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Prevalence of cigarette and e-cigarette use among U.S. adults eligible for lung cancer screening based on updated USPSTF guidelines

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ABSTRACT

Background: The United States Preventative Services Taskforce recently updated lung cancer screening guidelines for U.S. adults with high-risk smoking histories. This has generated a previously undescribed patient population in which the prevalence of cigarette and e-cigarette use has not been described.

Methods: We performed a cross-sectional study using population-based data from the Behavioral Risk Factor Surveillance System (2017–2018). We defined lung cancer screening eligibility as adults 50–80 years old with ≥ 20 pack-year smoking history who were currently smoking or quit within the last 15 years. We assessed several smoking-related outcomes including current cigarette use, ever e-cigarette use, and current e-cigarette use among respondents.

Results: Among 7541 screening-eligible adults, current cigarette use was reported by 3604 (47.8%) participants. Ever and current e-cigarette use were reported by 3003 (39.8%) and 670 (8.9%) participants, respectively. Compared to individuals who were previously eligible for screening, individuals newly eligible for screening (i.e., between 50 and 55 years old with a 20–30 pack-year smoking history) were more likely to currently smoke (aOR 1.828, 95% CI 1.649–2.026, $p < 0.001$). While newly eligible respondents were more likely to report a history of ever using an e-cigarette (aOR 1.144, 95% CI 1.034–1.266, $p = 0.009$), current e-cigarette use was similar in this group compared to those individuals who were previously screening-eligible (aOR 1.014, 95% CI 0.844–1.219, $p = 0.88$).

Conclusions: Cigarette and e-cigarette exposure are common among U.S. adults who are eligible for lung cancer screening. Expanded USPSTF criteria will capture a patient population with greater exposure to both of these products.

1. Introduction

Lung cancer is the leading cause of cancer-related mortality in the United States and cigarette smoking is the leading modifiable risk factor for this malignancy [1]. The United States Preventative Services Taskforce (USPSTF) recommends annual lung cancer screening for individuals with high-risk smoking histories [2]. These eligibility criteria were recently broadened to include individuals 50–80 years old (previously 55–80 years old) with a ≥ 20 pack-year smoking history (previously ≥30 pack-year history) who currently smoke or quit within the past 15 years [3]. The expanded criteria are projected to further reduce lung cancer deaths among lower-risk individuals while also reducing disparities in screening eligibility [4]. The prevalence of tobacco use in this newly captured patient population is undescribed compared to the previously eligible screening cohort.

Electronic cigarettes ("e-cigarettes") have gained popularity as an alternative to traditional cigarettes. While most literature has focused on the alarming trends of e-cigarette use among younger individuals, recent studies have demonstrated that e-cigarette use is significant in older adults, including those with cancer [5,6]. Use of such products in individuals who are eligible for lung cancer screening is poorly understood, especially in light of the updated USPSTF guidelines. The objective of this study is to describe the prevalence of cigarette and e-cigarette use among U.S. adults eligible for lung cancer screening

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Table 1
Characteristics of cigarette and e-cigarette use among U.S. adults eligible for lung cancer screening based on updated USPSTF criteria from 2017 to 2018.

