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RESEARCH ARTICLE

E-cigarettes and Smoking Cessation in Smokers With Chronic Conditions

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Introduction: Many smokers with chronic medical conditions use e-cigarettes. This study assessed the association between e-cigarette use and subsequent smoking-cessation efforts in adult smokers with and without chronic medical conditions.

Methods: This was a longitudinal cohort study of adult cigarette smokers using Waves 1 and 2 of the Population Assessment of Tobacco and Health Study (2013−2015), analyzed in 2018–2019. The exposure was the initiation of e-cigarette use by Wave 2. The outcomes at Wave 2 were: (1) past 12-month attempts to quit, (2) cigarette abstinence, (3) ≥50% reduction in cigarette use, and (4) past 12−month use of evidence-based smoking-cessation treatment.

Results: E-cigarette use initiation was associated with increased odds of attempting to quit smoking at Wave 2 among smokers with any chronic medical condition (AOR=1.92, 95% CI=1.42, 2.59) and without chronic medical conditions (AOR=1.81, 95% CI=1.50, 2.18). E-cigarette use initiation was also significantly associated with Wave 2 smoking abstinence in smokers with (AOR=1.95, 95% CI=1.11, 3.43) and without chronic medical conditions (AOR=1.63, 95% CI=1.17, 2.28).

Conclusions: At a population level, e-cigarette use by smokers with chronic medical conditions is associated with more quitting activity and smoking abstinence. Future studies are needed to assess e-cigarette safety and efficacy to determine whether they may provide an alternative smoking-cessation or harm-reduction strategy for adults with smoking-sensitive disease who cannot achieve these goals with other methods.

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INTRODUCTION

Cigarette smoking is the leading preventable cause of death worldwide, and stopping smoking is a critical factor in reducing this risk for all cigarette smokers. However, it is particularly urgent for cigarette smokers with chronic medical conditions that are caused or worsened by smoking. Evidence-based smoking-cessation treatments can help many of these individuals quit smoking.[1] However, some of these smokers are reluctant to try to quit or have failed when using proven treatments. These smokers may be using e-cigarettes as an option to quit smoking.

E-cigarettes are battery-operated devices that heat a liquid containing nicotine, propylene glycol or vegetable glycerin, and often flavorings, to produce a vapor that users inhale.[2] E-cigarettes do not burn tobacco, and therefore reduce a user's exposure to the chemicals produced by combustion of tobacco that is responsible for the vast majority of tobacco-related diseases.[3] Therefore, smokers who switch from conventional cigarettes to e-cigarettes ultimately should reduce their risk of developing tobacco-attributable diseases. How e-cigarettes affect the long-term health of individuals who already have chronic medical conditions is less clear. Some small studies have found e-cigarettes to be well tolerated in the short term in smokers with asthma[4,5] and chronic obstructive pulmonary

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disease,[6] though other studies have raised concerns about the potential effect of e-cigarettes on pulmonary health[7] and cardiovascular risk.[8] Potential risks will likely be minimized if e-cigarettes are used in the short term to aid cessation from conventional cigarettes rather than used as a long-term substitute for cigarettes.

E-cigarette use is already prevalent among current smokers, of whom 53% reported ever using an e-cigarette and 11% reported currently using e-cigarettes in 2016.[9] The odds of current e-cigarette use by smokers with chronic conditions such as asthma and cardiovascular disease are 1.5 times higher than among smokers with no chronic medical conditions (OR=1.50, 95% CI=1.10, 2.15 for asthma and OR=1.54, 95% CI=1.10, 2.15 for cardiovascular disease).[10] Smokers with chronic medical conditions are more likely to try to quit smoking than smokers without chronic medical conditions, and more than a quarter of smokers with chronic medical conditions report using e-cigarettes to try to quit.[11] Some studies have found that smokers perceive e-cigarettes as more satisfying than nicotine-replacement therapy,[12,13] and more useful for quitting smoking.[13] It is not known whether the use of e-cigarettes deters from use of evidence-based smoking-cessation treatments such as nicotine-replacement therapy. Reducing cigarette consumption is another common reason for e-cigarette use among clinical populations of adults,[13,14] and e-cigarettes may appeal to these individuals as vehicles for reducing health risks from cigarette smoking, even without smoking cessation. Whether e-cigarette use in smokers with chronic medical conditions is associated with longitudinal changes in cigarette consumption, either through cessation of or reduction in cigarette use, is not known.

