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RESEARCH ARTICLE

E-cigarette Use Among Young Adults in the U.S.

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Introduction: Use of e-cigarettes is increasing among young adults in the U.S. Whether e-cigarette use serves as an aid to smoking reduction or cessation among young adults remains a matter of contention. This analysis examines patterns of e-cigarette use in relation to cigarette smoking in a nationally representative sample of U.S. young adults.

Methods: Data were analyzed from nationally representative U.S. adults, aged 18 to 35 years (N=12,415), in the 2012–2013 National Epidemiologic Survey on Alcohol and Related Conditions-III. Logistic regression assessed associations between e-cigarette use and smoking intensity, continuity, and reduction while controlling for several potential confounding factors. Data were analyzed in 2018.

Results: Among cigarette smokers, e-cigarette use was associated with higher odds of tobacco use disorder (AOR=2.58, 95% CI=1.73, 3.83) and daily cigarette smoking (AOR=1.67, 95% CI=1.73, 3.83). Among adults aged 26–35 years, e-cigarette use was also associated with heavy cigarette smoking (AOR=2.01, 95% CI=1.09, 3.74). Among lifetime smokers, e-cigarette use was associated with lower odds of stopping smoking (AOR=0.14, 95% CI=0.08, 0.23) and lower odds of a 50% reduction in cigarettes smoked per day (AOR=0.63, 95% CI=0.43, 0.93). Only 13.1% of young adults who ever used e-cigarettes reported using them to help stop or quit smoking.

Conclusions: Use of e-cigarettes by U.S. young adults, most of which is not intended to help reduce smoking, is related to more rather than less frequent and intensive cigarette smoking.
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INTRODUCTION

Despite national declines in smoking over the last several years, large numbers of adults continue to smoke,[1] even though many have made unsuccessful efforts to quit.[2] In this context, e-cigarettes have gained the attention of tobacco researchers and cigarette smokers as a method for delivering nicotine without involving tobacco combustion. As compared with traditional cigarettes, e-cigarettes emit substantially lower levels of several carcinogens.[3] Nevertheless, e-cigarette use may substantially increase the risk of cardiovascular diseases, chronic obstructive pulmonary disease, and bacterial pneumonia.[4] The rise in popularity of e-cigarettes[5] has been linked to their strong behavioral and sensory resemblance to smoking cigarettes.[6] Yet there are concerns over the safety of e-cigarettes and their effectiveness as smoking cessation or reduction aids.[7]

Some evidence supports a role for e-cigarettes in helping smokers reduce or quit smoking cigarettes.[8,9] In an RCT of adult smokers who intended to quit, 6-month verified quit rates were 7.3% with nicotine e-cigarettes, 5.8% with nicotine patch, and 4.1% with placebo e-cigarettes.[10] In a second trial, however, smoking reductions were similar in groups assigned to nicotine e-cigarettes and placebo e-cigarettes.[11] Yet across 27 studies including clinical trials,

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cohort studies, and cross-sectional studies, smokers who use e-cigarettes had 27% lower odds of quitting smoking than smokers who did not use them.[4]

Alongside questions regarding the effectiveness of e-cigarettes as smoking reduction or cessation aids, there are uncertainties concerning the relationship between e-cigarette use and cigarette smoking in the general population. These issues are especially salient for young adults because of the high prevalence of e-cigarette use[12] and cigarette smoking[1] in this population and because they are the least likely age group to attempt to quit smoking.[13,14] More than half of current e-cigarette users in the U.S. are aged less than 35 years.[12] Although some evidence from adults of all ages suggests that many start using e-cigarettes to help reduce or quit smoking,[15–17] the use of e-cigarettes by young adults appears to be less strongly related to a desire to reduce or quit smoking.[18,19] A longitudinal study of young adult non-daily smokers further found that, as compared with those who only smoked cigarettes, those who were also frequent e-cigarette users reported greater increases in cigarette smoking over time.[20]

Little is known about the relationship of e-cigarette use to cigarette smoking among young adults in the U.S. If e-cigarette use by young adults is not accompanied by consistent reductions in cigarette smoking, then the harms of e-cigarettes may outweigh their benefits. By increasing nicotine tolerance and dependence, e-cigarettes could lead to increased cigarette smoking over time and complicate efforts to quit smoking.

To address gaps in understanding the relationships between e-cigarette use and cigarette smoking among young adults, patterns were analyzed in a nationally representative sample of adults, aged 18 to 35 years. Smoking intensity of young adult current cigarette smokers who report either using or not using e-cigarettes were compared first. Next, among young adults with a lifetime history of smoking cigarettes, the association between past-year e-cigarette use and stopping smoking was evaluated. Then the authors examined whether among young adult smokers, e-cigarette use is associated with reducing cigarettes smoked per day. Finally, the extent to which e-cigarette use among young adults is related to an intention to reduce or quit tobacco use was considered. The authors hypothesize that e-cigarette use among young people is associated with more intensive cigarette smoking and with a lower likelihood of reducing or stopping cigarette smoking.

