Preventive Medicine 150 (2021) 106529

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

U.S. healthcare spending attributable to cigarette smoking in 2014

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A B S T R A C T

Introduction: Cigarette smoking continues to be the leading cause of preventable disease and death in the U.S. Smoking also carries an economic burden, including smoking-attributable healthcare spending. This study assessed smoking-attributable fractions in healthcare spending between 2010 and 2014, overall and by insurance type (Medicaid, Medicare, private, out-of-pocket, other federal, other) and by medical service (inpatient, non-inpatient, prescriptions).

Methods: Data were obtained from the 2010–2014 Medical Expenditure Panel Survey linked to the 2008–2013 National Health Interview Survey. The final sample (n = 49,540) was restricted to non-pregnant adults aged 18 years or older. Estimates from two-part models (multivariable logistic regression and generalized linear models) and data from 2014 national health expenditures were combined to estimate the share of and total (in 2014 dollars) annual healthcare spending attributable to cigarette smoking among U.S. adults. All models controlled for socio-demographic characteristics, health-related behaviors, and attitudes.

Results: During 2010–2014, an estimated 11.7% (95% CI = 11.6%, 11.8%) of U.S. annual healthcare spending could be attributed to adult cigarette smoking, translating to annual healthcare spending of more than $225 billion dollars based on total personal healthcare expenditures reported in 2014. More than 50% of this smoking-attributable spending was funded by Medicare or Medicaid. For Medicaid, the estimated healthcare spending attributable fraction increased more than 30% between 2010 and 2014.

Conclusions: Cigarette smoking exacts a substantial economic burden in the U.S. Continuing efforts to implement proven population-based interventions have been shown to reduce the health and economic burden of cigarette smoking nationally.

1. Introduction

The prevalence of cigarette smoking has declined considerably in the U.S over the past several decades (Wang et al., 2018a), and more than three out of five U.S. adults who have ever smoked cigarettes have quit (U.S. Department of Health and Human Services, 2020). However, the number of people who have ever smoked cigarettes has continued to increase over time (American Lung Association, 2020), and in 2014, 92.2 million U.S. adults were ever-cigarette smokers, among whom, 61.7% were former smokers (American Lung Association, 2020). The benefits of quitting smoking, at any age, are overall improved health status and enhanced quality of life (U.S. Department of Health and Human Services, 2020). Current and former smokers are at an increased risk for smoking-attributable adverse health outcomes compared to never smokers, and cigarette smoking continues to be the leading cause of preventable death in the U.S., accounting for an estimated 480,000 deaths each year (U.S. Department of Health and Human Services, 2014). Moreover, smoking prevalence remains persistently high among certain sub-populations, including those with lower socioeconomic status and those who are uninsured or covered by Medicaid (U.S. Department of Health and Human Services, 2014). Among U.S. adults in 2018, current cigarette smoking ranged from 23.9% among uninsured adults or those insured by Medicaid to 9.4% among adults with Medicare only (Creamer et al., 2019).

In addition to the health burden, cigarette smoking also creates an economic burden for U.S. society (U.S. Department of Health and Human Services, 2014). By 2010, the annual economic cost of cigarette smoking exceeded $300 billion, including nearly $170 billion in direct healthcare spending (Creamer et al., 2019; Xu et al., 2015). The majority of this attributable healthcare spending was paid by public health insurance programs (Xu et al., 2015; Congressional Budget Office, 2012). Medicaid and Medicare paid for approximately half of the total smoking-attributable healthcare spending in 2010 (Xu et al., 2015).

