<b>Age</b>																
18–34	-0.15	.000	1.55	.000	-0.15	.000	1.01	.740	0.22	.000	1.22	.000	1.30	.000	1.38	.040
35–64	0.40	.000	1.68	.000	0.13	.011	0.83	.001	0.91	.000	1.13	.035	2.51	.000	1.47	.016
65+			Ref			Ref				Ref				Ref		
<b>Race/ethnicity</b>																
NH white	-0.22	.000	0.96	.497	-0.22	.000	0.94	.177	-0.31	.000	0.99	.861	-0.19	.077	1.02	.830
Hispanic	0.02	.578	1.15	.028	0.26	.000	1.11	.004	-0.12	.067	1.02	.761	0.24	.002	0.94	.328
NH black	-0.40	.000	0.99	.946	-0.43	.000	0.80	.011	-0.16	.175	0.74	.002	-0.70	.000	0.98	.931
NH Asian	0.39	.002	1.08	.715	0.25	.024	1.29	.032	-0.06	.757	1.15	.351	0.31	.245	0.96	.764
NH other			Ref			Ref				Ref				Ref		
<b>Education</b>																
Less than high school	-0.13	.002	1.05	.538	-0.09	.038	0.89	.011	0.05	.464	0.93	.253	-0.35	.000	1.27	.001
High school	-0.12	.005	1.02	.766	-0.06	.189	0.81	.000	0.15	.034	1.00	.986	-0.47	.000	1.00	.978
Some college	-0.21	.000	0.89	.156	-0.26	.000	0.71	.000	0.20	.057	1.01	.883	-0.69	.000	1.21	.095
College +			Ref			Ref				Ref				Ref		
<b>Poverty status</b>																
Poor	-0.28	.000	0.88	.099	-0.20	.000	0.80	.000	-0.02	.790	0.84	.043	-0.43	.000	0.93	.327
Low income	-0.54	.000	0.85	.090	-0.45	.000	0.65	.000	-0.20	.031	0.83	.042	-0.88	.000	1.02	.866
Middle income	-0.72	.000	0.69	.000	-0.46	.000	0.49	.000	-0.07	.531	0.76	.007	-1.32	.000	0.98	.857
High income	-0.49	.000	0.83	.064	-0.57	.000	0.83	.020	-0.34	.005	0.84	.088	-0.53	.000	1.14	.255
Unknown			Ref			Ref				Ref				Ref		
<b>Marital status</b>																
Married	0.15	.000	1.11	.103	0.20	.000	1.04	.304	0.22	.000	1.00	.943	0.77	.000	1.23	.022
S/D/W	-0.48	.000	1.29	.012	0.03	.354	0.95	.222	-0.03	.522	1.02	.601	0.85	.000	1.53	.000
Never married	0.13	.028	1.02	.881	0.31	.000	1.08	.194	0.04	.573	1.09	.226	0.35	.095	0.79	.164
Living with partner			Ref			Ref				Ref				Ref		
<b>Region</b>																
Northeast	-0.05	.272	1.08	.403	-0.07	.131	1.09	.056	-0.12	.102	1.00	.951	-0.32	.005	0.94	.522
Midwest	-0.07	.067	0.92	.173	-0.10	.030	1.02	.545	0.11	.061	0.86	.002	-0.17	.118	1.02	.836
South	-0.20	.000	1.03	.731	-0.20	.000	1.08	.083	-0.12	.055	1.03	.574	-0.38	.003	1.29	.018
West			Ref			Ref				Ref				Ref		
<b>Binge drinking</b>																
Yes	0.48	.000	1.24	.012	0.02	.502	1.05	.208	0.05	.366	1.14	.004	0.87	.000	1.14	.437
No			Ref			Ref				Ref				Ref		

