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Healthcare Utilization and Expenditures Attributable to Smokeless Tobacco Use among US Adults

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ABSTRACT

Introduction This study estimated the healthcare 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=139,451 adults) to estimate a zero-inflated Poisson (ZIP) regression model on four healthcare 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 healthcare expenditures.

Results. During 2012-2015, 2.1% of adults were current ST users and 7.7% were former ST users. ST-attributable healthcare 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 healthcare burden.

IMPLICATIONS

This is the first study to assess the impact of smokeless tobacco (ST) use on healthcare burden in the US. Findings indicate that excess annual healthcare 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%.¹ Annual consumption of moist snuff increased especially rapidly during this period from 66.2 to 117.4 billion pounds,¹ and by 2014, accounted for 88% of all ST sales nationally.²

Over 8 million US adults now use ST,³ and use is notably higher in certain subgroups, including rural dwellers,⁴ young adult males,⁵ and participants in certain sports and activities.⁶ On average, 1,315 adolescents aged 12-17 are first-time ST users every day.⁷ According to the 2015 National Youth Risk Behavior Survey (YRBS), 10.8% of high school students reported smoking cigarettes and 7.3% reported having used ST in the past 30 days.⁸ 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.⁹

Although existing and potential ST users may perceive ST products as safe alternatives to cigarettes,¹⁰ 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,^{3,11} and oral, esophageal, and pancreatic cancer.^{12,13} In addition, 54.8% of chewing tobacco users and 42.5% of snuff users also use other tobacco products ¹⁴ and thus may be exposed to even greater health risks.

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

METHODS

Data Source

National Health Interview Survey (NHIS). The NHIS is a nationally representative crosssectional survey of approximately 35,000 households in the US civilian non-institutionalized 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 socio-demographics, health conditions, healthcare 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 healthcare 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 (MEPS). The MEPS provides nationally representative estimates of healthcare use, expenditures, sources of payment, and health insurance coverage for the US civilian non-institutionalized population. We used the 2014 MEPS to calculate the unit costs for healthcare utilization.

Outcome Variables

Four types of healthcare 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 users 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).

Socio-demographic 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 (< high school (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,^{15,16} we categorized poverty status as: poor (<100% of Federal Poverty Level (FPL)), low income (100%-199% of

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FPL), middle income (200%-399% of FPL), high income (\geq 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/m²), normal (BMI= 18.5–24.9 kg/m²), overweight (BMI= 25.0–29.9 kg/m²), and obese (BMI \geq 30.0 kg/m²).

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 healthcare services and the average healthcare utilization among those who used healthcare services by tobacco use status. The healthcare 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.¹⁷ 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 healthcare 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 healthcare services because they are not ill or injured. For each healthcare utilization outcome variable, we used a separate ZIP regression model to estimate healthcare 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 healthcare utilization. For the Poisson model, the exponentiated coefficients are reported in this paper because they are easier to interpret.

ST-attributable healthcare 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 healthcare utilization for both current and former ST users: one for a factual case and

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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 healthcare 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 healthcare utilization measures were based on a 2-week timeframe.

ST-attributable healthcare expenditures were determined by multiplying the ST-attributable healthcare utilization by the unit cost per utilization. For each healthcare 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 healthcare expenditure was derived by dividing the four-year total of ST-attributable healthcare 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-value <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 healthcare expenditures attributable to sole ST use.

Study Sample

The pooled 2012- 2015 NHIS data contained 139,451 adults aged 18+. Excluding the 3,416 (2.6%) respondents with missing values for tobacco use status resulted in a sample size of 136,035 for the analysis of tobacco use prevalence. For the ZIP regression model analyses, we further excluded those respondents with missing values for the healthcare utilization outcome variables, education, marital status, binge drinking, BMI, and proportion of uninsured months, resulting in final study samples of 129,156 adults for hospital night analysis, 128,722 adults for ER visit analysis, 129,210 adults for doctor visit analysis, and 129,287 adults for home care visit analysis.

RESULTS

Among the 136,035 sampled adults (Table 1), more than half the respondents were female, 51.3% were between ages 34-64, 66.4% were non-Hispanic White, 13.4% had less than a high school 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 50.2% were never tobacco users. The prevalence of tobacco use varied by all covariates except survey year.

Average Healthcare Utilization

Average healthcare utilization for each type of healthcare 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 Healthcare Utilization

Table 3 presents the estimated results from the ZIP regression models, which includes a logit and a Poisson regression, for each healthcare 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 two 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 two 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.

