Prevalence and Correlates of Electronic Cigarette Use Among U.S. Adult Survivors of Adolescent and Young Adult Cancer

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Abstract

Use of e-cigarettes, which contain nicotine and other harmful substances, is trending upward and posing adverse health effects for users. A review of literate demonstrated a dearth of studies regarding e-cigarettes use and its associated factors in adult Cancer Survivors, ages ≥ 18 years, who were Adolescents or Young Adults, ages 15-39, at disease Onset (AYAO-CS). This study seeks to examine the cross-sectional relationships between e-cigarette use and combustible cigarette smoking, plus demographic characteristics, in AYAO-CS and matched controls with no history of cancer.

Using pooled data from the 2017 and 2018 Behavioral Risk Factor Surveillance System; logistics regression analysis estimated odds of e-cigarette use in a sample of 2,592 adults (1,296 AYAO-CS and 1, 296 non-cancer controls). Overall, approximately 6% reported current e-cigarette use; 6.41% and 4.38% of AYAO-CS and controls, respectively. Approximately 25% were current combustible cigarette smokers; 28.37% and 17.86% of AYAO-CS and controls, respectively. Current and former combustible cigarette smokers were more likely to be current e-cigarette users (OR=48.99, 95% CI: 15.53-154.56) and (OR=4.41, 95% CI: 1.41-13.77) respectively.

Although AYAO-CS had greater, but non-significant, odds of current e-cigarette use (OR=1.34, 95% CI: 0.75-2.43) compared with non-cancer controls, findings support the need for coordinated efforts to generate greater awareness among cancer survivors of the potential adverse outcomes associated with e-cigarette use and concurrent use with combustible cigarettes, as well as counseling services regarding other proven smoking cessation strategies in lieu of e-cigarette use

Introduction

Electronic Nicotine Delivery Systems (ENDS or e-cigarettes) entered the U.S. tobacco market in 2007 and have since seen a dramatic use prevalence increase, particularly among adolescents and young adults [1]. The e-cigarette brand JUUL, alone, recorded increased sales of approximately 600% during 2016-2017, making it the most popular and the most commonly used e-cigarette in the U.S. [2]. The upward trend in the prevalence of e-cigarettes is not unique to the general population, as prior studies have reported similar findings in the cancer survivor subpopulation. For instance, one prior study observed a three-fold increase in e-cigarette use in a sample of cancer patients enrolled in a tobacco treatment program of a comprehensive cancer center after a 12-month fellow-up period [3].

Noteworthy, significant positive associations have been reported between e-cigarette use and use of other substances, particularly combustible cigarette smoking. For example, a past study concluded that current e-cigarette use was associated with significant odds of combustible cigarette smoking among adolescents (OR=2.73, 95% CI: 2.00-3.73) [4]. A prior longitudinal study concluded that current e-cigarette use had an independent significant association with future cigarette smoking initiation (OR=5.48, 95% C1:2.69-11.2) [5]. The same study found a greater than 40% combustible cigarette smoking initiation rate among ever e-cigarette users during a 16-month follow-up period [5]. Within the cancer survivor subpopulation, one study found that 38.5% of current combustible cigarette smokers reported past month e-cigarette use [3]. In a sample of cancer survivors in the U.S., a prior study observed that the odds of current cigarette smoking were significantly higher for survivors who reported ever e-cigarette use by a multiplicative factor of 11.81 (95%CI, 5.38-25.93) [6]. Lastly, one study involving a large sample of 36,308 U.S. adults, recorded that daily and nondaily e-cigarette use were significantly associated with alcohol use disorder (OR =2.54 95% CI=1.52-4.25) and (OR =3.56 95% CI=1.24-10.26) respectively, after controlling for other factors [7].

Furthermore, previous research has established that almost all e-cigarettes contain nicotine and other harmful products such as ultrafine, diacetyl [1,8]. Prior research further found that all e-cigarettes contain nicotine; even cartridges labeled as nicotine-free contain some amount of nicotine [8]. Over 70 e-liquid brands now sell high level nicotine e-cigarette products ranging between 5% and 7%, equivalent to packs of more than 40 cigarette [9]. Since evidence is mounting that ingredients in e-cigarette pose health risks to users, in general [10] it stands to reason that such use could also generate adverse health effects among those with chronic illnesses, including adults who survived cancers that were effectively treated during their adolescent and young adult years.