Studies of the association between e-cigarette use and smoking cessation have had varying conclusions.[15–17] Although a Cochrane meta-analysis of 2 RCTs showed an association between e-cigarette use and subsequent smoking cessation,[17] several observational studies have found a negative association.[15] Additionally, there are few longitudinal studies examining the relationship of e-cigarette use with subsequent cigarette consumption among smokers with chronic medical conditions.[18] Longitudinal studies are needed to better inform clinicians' counseling of smokers with chronic medical conditions about e-cigarette use, and to understand reasons underlying the high prevalence of e-cigarette use in this population observed in cross-sectional studies. In the present study, data from Waves 1 (2013–2014) and 2 (2014–2015) of the nationally representative Population Assessment of Tobacco and Health (PATH) study were used to determine smoking-cessation behavior and cigarette consumption over time among a cohort of smokers with and without chronic medical conditions who use e-cigarettes.

METHODS

Study Population

The PATH study follows a longitudinal cohort of U.S. adults and youth.[3,19] Address-based sampling methods were used to sample households and adults who live in those households, and surveys were administered through audio computer-assisted self-interview technology. Data were collected on tobacco use and related attitudes and health factors. Publicly available data from adults who participated in both Waves 1 and 2 of the PATH study were used for the current analyses. The weighted response rates for Wave 1 were 54% for the household screening and 74% for the adult interviews, and the weighted retention rate for Wave 2 was 83%. This study was deemed exempt by the IRB at Partners Healthcare.

Measures

Participants reported medical diagnoses that they recalled having ever received from a doctor or other health professional. A chronic medical condition was defined as ≥1 of the following: asthma, cancer, diabetes or prediabetes, stroke, heart attack, myocardial infarction, needed bypass surgery, congestive heart failure, or chronic obstructive pulmonary disease (defined as COPD, chronic bronchitis, or emphysema and age ≥35 years). Having no chronic medical condition was defined as reporting none of these medical conditions.

Current cigarette smokers were defined as those who reported: (1) smoking ≥100 cigarettes in their lifetime and (2) now using cigarettes every day or some days at either study wave. For smokers who reported smoking on some days, cigarettes per day were calculated as the product of the number of days smoked in the last 30 days and cigarettes smoked per day on days smoked divided by 30.

Any current e-cigarette use at Wave 1 was defined as using e-cigarettes every day or some days at the time of the survey. Owing to the addition of questions about other forms of ENDS in Wave 2, current e-cigarette use at Wave 2 was defined as current use of e-cigarettes, e-cigars, e-pipes, or e-hookahs every day or on some days. The primary predictor used in analyses was initiation of e-cigarette use between Waves 1 and 2, defined as current use of e-cigarettes at Wave 2, but not Wave 1.

Two primary outcomes were assessed in this study: (1) having tried to quit in the past 12 months at Wave 2 and (2) cigarette abstinence at Wave 2. Having tried to quit was assessed by asking whether a participant tried to quit cigarettes or tobacco in the past 12 months. Those who responded, *Yes, I have tried to quit completely,* or *Yes, I have tried to quit by reducing or cutting back* were further asked how many times they tried to quit. Having tried to quit was defined as reporting at least 1 try. Cigarette abstinence at Wave 2 was defined as currently smoking *not at all*; participants using e-cigarettes but not cigarettes at Wave 2 were considered cigarette abstinent. There were 2 secondary outcomes: (1) ≥50% reduction in cigarettes per day from Wave 1 to Wave 2 and (2) use of evidence-based smoking-cessation medication at follow-up, which was defined as past 12-month use of either nicotine-replacement therapy or prescription medication (varenicline or bupropion).

Statistical Analysis

Data came from Wave 1 current cigarette smokers aged ≥18 years who did not use e-cigarettes and had nonmissing data on chronic

medical conditions. Participants did not need to be current cigarette smokers at Wave 2 to be included in the analysis. Analyses were stratified by the presence or absence of chronic medical conditions. Complex survey procedures and replicate weights were used for all analyses. Longitudinal weights accounted for nonresponse at Wave 2. All *n* are reported as unweighted, and all percentages as population-weighted. Stata, version 14 (StataCorp LP, College Station, TX) was used for all analyses, which was done in 2018–2019.