Existing studies show that cigarette smoking-attributable healthcare spending has historically accounted for 5–14% of U.S. annual healthcare expenditure through 2010 (U.S. Department of Health and Human Services, 2014; Xu et al., 2015; Congressional Budget Office, 2012; Miller et al., 1999; Centers for Disease Control and Prevention, 2002. However, less is known about changes in such spending by payers in recent years, especially following changes to health insurance coverage since 2010 (Cohen and Martinez, 2014), and a period of Medicaid expansion beginning in January 2014 and early adoption of expanded

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https://doi.org/10.1016/j.ypmed.2021.106529

Received 16 August 2020; Received in revised form 15 March 2021; Accepted 21 March 2021

Available online 23 March 2021

0091-7435/Published by Elsevier Inc.

Medicaid in a few states between 2010 and 2013 (Cohen and Martinez, 2014; Black and Cohen, 2015; Frean et al., 2017; Wherry and Miller, 2016a). Recent data show the percentage of the U.S. population that was uninsured had declined as of 2014 (Cohen and Martinez, 2014; Black and Cohen, 2015; Frean et al., 2017; Wherry and Miller, 2016a). Given the higher prevalence of cigarette smoking among the uninsured and Medicaid populations (Creamer et al., 2019; Greene et al., 2014; Kostova et al., 2018), the expansion in coverage could help to reduce disparities in current cigarette smoking, and improve the health and quality of life for these populations, by providing access to more affordable cessation prescriptions and counselling services. This paper provides more recent national estimates of adult cigarette smoking-attributable healthcare expenditure fractions (SAFs), which represent the percentages of healthcare expenditure that can be attributable to cigarette smoking, during 2010–2014 and associated spending by payer.

2. Methods

2.1. Data sources

For the purpose of this analysis, data from the 2010–2014 Medical Expenditure Panel Survey (MEPS) were linked to respondents from the 2008–2013 National Health Interview Survey (NHIS). MEPS, administered by the Agency for Healthcare Research and Quality's (AHRQ), is a series of nationally representative surveys of families and individuals, their medical providers (physicians, hospitals, pharmacies, etc.), and employers across the U.S. The survey provides the most comprehensive source of U.S. data on healthcare spending, medical care utilization, and health insurance coverage. However, MEPS only collects information on current cigarette smoking status at the time of the interview. Therefore, the data by itself cannot be used to assess healthcare utilization or expenditures associated with former smoking. However, smoking status can be determined by linking MEPS and NHIS. NHIS is an annual, cross-sectional household interview survey that collects health information of the civilian non-institutionalized U.S. population. NHIS also contains detailed questions on the respondent's smoking history. Because annual MEPS uses the past two years of NHIS as its sampling frame, records for selected respondents from the two surveys can be directly linked with confidential linkage files in the AHRQ Data Center through a data application process (Agency for Healthcare Research and Quality, 2020). The 2010–2014 MEPS link files to NHIS were the most recent information at the time of data application of this study. In this analysis, information on respondents' smoking status came from NHIS, while respondents' demograohic information, healthcare spending and health insurance coverage data came from MEPS.

After the data linkage, the final sample ($n = 49{,}540$) was limited to non-pregnant adults aged 18 years or older. To account for nonresponse between the NHIS and MEPS surveys, the final sample was reweighted to be nationally representative of the U.S. non-institutionalized adult population using inverse probability weighting with the population from the 2010 American Community Survey 5-year estimates (The US Census Bureau, 2019). Since this was a secondary analysis of deidentified data, Institutional Review Board review was not required.

2.2. Measures

2.2.1. Cigarette smoking status

Based on available NHIS questions on respondents' cigarette smoking history, four categories of smokers were constructed. Current cigarette smokers were defined as respondents who smoked 100 cigarettes in their lifetime, and smoked some days or every day at the time of interview. Former smokers were categorized into either recent quitters (those who quit smoking within the last 5 years) and long-term quitters (those who quit smoking more than 5 years ago). Former smokers were categorized by the length of cessation (i.e. within the last 5 years or more than 5 years ago) because studies have found that recent successful quits can be caused by the onset of adverse symptoms or new diagnosis of a disease, and thus could be associated with higher medical expenditures (Fishman et al., 2003; Fishman et al., 2006; Hockenberry et al., 2012). Finally, never cigarette smokers were those who reported smoking less than 100 cigarettes in their lifetime.