Table 3. Continued

	Hospital nights (N = 129 156)			Emergency room visits (N = 128 722)			Doctor visits (N = 129 210)			Home care visits (N = 129 287)						
	Logit <sup>a</sup>		Poisson <sup>b</sup>	Logit <sup>a</sup>		Poisson <sup>b</sup>	Logit <sup>a</sup>		Poisson <sup>b</sup>	Logit <sup>a</sup>		Poisson <sup>b</sup>				
	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p	Coef.	p				
BMI																
Underweight	0.17	.070	1.24	.062	0.00	.979	1.11	.183	0.11	.487	1.15	.226	0.75	.000	0.92	.551
Normal		Ref				Ref				Ref				Ref		
Overweight	0.10	.003	0.78	.000	0.08	.033	0.95	.230	0.11	.050	1.02	.641	-0.19	.016	0.91	.246
Obese	0.28	.000	0.85	.010	0.23	.000	1.09	.036	0.31	.000	1.12	.010	0.06	.495	0.90	.158
Proportion of months uninsured	-0.52	.000	0.87	.129	-0.22	.000	0.92	.027	-0.94	.000	0.93	.377	-1.54	.000	0.83	.298
Constant	-2.02	.000	4.11	.000	-0.63	.000	2.23	.000	-0.78	.000	0.76	.006	-5.69	.000	2.77	.000

BMI = body mass index; NH = non-Hispanic; S/D/W = separated/divorced/widowed. Bold results indicate statistically significant results at the  $p < .05$  level.

<sup>a</sup>For the convenience of interpretation, the signs of the coefficients have been reversed so that the logit model reflects the probability of potentially having non-zero health care utilization.

<sup>b</sup>The exponentiated coefficients are reported for Poisson models.

Table 4. Smokeless Tobacco Attributable Health Care Utilization and Expenditures by Type of Health Care Service Among US Adults

	Hospital nights			Emergency room visits			Doctor visits			
	Mean	SE	95% CI	Mean	SE	95% CI	Mean	SE	95% CI	
	Total utilization 2012–2015 (thousands)	2723	60	2604	2841	58	2380	2608	714	15
Utilization per year (thousands)	681			624			4638			743
Expenditures per year (\$ thousands)	1 825 599			667 778			909 009			
Total expenditures per year (\$ thousands)	3 402 386									

ST = smokeless tobacco; ZIP = zero-inflated Poisson. Due to nonsignificant estimated coefficients for current ST use and former ST use variables in the ZIP regression model on home care visits, the attributable utilization, and expenditures for home care visits are set to be zero.



specific ST product types. Presumably, most costs can be attributed to the use of conventional moist snuff and chewing tobacco, which account for the vast majority of US sales.<sup>2</sup>

The true economic burden of ST use is likely to be much larger than the \$3.4 billion we estimated, and would also include indirect mortality costs due to lost productivity from premature death and lost time from work and other productive activities that were attributable to ST. Our sensitivity results showed that even sole ST users incurred nonnegligible excess health care expenditure compared to never tobacco users. Therefore, ST use represents an important public health issue that significantly affects the health and well-being of millions of Americans and results in substantial health care expenditures. To reduce ST use and the related health care expenditures, interventions to prevent ST initiation, and increase ST cessation, including increases in ST taxes, mass media campaigns, health warnings, and cessation treatment policies,<sup>27</sup> need to continue and be successfully implemented. Education on the adverse health impacts of ST use are needed to correct misperceptions that ST is less harmful than cigarettes especially among adolescents and young adults.<sup>28,29</sup> In addition, given that ST products in the United States contain many of the same toxic and carcinogenic constituents as cigarette smoke, regulation to set an upper limit on those constituents as proposed by the FDA in early 2017,<sup>26</sup> needs to be implemented as soon as possible. Furthermore, because more than 12% of ST users also smoke cigarettes,<sup>14</sup> ST-focused policies need to be designed in tandem with cigarette-oriented policies to reduce the impact of tobacco use in the United States.

In conclusion, ST use is associated with substantial excess health care utilization and expenditures. Therefore, comprehensive tobacco control policies and interventions are needed to decrease ST use and the resulting health care expenditure burden.

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## Declaration of Interests

None declared.

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