First, the population-weighted prevalence of initiation of e-cigarette use among smokers by the presence or absence of chronic medical conditions was calculated. Current e-cigarette users were compared with nonusers using chi-square tests for categorical variables and adjusted Wald tests for continuous variables. Multivariable logistic regression models assessed the association between initiation of e-cigarette use and primary and secondary outcomes at the individual participant level. Regression models controlled for demographics, including age (categorized as 18–34 years, 35–54 years, and ≥55 years), sex, race/ethnicity (dichotomized into non-Hispanic white and other for regression analyses), education (less than high school, high school diploma/GED, or some college or more), and income below the federal poverty level; region of residence (Northeast, Midwest, South, and West); baseline cigarettes per day (this was censored at the 99th percentile, 60 cigarettes per day, to minimize the impact of extreme outliers); and nicotine dependence (measured as time to first cigarette within 30 minutes of waking[20]). For the secondary outcome of ≥50% change in cigarettes per day, analyses were limited to smokers who reported a change in cigarettes per day of ≤60 to minimize the impact of extreme outliers. With 2 primary outcomes, a 2-sided *p*-value ≤0.025 was considered statistically significant.

RESULTS

Among adult current smokers who did not use e-cigarettes at Wave 1 (unweighted *n*=7,169), 31% reported at least one chronic medical condition. The prevalence of initiation of e-cigarette use by Wave 2 was 14% for smokers with chronic medical conditions and 15% for those with no chronic medical conditions (p=0.35). Table 1 shows the characteristics of the study population by chronic medical condition and initiation of e-cigarette use by Wave 2.

Table 2 shows the unadjusted association between e-cigarette use and each study outcome. In multivariable models, e-cigarette initiation (versus no e-cigarette initiation) by Wave 2 was associated with trying to quit smoking in the past 12 months at Wave 2 among smokers with and without chronic medical conditions (Table 3). E-cigarette use initiation was also significantly associated with cigarette abstinence at Wave 2 among smokers with and without chronic medical conditions (Table 3).

In secondary analyses, e-cigarette use initiation was not associated with the use of evidence-based smoking-cessation medication at follow-up among smokers with or without chronic medical conditions in unadjusted or adjusted analyses (Tables 2 and 3). E-cigarette use initiation was not associated with a ≥50% reduction in cigarettes per day at Wave 2 among smokers with or without chronic medical conditions.

DISCUSSION

In this large nationally representative longitudinal cohort of U.S. adult smokers, initiation of e-cigarette use was associated both with trying to quit smoking and cigarette abstinence at follow-up among smokers with a chronic medical condition, as well as among smokers without a chronic medical condition. Smokers with a chronic medical condition that initiated e-cigarette use by Wave 2 were no more or less likely to use evidence-based smoking-cessation treatment at follow-up compared with those who did not use e-cigarettes. These results suggest that among adult smokers, e-cigarettes did not discourage quitting-related behaviors such as quit attempts and the use of evidence-based treatments. Furthermore, similar to smokers without chronic medical conditions, e-cigarette use initiation among smokers with chronic medical conditions was positively associated with cigarette abstinence at follow-up.

Chronic disease diagnosis can be a catalyst for smoking behavior change,[21] and much of the e-cigarette use in smokers with chronic medical conditions may reflect attempts to quit or reduce cigarette smoking, which is supported by the findings that smokers with chronic medical conditions who used e-cigarettes were more likely to try to quit at follow-up. It is consistent with a repeated cross-sectional study demonstrating that e-cigarette use was associated with a higher quit attempt rate on the population level in the 2014–2015 Current Population Survey-Tobacco Use Supplement,[22] and with findings from a different study using the same survey that found that e-cigarettes were associated with more quit attempts.[23] Further waves of the PATH study can help to understand these longitudinal patterns better.