Although prior studies have examined e-cigarette use and its association with other substances, both in the general population and the cancer survivor subpopulation, a review of the available literature demonstrates a dearth of studies focusing on e-cigarettes use and its association with combustible cigarette smoking among adult cancer survivors, ages 18 years and older, who were first diagnosed when they were adolescents or young adults between the ages of 15 and 39 [11]. (This population is hereafter be referred to Adolescent and Young Adult Onset Cancer Survivors, using the acronym "AYAO-CS"). Therefore, the current study seeks to examine the cross-sectional relationships between combustible cigarette smoking and e-cigarette use among AYAO-CS and their age and sex matched peers with no history of cancer (Non-cancer matched controls).

Methods

Data Source

This study utilized a pooled data from the 2017 and 2018 Behavioral Risk Factor Surveillance Survey (BRFSS). BRFSS is the largest annual cross-sectional and premier national survey in the U. S. whereby a Computer-Assisted Telephone Interview (CATI) system is utilized to gather data from all the 50 states, the District of Columbia and three U.S. territories (Puerto Rico, Guam, and the U.S. Virgin Islands) [12,13]. Data collection occurs at the state levels by employing a multistage cluster sampling design based on random digit-dialing methods to collect data from noninstitutionalized U.S. civilian adults [12,13].

Study Sample

The current study includes individuals with a cancer diagnosis during adolescence and young adulthood and a matched control with no history of cancer diagnosis (non-cancer controls). Participants' cancer status was determined via the survey questions: "Has a doctor, nurse or other health care professional ever told you had any other types of cancer?" (That is all other cancers except skin cancer). Those who responded "yes" were asked a follow-up question; "At what age were you told that you had cancer?" Individuals who were age ≥ 18 years at time of survey administration and ages 15 to 39 years at the time of cancer onset were included in the current study (AYAO-CS). A one-by-one (1:1) propensity score-matched analysis, controlling for age and sex, was conducted to select the non-cancer controls. The 1:1 propensity score matching yielded matched pairs of 1,296 AYAO-CS and 1, 296 non-cancer controls.

This study was deemed exempt for review by the Institutional Review Board at Indiana University, Bloomington

Measures

Seminal to this study, prevalence of e-cigarette use and combustible cigarette smoking among both AYAO-CS and matched non-cancer controls were determined.

E-cigarette User Status was derived from two survey questions: "Have you ever used an e-cigarette or other electronic "vaping" product, even just one time, in your entire life?" and "Do you now use e-cigarettes or other electronic "vaping" products every day, some days, or not at all?" Based on responses, three categories were identified: *Current*-(those who use e-cigarettes currently every day or some days); *former*-user (those who do not use e-cigarette currently but had used it in the past); *never*-users (those who had never used e-cigarettes in their lifetime).

Combustible Cigarette Smoking Status was determined from two survey questions: "Have you smoked at least 100 cigarettes in your entire life?" and "Do you now smoke cigarettes every day, some days, or not at all?" Based on responses, three categories were identified: *current* - (those who smoke cigarettes currently every day or some days); *former* smokers (those who do not smoke currently but had smoked at least 100 cigarettes in their entire life); *never* smokers (those who had never smoked in their lifetime).

Covariates included for analysis were age, gender, race, marital status, educational level, employment status, general health

status and past month alcohol use. All covariates were treated as categorical variables.

Statistical analysis

All analyses were weighted to account for the complex sample design. Descriptive statistics were used to summarize e-cigarette user status, smoking status, past month alcohol use and demographic characteristics by cancer status. Pearson Chi-squared Test (χ2) was conducted to determine if differences were significant. Multinomial logistic regression examined the independent associations between combustible cigarette smoking status, past month alcohol use, cancer status and e-cigarette user status adjusting for age, gender, race, marital status, educational level, employment status, and general health status. SAS version 9.4 (SAS Institute, Inc., Cary, North Carolina) was used for all statistical analyses.

Results

Participants' demographics

Table-1 provides study participant characteristics; a majority were female (73.44 %); middle-aged (between 40- 65 years; 58.71%), Non-Hispanic Whites (80.83%) and currently employed (52.19%). Approximately one-fourth (25.83 %) had college degree or beyond. The total unweighted sample size for this study was 2,592(1,296 AYAO-CS and 1,296 Non-cancer controls).

The overall prevalence rates for current and former e-cigarette use were 5.89% and 19.57%, respectively; while 74.54 % had never used e-cigarette in their entire life. The overall prevalence rate for current combustible cigarette smoking was 25.35%; respectively, 26.10% and 48.55% were former and never-combustible cigarette smokers. Furthermore, 51.95% of the participants reported past month alcohol use.