METHODS

Study Sample

The National Epidemiologic Survey on Alcohol and Related Conditions-III (NESARC-III; 2012–2013) was a nationally representative face-to-face interview survey of 36,309 adults, residing in households and group quarters, conducted by the National Institute on Alcohol Abuse and Alcoholism.[21] The current analysis focused on adults aged 18–35 years at the time of the survey (N=12,415), given their high rates of smoking and e-cigarette use. Multistage probability sampling was used to randomly select respondents. Primary sampling units were either individual counties or groups of contiguous counties and secondary sampling units were groups of census-defined blocks from which households were selected. This sample involved random selection of eligible adults within sampled households.

The household screener response rate was 72% with a person-level response rate of 84% to yield an overall response of 60.1%, which is comparable with rates for other current U.S. surveys.[22,23] The samples were weighted to adjust for nonresponse at the household and person levels, selection of one person per household, and oversampling of African Americans, Asians, and Hispanics. After weighting, the data were adjusted to be representative of the U.S. population for variables including region, age, sex, race, and ethnicity based on the American Community Survey.[24] Informed consent was electronically recorded and IRBs of NIH and Westat approved the study protocols. Data were analyzed in 2018.

Measures

Sociodemographic measures included age, sex, race/ethnicity, education, personal income, and marital status by self-report. The Alcohol Use Disorder and Associated Disabilities Interview Schedule–DSM-5 (AUDADIS-5) version was used.[25] Lifetime alcohol and drug use (cannabis, cocaine, and other drug use disorders, excluding tobacco), depressive disorders (major depressive disorders and persistent depression disorder), and anxiety disorders (panic, social anxiety, generalized anxiety, and specific phobia disorders) were assessed by structured diagnostic interviews. Test–retest reliability of the AUDADIS-5 for DSM-5 disorder is good to excellent for substance use disorders (κ, 0.50–0.85) and fair to good for other psychiatric disorders (κ, 0.35–0.54).[25]

The main dependent variables were measures of smoking intensity (daily smoking, cigarettes per smoking day, heavy smoking, and tobacco use disorder), smoking reduction, and having stopped smoking among adults who had smoked ≥100 cigarettes during their lifetime and had smoked cigarettes in the past year. Daily smoking was measured by endorsement of *every day* as opposed to *5 to 6 days a week*, *3 to 4 days a week*, *1 to 2 days a week*, *2 to 3 days a month*, or *once a month or less* in response to, *About how often did you usually smoke cigarettes?* The number of cigarettes per smoking day was measured with the following open-ended question: *On days that you smoked, about many cigarettes did you usually smoke?* Heavy smoking was defined as smoking ≥24 cigarettes per smoking day in the last year[26] in response to the item, *On the days that you smoked, about how many cigarettes did you usually smoke?* among respondents who smoke ≥5 days per week. Consistent with DSM-5, 12-month tobacco use disorder required more than two of the 11 criteria in the last 12 months before the interview. Reducing smoking was defined as decreasing daily cigarettes in the last year by ≥50% of the usual number of cigarettes smoked per day in preceding years.[27] Having stopped cigarette smoking[28] was defined by responding *no* to *During the last 12 months, did you smoke at least*

one cigarette? The cigarette tobacco use measures were highly reliable (intraclass correlation coefficients, 0.91–0.74).[25]

The main independent variables were lifetime and past-year use of e-cigarettes. Lifetime use was assessed with, *In your entire life, have you ever used e-cigarettes or e-liquid?* and past-year use was assessed with, *During the last 12 months, did you smoke at least one e-cigarette cartridge or 4 drops of e-liquid?* Frequent e-cigarette use was defined as use on ≥5 days per week using the same response options listed above for usual cigarette smoking. An item inquiring whether respondents had ever used e-cigarettes to "get help for tobacco or nicotine use" distinguished e-cigarette users who used e-cigarettes to help quit smoking from those who used e-cigarettes for other purposes.

Statistical Analysis

Analyses of adults aged 18–35 years were conducted in four stages focused respectively on smoking intensity, stopping, reduction, and reason for e-cigarette use. The first stage was limited to young adults who reported smoking ≥100 cigarettes during their lifetime[27] and smoking cigarettes in the past year. Unadjusted ORs and 95% CIs evaluated group differences in the demographic and clinical characteristics among these smokers with and without past-year e-cigarette use. Separate AORs assessed relationships of past-year e-cigarette use and each measure of smoking intensity while mutually controlling for the background sociodemographic and clinical variables.

The second stage was limited to young adults who reported a lifetime history of smoking ≥100 cigarettes with or without smoking cigarettes in the past year. Unadjusted ORs and 95% CIs assessed group differences in demographic and clinical characteristics of stopping smoking in the last year with and without past-year use of e-cigarettes. Fully AORs assessed the strength of associations of respondent characteristics with stopping smoking during the last year. The independent variable of interest was past-year e-cigarette use. These analyses were conducted in the overall young adult sample and separately in young adults aged 18–25 years and 26–35 years.

The third stage of the analysis was limited to lifetime daily smokers who reported smoking cigarettes in the past year. Unadjusted ORs and AORs assessed associations of e-cigarette use and past-year reduction in cigarette use.