The present analyses also found an association between e-cigarette use and cigarette abstinence among smokers with chronic medical conditions. Previous analyses have found that smokers with chronic medical conditions are more likely to have a past-year doctor visit than smokers without chronic medical conditions,[11] which is one factor that may impact the association between e-cigarette use and longitudinal quitting behavior. In addition, having a chronic medical condition may influence reasons for e-cigarette use (e.g., as part of a quitting strategy). Prior studies have found daily e-cigarette use to be associated with smoking abstinence in general populations in the U.S.[24] and United Kingdom.[25] Because of the small sample size, the present analyses were not able to evaluate e-cigarette use frequency and its association with quitting behavior in smokers with

Table 1. Wave 1 (Baseline) Characteristics of Study Population by Presence of Chronic Medical Conditions and E-cigarette Use Initiation by Wave 2[a]

	Any chronic medical condition			No chronic medical conditions		
Characteristics	**E-cigarette initiation, (*n*=317)**	**No e-cigarette initiation, (*n*=1,887)**	***p*-value**	**E-cigarette initiation, (*n*=762)**	**No e-cigarette initiation, (*n*=4,156)**	***p*-value**
Age, years			**<0.001**			**<0.001**
18–34	**26 (22, 31)**	**21 (19, 23)**		**54 (50, 58)**	**42 (40, 43)**	
45–54	**49 (43, 56)**	**38 (35, 40)**		**36 (32, 40)**	**40 (39, 41)**	
≥55	**25 (19, 31)**	**42 (39, 44)**		**10 (8, 13)**	**18 (17, 20)**	
Female sex	59 (52, 65)	52 (49, 55)	0.07	41 (37, 44)	41 (40, 42)	0.82
Non-Hispanic white race/ ethnicity	73 (68, 78)	69 (66, 71)	0.11	**74 (69, 77)**	**67 (66, 69)**	**0.01**
Education			0.58			0.23
Less than high school	21 (17, 25)	21 (19, 23)		13 (10, 15)	15 (14, 16)	
High school/ GED	36 (30, 42)	39 (36, 41)		40 (37, 44)	40 (38, 42)	
Some college or more	43 (38, 49)	41 (38, 43)		47 (43, 51)	45 (43, 47)	
Income below federal poverty level	**46 (41, 52)**	**40 (38, 43)**	**0.04**	38 (33, 44)	36 (34, 38)	0.39
Region of residence			0.85			0.10
Northeast	18 (13, 23)	19 (16, 22)		16 (13, 19)	19 (17, 20)	
Midwest	25 (20, 30)	27 (23, 30)		25 (21, 29)	24 (23, 26)	
South	39 (33, 46)	37 (34, 41)		44 (39, 49)	40 (38, 42)	
West	19 (14, 24)	17 (15, 20)		16 (13, 18)	17 (15, 20)	
Cigarettes per day, mean (SE)	**16.5 (0.7)**	**15.0 (0.3)**	**0.04**	**13.8 (0.4)**	**12.8 (0.2)**	**0.04**
First cigarette within 30 minutes of waking	72 (66, 77)	68 (65, 70)	0.21	**65 (61, 69)**	**55 (53, 57)**	**<0.001**

Notes: Values are % (95% CI) unless otherwise noted. All *n* are unweighted and percentages are population-weighted. Boldface indicates statistical significance ($p<0.05$).
[a]Data were missing as follows (unweighted): <1% for age and education, 7% for income, 2% for cigarettes per day, and 1% for first cigarette within 30 minutes of waking.
GED, general education development.

chronic medical conditions; however, this should be a focus of future research.

Although e-cigarettes are not discouraging quitting activity among vulnerable smokers such as those with chronic medical conditions, a separate important consideration is whether e-cigarettes should be promoted to these patients as a cessation strategy. Until more is known about the health effects of e-cigarettes, particularly among individuals who have chronic health conditions that may be worsened by e-cigarette use, and until more RCTs are able to test the efficacy of e-cigarettes for smoking cessation, smokers should continue to be encouraged to try evidence-based smoking-cessation medications such as nicotine-replacement therapy, varenicline, and bupropion first.[26] However, for smokers who are not interested in quitting with other modalities or at all, a harm reduction approach that involves using e-cigarettes instead of cigarettes may serve as an alternative or complementary strategy.[27,28] Such approaches should be revisited as more is known about the health effects of e-cigarettes and as these devices evolve.