The prevalence of current e-cigarette use and combustible cigarette smoking in AYAO-CS were 6.41% and 28.37% respectively; both were greater than for non-cancer matched controls; 4.38% and 17.86% respectively. Among AYAO-CS, 51.73% reported past month alcohol use, compared to 52.48% of non-cancer matched controls.

Table 1: Participants' Demographic Characteristics, E-cigarette Use, Combustible Cigarette Smoking and Alcohol Use by Cancer Status

	Overall Sample			AYAO-CS	Non-Cancer Controls
	N	Weighted	%	Col %	Col %
Age					
18- 39 years (Young Adult)	464	219518	28.29	26.26	33.35
40-64 years (Middle-aged)	1486	455534	58.71	60.68	53.82
≥ 65 years (Older Adult)	642	100870	13.00	13.08	12.83
Gender					
Female	1908	569852	73.44	70.97	79.57
Male	684	206070	26.56	29.03	20.43
Race/Ethn.					
White	2084	627170	80.83	86.61	66.48
Black	74	43758	5.64	6.30	3.99
Hispanic	363	72576	9.35	3.35	24.25
Other	71	32418	4.18	3.74	5.28
Marital Status					
Married	1562	461905	59.53	60.43	57.29
Divorced	534	126201	16.27	17.15	14.08
Single	330	115094	14.83	13.15	19.01
Other	166	72722	9.37	9.27	9.62
Education					
< High school	140	78712	10.14	10.52	9.20
High school graduate	696	218311	28.14	29.51	24.73
Some college	768	278472	35.89	34.87	38.43
College or more	988	200427	25.83	25.20	27.65
Employment Status					
Employed	1379	422567	54.46	52.19	60.10
Unemployed	121	52930	6.82	7.49	5.15

Homemaker	146	56177	7.24	7.18	7.38
Other	946	244249	31.48	33.13	27.37
General Health Status					
Excellent	339	81523	10.51	7.54	17.88
Good	1599	477794	61.58	60.63	63.92
Fair	441	130224	16.78	17.47	15.08
Poor	213	86380	11.13	14.36	3.12
E-cigarette User Status					
Current-User	101	45664	5.89	6.49	4.38
Former-User	423	151842	19.57	20.52	17.20
Never-Never	2068	578416	74.54	72.99	78.42
combustible cigarette smoking Status					
Current-Smoker	531	196702	25.35	28.37	17.86
Former-Smoker	747	202512	26.1	26.72	24.55
Never-Smoker	1314	376708	48.55	44.91	57.6
Past Month Alcohol Use					
No	1225	372863	48.05	48.27 %	47.52 %
Yes	1367	403059	51.95	51.73 %	52.48 %

Table 2 presents the crude associations between e-cigarette use and combustible cigarette smoking as well as all other independent variables. Among current e-cigarette users, 76.43% reported current cigarette smoking compared with 11.90% of never e-cigarette users who reported current combustible cigarette smoking. Among current e-cigarette users, 78.63% were AYAO-CS and 21.37% were non-cancer matched controls.

Table 2: Unadjusted Associations between E-cigarette Use, Demographic Characteristics, Combustible Cigarette Smoking and Alcohol Use

	Current e-cig user	Former e-cig user	Never e-cig user	P-value
Age	weighted %	weighted %	weighted %	
Young Adult	45.84	37.59	24.47	
Middle-aged	49.43	57.64	59.72	<.0001
Older Adult	4.73	4.77	15.81	
Gender				
Female	82.87	74.5	72.42	0.328
Male	17.13	25.5	27.58	
Race/Ethn.				
White	80.50	79.84	81.12	
Black	1.42	3.84	6.45	
Hispanic	11.39	12.49	8.37	0.386
Other	6.69	3.84	4.07	
Marital Status				
Married	48.55	38.85	65.83	
Divorced	10.52	29.21	13.32	<.0001
Single	19.18	20.44	13.02	
Other	21.75	11.50	7.84	
Education				