The fourth stage of the analyses was limited to lifetime daily smokers who reported lifetime e-cigarette use. Young adults who used e-cigarettes to get help in reducing or stopping tobacco or nicotine use were compared with those who used e-cigarettes for other purposes. Because of evidence that quit attempts and quit success is related to frequency of e-cigarette use,[29] supplementary analyses involved frequent e-cigarette use. All statistical analyses were performed with SAS or SUDAAN, version 11.0 software to accommodate the complex sample design and weighting of observations.

RESULTS

In unadjusted analyses of young adults who were past-year cigarette smokers, e-cigarette use was correlated with an earlier age of having started smoking cigarettes, tobacco use disorder, and smoking more cigarettes per day in the last year (Table 1). Past-year e-cigarette use was also associated younger age, male sex, white as compared with African American or Hispanic race/ethnicity, having completed at least some college compared with less than high school, having never married compared with currently married or cohabitating, and having a history of drug and alcohol use disorders.

After controlling for several background and clinical characteristics, any past-year e-cigarette use was related to 1.67 increased odds of daily cigarette smoking and 2.58 greater odds of meeting criteria for tobacco use disorder. Among adults aged 26–35 years, any past-year e-cigarette use was associated with 2.01 greater odds of heavy smoking, 3.55 greater odds of tobacco use disorder, and 2.27 greater odds of daily smoking. For the group aged 18–25 years, past-year e-cigarette use was significantly related to tobacco use disorder, but not the other smoking intensity measures (Table 2). In similar analyses, frequent past-year e-cigarette use was associated with significantly increased odds of tobacco use disorder and daily cigarette smoking among the overall young adult group and among the older, but not younger, subgroup (Appendix 1, available online).

Among young adults with a lifetime history of cigarette smoking, those with past-year e-cigarette use were significantly less likely than those without past-year e-cigarette use to have stopped smoking cigarettes in the last year (3.2% vs 19.2%, OR=0.14, 95% CI=0.08, 0.23; Table 3). In unadjusted analyses, the overall pattern of past-year e-cigarette use for lifetime smokers (Table 3) resembled the e-cigarette use pattern for past-year smokers (Table 1), except that for lifetime smokers, e-cigarette use was significantly more common among people with lower rather than higher personal income and those who were widowed, separated or divorced rather than married or cohabiting marital status; e-cigarette use was also associated with a younger age of smoking initiation.

After controlling for demographic and clinical characteristics, any past-year e-cigarette use was related to lower odds of having stopped smoking among the overall sample (AOR=0.15, 95% CI=0.09, 0.26), among adults aged 18–25 years (AOR=0.17, 95% CI=0.05, 0.53), and among those aged 26–35 years (AOR=0.14, 95% CI=0.08, 0.24; Table 4). Past-year frequent e-cigarette use was also associated with lower odds of having stopped smoking (AOR=0.12, 95% CI=0.05, 0.31; data not shown).

As compared with young adults with a lifetime history of daily smoking who had no e-cigarette use, those with any e-cigarette use were 3.7% less likely and those with frequent use were 2.9% less likely to have reduced their smoking in the last year (Appendix Figure 1). In adjusted analyses, any past-year e-cigarette use was associated with decreased odds of reducing smoking (0.63,

Table 1. Characteristics of Young Adult Past-year Cigarette Smokers by Past-year Use of E-cigarettes

Characteristic	Past-year smokers without past-year e-cigarette use, % (*n*=2,916)	Past-year smokers with past-year e-cigarette use, % (*n*=571)	OR (95% CI)[a]
Age, years			
18–25	39.6	46.8	**1.34 (1.10, 1.63)**
26–35	60.4	53.2	1.00
Sex			
Male	53.6	60.5	**1.33 (1.06, 1.67)**
Female	46.4	39.5	1.00
Race/Ethnicity			
White	66.3	73.8	1.00
Black	12.6	6.4	**0.45 (0.33, 0.62)**
Hispanic	15.8	11.3	**0.64 (0.47, 0.88)**
Other	5.3	8.6	1.44 (0.94, 2.21)
Education (at interview)			
<High school	18.4	12.0	**0.58 (0.40, 0.84)**
High school	23.7	23.4	0.89 (0.70, 1.12)
At least some college	57.9	64.6	1.00
Personal income, $			
0–19,999	57.7	61.0	1.24 (0.89, 1.73)
20,000–39,999	29.0	27.7	1.12(0.77, 1.63)
≥40,000	13.3	11.4	1.00
Marital status			
Married or cohabiting	42.2	35.7	1.00
Widowed, separated, divorced	9.5	11.0	1.37 (0.89, 2.09)
Never married	48.3	53.3	**1.30 (1.01, 1.68)**
Behavioral health disorders			
Drug use disorder, lifetime	28.3	38.0	**1.55 (1.25, 11.92)**
Alcohol use disorder, lifetime	55.8	70.8	**1.92 (1.56, 2.37)**
Depressive disorder, lifetime	26.5	28.1	1.08 (0.85, 1.39)
Anxiety disorder, lifetime	22.0	25.6	1.22 (0.94, 1.59)
Tobacco use			
Age (SD) started daily cigarette smoking, years	18.2 (7.9)	17.2 (3.4)	*t*=3.23, *p*=0.002
Heavy smoker, past year	3.8	5.9	1.57 (0.91, 2.70)
Tobacco use disorder, past year	75.1	89.9	2.96 (2.02, 4.34)
Mild	62.4	43.3	1.00
Moderate	21.1	24.0	**1.64 (1.27, 2.11)**
Severe	16.5	32.6	**2.84 (2.23, 3.61)**
Daily cigarette smoker, past year	69.3	78.4	**1.61 (1.26, 2.05)**
Mean (SD) number of cigarettes/day, past year	12.0 (8.0)	13.2 (7.6)	***t*=2.76, *p*=0.007**