2.2.2. Socio-demographic characteristics

Sociodemographic control variables included: sex (male or female); age group (18–24, 25–44, 45–64, 65–74, or $\geq$ 75 years); race/Hispanic origin (non-Hispanic white, non-Hispanic black, Hispanic, non-Hispanic other); educational attainment (less than high school, high school diploma or GED, some college, or college and above); marital status (married or cohabitating, not married/cohabitating, or unknown); and annual household income as a percentage of federal poverty level ($<$100%, 100%–124%, 125%–199%, 200%–399%, or $\geq$ 400%).

2.2.3. Health related behaviors and attitudes

Health-related behaviors and attitudes can be confounding factors through their associations with both healthcare utilization and cigarette smoking (Xu et al., 2015; Congressional Budget Office, 2012; Miller et al., 1999; Baumgardner et al., 2012). Therefore, consistent with existing studies (Xu et al., 2015; Congressional Budget Office, 2012; Miller et al., 1999; Baumgardner et al., 2012), the analysis controlled for a set of self-reported health variables, including: alcohol consumption (non-drinker, current drinker, or unknown); body mass index (defined as weight (kg)/ height (m) (U.S. Department of Health and Human Services, 2020): underweight, $<$18.5; normal weight, 18.5- $<$ 25; overweight, 25- $<$ 30; obese, $\geq$30); receipt of influenza vaccine in the past 12 months (yes or no); seatbelt use (always/nearly always or sometimes/never); extent to which respondent takes more risks than the average person (agree somewhat/strongly or uncertain/strongly disagree); and belief in own ability to overcome illness without medical help (agree somewhat/strongly or uncertain/strongly disagree).

2.3. Analysis

Both two-part and four-part models were employed for this analysis (Xu et al., 2015; Congressional Budget Office, 2012; Finkelstein et al., 2009; Manning et al., 1987; Finkelstein et al., 2003; Armour et al., 2009). Because of highly skewed individual healthcare spending data, Copas tests were used to evaluate over-fitting and misspsecification among the two- and four- part models (Copas, 1983). During Copas tests, the final sample was split randomaly into two independent sub-samples with equal sizes; one was used for the two- or four- part model estimation, and the other was used for the forcasting test. The results of Copas tests suggest that the two-part model fitted individual healthcare spending better for this sample, although findings from the two different approaches were very similar. Therefore, a description of the two-part model used is provided in this paper, while the implementation of the four-part model can be found elsewhere (Armour et al., 2009).

Logistic regression was used in the first part of the two-part model to estimate the probability of having any positive healthcare spending for each respondent. In the second part of the model, based on the specification tests, a generalized linear model with a log link and gamma distribution was selected to assess the amount of healthcare spending conditional on having positive expenditures. Finally, the estimates from both parts of the model were jointly used to predict the proportion of the annual healthcare spending that could be reduced if all current and former smokers had never smoked before. The total smoking-attributable healthcare spending was projected by subtracting the predicted healthcare spending for current or former smokers from their predicted spending if they were never smokers. Finally, the smoking-attributable fraction was calculated by dividing the total smoking-attributable healthcare spending by the total predicted spending for the entire population.

A total of eleven two-part models were used to estimate cigarette

smoking-attributable fractions overall; by payer, including Medicare, Medicaid, other federal insurance (including Tricare, Veterans Affairs health benefits, Indian Health Service, military treatment facilities, and other care provided by the federal government), private insurance, out of pocket (including medicaid expenditure paid by the uninsured or out-of-pocket medical payment from the insured), and others (including other state and local sources, state and local health departments, state programs other than Medicaid, or other unclassified sources); and by type of medical services, including inpatient, non-inpatient (including outpatient services, physician and clinical services, and other professional services), and prescription drugs.