Variable	All Respondents (n = 7541)	Cigarette Use			E-cigarette Use[e]		
		Current smoker (n = 3604)	Former smoker (n = 3937)	P-value	Ever user (n = 3003)	Never User (n = 4538)	P-value
Age, mean (SD)	64.6 (7.8)	63.4 (7.3)	65.8 (8.0)	< 0.001	62.6 (7.1)	66.0 (7.9)	< 0.001
Sex (%)	3780 (50.1)	1786 (49.6)	1994 (50.6)	0.34	1375 (45.8)	2405 (53.0)	<
Male	3761 (49.9)	1818 (50.4)	1943 (49.4)		1628 (54.2)	2133 (47.0)	0.001
Female							
Race (%)	6445 (85.5)	3043 (84.4)	3402 (86.4)	0.01	2631 (87.6)	3814 (84.0)	<
White	472 (6.3)	227 (6.3)	245 (6.2)		123 (4.1)	349 (7.7)	0.001
Black	624 (8.3)	334 (9.3)	290 (7.4)		249 (8.3)	375 (8.3)	
Other							
Body Mass Index (BMI, %)	208 (2.8)	127 (3.5)	81 (2.1)	<	99 (3.3)	109 (2.4)	0.007
Underweight (BMI<18.5)	2253 (29.9)	1317 (36.5)	936 (23.8)	0.001	941 (31.3)	1312 (28.9)	
Normal (BMI 18.5–25.0)	2690 (35.7)	1233 (34.2)	1457 (37.0)		1027 (34.2)	1663 (36.6)	
Overweight (BMI 25.0–30.0)	2390 (31.7)	927 (25.7)	1463 (37.2)		936 (31.2)	1454 (32.0)	
Obese (BMI>30.0)							
Marital Status (%)	3262 (43.3)	1340 (37.2)	1922 (48.8)	<	1277 (42.5)	1985 (43.7)	0.004
Married	1951 (25.9)	1055 (29.3)	896 (22.8)	0.001	842 (28.0)	1109 (24.4)	
Divorced	528 (7.0)	288 (8.0)	240 (6.1)		205 (6.8)	323 (7.1)	
Never married	1800 (23.9)	921 (25.6)	879 (22.3)		679 (22.6)	1121 (24.7)	
Other							
Education (%)[a]	869 (11.5)	498 (13.8)	371 (9.4)	<	343 (11.4)	526 (11.6)	<
Did not graduate high school	2804 (37.2)	1372 (38.1)	1432 (36.4)	0.001	1072 (35.7)	1732 (38.2)	0.001
Graduated high school	2435 (32.3)	1169 (32.4)	1266 (32.2)		1074 (35.8)	1361 (30.0)	
Attended college or technical school	1433 (19.0)	565 (15.7)	868 (22.0)		514 (17.1)	919 (20.3)	
Graduated college of technical school							
Income (%)[b]	1035 (13.7)	616 (17.1)	419 (10.6)	<	481 (16.0)	554 (12.2)	<
Less than $15,000	1529 (20.3)	831 (23.1)	698 (17.7)	0.001	633 (21.1)	896 (19.7)	0.001
$15,000 to less than $25,000	804 (10.7)	405 (11.2)	399 (10.1)		305 (10.2)	499 (11.0)	
$25,000 to less than $35,000	991 (13.1)	456 (12.7)	535 (13.6)		396 (13.2)	595 (13.1)	
$35,000 to less than $50,000	2113 (28.0)	791 (21.9)	1322 (33.6)		810 (27.0)	1303 (28.7)	
$50,000 or more	1069 (14.2)	505 (14.0)	564 (14.3)		378 (12.6)	691 (15.2)	
Unsure/Other							
Insurance (%)[c]	6916 (91.7)	3180 (88.2)	3736 (94.9)	<	2686 (89.4)	4230 (93.2)	<
Yes	625 (8.3)	424 (11.8)	201 (5.1)	0.001	317 (10.6)	308 (6.8)	0.001
No							
Primary healthcare provider (%)[d]	6608 (87.6)	3002 (83.3)	3606 (91.6)	<	2609 (86.9)	3999 (88.1)	0.11
Yes	933 (12.4)	602 (16.7)	331 (8.4)	0.001	394 (13.1)	539 (11.9)	
No							

[a] Assessed by asking "What is the highest grade or year of school you completed?".
[b] Assessed by asking "[What] is your annual household income from all sources?".
[c] Assessed by asking "Do you have any kind of health care coverage, including health insurance, prepaid plans such as HMOs, or government plans such as Medicare, or Indian Health Service?".
[d] Assessed by asking "Do you have one person you think of as your personal doctor or health care provider?".
[e] Assessed by asking "Have you ever used an e-cigarette or other electronic vaping product, even just one time, in your entire life?".

based on the current USPSTF criteria.