Healthcare Expenditures Attributable to ST Use

ST use resulted in an excess healthcare 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 \$2,682 per hospital night, \$1,071 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 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 healthcare 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 healthcare expenditures compared to never tobacco users.

DISCUSSION

This is the first study to assess the healthcare expenditures attributable to ST use in the US. We estimated ST-attributable healthcare expenditures for four types of services alone to be \$3.4 billion per year. While this is far less than the healthcare expenditures attributable to cigarette smoking, which was estimated to be \$170 billion in 2010,¹⁸ 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.⁴⁻⁶ Given the increasing popularity of ST use,¹

these costs are likely to increase in the future.ST use is associated with multiple health consequences that could result in healthcare expenditures, including increased risk of oral, pharyngeal, and pancreatic cancer.^{2,13} 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.^{19,20} ST use leads to dental diseases, such as periodontal disease and tooth decay,^{11,21} and these dental related problems sometimes result in emergency room visits.²² Additionally, some studies have reported an association between ST use and hypertension or other cardiovascular conditions, although the published evidence is inconsistent.²³ Our study documents that these health outcomes result in excess healthcare expenditures attributable to ST use.

Our estimated ZIP model can also be used to compare the healthcare 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 healthcare 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 healthcare 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 healthcare utilization from the NHIS. Self-reported healthcare use may be subject to recall bias or underreporting.²⁴ 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.^{6,8,9} Third, several types of healthcare 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 healthcare 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 US, snus products account for a small portion of total ST sales.² Furthermore, some US snus products manufactured differently from Scandinavian snus, can contain nitrosamine levels comparable to those in conventional moist snuff.²⁵ In early 2017, the US Food and Drug Administration proposed regulation that would set an upper limit on the carcinogen TSNA Nnitrosonornicotine in all finished SLT products,²⁶ but that regulation is yet to be implemented.

Thus, our results cannot apportion excess healthcare expenditures among 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.²

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 non-negligible excess healthcare 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 healthcare expenditures. To reduce ST use and the related healthcare expenditures, interventions to prevent ST initiation and increase ST cessation, including increases in ST taxes, mass media campaigns, health warnings, and cessation treatment policies,²⁷ 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.^{28, 29} In addition, given that ST products in the US 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 2017,²⁶ needs to be implemented as soon as possible. Furthermore, because more than 12% of ST users also smoke cigarettes,¹⁴ ST-focused policies need to be designed in tandem with cigarette-oriented policies to reduce the impact of tobacco use in the US.

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

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DECLARATION OF INTERESTS

None declared.