All models were estimated using Stata, version 15.0, in 2019 and bootstrapped standard errors were reported based on 2000 simulations. All dollar amounts were adjusted to 2014 dollars using the Medical Care component of the Consumer Price Index for All Urban Consumers provided by the U.S. Bureau of Labor Statistics (U.S. Bureau of Labor Statistics, 2020).

Consistent with previous studies (Xu et al., 2015; Finkelstein et al., 2009; Finkelstein et al., 2003), the estimated cigarette smoking-attributable fractions from the combined data of 2010–2014 MEPS and 2008–2013 NHIS were multiplied by the 2014 personal healthcare expenditure reported in the National Health Expenditure Accounts (NHEA) to determine smoking-attributable spending (Centers for Medicare and Medicaid Services, 2020). This approach addresses the potential underestimation of healthcare spending in MEPS given that it does not include healthcare spending for institutionalized populations, for long-term care greater than 445 days, or for certain healthcare spending such as over-the-counter medications (Sing et al., 2006; Zuvekas and Olin, 2009; Bernard et al., 2012; Bernard et al., 2018). Consistent with previous research (Xu et al., 2015), healthcare expenditures associated with dental care (approximately 4.4% of the 2014 NHEA) (Centers for Medicare and Medicaid Services, 2020), and spending for persons aged 18 years old or younger were excluded from the analysis (Centers for Medicare and Medicaid Services, 2020a). Since the expenditure data are not available specifically for other federal insurance, the national share of the total expenditure for persons aged 19 years and older were used for this insurance group. The national share was also used for all types of medical services.

3. Results

Since the results of the Copas tests indicated that the two-part model predicted annual healthcare spending more precisely for this sample, all results reported are based on the two-part model.

An estimated 11.7% (95% CI = 11.6%, 11.8%) of annual healthcare spending among non-pregnant U.S. adults during 2010–2014 was attributable to current or former cigarette smoking (Table 1). Stratifying by smoking status, 6.0% (95% CI = 3.6%, 8.9%) was for current cigarette smokers, 1.3% (95% CI = 0.8%, 2.0%) was for former smokers who quit within the last 5 years, and 4.4% (95% CI = 2.3%, 7.0%) was for former smokers who quit more than 5 years ago.

During 2010–2014, an estimated 16.4% (95% CI = 7.9%, 26.1%) of inpatient healthcare spending, 6.0% (95% CI = 2.3%, 10.5%) of non-inpatient health care spending, and 13.4% (95% CI = 8.4%, 18.7%) of healthcare spending on prescription medications each year was attributable to current or former cigarette smoking (Table 2).

Cigarette smoking-attributable healthcare spending for adults was estimated to be $226.7 (95% CI = $224.9, $228.6) billion in 2014 (Table 3). We estimated that 9.9% (95% CI = 9.7%, 10.0%) of Medicare spending and 20.3% (95% CI = 20.0%, 20.6%) of Medicaid spending between 2010 and 2014 was attributable to cigarette smoking. These percentages represented $57.4 (95% CI = $56.6, $58.3) billion and $68.3 (95% CI = $67.4, $69.2) billion in 2014 Medicare and Medicaid spending, respectively. As a result, more than half of smoking-attributable healthcare expenditures ($125.7 billion/$226.7) were paid by Medicare and Medicaid in 2014.

Additionally, smoking-attributable spending comprised an estimated: 27.3% (95% CI = 27.0%, 27.7%) of healthcare spending paid by other federal government–sponsored insurance programs; 7.0% (95% CI = 6.8%, 7.1%) of healthcare spending paid by private health insurance programs; 5.3% (95% CI = 5.2%, 5.4%) of healthcare spending beared by patients themselves; and 11.0% (95% CI = 10.8%, 11.3%) of healthcare spending from other insurance programs (Table 3). These attributable fractions represented another $101.0 billion attributable to cigarette smoking in 2014, including $20.5 (95% CI = $20.2, $20.7) billion paid by other federal insurance programs, $50.3 (95% CI = $49.2, $51.4) billion paid by private insurance programs, $13.5 (95% CI = $13.2, $13.7) billion paid by patients themselves, and $16.7 (95% CI = $16.4, $17.1) billion paid by other insurance programs.