Note: Boldface indicates statistical significance ($p<0.05$). Data from NESARC-III. Results are unadjusted.
[a]Ref=no e-cigarettes.
NESARC-III, National Epidemiologic Survey on Alcohol and Related Conditions-III.

95% CI=0.43, 0.93; data shown in Appendix Figure 1 legend).

A small minority of young adults with any e-cigarette use (13.1%) or any frequent e-cigarette use (15.8%) reported having used them to help stop or quit smoking (data not shown). As compared with young adults who had used e-cigarettes for purposes other than to get help with tobacco or nicotine use, those who used them to help reduce tobacco use were significantly more likely to be older and female and to have a lifetime history of depressive disorder or anxiety disorder (Appendix 2).

DISCUSSION

There is an ongoing clinical, public health, and policy debate over whether e-cigarettes are an effective means

Table 2. Odds of Past-year Intensive Smoking Among Young Adult Past-year Smokers by Past-year Use of E-cigarettes

Characteristic	Total sample (N=3,487)	18–25 years (*n*=1,282)	26–35 years (*n*=2,205)
Heavy smoking			
Past-year e-cigarette use	1.53 (0.88, 2.68)	0.98 (0.38, 2.53)	**2.01 (1.09, 3.74)**
No past-year e-cigarette use	1.00	1.00	1.00
Tobacco use disorder			
Past-year e-cigarette use	**2.58 (1.73, 3.83)**	**1.80 (1.12, 2.87)**	**3.55 (2.03, 6.19)**
No past-year e-cigarette use	1.00	1.00	1.00
Daily cigarette smoker			
Past-year e-cigarette use	**1.67 (1.29, 2.16)**	1.22 (0.84, 1.77)	**2.27 (1.52, 3.38)**
No past-year e-cigarette use	1.00	1.00	1.00
Number of daily cigarettes, β (95%CI) (no past-year e-cigarette, reference)	0.65 (−0.12, 1.41)	−0.11 (−1.19, 0.96)	**1.36 (0.14, 2.58)**

Note: Data are shown as OR (95% CI) unless otherwise noted. Boldface indicates statistical significance ($p<0.05$). Data from NESARC-III. All regressions are controlled for age, sex, race/ethnicity, education, personal income, marital status, behavioral health disorder, and age started cigarette smoking.
NESARC-III, National Epidemiologic Survey on Alcohol and Related Conditions-III.

of harm reduction for adults who smoke cigarettes.[30–32] The results suggest that, for young adult smokers, e-cigarettes may decrease their likelihood of stopping smoking and lower their likelihood of reducing smoking. Although some smokers who are motivated to quit smoking likely benefit from e-cigarettes,[9] the overall results call into question assertions that e-cigarettes are effective at the population level in reducing smoking among young adults.[18]

Most young adults who used e-cigarettes, even most who used them frequently, did not report using them to help reduce tobacco or nicotine use. Consistent with this observation, previous research with smokers who were young adults[33] or college students[19] has reported that intention to quit smoking is not related to use of e-cigarettes. Focus groups with young people further suggest that their intentions to use e-cigarettes are more closely related to affect regulation, social enhancement, and positive sensory experiences than to avoiding negative health outcomes of cigarette smoking.[34,35] In light of these motivations, it is perhaps not surprising that e-cigarette use is not related to smoking reduction among young adult smokers. Because older adults are more likely than younger adults to use e-cigarettes with an intent to reduce or stop smoking,[36] the results of the present analysis may not generalize to e-cigarette use among older adult smokers.

In relation to young adult smokers who do not use e-cigarettes, those who use e-cigarettes were more likely to smoke every day and meet criteria for tobacco use disorder. This pattern is consistent with a recent longitudinal study of young adults in which dual users experienced greater increases in cigarette smoking than their counterparts who did not use e-cigarettes.[20] These relationships were stronger for adults aged 26 to 35 years than for adults 18 to 25 years. As adults age, successfully quitting or reducing smoking tends to become more difficult,[37] perhaps because of higher levels of tobacco dependence or weaker social norms against smoking. These and other individual characteristics may influence the effects of e-cigarette use on smoking patterns.