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					Former	r ST	Non-ST t	obacco	Never tobacco		Р
Variables	All ad	ults	Current S	ST users	user	S	usei	"S	user	S	value
	Ν	%	Ν	%	Ν	%	Ν	%	Ν	%	
Total	136,035	100.0	2,771	2.1	10,338	7.9	55,320	39.8	67,606	50.2	
Year							40.00-	10.0	10.000		
2012	34,026	24.9	667	2.1	2,541	8.2	13,925	40.3	16,893	49.4	0.18
2013	34,120	25.2	637	2.0	2,504	7.8	13,867	40.0	17,112	50.2	
2014	36,233	25.5	792	2.2	2,875	7.8	14,513	39.2	18,053	50.7	
2015	31,656	24.4	675	2.3	2,418	7.7	13,015	39.7	15,548	50.3	
Gender								10.0		20.4	
Male	60,332	47.9	2,532	4.2	8,507	14.0	26,696	42.8	22,597	39.1	<.001
Female	75,703	52.1	239	0.3	1,831	2.3	28,624	37.1	45,009	60.4	
Age											
18-34	36,513	30.1	965	2.8	3,002	8.1	12,793	33.8	19,753	55.2	<.001
35-64	68,063	51.3	1,476	2.1	5,778	8.8	27,784	40.3	33,025	48.8	
65+	31,459	18.6	330	1.1	1,558	5.1	14,743	48.2	14,828	45.7	
Race/Ethnicity								·0 -			
NH White	83,625	66.4	2,372	2.9	8,440	10.2	37,325	43.5	35,488	43.4	<.001
Hispanic	22,964	15.3	101	0.4	732	3.3	7,148	30.5	14,983	65.9	
NH Black	19,719	12.0	205	0.9	769	3.7	7,900	37.5	10,845	58.0	
NH Asian	8,155	5.6	24	0.3	219	2.4	2,263	26.1	5,649	71.3	
NH other	1,572	0.9	69	4.8	178	9.8	684	41.0	641	44.3	
Education				~ -			0.000				
Less than high school	20,483	13.4	484	2.7	1,134	6.1	8,388	40.1	10,477	51.1	<.001
High school	34,784	25.6	942	2.9	2,730	8.3	15,237	43.4	15,875	45.4	
Some college	41,627	30.9	932	2.2	3,633	8.6	17,572	41.1	19,490	48.1	
College +	38,562	29.7	407	1.1	2,825	7.6	13,933	35.4	21,397	55.9	
Missing	579	0.5	6	2.3	16	4.0	190	34.8	367	58.9	
Poverty Status		10.0					0 = 01				
Poor	22,482	12.6	406	2.0	1,351	6.2	9,561	41.9	11,164	49.9	<.001
Low income	25,915	17.0	482	2.0	1,762	7.0	10,785	40.6	12,886	50.4	
Middle income	35,395	26.5	875	2.6	2,995	8.8	14,559	40.0	16,966	48.7	
High income	40,489	34.8	855	2.1	3,615	8.8	16,080	39.3	19,939	49.8	
Unknown	11,754	9.2	153	1.3	615	5.9	4,335	36.9	6,651	55.9	
Marital Status	FO 202	52.0	1 1 75	D 1	4 600	0.2	22 52 4	20.7	20.005	F1 0	< 0.01
Married	59,302	53.0	1,1/5	2.1	4,698	8.2	22,524	38./	30,905	51.0	<.001
S/D/W	36,130	17.4	663	1.8	2,328	6./	16,829	4/.2	16,310	44.3	
Never married	32,022	22.2	6/4	2.2	2,491	/.4	11,957	34.3	16,900	56.2	
Living with partner	8,274	/.2	259	3.4	800	9.8	3,892	4/.2	3,323	39.6	
Missing	307	0.2	0	0.0	21	6.6	118	41.5	168	51.9	
Region	22 202	177	207	1.0	1 1 5 6	Γ 4	0.051	41 7	11 170	F1 0	< 001
INOILIIEdSL Midwoot	22,393	1/./	207	1.0	1,150	5.4 10.2	9,001	41.7	11,179	51.9 4F D	<.001
Fourth	20,400	22.0	/09	2.7	2,795	10.2	11,911	41.9	12,955	45.2	
South	48,592	30.9	1,118	2./	3,398	7.8	19,4/3	38.9	24,603	50.6	
West Bingo Drinking	30,044	22.0	0//	1.0	2,991	/./	14,005	37.0	10,091	55.0	
Mo	102 707	75.0	1 200	1 0	E 2E7	БЭ	20 007	26.4	E0 333	E7 0	< 001
NO	103,707	70.2	1,300	1.5	4 707	16.0	15 224	50.4	0.255	37.0	<.001
105 Missing	29,703	23.0	1,300	4./ วา	4,707	10.5	1 1 1 9 0	30.3 47.1	1 010	20.0 41 E	
DMI	2,405	1.0	05	5.2	194	0.2	1,109	4/.1	1,019	41.5	
Divin Lindorwoight	רג ר	10	22	1 1	10E	12	1.057	20.7	1 227	EE O	< 001
Normal	2,422 15 109	33 E 1.0	643	1.1 1 /	2 000	4.3 6.4	17 070	38 5	1,237 73 590	53.9 53.7	~.001
	40,100 /5 10/	22.0	1 096	1.4	2,050	0.4	18 674	70 8 20'3	20,009 71 /Q1	33.7 47 5	
Obese	40,104 20 100	- 20.2 20.2	1,030 078	2.5	3,343	<i>3.</i> 2	16 176	40.0	21,401 18 710	47.5	
Missing	J3,120 A 101	∠0.∠ 3.1	370	2.0 0.8	3,230 Q/	3.0 7 /	1 /185	40.0	7 581	47.5 61.1	
Health Insurance Coverage Status	4,131	3.1	10	0.0	34	4.4	1,400	55.7	∠,J01	01.1	
No	19 977	1/1 1	467	25	1 562	77	8 176	40.9	9 822	<u>4</u> 9.0	0.00
Voc	115 540	14.1 85 /	7 7 20	2.J D 1	1,302 8 7/2	7.7	47 020	30.7	57 199		0.00
Missing	110,040 510	05.4	2,203 15	2.1	0,743 20	7. 3 Q 1	47,020 174	35.9	טט י, 4 00 סמב	53.0	
1viioonig	210	0.5	15	3.1	33	0.1	1/4	55.0	230	55.0	

Table1: Sample distribution of the study sample adults and prevalence of tobacco use, 2012-2015 NHIS

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

	Current ST	Former ST	Non-ST	Never
	users	users	tobacco users	tobacco users
Sample size	2,771	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)