Table 1
Share of total annual health care spending attributable to U.S. Adult Cigarette Smoking, by cigarette smoking status, 2010–2014.

Smoking status	Percent attributable fraction[a] (95% CI)
Current smokers[b]	6.0% (3.6%–8.9%)
Former smokers	
Quit within the last 5 years	1.3% (0.8%–2.0%)
Quit more than 5 years	4.4% (2.3%–7.0%)
Overall	11.7% (11.6%–11.8%)

Note: The sum of individual categories may not equal the total because of rounding.
CI, Confidence interval.
[a] Health care spending associated with dental services was excluded.
[b] Current smokers were defined as those who smoked 100 cigarettes in their lifetime and smoked cigarettes some days or every day at the time of the interview.

4. Discussion

The findings from this analysis indicate that cigarette smoking accounted for an estimated 11.7% of total healthcare spending in the U.S. during 2010–2014, translating to annual healthcare spending of approximately $227 billion based on total personal healthcare expenditures reported in 2014. This estimate is consistent with previous cross-sectional studies that reported smoking-attributable healthcare spending fractions ranging from 5% to 14% (U.S. Department of Health and Human Services, 2014; Xu et al., 2015; Congressional Budget Office, 2012; Miller et al., 1999; Centers for Disease Control and Prevention, 2002; Warner et al., 1999).

More than 60% of annual smoking-attributable healthcare spending in the U.S. was paid through public health insurance programs, including either Medicaid, Medicare, or other federal health insurance

Table 2
Share of total annual health care spending attributable to U.S. Adult cigarette smoking, by type of service, 2010–2014.

Type of service	Percent attributable fraction[a] (95% CI)
Inpatient	16.4% (7.9%–26.1%)
Non-Inpatient[b]	6.0% (2.3%-10.5%)
Prescription drug	13.4% (8.4%–18.7%)

Note: The sum of individual categories may not equal the total because of rounding.
CI, Confidence interval.
[a] Health care spending associated with dental services was excluded.
[b] Non-inpatient care includes outpatient services, physician and clinical services, and other professional services.

Table 3
Smoking-attributable fractions and estimated annual health care spending attributable adult cigarette smoking, by payer, 2010–2014.

Payer	Percent attributable fraction (95% CI)	2014 estimated National Health Expenditure Accounts ($ billions, 95% CI)[a]
Medicaid[b]	20.3% (20.0%-20.6%)	$68.3 ($67.4–$69.2)
Medicare	9.9% (9.7%–10.0%)	$57.4 ($56.6–$58.3)
Private insurance	7.0% (6.8%–7.1%)	$50.3 ($49.2–$51.4)
Other federal[c]	27.3% (27.0%–27.7%)	$20.5 ($20.2–$20.7)
Others[d]	11.0% (10.8%-11.3%)	$16.7 ($16.4–$17.1)
Out-of-pocket	5.3% (5.2%–5.4%)	$13.5 ($13.2–$13.7)
Total	11.7% (11.6%–11.8%)	$226.7 ($224.9–$228.6)

Note: The sum of individual categories may not equal the total because of rounding.
CI, Confidence interval.
[a] Health care spending associated with dental services was excluded. All dollar values were adjusted to 2010 using the consumer Price index for all urban consumers: Medical care provided by the U.S. Bureau of Labor Statistics.
[b] Medicaid payments reported for persons who were listed as enrolled in the Medicaid program at any time during the year.
[c] Other federal insurance includes Tricare, VA health benefits, Indian Health Service, military treatment facilities, and other care provided by the federal government.
[d] Others include other state and local sources (community and neighborhood clinics, state and local health departments, and state programs other than Medicaid); other unclassified sources (automobile, homeowner's liability, and other miscellaneous or unknown sources); and other public resources.

programs (such as Tricare, VA health benefits, Indian Health Service, military treatment facilities, and other care provided by the federal government). When combined, Medicaid and Medicare paid more than half of the smoking-attributable expenditures, or $125.7 billion dollars in 2014. This finding is also comparable to the existing scientific literature, which also found that about 50.5% of smoking-attritutable expenditures in 2010 were paid by Medicare and Medicaid combined (Xu et al., 2015).