Among lifetime smokers, past-year e-cigarette use, including frequent e-cigarette use, was associated with a lower likelihood of stopping smoking. These findings demonstrate in young adults an observation that has been previously reported in adolescents. In a nationally representative cross-sectional survey of U.S. middle and high school students, use of e-cigarettes was associated with higher odds of current cigarette smoking; and among infrequent e-cigarette users, lower odds of smoking cessation.[38] Similar results have been reported from a large cross-sectional study of Korean adolescents.[39] These findings collectively suggest that among youth and young adults in the general population, e-cigarette use tends to reduce the odds of smoking cessation.

Relationships between e-cigarette use and smoking are complex and incompletely understood. In the older group of young adult smokers, there was a nonsignificant association between frequent e-cigarette use and lower odds of heavy smoking, despite increased odds of tobacco use disorder and daily smoking. For some adult smokers, frequent, but not infrequent, e-cigarette use might help reduce smoking.[40] Variations in the level of nicotine dependence,[41] motivation to use e-cigarettes, extent of dual smoking, concentration of e-liquid, frequency of e-cigarette use, experience with e-cigarettes, and other factors might influence the effects of e-cigarette use on smoking behavior.[42]

Table 3. Characteristics of Young Adult Lifetime Cigarette Smokers by Past-year Use of E-cigarettes

Characteristic	Lifetime smokers without past-year e-cigarette use, % (*n*=3,555)	Lifetime smokers with past-year e-cigarette use, % (*n*=592)	OR (95% CI)[a]
Age, years			
18–25	35.6	46.2	**1.55 (1.29, 1.87)**
26–35	64.4	53.8	1.00
Sex			
Male	52.4	60.9	**1.41 (1.13, 1.76)**
Female	47.6	39.1	1.00
Race/Ethnicity			
White	67.7	73.4	1.00
Black	11.1	6.3	**0.52 (0.38, 0.72)**
Hispanic	16.0	11.7	**0.68 (0.50, 0.91)**
Other	5.2	8.6	1.52 (1.00, 2.31)
Education (at interview)			
< High school	16.3	11.7	**0.67 (0.47, 0.96)**
High school	22.8	22.8	0.93 (0.74, 1.18)
At least some college	61.0	65.5	1.00
Personal income, $			
0–19,999	54.7	60.5	**1.52 (1.08, 2.14)**
20,000–39,999	28.8	27.6	1.31 (0.91, 1.90)
≥40,000	16.5	12.0	1.00
Marital status			
Married or cohabiting	47.2	36.5	1.00
Widowed, separated, divorced	8.8	10.7	**1.57 (1.03, 2.38)**
Never married	44.0	52.8	**1.55 (1.21, 1.99)**
Behavioral health disorders			
Drug use disorder, lifetime	27.6	37.8	**1.59 (1.28, 1.97)**
Alcohol use disorder, lifetime	55.3	71.6	**2.03 (1.65, 2.51)**
Depressive disorder, lifetime	26.5	28.0	1.08 (0.85, 1.36)
Anxiety disorder, lifetime	21.6	25.5	1.25 (0.97, 1.61)
Stopped smoking, past year			
No	80.8	96.8	1.00
Yes	19.2	3.2	**0.14 (0.08, 0.23)**
Started cigarette smoking, Age (SD), mean	15.8 (5.7)	14.9 (3.5)	***t*=4.04, *p*<0.0001**

Note: Boldface indicates statistical significance ($p<0.05$). Data from NESARC-III. ORs are unadjusted.
[a]Ref=no e-cigarettes.
NESARC-III, National Epidemiologic Survey on Alcohol and Related Conditions-III.

Limitations

This study has several limitations. First, without more detailed longitudinal information on the timing and pattern of e-cigarette use in relation to cigarette smoking, it is premature to conclude with certainty that using e-cigarettes increases the intensity of cigarette smoking in young adults. Unmeasured confounding factors, such as level of nicotine craving, may be related to e-cigarette initiation and smoking intensity and thereby help to account for the observed associations. Second, information about e-cigarettes and tobacco use was based on self-report and not confirmed by objective methods and was assessed retrospectively, which could have led to recall bias. Third, missing data prevented analysis of e-liquid nicotine concentration. In addition, newer e-cigarettes may limit the applicability of the NESARC-III results to current smoking patterns. When the NESARC-III survey was conducted, available e-cigarettes delivered lower nicotine doses than combustible cigarettes.[3] Some newer generation e-cigarettes, however, can deliver nicotine faster than cigarettes.[43] Fourth, since the fielding of the NESARC, e-cigarette use has increased, especially among young people,[44] and changing trends in e-cigarette use may have altered associations between e-cigarette use and cigarette smoking patterns. Finally, the survey is limited to community-dwelling adults and

Table 4. Odds of Stopping Cigarette Smoking in Last 12 Months Among Young Adult Lifetime Smokers