Table 2: Healthcare utilization by types of healthcare service and tobacco use status among U.S. adults, 2012-2015

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

cypes of neurin	Hospital nights					nordonesi	room vie	ite	1	Doctor	Vicito		Home Care Visits				
	(N=129.156)				Emergency room visits (N= 128 722)				(N=129 210)				(N=129,287)				
	Lo	git*	Poiss	son**	Lo		Poise	son**	Los		Pois	son**	Lo		Pois	son**	
	Coef	P value	Coef	P	Coef	P value	Coef	P value	Coef	P value	Coef	P value	Coef	P value	Coef	P	
Tobacco use status		vulue	•	vulue	•	Vulue		vuiue	1.	Vulue		vuite	•	Vulue		vulue	
Current ST users	0.28	0.01 0	1.34	0.33 6	0.41	0.00 1	1.25	0.04 3	0.34	0.05 7	0.94	0.58 0	-0.27	0.46 5	1.10	0.704	
Former ST users	0.30	0.00 0	0.93	0.49 0	0.39	0.00 0	1.11	0.05 7	0.14	0.10 5	1.19	0.00 8	0.13	0.35 9	0.98	0.884	
Non-ST tobacco users	0.29	0.00 0	1.04	0.53 5	0.32	0.00 0	1.10	0.00 3	0.15	0.00 4	1.17	0.00 0	0.07	0.30 5	0.99	0.905	
Never tobacco Users		RE	EF			RI	EF			RE	ΞF			RE	EF		
Gender		0.00		0.00		0.00		0.00		0.00		0.01		0 02			
Male Female	-0.34	0.00 0 RF	1.32	0.00	-0.25	0.00 0 RI	0.90	4	-0.44	0.00 0 RF	0.92	3	0.02	0.05 0 RF	1.05 EF	0.545	
Age																	
18-34		RE	EF			RI	EF			RE	EF			RE	EF		
35-64	-0.15	0.00 0	1.55	0.00 0	-0.15	0.00 0	1.01	0.74 0	0.22	0.00 0	1.22	0.00 0	1.30	0.00 0	1.38	0.040	
65+	0.40	0.00 0	1.68	0.00 0	0.13	0.011	0.83	0.00 1	0.91	0.00 0	1.13	0.03 5	2.51	0.00 0	1.47	0.016	
Race/Ethnicity																	
NH White		RE	EF	0.40		RI	EF	0.17		RE	EF	0.00		RE 0.07	EF		
Hispanic	-0 22	0.00	0.96	0.49	-0 22	0.00	0 94	0.17	-0.31	0.00	0 99	0.86	-0 19	0.07	1 02	0.830	
NH Black	0.02	0.57 8	1 15	0.02	0.22	0.00	1 11	0.00 4	-0.12	0.06 7	1.02	0.76	0.15	0.00	0.94	0.000	
NH Asian	-0.40	0.00	0.99	0.94	-0.43	0.00	0.80	ب 0.011	-0.16	0.17	0.74	0.00	-0 70	0.00	0.98	0.920	
1117 (Sidii	-0.40	0.00	0.55	0.71	-0.45	0.02	0.00	0.03	-0.10	0.75	0.74	0.35	-0.70	0.24	0.50	0.551	
NH other Education	0.39	2	1.08	5	0.25	4	1.29	2	-0.06	7	1.15	1	0.31	5	0.96	0.764	
Less than high		рг	717			ות	717			л	717			пт	717		
SCHOOL		0.00	5 F	0.53		0.03	2F			0.46	2 F	0.25		0.00	2F		
High school	-0.13	2	1.05	8 0.76	-0.09	8 0.18	0.89	0.011	0.05	4	0.93	3	-0.35	0	1.27	0.001	
Some college	-0.12	5	1.02	0.70 6 0.15	-0.06	9	0.81	0.00	0.15	0.05 4	1.00	0.50 6 0.88	-0.47	0.00	1.00	0.978	
College +	-0.21	0.00	0.89	6	-0.26	0.00	0.71	0.00	0.20	0.03	1.01	3	-0.69	0.00	1.21	0.095	
Poverty Status		DE	ε.			D1	7E			D1	7E			DE	7E		
1 001		0.00		0.09		0.00		0.00		0.79		0.04		0.00			
Low income	-0.28	0 0.00	0.88	9 0.09	-0.20	0 0.00	0.80	0 0.00	-0.02	0 0.03	0.84	3 0.04	-0.43	0 0.00	0.93	0.327	
Middle income	-0.54	0 0.00	0.85	0 0.00	-0.45	0 0.00	0.65	0 0.00	-0.20	1 0.53	0.83	2 0.00	-0.88	0 0.00	1.02	0.866	
High income	-0.72	0 0.00	0.69	0 0.06	-0.46	0 0.00	0.49	0 0.02	-0.07	1 0.00	0.76	7 0.08	-1.32	0 0.00	0.98	0.857	
Unknown Marital status	-0.49	0	0.83	4	-0.57	0	0.83	0	-0.34	5	0.84	8	-0.53	0	1.14	0.255	
Married		RE	EF			RI	EF			RE	EF			RF	EF		
		0.00		0.10		0.00		0.30		0.00		0.94		0.00			
S/D/W	0.15	0 0.00	1.11	3 0.01	0.20	0 0.35	1.04	4 0.22	0.22	0 0.52	1.00	3 0.60	0.77	0 0.00	1.23	0.022	
Never married Living with	-0.48	0 0.02	1.29	2 0.88	0.03	4 0.00	0.95	2 0.19	-0.03	2 0.57	1.02	1 0.22	0.85	0 0.09	1.53	0.000	
partner Region	0.13	8	1.02	1	0.31	0	1.08	4	0.04	3	1.09	6	0.35	5	0.79	0.164	
Northeast		RE	EF			RI	EF			RI	EF			RF	ΞF		
Midwest	-0.05	0.27 2	1.08	0.40 3	-0.07	0.13 1	1.09	0.05 6	-0.12	0.10 2	1.00	0.95 1	-0.32	0.00 5	0.94	0.522	
South	-0.07	0.06 7	0.92	0.17 3	-0.10	0.03 0	1.02	0.54 5	0.11	0.06 1	0.86	0.00 2	-0.17	0.11 8	1.02	0.836	
				0		•		0		-		-		0			