< High school	9.60	13.18	9.39	
High school graduate	41.34	34.08	25.53	<.0001
Some college	41.72	40.01	34.35	
College or more	7.34	12.73	30.73	
Employment Status				
Employed	48.07	44.21	57.66	
Unemployed	13.11	12.84	4.74	0.002
Homemaker	11.22	5.69	7.33	
Other	27.59	37.26	30.27	
General Health Status				
Excellent	7.82	5.62	12.00	
Good	55.34	50.35	65.02	<.0001
Fair	27.07	24.05	14.06	
Poor	9.76	19.97	8.92	
Cancer Status				
AYAO-CS	78.63	74.77	69.8	0.126
Non-Cancer Controls	21.37	25.23	30.20	
Combustible Cigarette Smoking Status				
Current-Smoker	76.43	61.23	11.90	
Former-Smoker	14.53	21.89	28.12	<.0001
Never-Smoker	9.04	16.88	59.98	
Past Month Alcohol Use				
No	43.74	53.4	46.99	0.326
Yes	56.26	46.60	53.01	

The multivariable logistics regression model predicting e-cigarette user status is presented in Table 3. The "never-users" group served as the reference category for e-cigarette use.

Table 3: Adjusted Association between E-cigarette Use and Combustible Cigarette Smoking

	Current E-cigarette User		Former E-cigarette User	
	OR	95% CI	OR	95% CI
Combustible Cigarette Smoking				
Never-Smoker	1	_	1	
Current-Smoker	48.99	15.53-154.56	15.97	9.38-27.19
Former-Smoker	4.41	1.41-13.77	3.07	1.76-5.37
Cancer Status				
Control	1	_	1	
AYAO-CS	1.34	0.74-2.43	0.97	0.64-1.49
Age				
Older	1	_	1	_
Middle-aged	2.70	1.09-6.66	4.06	2.33-7.10
Young Adults	5.26	2.02-15.80	7.94	3.51-17.98
Gender				

Female	1	_	1	_
Male	0.77	0.37-1.59	1.11	0.68-1.83
Race/Ethnicity				
White	1	_	1	_
Black	0.24	0.02-2.62	0.48	0.12-1.97
Hispanic	0.95	0.29-3.11	1.07	0.57-2.01
Other	1.71	0.55-5.30	1.07	0.28-4.19
Marital Status				
Married	1	_	1	_
Divorced	0.81	0.33-1.96	2.57	1.49-4.45
Single	1.71	0.67-4.40	2.08	0.99-4.34
Other	2.37	0.88-6.39	1.35	0.67-2.75
Educational Level				
< High school	1	_	1	-
High school graduate	2.42	0.74-7.95	1.57	0.72-3.43
Some college	3.43	1.07-11.04	2.34	1.10-5.00
College or more	1.11	0.27-4.41	1.4	0.62-3.16
Employment Status				
Employed	1	_	1	_
Unemployed	1.26	0.44-3.60	1.27	0.55-2.97
Homemaker	2.39	0.71-8.07	1.24	0.58-2.66
Other	1.17	0.52-2.64	1.34	0.73-2.47
General Health Status				
Excellent	1	_	1	_
Good	0.73	0.21-2.62	1.14	0.58-2.25
Fair	0.99	0.24-4.02	1.57	0.69-3.54
Poor	0.39	0.07-2.20	1.32	0.47-3.74
Past Month Alcohol Use				
No	1	_	1	_
Yes	2.02	1.02-4.08	1.15	0.74-1.81

Current E-Cigarette user vs never E-Cigarette user

Participants who reported current and former combustible cigarette smoking had significantly greater odds of being current e-cigarette users, compared with never-combustible cigarette smokers (OR=48.99, 95% CI: 15.53-154.56) and (OR=4.41, 95% CI: 1.41-13.77) respectively. Although, AYAO-CS have greater odds of being current e-cigarette users compared with non-cancer controls, the difference was not statistically significant. Participants who reported past month alcohol use had significantly greater odds of being current e-cigarette users than those who had not used alcohol in the past month (OR=2.02, 95% CI: 1.02-4.08). Moreover, young adults (OR=5.62, 95% CI: 2.02-15.80); middle-aged adults (OR=2.70, 95% CI: 1.09-15.80) and participants with some college education (OR=3.43, 95% CI: 1.07-11.04) were more likely to be current e-cigarette users.

Former E-Cigarette use vs never E-Cigarette use

After controlling for all other variables, the odds of being a former e-cigarette user were significantly greater for current combustible cigarette smokers (OR=15.97, 95% CI: 9.38-27.19) and former e-cigarette users (OR=3.07, 95% CI: 1.76-5.37) than never combustible cigarette smokers. Likewise, young adults (OR=7.94, 95% CI: 3.51-17.98); middle-aged adults (OR=4.06, 95% CI: 2.33-7.10); divorced participants (OR=2.57, 95% CI: 1.49-4.45) and those with some college education (OR=2.34, 95% CI: 1.10-5.00), were significantly more likely to be former e-cigarette users.