Characteristic	Total sample, OR (95% CI) (N=4,147)	18–25 years, OR (95% CI) (*n*=1,395)	26–35 years, OR (95% CI) (*n*=2,752)
Past year, e-cigarette use			
Yes	**0.15 (0.09, 0.26)**	**0.17 (0.05, 0.53)**	**0.14 (0.08, 0.24)**
No	1.00	1.00	1.00
Age (at interview), years			
18–25	**0.48 (0.36, 0.65)**	N/A	N/A
26–35	1.00	N/A	N/A
Sex			
Male	**0.75 (0.61, 0.91)**	1.14 (0.74, 1.75)	**0.66 (0.52, 0.84)**
Female	1.00	1.00	1.00
Race/Ethnicity			
White	1.00	1.00	1.00
Black	**0.48 (0.33, 0.70)**	0.63 (0.31, 1.27)	**0.45 (0.29, 0.68)**
Hispanic	1.23 (0.96, 1.59)	0.85 (0.47, 1.54)	**1.41 (1.04, 1.89)**
Other	0.72 (0.45, 1.15)	1.59 (0.58, 4.35)	0.60 (0.35, 1.02)
Education (at interview)			
<High school	**0.36 (0.26, 0.49)**	**0.38 (0.20, 0.75)**	**0.33 (0.23, 0.48)**
High school	**0.67 (0.52, 0.86)**	0.65 (0.35, 1.18)	**0.68 (0.50, 0.93)**
At least some college	1.00	1.00	1.00
Personal income, $			
0–19,999	**0.52 (0.39, 0.70)**	1.75 (0.51, 6.25)	**0.49 (0.36, 0.67)**
20,000–39,999	**0.53 (0.40, 0.69)**	2.08 (0.60, 7.14)	**0.47 (0.35, 0.63)**
≥40,000	1.00	1.00	1.00
Marital status			
Married or cohabiting	1.00	1.00	1.00
Widowed, separated, divorced	**0.34 (0.24, 0.49)**	0.78 (0.24, 2.56)	**0.31 (0.21, 0.45)**
Never married	**0.47 (0.37, 0.59)**	**0.45 (0.26, 0.76)**	**0.41 (0.36, 0.62)**
Behavioral health disorders			
Drug use disorder, lifetime	1.05 (0.80, 1.37)	1.15 (0.61, 2.17)	1.02 (0.76, 1.37)
Alcohol use disorder, lifetime	0.83 (0.68, 1.02)	**0.53 (0.32, 0.91)**	0.94 (0.74, 1.22)
Depressive disorder, lifetime	1.00 (0.77, 1.31)	1.54 (0.85, 2.78)	0.88 (0.67, 1.18)
Anxiety disorder, lifetime	0.90 (0.67, 1.20)	0.75 (0.40, 1.39)	0.95 (0.68, 1.32)
Age started daily cigarette smoking	1.00	1.00	1.00

Note: Boldface indicates statistical significance ($p<0.05$). Data from NESARC-III. All regressions are controlled for age, sex, race/ethnicity, education, personal income, marital status, behavioral health disorders, and age started cigarette smoking.
N/A, not applicable; NESARC-III, National Epidemiologic Survey on Alcohol and Related Conditions-III.

different results may have been obtained in young adults who are homeless, incarcerated, or in other institutions.

CONCLUSIONS

The present findings raise concerns about the overall net effects of e-cigarette use on smoking patterns of young adults. Young adulthood is a formative period for the development of long-term health habits.[45] Because e-cigarette use is rising among young adults,[44,46] it is important that regulation of e-cigarettes be informed not only by an understanding of their safety and effectiveness as smoking reduction or cessation aids in selected motivated individuals in clinical trials, but also by their consequences in the broader population of people who smoke cigarettes.

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SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at https://doi.org/10.1016/j.amepre.2018.12.004.