2. Methods

We used data from the Behavioral Risk Factor Surveillance System (BRFSS) to explore cigarette and e-cigarette use among U.S. adults eligible for lung cancer screening from 2017 to 2018. The BRFSS is a population-based dataset established by the U.S. Centers for Disease Control and Prevention which collects self-reported, health-related data across all 50 U.S. states, Washington D.C., and three U.S. territories through telephone surveys. It is the largest health-related survey data repository in the world, collecting over 400,000 surveys annually [7]. The study was deemed Institutional Review Board exempt by the Washington University Human Resource Protection Office given the de-identified nature of the analysis on publicly available data.

Screening eligibility was defined according to USPSTF criteria as individuals 50–80 years old, with ≥ 20 pack-year smoking history, and currently smoking or quitting within the last 15 years (Supplementary methods) [3,8]. Our smoking-related outcomes of interest were the prevalence of (1) current cigarette use, (2) *ever* e-cigarette use, (3) *current* e-cigarette use, and (4) cessation attempt in the prior 1 year. We used multivariable logistic regression models to compare smoking-related outcomes between individuals previously eligible for screening (i.e., individuals between 55 and 80 years old with ≥30 pack-year smoking history) and individuals newly eligible for screening (i.e., individuals between 50 and 55 years old with a 20–30 pack-year smoking history). In separate models, we performed stratified analyses to better understand smoking habits based on income and education level. Missing data were handled via complete case analysis (eTable 1). Descriptive statistics and standard errors were estimated using survey population weights [7]. To compare between groups, two-tailed, *t*-tests were used for continuous variables and $\chi 2$ tests were used for categorical variables. Statistical analyses were performed using SAS Studio 3.81 (SAS Institute, Cary, NC).

3. Results

A total of 7541 respondents were eligible for lung cancer screening between 2017 and 2018 (eFig. 1). Current cigarette use was reported by 3604 (47.8%) participants of whom 1687 (46.8%) reported a quit attempt in the prior year. Compared to former smokers, current smoking was associated with younger age, lower BMI, divorced marital status,

Table 2
Comparison of current smoking status, e-cigarette use, and smoking cessation practices between US adults previously eligible and newly eligible for lung cancer screening based on updated USPSTF criteria, stratified by education level and income (adjusted results).

		Stratified by income		Stratified by education level	
	All respondents[a]	Low income[a,b]	High income[a,b]	Less education[a,c]	More education[a,c]
Total no. of respondents	7541	3368	3104	3673	3868
Currently smoking, odds ratio (95% CI)[b]	1.828 (1.649–2.026)	1.832 (1.567–2.142)	1.785 (1.521–2.095)	1.808 (1.558–2.098)	1.902 (1.648–2.196)
Cessation attempt in last year, odds ratio (95% CI)[d,e]	1.614 (1.405–1.853)	1.498 (1.233–1.820)	1.656 (1.305–2.103)	1.427 (1.175–1.732)	1.859 (1.521–2.272)
Ever e-cigarette use, odds ratio (95% CI)[d]	1.144 (1.034–1.266)	1.169 (1.005–1.360)	1.130 (0.965–1.324)	1.089 (0.941–1.262)	1.190 (1.034–1.369)
Current e-cigarette use, odds ratio (95% CI)[d,f]	1.014 (0.844–1.219)	0.864 (0.652–1.144)	1.288 (0.973–1.703)	1.078 (0.813–1.431)	0.961 (0.753–1.227)

[a] Estimate for patients eligible for lung cancer screening based on new (patients between 50 and 55 years old with a 20–30 pack-year smoking history) vs. old (patients between 55 and 80 years old with ≥30 pack-year smoking history) USPSTF criteria.
[b] Low income is defined as annual household income less than $35,000; unsure/other category is excluded.
[c] Less education is defined as graduating high school or less.
[d] Multivariable logistic regression models adjusting for sex, race, BMI, marital status, education level, income, insurance status, and primary care physician status (except education level and income were excluded from the stratified models).
[e] Of those respondents who were currently smoking.
[f] Of those respondents who had ever used e-cigarettes.

lower income, lack of health insurance, and lack of a primary healthcare provider (Table 1). Ever and current e-cigarette use were reported by 3003 (39.8%) and 670 (8.9%) participants, respectively. Compared to never use, ever e-cigarette use was associated with younger age, female sex, white race, lower income, and lack of health insurance (Table 1).