Discussion

The primary objective of this study was to examine the association between e-cigarette use and combustible-cigarette smoking among AYAO-CS and matched controls with no history of cancer. To the best of the authors' knowledge, this is the first study that has examined these associations among AYAO-CS in comparison to never-cancer controls using national representative data. Study findings demonstrate that, in both AYAO-CS and matched control groups, current and former cigarette smokers were significantly more likely to use e-cigarette. For instance, the crude analysis, found that nearly eight of every ten current e-cigarette users reported currently smoking combustible cigarettes. The strong and positive association between e-cigarette use and combustible cigarette was consistent with findings from prior studies both in the general population [4,5,14] and among the cancer survivor subpopulation [3,15,16]. For instance, a study reported that among cancer survivors who were current cigarette smokers, 34.3 % reported ever e-cigarette use [15]. In the same study, current cigarette smoking independently had significant associations with higher odds of e-cigarette use (OR=8.46, 95% CI =3.69, 19.35) [15]. In a sample of 2, 448 U.S. adults who reported current e-cigarette users, Patel et al. [14] estimated that 92.6% were also current cigarette smokers. Additionally, recent longitudinal studies have determined significant cause and effect relationships between e-cigarette use and combustible cigarette smoking both in the general population and among the cancer survivor subpopulation [3,17]; a prospective study involving cancer patients determined that, relative to non- e-cigarette users, the odds of initiating combustible cigarette smoking were significantly greater for e-cigarette users (OR=5.23, 95% CI: 2.91-9.41) [3].

The high rate of concurrent combustible cigarette and e-cigarette use among participants in this study is very concerning since these behaviors could potentially result in adverse health outcomes. The American Association for Cancer Research has argued that concurrent use of e-cigarettes and combustible cigarettes poses serious threats to health, [18] including cancer recurrence or developing additional primary cancers of the esophagus, larynx, kidney, liver, or stomach, etc. [19]. Moreover, the effects could be far more detrimental for cancer survivors who engage in such behavior. Although evidence regarding the long-term effects of e-cigarette is scanty, limited available epidemiological data suggest that e-cigarette use also can potentially result in cardiovascular issues associated with nicotine addiction [1,20,21]. For example, a prior study using national representative data, determined that daily use of e-cigarettes was positively correlated with higher odds of developing myocardial infarction among U.S. adults (OR=1.79, 95% CI=1.20, 2.66, p=0.004) [22]. Furthermore, sufficient data have linked acute administration of nicotine to a number of adverse outcomes including increases in heart rate and blood pressure as well as respiratory and gastrointestinal disorders [1,23].

Some of the most common cancers in adolescents and young adults, including breast cancer, cervical and thyroid, [24] are relatively more prevalent in women; this circumstance could possibly explain the disproportionate representation of women (73.44%) in this study. Regarding demographic characteristics consistent with previous research, young adults were relatively more likely to report current e-cigarettes use [6]. Additionally, high rate of current e-cigarette use were observed among participants with some college education and divorced participants.

Thus, intervention design programs need to prioritize individuals with such characteristics.

Available studies identified easy access, low cost of e-cigarette, low perceived harm, less stigmatization, less toxicity than combustible cigarettes, social attractiveness, flavoring and much higher nicotine content in newer e-cigarettes as key contributing factors to the increased trend in e-cigarette use [16,25,27]. Particularly, a recent study that examined cancer patients' beliefs about e-cigarette use recorded that patients use e-cigarette for different reasons including; managing cancer-related stress, less likelihood of interfering with cancer treatment and use as a combustible cigarette smoking cessation aid [16]. Consistent with the last point, studies in the general population have concluded that using e-cigarette for quitting combustible cigarette smoking partly accounts for the high rate of the concurrent use of both substances [28,29]. Nevertheless, a study that examined the influence of e-cigarette use on quitting combustible cigarette smoking concluded that e-cigarettes only had moderately positive effects on helping smokers quit, with no statistical evidence of superiority over other cessation strategies such as nicotine replacement therapy [30].