The estimated 11.7% of healthcare spending attributble to cigarette smoking during 2010–2014 is higher than the 8.7% estimate observed during 2006–2010 and the 7% estimate observed during 2000–2008 (Xu et al., 2015; Congressional Budget Office, 2012). However, it is important to note that the estimated annual healthcare spending fractions attributable to former smokers, including both recent (less than 5 years) quitters and long-term (5 years or more) quitters, was somewhat similar between 2006 and 2010 and 2010–2014; 1.5% vs. 1.3%, and 4.0% vs. 4.4%, respectively (Xu et al., 2015). In contrast, the attributable fraction for current cigarette smokers increased substantially during these two time periods, from an estimated 3.2% to 6.0%. Similarly, although the attributable fractions to non-inpatient care remained relatively comparable between the two time periods (5.3% vs. 6.0%), the attributable fractions related to inpatient care (11.1% to 16.4%) and prescription drugs (10.4% and 13.4%) appear to increase between the two time periods (Xu et al., 2015). Since the proportion of U.S. adults who currently smoke cigarettes declined from 19.3% in 2010 to 15.1% in 2015 (Jamal et al., 2016; Agaku et al., 2012), one potential explanation of this finding is a disproportionately higher percentage of current cigarette smokers who previously were uninsured obtained health insurance and began to use medical care for their health issues that need immediate attention (Wherry and Miller, 2016a; Centers for Medicare and Medicaid Services, 2020b; Kaufman et al., 2015; Wherry and Miller, 2016b; Sommers et al., 2017; Kominski et al., 2017). This possibly may be due to changes to health insurance coverage in and after 2010 and early adoption of expanded Medicaid in a few states between 2010 and 2013 (Cohen and Martinez, 2014; Black and Cohen, 2015; Frean et al., 2017; Wherry and Miller, 2016a). However, further research is warranted to more fully understand the underlying drivers of these observed patterns.

Cigarette smoking-attributable fractions among the Medicare population were stable between 2006 and 2010 and 2010–2014; 9.6% and 9.9% respectively (Xu et al., 2015). In contrast, the attributable fractions were higher among Medicaid programs during the time period of 2010 through 2014, compared to that during 2006 through 2010 (Xu et al., 2015). This is possibly due to the period of Medicaid expansion and enhancements to health insurance coverage that ocurred during 2010–2014. For example, as of January 2013, 7 states and the District Columbia had opted into the early Medicaid expansion available under the Patient Protection and Affordable Care Act, which allowed states to impose income eligibility limits at, below, or above 138% FPL (Kaiser Family Foundation, 2012). A total of 24 states and the District of Columbia had adopted Medicaid expansion as of January 1, 2014 (Kiser Family Foundation, 2020). Medicaid expansion and other reforms significantly reduced the uninsured population in the U.S. (Cohen and Martinez, 2014; Black and Cohen, 2015; Frean et al., 2017; Wherry and Miller, 2016a). This finding is consistent with studies that have shown that newly enrolled Medicaid patients in Medicaid expansion states had higher rates of diagnosis of chronic health conditions and increased utilization of medical services, including both overnight hospital stays and medical prescriptions, compared to Medicaid enrollees from non-expansion states or those in traditional Medicaid (Kaufman et al., 2015; Wherry and Miller, 2016b; Sommers et al., 2017; Kominski et al., 2017). Taken together, the combined effects of higher cigarette smoking prevalence among the newly insured, as well as increased use of medical services among the newly insured Medicaid enrollees, may contribute to the increase in cigarette smoking-attributable fractions observed between 2006 and 2010 and 2010–2014.