Compared to the previous cohort of screening-eligible patients (i.e., individuals between 55 and 80 years old with ≥30 pack-year smoking history), patients newly eligible for screening (i.e., individuals between 50 and 55 years old with a 20–30 pack-year smoking history) were more likely to currently smoke (aOR 1.828, 95% CI 1.649–2.026, $p < 0.001$, Table 2) but were also more likely to report a cessation attempt in the prior year (aOR 1.614, 95% CI 1.405–1.853, $p < 0.001$). While newly eligible respondents were more likely to report a history of ever using an e-cigarette (aOR 1.144, 95% CI 1.034–1.266, $p = 0.009$), current e-cigarette use was similar in this group compared to those individuals who were previously screening-eligible (aOR 1.014, 95% CI 0.844–1.219, $p = 0.88$). These findings did not vary significantly when the analyses were stratified by income and education level. Of note, among current smokers, ever e-cigarette users had a higher likelihood of reporting a cessation attempt in the prior year compared to never users (aOR 1.453, 95% CI 1.266–1.667, $p < 0.001$).

4. Discussion

Our population-based study of US adults eligible for lung cancer screening shows that a significant proportion of these individuals smoke cigarettes and e-cigarettes despite their risk for lung cancer. Further, recent changes to USPSTF eligibility criteria will now capture a patient population that is using these products more frequently. An encouraging finding was that this newly eligible group was also more likely to report a smoking cessation attempt in the prior year, suggesting that this cohort of younger individuals may be highly motivated to stop smoking. Interestingly, while e-cigarettes are not currently recommended for smoking cessation [9], our study shows that e-cigarette use was associated with more cessation attempts which is notable in a population that is heavily addicted to nicotine. Further research is needed to assess the safety of these products, particularly within this population that already has a high cumulative exposure to carcinogens.

The incidence of early-stage lung cancer is increasing in the U.S., in part due to stage migration associated with lung cancer screening [2]. Smoking at the time of any oncologic treatment – especially surgery – is extraordinarily detrimental to outcomes [10]. Since the time between cancer diagnosis and treatment is limited [11], every effort should be made to encourage cessation in these patients before cancer diagnosis. Meanwhile, the effects of e-cigarettes on peri-operative and oncologic outcomes are unknown and require urgent study.

It is imperative for clinicians to routinely assess and treat tobacco dependence at the time of lung cancer screening, especially given our findings that expanded criteria will likely capture a patient population with higher rates of current tobacco use. While several trials have attempted to integrate smoking cessation into lung cancer screening programs, it remains unclear how successful these interventions have been on a population level [3,12]. Implementing low-burden interventions that combine lung cancer screening and smoking cessation could have disproportionate impact on early-stage lung cancer outcomes [13,14].

This study has several strengths. In particular, we used population-based data to describe this new population of U.S. adults with less intense smoking histories who are now eligible for lung cancer screening. Conversely, this study has some limitations. In particular, due to the nature of the data set, variables are self-reported. Additionally, data on lung cancer screening results are unavailable.

5. Conclusion

Both cigarette and e-cigarette use are relatively common among U.S. adults eligible for lung cancer screening. Expanded USPSTF criteria will capture a patient population with greater exposure to both of these products. Further efforts are needed to promote smoking cessation in this vulnerable population, especially given these expanded screening criteria.

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CRediT authorship contribution statement

Brendan T. Heiden: Conceptualization, Methodology, Formal analysis, Writing – original draft. **Kathryn E. Engelhardt:** Conceptualization, Writing – review & editing. **Chao Cao:** Conceptualization, Methodology, Writing – review & editing. **Bryan F. Meyers:** Conceptualization, Writing – review & editing. **Varun Puri:** Conceptualization, Writing – review & editing. **Yin Cao:** Conceptualization, Methodology, Writing – review & editing. **Benjamin D. Kozower:** Conceptualization, Writing – review & editing.

Author contribution statement

All authors made substantial contributions to 1) the conception and design, acquisition of data, or analysis and interpretation of data; 2) the drafting of the article or revising it critically for important intellectual content; and 3) the final approval of the version to be published.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.canep.2021.102079.

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