Another interesting and quite troubling finding from the current study is the higher prevalence of both current e-cigarettes use and combustible cigarette smoking among AYAO-CS compared with the never-cancer control group. This finding highlights the urgent need for sustained availability and accessibility of tobacco cessation programs for AYAO-CS. Currently, few if any, studies have been conducted to determine the short and long-term effects of e-cigarette use among cancer patients and/or survivors. This lack of research could possibly contribute to the high prevalence of e-cigarette use in this unique at-risk population.

Implications

This study is the first to examine the association between combustible cigarette smoking and e-cigarette use among AYAO-CS with matched controls, using a national representative data. The findings can contribute substantially to the limited literature on e-cigarette use among cancer survivors and serve as justification for implementation of effective behavioral, environmental and policy interventions aimed at reducing e-cigarette use, combustible cigarette smoking and/or concurrent use of both products. First, the strong significant positive association between use of the two products and the previously identified potential detrimental health effects associated with concurrent use of e-cigarettes and combustible cigarettes justify the need for a more comprehensive approach to prevention of substitute use and/or dual use of both, particularly among AYAO-CS. Specific strategies such as mass media campaigns, high taxation of e-cigarette products and raising the legal purchase and use age as well as creating more awareness about the potential harmful effects of e-cigarette use, can help protect the health of AYAO-CS who are already at greater risk for other negative health conditions including cardiovascular disease, obesity, poor physical and mental health [31].

The higher rate of e-cigarette use among AYAO-CS in the current study and the low likely perception of harm associated with e-cigarette use suggest the need for creating awareness about the potential detrimental effects of e-cigarette use alone as well as concurrently with combustible cigarettes, particularly among AYAO-CS.

Moreover, long-term counselling services are needed for cancer survivors who are combustible cigarette smokers to educate them regarding effective and proven smoking cessation strategies besides e-cigarettes, as this may help prevent the concurrent use of both products. Specific strategies such as nicotine replacement therapy, motivational interviewing, physician-based counseling and peer-based counselling [1,32,33] have proven effective with both the general population and the cancer survivor subpopulation. Because higher rates of e-cigarettes use and concurrent use of both products were recorded among AYAO-CS less than 65 years of age; thus, intervention designers should prioritize young and middle-aged adults.

Additional new approaches that apply health behavior theories such as Protection Motivation Theory (PMT) should also be considered. PMT has been shown to significantly influence substance use behaviors in the general population [34] [35]; for example, one study reported that adolescents' smoking behaviors were significantly associated with both threat and coping appraisals, after adjusting for other covariates [34]. A second study found that, relative to adolescents with higher perceived smoking-related health risks, those with lower perceived risks had 3.64 times greater the odds of initiating cigarette smoking [36]. Therefore, future studies can incorporate health behavior theories to examine whether AYAO-CS' threat and coping appraisal skills moderate the associations between combustible cigarette smoking and e-cigarette use. Lastly, more longitudinal data are needed to examine both the short and long-term effects of e-cigarette use on cancer survivorship and overall quality of health.

Limitations

A key limitation of the current study is the cross-sectional nature of the data which limits the authors' ability to draw causal conclusions about the association between combustible cigarette smoking and e-cigarette use. Secondly, data on combustible cigarette smoking and e-cigarette use were gathered through self-reporting and, thus, could potentially suffer from social desirability bias. Nevertheless, a prior study reported that questions relating to self-reported cigarette smoking behaviors demonstrated high agreement (Kappa = 0.81 95% CI 0.72-0.89), respectively [37]. Additionally, previous research justifies the assumption that alcohol and tobacco use behavior self-reported by the participants were reliable and reflected their true behavior [38]. Another limitation, not unique to the current study, is the under representation of minority race/ethnicity and individuals with lower socioeconomic status in national surveys [39] [40]. Lastly, though the sample is a true representative of the AYAO-CS population in the United States, the generalizability of the findings could vary by state due to differences in state-level response rate [12,13], plus differences in tobacco control policies and programs including taxation rates.

Conclusion

Among AYAO-CS and matched controls, current and former combustible cigarette smoking was associated with higher odds of e-cigarette use, after adjusting for other variables. Young and middle-aged adults in both groups were more likely to engage in concurrent use of both products, highlighting the need for intervention designers to prioritize these sub-groups. Finally, study findings suggest the need for coordinated efforts to generate greater awareness of the potential adverse outcomes associated with e-cigarette use and concurrent use of both products as well as counseling services for combustible cigarette smokers with history of cancer diagnosis on proven effective smoking cessation strategies.

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