By using the linked NHIS and MEPS data and fitting multi-part models to assess healthcare spending, our study offers novel methodological and empirical contributions to the existing scientific literature, for example, using Copas tests to assess the fitness of the 2-part and 4-part model to the data. Nonetheless, this analysis is subject to at least seven limitations. First, this analysis is limited to healthcare attributable fractions related to cigarette smoking. The healthcare spending associated with the use of other tobacco products, including other combustible products such as cigars and non-combustible products such as smokeless tobacco, were not included (Wang et al., 2018b). Second, the estimated smoking-attributable healthcare spending are likely to be conservative, because this analysis does not consider potential smoking-attributable healthcare spending associated with secondhand smoke, dental care, or infant and maternal medical services; although the smoking-attributable dental care were not considered in this analysis, other studies have shown that smoking may account for more than half of periodontitis cases among U.S. adults (Tomar, 2000). Third, the findings of this analysis may be subject to recall bias from self-reported healthcare use or cigarette smoking history. Fourth, the variation in time between self-reported cigarette smoking status and the assessment of expenditure data may introduce inconsistencies, including among those who recently quit. Fifth, the bootstrapped approach used in the analysis may underestimate standard errors. Sixth, given the lag between smoking initiation and smoking-attributable disease, including young adults in the analysis may introduce bias; however, the immediate health risks of smoking, particularly to the cardiovascular system, are well documented (U.S. Department of Health and Human Services, 2020; U.S. Department of Health and Human Services, 2014; U.S. Department of Health and Human Services, 2012), and would contribute to healthcare expenditures among this population. Therefore, consistent with the existing literature (Xu et al., 2015; Congressional Budget Office, 2012; Armour et al., 2009), young adults were included in the analysis. Finally, by applying the smoking-attributable fractions estimated from MEPS to the annual personal healthcare spending from NHEA, this analysis implicitly

assumes that these attributable fractions were similar between the institutionalized and non-institutionalized U.S. populations.

5. Conclusions

This study provides an update on health care spending attributable to smoking among adults in the U.S. in 2014. The estimates from the study show that cigarette smoking continues to exact a substantial financial burden on the U.S. health care system, and the results also appear to show an increase of approximately $47 billion (in 2014 Dollars) from previous studies that reported similar expenditures in 2010 (Xu et al., 2015). These updated estimates can be used by decision makers to inform population-based interventions to prevent and reduce the health and economic burden of cigarette smoking nationally. Proven tobacco prevention and control interventions, including increasing the price of tobacco products, comprehensive smoke-free laws, mass reach tobacco education campaigns, and barrier free cessation access, coupled with state comprehensive tobacco control programs and emerging strategies such as FDA's final rule requiring new health warning on cigarette packages and advertisements, have been shown to be effective strategies for continuing progress toward reducing smoking-attributable disease and death in the U.S. (U.S. Department of Health and Human Services, 2020; U.S. Department of Health and Human Services, 2014; U.S. Food and Drug Administration, 2020). The continued and comprehensive implementation of these interventions can help reduce the need for healthcare aimed at smoking-related disease, and thereby help to reduce smoking-attributable healthcare spending in the U.S.

Credit authorship contribution statement

Xin Xu: Conceptualization, Methodology, Writing - original draft. **Sundar S. Shrestha**: Conceptualization, Writing - review & editing. **Katrina F. Trivers**: Writing - review & editing. **Linda Neff**: Writing - review & editing. **Brian S. Armour**: Conceptualization, Writing - review & editing. **Brian A. King**: Writing - review & editing.

Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the US Centers for Disease Control and Prevention.

Financial disclosure

All authors have no financial disclosure.

Declaration of competing interest

Authors have no conflict of interest to report.

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