REFERENCES

1. Jamal A, King BA, Neff LJ, Whitmill J, Babb SD, Graffunder CM. Current cigarette smoking among adults — United States, 2005–2015. *MMWR Morb Mortal Wkly Rep.* 2016;65(44):1205–1211. https://doi.org/10.15585/mmwr.mm6544a2.
2. Babb S, Malarcher A, Schauer G, Asman K, Jamal A. Quitting smoking among adults — United States, 2000–2015. *MMWR Morb Mortal Wkly Rep.* 2017;65(52):1457–1464. https://doi.org/10.15585/mmwr.mm6552a1.
3. Goniewicz ML, Knysak J, Gawron M, et al. Levels of selected carcinogens and toxicants in vapour from electronic cigarettes. *Tob Control.* 2014;23(2):133–139. https://doi.org/10.1136/tobaccocontrol-2012-050859.
4. Glantz SA, Bareham DW. E-cigarettes: use, effects on smoking, risks, and policy implications. *Annu Rev Public Health.* 2018;39:215–235. https://doi.org/10.1146/annurev-publhealth-040617-013757.
5. Marynak KL, Gammon DG, King BA, et al. National and state trends in sales of cigarettes and e-cigarettes, U.S., 2011–2015. *Am J Prev Med.* 2017;53(1):96–101. https://doi.org/10.1016/j.amepre.2017.01.016.
6. Barbeau AM, Burda J, Siegel M. Perceived efficacy of e-cigarettes versus nicotine replacement therapy among successful e-cigarette users: a qualitative approach. *Addict Sci Clin Pract.* 2013;8(1):5. https://doi.org/10.1186/1940-0640-8-5.
7. Crowley RA. Health Public Policy Committee of the American College of Physicians. Electronic nicotine delivery systems: executive summary of a policy position paper from the American College of Physicians. *Ann Intern Med.* 2015;162(8):583–584. https://doi.org/10.7326/M14-2481.
8. Malas M, van der Tempel J, Schwartz R, et al. Electronic cigarettes for smoking cessation: a systematic review. *Nicotine Tob Res.* 2016;18(10):1926–1936. https://doi.org/10.1093/ntr/ntw119.
9. Rahman MA, Hann N, Wilson A, Mnatzaganian G, Woorall-Carter L. E-cigarettes and smoking cessation: evidence from a systematic review and meta-analysis. *PLoS One.* 2015;10(3):e0122544. https://doi.org/10.1371/journal.pone.0122544.
10. Bullen C, Howe C, Laugesen M, et al. Electronic cigarettes for smoking cessation: a randomised controlled trial. *Lancet.* 2013;382(9905):1629–1637. https://doi.org/10.1016/S0140-6736(13)61842-5.
11. Caponnetto P, Campagna D, Cibella F, et al. EffiCiency and Safety of an eLectronic cigAreTte (ECLAT) as tobacco cigarettes substitute: a prospective 12-month randomized control design study. *PLoS One.* 2013;8(6):e66317. https://doi.org/10.1371/journal.pone.0066317.
12. Mirbolouk M, Charkhchi P, Kianoush S, et al. Prevalence and distribution of e-cigarette use among U.S. adults: Behavioral Risk Factor Surveillance System, 2016. *Ann Intern Med.* 2018;169(7):429–438. https://doi.org/10.7326/M17-3440.
13. Curry SJ, Sporer AK, Pugach O, Campbell RT, Emery S. Use of tobacco cessation treatments among young adult smokers: 2005 National Health Interview Survey. *Am J Public Health.* 2007;97(8):1464–1469. https://doi.org/10.2105/AJPH.2006.103788.
14. Hughes JR, Cohen B, Callas PW. Treatment seeking for smoking cessation among young adults. *J Subst Abuse Treat.* 2009;37(2):211–213. https://doi.org/10.1016/j.jsat.2008.11.006.
15. Dawkins K, Turner J, Roberts A, Soar K. 'Vaping' profiles and preferences: an online survey of electronic cigarette users. *Addiction.* 2011;108:1115–1125. https://doi.org/10.1111/add.12150.
16. Biener L, Hargraves JL. A longitudinal study of electronic cigarette use among a population-based sample of adult smokers: association with smoking cessation and motivation to quit. *Nicotine Tob Res.* 2015;17(2):127–133. https://doi.org/10.1093/ntr/ntu200.
17. Rostron BL, Schroeder MJ, Ambrose BK. Dependence symptoms and cessation intentions among U.S. adult daily cigarette, cigar, and e-cigarette users, 2012—2013. *BMC Public Health.* 2016;16:814. https://doi.org/10.1186/s12889-016-3510-2.
18. Birkamnis K, Petersen A, Doran A. E-cigarette use, perceptions, and cigarette smoking intentions in a community sample of young adult nondaily cigarette smokers. *Psychol Addict Behav.* 2017;31(3):336–342. https://doi.org/10.1037/adb0000257.
19. Sutfin EL, McCoy TP, Morrell HE, Hoeppner BB, Wolfson M. Electronic cigarette use by college students. *Drug Alcohol Depend.* 2013;131(3):214–221. https://doi.org/10.1016/j.drugalcdep.2013.05.001.
20. Doran N, Brikmanis K, Petersen A, et al. Does e-cigarette use predict cigarette escalation? A longitudinal study of young adult non-daily smokers. *Prev Med.* 2017;100:279–284. https://doi.org/10.1016/j.ypmed.2017.03.023.
21. Grant BF, Amsbary M, Chu A, et al. *Source and Accuracy Statement: National Epidemiologic Survey on Alcohol and Related Conditions-III (NESARC-III).* Rockville, MD: National Institute on Alcohol Abuse and Alcoholism, 2014.
22. Substance Abuse and Mental Health Services Administration. Rockville, MD: SAMHSA, 2012.
23. Adams PF, Kirzinger WK, Martinez ME. National Center for Health Statistics. Summary health statistics for U.S. adults: National Health Interview Survey. *Vital Health Stat.* 2012;10(259):2013.
24. United States Census Bureau. Suitland, MD: U.S. Census Bureau, 2013.
25. Grant BF, Goldstein RB, Smith SM, et al. The Alcohol Use Disorder and Associated Disabilities Interview Schedule-5 (AUDADIS-5): reliability of substance use and psychiatric disorder modules in a general population sample. *Drug Alcohol Depend.* 2015;148(1):27–33. https://doi.org/10.1016/j.drugalcdep.2014.11.026.
26. Lasser K, Boyd JW, Woolhandler S, et al. Smoking and mental illness. *JAMA.* 2000;284(20):2606–2610. https://doi.org/10.1001/jama.284.20.2606.
27. Gilpin EA, Pierce JP, Farkas AJ. Duration of smoking abstinence and success in quitting. *J Natl Cancer Inst.* 1997;89(8):572–576. https://doi.org/10.1093/jnci/89.8.572.
28. Hughes JR, Carpenter MJ. The feasibility of smoking reduction: an update. *Addiction.* 2005;100(8):1074–1089. https://doi.org/10.1111/j.1360-0443.2005.01174.x.
29. Levy DT, Yuan MS, Luo Y, Abrams DB. The relationship of e-cigarette use to cigarette quit attempts and cessation: insights from a large, nationally representative U.S. survey. *Nicotine Tob Res.* 2018;20(8):931–939. https://doi.org/10.1093/ntr/ntx166.
30. Green LW, Fielding JE, Brownson RC. The debate about e-cigarettes: harm minimization or the precautionary principle. *Annu Rev Pub Health.* 2018;39:189–191. https://doi.org/10.1146/annurev-publhealth-102417-124810.
31. Cahn Z, Siegel M. Electronic cigarettes as a harm reduction strategy for tobacco control: a step forward or a repeat of past mistakes? *J Public Health Policy.* 2011;32(1):16–31. https://doi.org/10.1057/jphp.2010.41.
32. Flouris AD, Oikonomou DN. Electronic cigarettes: miracle or menace? *BMJ.* 2010;340:c311. https://doi.org/10.1136/bmj.c311.
33. Etter J-F, Bullen C. Electronic cigarette: users profile, utilization, satisfaction and perceived efficacy. *Addiction.* 2011;106(11):2017–2028. https://doi.org/10.1111/j.1360-0443.2011.03505.x.
34. Choi K, Fabian L, Mottey N, Corbett A, Forster J. Young adults' favorable perceptions of snus, dissolvable tobacco products, and electronic cigarettes: findings from a focus group study. *Am J Public Health.* 2012;102(11):2088–2093. https://doi.org/10.2105/AJPH.2011.300525.