Limitations

This study is subject to several limitations. First, the survey data were self-reported and may be subject to reporting bias. Also, data on chronic medical conditions and tobacco product use were not validated by objective measurements or health records. Second, current e-cigarette users could not be analyzed separately by each chronic medical condition because of small sample sizes for some chronic medical conditions. Participants with different chronic medical

Table 2. Percentage of Cessation-Related Outcomes at Wave 2 Among Smokers With and Without Chronic Medical Conditions by E-Cigarette Initiation by Wave 2

	Any chronic medical condition, (*n*=2,221)		No chronic medical condition, (*n*=4,948)	
Variable	**Unweighted N**	**Weighted % (95% CI)**	**Unweighted N**	**Weighted % (95% CI)**
Tried to quit smoking/tobacco				
No e-cigarette initiation by Wave 2	815	43 (40, 45)	1,544	37 (35, 39)
E-cigarette initiation by Wave 2	172	55 (49, 61)	374	49 (45, 53)
Cigarette abstinence at Wave 2				
No e-cigarette initiation by Wave 2	122	7 (6, 8)	334	8 (7, 9)
E-cigarette initiation by Wave 2	29	9 (6, 14)	78	11 (8, 13)
Follow-up evidence based—treatment use				
No e-cigarette initiation by Wave 2	367	20 (17, 22)	423	11 (10, 12)
E-cigarette initiation by Wave 2	72	24 (19, 29)	82	11 (9, 14)
At least 50% reduction in cigarettes/day				
No e-cigarette initiation by Wave 2	470	27 (24, 29)	1,019	25 (24, 27)
E-cigarette initiation by Wave 2	85	26 (21, 32)	229	31 (28, 35)

Note: Missing data for each outcome was <4% (unweighted).

Table 3. Association Between E-Cigarette Use Initiation by Wave 2 and Cessation-Related Outcomes Among Smokers With and Without Chronic Medical Conditions

Variable	**Any chronic medical condition**	**No chronic medical condition**
Tried to quit smoking/tobacco[a]		
No e-cigarette initiation by Wave 2	ref	ref
E-cigarette initiation by Wave 2	**1.92 (1.42, 2.59)*** **	**1.81 (1.50, 2.18)*** **
Cigarette abstinence at Wave 2[b]		
No e-cigarette initiation by Wave 2	ref	ref
E-cigarette initiation by Wave 2	**1.95 (1.11, 3.43)***	**1.63 (1.17, 2.28)** **
Follow-up evidence based—treatment use[a]		
No e-cigarette initiation by Wave 2	ref	ref
E-cigarette initiation by Wave 2	1.27 (0.90, 1.79)	1.05 (0.76, 1.46)
At least 50% reduction in cigarettes/day[a]		
No e-cigarette initiation by Wave 2	ref	ref
E-cigarette initiation by Wave 2	1.13 (0.80, 1.62)	1.13 (0.80, 1.62)

Notes: Values are AOR (95% CI) unless otherwise noted. Boldface indicates statistical significance (*$p<0.05$, **$p<0.01$, ***$p<0.001$).
[a]Controlling for age, race/ethnicity, sex, education, income, region of residence, baseline cigarettes per day, nicotine dependence.
[b]Controlling for age, race/ethnicity, sex, education, income, region of residence, baseline cigarettes per day, nicotine dependence, and past 12-month use of evidence-based treatment at follow-up.

conditions may differ in e-cigarette use behaviors and longitudinal use patterns. Third, e-cigarette devices have continued to evolve since the data were collected for these analyses, and the findings may not be generalizable to all current cigarette smokers. Fourth, the analysis did not take into account specific reasons for e-cigarette use and perceptions of e-cigarettes, and some participants may have been using e-cigarettes for reasons unrelated to cessation. Fifth, analyses did not capture the duration of e-cigarette use, a factor that may help understand the observed associations. Finally, the exact timing of e-cigarette use and quit attempts could not be ascertained, and some participants may have stopped using e-cigarettes before making attempts to quit. Further studies using new waves of PATH study data can help to determine timing of cigarette use, e-cigarette use, and quitting behavior.

CONCLUSIONS

Current e-cigarette use by smokers with chronic medical conditions is associated with more longitudinal attempts to quit and longitudinal smoking abstinence. On a population level, e-cigarette availability does not appear to be discouraging quitting activity among adult smokers with

health-related reasons to quit smoking. Longer-term studies are needed to assess the safety of these devices and their potential to serve as a substitute for cigarettes.

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