Table 3: Estimated results from Zero-Inflated Poisson (ZIP) regression models on healthcare utilization by types of healthcare services, 2012-2015

West	-0 20	0.00	1.03	0.73 1	-0 20	0.00	1.08	0.08 3	-0.12	0.05	1.03	0.57 4	-0 38	0.00 3	1 29	0.018
Binge Drinking	0.20	v	1.05	1	0.20	Ū	1.00	5	0.12	5	1.05	-	0.50	5	1.25	0.010
5 5		0.00		0.01		0.50		0.20		0.36		0.00		0.00		
Yes	0.48	0	1.24	2	0.02	2	1.05	8	0.05	6	1.14	4	0.87	0	1.14	0.437
No		RE	F			RE	F			RE	F			RE	F	
BMI																
		0.07		0.06		0.97		0.18		0.48		0.22		0.00		
Underweight	0.17	0	1.24	2	0.00	9	1.11	3	0.11	7	1.15	6	0.75	0	0.92	0.551
Normal		RE	F			RE	F			RE	F			RE	F	
		0.00		0.00		0.03		0.23		0.05		0.64		0.01		
Overweigh	0.10	3	0.78	0	0.08	3	0.95	0	0.11	0	1.02	1	-0.19	6	0.91	0.246
		0.00		0.01		0.00		0.03		0.00		0.01		0.49		
Obese	0.28	0	0.85	0	0.23	0	1.09	6	0.31	0	1.12	0	0.06	5	0.90	0.158
Proportion of		0.00		0.12		0.00		0.02		0.00		0.37		0.00		
months uninsured	-0.52	0	0.87	9	-0.22	0	0.92	7	-0.94	0	0.93	7	-1.54	0	0.83	0.298
		0.00		0.00		0.00		0.00		0.00		0.00		0.00		
constant	-2.02	0	4.11	0	-0.63	0	2.23	0	-0.78	0	0.76	6	-5.69	0	2.77	0.000

Note: BMI=body mass index; NH=non-Hispanic. S/D/W=separated/divorced/widowed. Bold results indicate statistically significant results at the p<0.05 level.

*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 healthcare utilization.

**The exponentiated coefficients are reported for Poisson models.

Table 4. Smokeless tobacco attributable healthcare utilization and expenditures by type of healthcare service among US adults

	Ho	ospital	nights		Emer	gency	room vi	sits	Doctor visits			
	Mean	E	95% CI		Mean	SE	95% CI		Mean	SE	95%	% CI
Total utilization												
2012-15			2,60				2,38	2,60			68	
(thousands)	2,723	60	4	2,841	2,494	58	0	8	714	15	4	743
Utilization per year												
(thousands)	681				624				4,638			
Expenditures per year	1,825,59				667,77				909,00			
(\$ thousands)	9				8				9			
Total expenditures per year	3,402,38											
(\$ thousands)	6											

Note: Due to non-significant 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.