35. Pokhrel P, Little MA, Fagan P, Muranaka N, Herzog TA. Electronic cigarette use outcome expectancies among college students. *Addict Behav.* 2014;39(6):1062–1065. https://doi.org/10.1016/j.addbeh.2014.02.014.
36. Chapman SLC, Wu LT. E-cigarette prevalence and correlates of use among adolescents versus adults: a review and comparison. *J Psychiatr Res.* 2014;54:43–54. https://doi.org/10.1016/j.jpsychires.2014.03.005.
37. Messer K, Trinidad DR, Al-Delaimy WK, Pierce JP. Smoking cessation rates in the United States: a comparison of young adult and older smokers. *Am J Public Health.* 2008;98(2):317–322. https://doi.org/10.2105/AJPH.2007.112060.
38. Dutra LM, Glantz SA. Electronic cigarettes and conventional cigarette use among U.S. adolescents: a cross-sectional study. *JAMA Pediatr.* 2014;168(7):610–617. https://doi.org/10.1001/jamapediatrics.2013.5488.
39. Lee S, Grana RA, Glantz SA. Electronic cigarette use among Korean adolescents: a cross-sectional study of market penetration, dual use, and relationship to quit attempts and former smoking. *J Adolesc Health.* 2014;54(6):684–690. https://doi.org/10.1016/j.jadohealth.2013.11.003.
40. Berry KM, Reynolds LM, Collins JM, et al. E-cigarette initiation and associated changes in smoking cessation and reduction: the Population Assessment of Tobacco and Health Study, 2013–2015. *BMJ Open.* 2019;28(1):42–49. https://doi.org/10.1136/tobaccocontrol-2017-054108.
41. Selya AS, Dierker L, Rose JS, Hedeker D, Mermelstein RJ. The role of nicotine dependence in e-cigarettes' potential for smoking reduction. *Nicotine Tob Res.* 2018;20(10):1272–1277. https://doi.org/10.1093/ntr/ntx160.
42. Schroeder MJ, Hoffman AC. Electronic cigarettes and nicotine clinical pharmacology. *Tob Control.* 2014;23(suppl 2):30–35. https://doi.org/10.1136/tobaccocontrol-2013-051469.
43. Farsalinos KE, Spyrou A, Stefopoulos C, et al. Nicotine absorption from electronic cigarette use: comparison between experienced consumers (vapers) and naïve users (smokers). *Sci Rep.* 2015;5:11269. https://doi.org/10.1038/srep11269.
44. CDC. Tobacco use among middle and high school students—United States, 2011–2017. *MMWR Morb Mortal Wkly Rep.* 2018;67(22):629–633. https://doi.org/10.15585/mmwr.mm6722a3.
45. Laska MN, Pasch KE, Lus K, Story M, Ehlinger E. Latent class analysis of lifestyle characteristics and health risk behaviors among college youth. *Prev Sci.* 2009;10:376–386. https://doi.org/10.1007/s11121-009-0140-2.
46. McMillen RC, Gottlieb MA, Shaefer RMW, Winickoff JP, Klein JD. Trends in electronic cigarette use among U.S. adults: use is increasing in both smokers and nonsmokers. *Nicotine Tob Res.* 2015;17(10):1195–1202. https://doi.org/10.1093/ntr/ntu213.